POST OFFICE TELEGRAPHS.

TECHNICAL INSTRUCTIONS, I.

BATTERIES.

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GENERAL POST OFFICE, LONDON,
JUNE 1898.

BATTERIES.

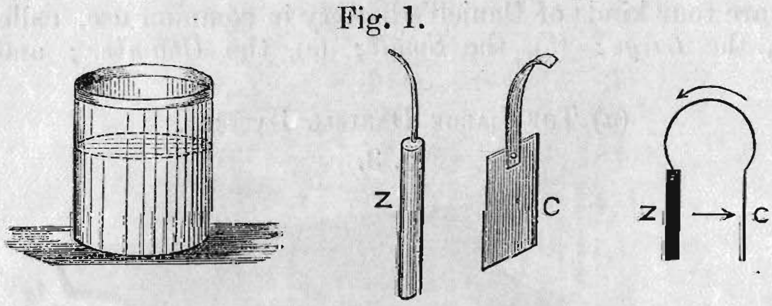
1. A battery produces electricity by the combustion of its positive plate (generally zinc) as a fire produces heat by the combustion of coal. To obtain heat from coal, however, it is only necessary to light it in the presence of air, whereas to obtain electricity from zinc a special combination of that metal with another metal or conductor and a liquid is required. The liquid must be one which has a strong chemical affinity or attraction for zinc, and the second metal or conductor must be one for which the liquid has no, or very little, affinity. Sulphuric acid in one shape or another is the liquid which is most frequently used, and the second conductor is generally either copper or carbon. The combustion of coal in air produces (in addition to other residues) carbon di-oxide, commonly known as carbonic acid gas, which immediately passes away up the chimney and is lost, but the combustion of zinc in sulphuric acid in a battery produces sulphate of zinc. The carbonic acid gas escapes from the fire of itself, but the sulphate of zinc has to be removed from the battery, otherwise it would stop its action.

2. The arrangement of a piece of zinc and a piece of platinum, silver, copper, or carbon in a liquid to produce electricity is called a *cell*, and a series of such cells properly arranged is called a *battery*.

THE SIMPLE VOLTAIC CELL.

3. If a glass jar or earthen pot be half filled with water mixed with a small quantity of sulphuric acid, and a pure zinc rod with a piece of wire soldered to it, as shown at Z, Fig. 1, be immersed in the acidulated water, *practically* no action will be observed, but if a plate of copper with a wire attached, like that shown at C, be also immersed, and the two wires be connected together, then the zinc at once commences to be attacked, and bubbles of gas are copiously given forth from the copper plate.

Fig. 1.



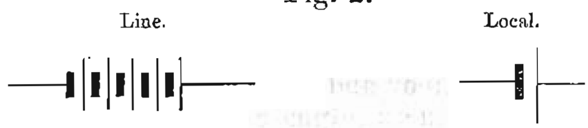
As long as the wires or straps attached to the zinc and copper are kept apart, *practically* no action takes place, but the moment they are connected voltaic action begins, the zinc is consumed, and electricity is generated. The current is conventionally said to flow from the zinc through the liquid to the copper, and thence through the wire back to the zinc; the zinc combines with the sulphuric acid, forming sulphate of zinc, and hydrogen is given off on the copper. Hence, in process of time all the zinc would be converted into sulphate of zinc, but the action of the cell ceases before this can occur; the water will only dissolve a given quantity of the sulphate, and, when this point, called the *point of saturation*, is reached, the sulphate will form in white transparent crystals on the zinc, and isolate it from the liquid. Again, the hydrogen in forming on the copper leaves less of the plate in contact with the liquid and "polarises" it, as it is called, that is, it causes it to set up an electrical effect in opposition to the prime current; it also reacts on that portion of the sulphate of zinc which is still dissolved in the liquid, causing zinc to be

deposited on the copper plate itself. The deposit of crystals on the zinc can be provided against by care and attention in any cell, but that of zinc on the copper plate cannot be obviated in the simple voltaic cell; and cells of a different kind have, therefore, had to be adopted, as will be shown hereafter.

4. In the cell described, the zinc is called the positive plate or element, and the copper is called the negative plate or element. Outside the battery, the copper end is called the positive pole, and the zinc end the negative pole. This seeming contradiction of calling the copper plate in the battery the negative element and the terminal connected with it outside the positive pole, and similarly calling the zinc plate the positive element and the terminal connected with it the negative pole, is explained by the fact that the electricity produced by the chemical action on the zinc or other positive plate, as already shown, passes through the liquid in the cell to the copper or other negative plate, and from the copper plate through the wire connecting the two plates back to the zinc; thus *positive* electricity flows from the negative plate, and the wire connected to this plate is, therefore, called the positive pole.

5. A battery is usually shown symbolically thus:

Fig. 2.



The perpendicular fine lines represent the negative, and the perpendicular short thick lines the positive plates.

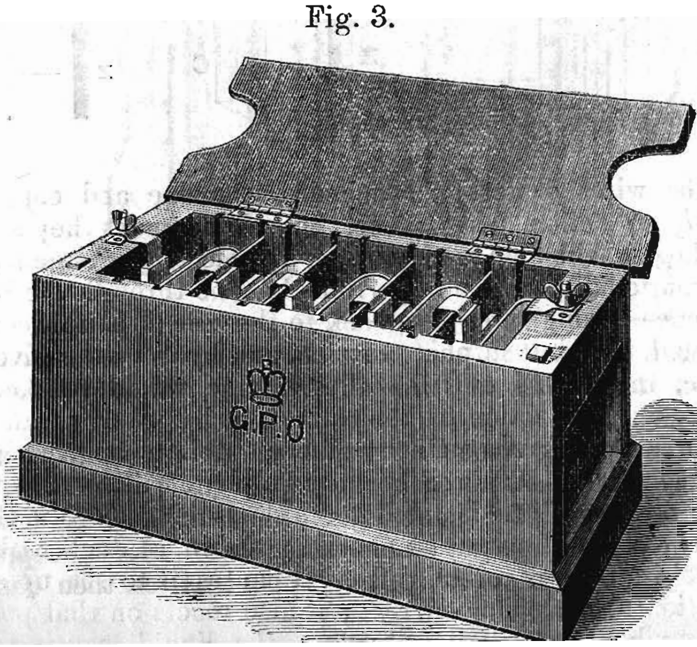
DANIELL'S BATTERY.

6. Daniell succeeded in removing the hydrogen from the copper by placing the copper plate in a solution of sulphate of copper, the zinc remaining in dilute sulphuric acid, and the two liquids being separated from each other by a porous material, which, while it checked the mixture of the liquids, did not prevent the flow of electricity. The action of this cell is like that of the simple one, sulphate of zinc being formed in the dilute sulphuric acid and hydrogen being produced on the negative plate; but the hydrogen at once decomposes part of the sulphate of copper in which the negative plate is placed, throwing down upon that plate pure metallic copper, which keeps the plate bright and clean, whilst at the same time zinc sulphate is formed at the zinc plate.

7. There are four kinds of Daniell's battery in common use, called respectively: (*a*), the *Large;* (*b*), the *Small;* (*c*), the *Chamber;* and (*d*), the *Ordinary.*

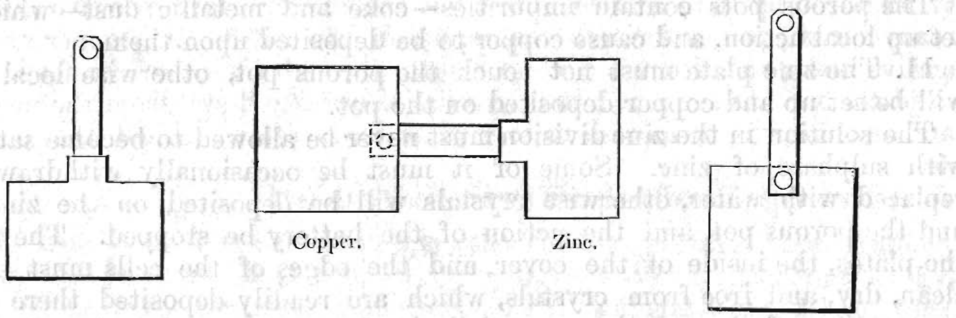
(*a*) The Large Daniell Battery.

Fig. 3.



8. A trough 1 ft. 2 in. long, 6 in. wide, and 6 in. deep is made of teak and divided into 5 cells by slate partitions; to make it water-tight it is coated internally with marine glue, which is a mixture of india-rubber, naphtha, and shellac. Against the coated surfaces of the slate partitions, and also at the bottom of the cells, glass plates are fixed for the purpose of covering over the adhesive surface of the glue. Into each cell is placed a porous earthenware pot, in which a thin copper plate, Fig. 4, $4\frac{1}{2}$ in. square, is inserted; a zinc plate, $4\frac{1}{2}$ in. wide and $2\frac{1}{2}$ in. deep, is placed in the cell opposite the porous pot. The copper plate of one cell is permanently connected with the zinc of the next cell by a copper strap cast into the zinc and riveted to the copper, which is easily bent over the slate partition.

Fig. 4.



Terminal Zinc. Pair of Plates. Terminal Copper.

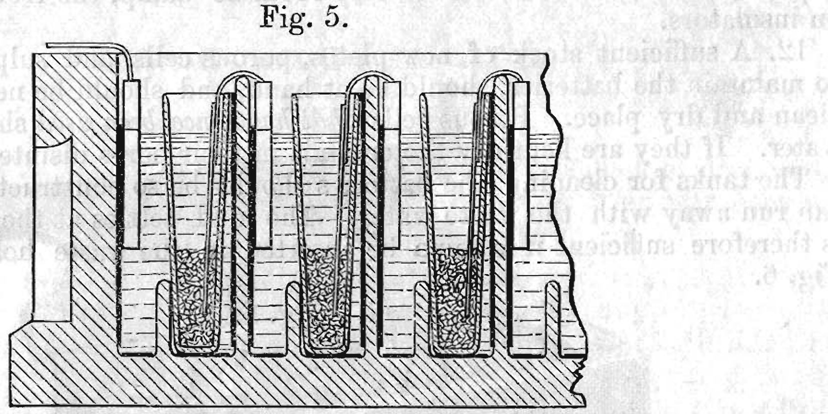
The last copper and the last zinc plate are each connected to brass binding screws or terminals, which become respectively the positive and negative poles of the battery.

In order to check as far as possible the diffusion of the sulphate of copper solution from the porous pot into the zinc cell, the pot is saturated with melted paraffin wax, except at the part immediately opposite the zinc plate. Particular care must be taken to place the non-saturated side of the porous pot opposite the zinc plate.

To charge the Daniell battery.

9. About 4 oz. of sulphate of copper crystals, which must be about the size of hazel nuts, are placed in the porous pots, filling them to about one third of their height, and pure water (hard water should never be used) is then poured in until it reaches the same level as the top of the zinc plates. A little time is then allowed for the copper sulphate solution to force the air out of and saturate the porous pots, and, when this process is observed to be complete, the zinc divisions are filled with pure water to within a quarter of an inch of the top of the zinc plates. As the porous pots will have absorbed water they must be replenished to the same level as in the zinc divisions. (See Fig. 5.)

Fig. 5.



When batteries are charged in this way, they begin to act efficiently much sooner than when the copper and zinc divisions are filled with water almost simultaneously.

The battery at the end of about 24 hours will be found to be in working order, the sulphate having dissolved in the copper division.

If the battery be wanted for immediate use, then the zinc division must be filled with a weak solution of sulphate of zinc, and the copper division with a saturated solution of sulphate of copper; action then commences at once.

The action of the Daniell battery.

10. The ordinary action of the battery is as follows:—Zinc is consumed, sulphate of zinc is formed, sulphate of copper is decomposed, and pure copper is deposited on the copper plate. If all the materials were pure, and no causes of interference were present, it would simply be necessary to occasionally remove the sulphate of zinc and replace the sulphate of copper; but the solution of sulphate of copper diffuses through the porous pot, and the sulphuric acid leaves the copper with which it was united and attacks the zinc, for which it has a greater affinity. Pure copper, in the form of *black mud*, is then deposited on the zinc plate, and the action of the battery is weakened.

Zinc, again, cannot be obtained pure, and the particles of lead, iron, and other matter which are mixed with it set up local action, which is evidenced by the way in which the plate is pitted.

The porous pots contain impurities—coke and metallic dust—which also set up local action, and cause copper to be deposited upon them.

The care of the Daniell battery.

11. The zinc plate must not touch the porous pot, otherwise local action will be set up and copper deposited on the pot.

The solution in the zinc division must never be allowed to become saturated with sulphate of zinc. Some of it must be occasionally withdrawn and replaced with water, otherwise crystals will be deposited on the zinc plate and the porous pot, and the action of the battery be stopped. The tops of the plates, the inside of the cover, and the edges of the cells must be kept clean, dry, and free from crystals, which are readily deposited there by the evaporation of the solution, especially in dry rooms; otherwise the liquid will be drawn off by capillary action between the crystals and the sides of the cells. A damp cloth is best for cleaning off these crystals.

Some crystals of sulphate of copper must always be kept in the copper cell, otherwise the battery will become exhausted, and zinc will be deposited on the copper plate, instead of copper, by the action of the hydrogen on the sulphate of zinc.

Before fresh crystals are added the remainder of the old charge should be stirred, so as to clear the surface of the copper plates. The zinc plates should be scraped on the more active side on each occasion of refreshing the battery, but care must be taken to avoid injury to the glue coating of the battery.

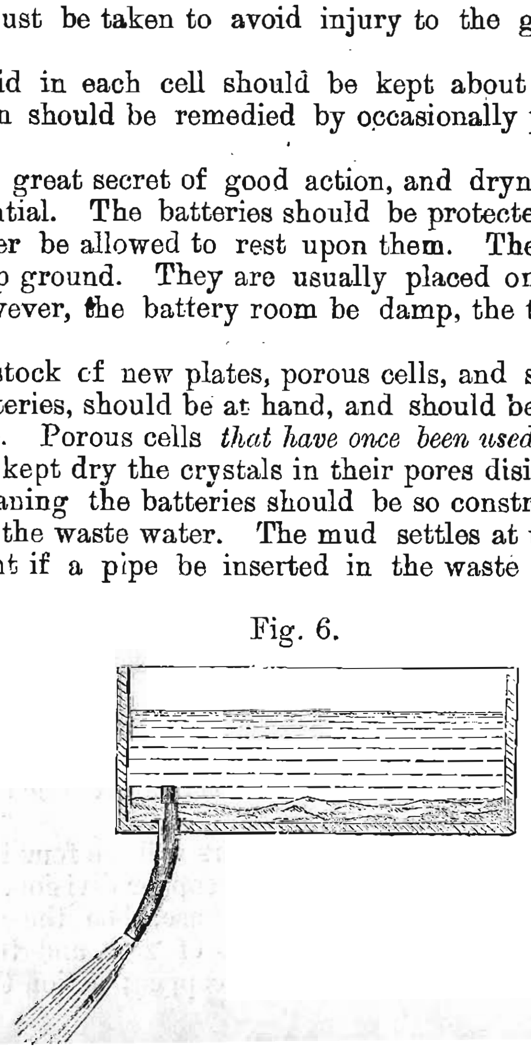
The level of liquid in each cell should be kept about the same, and the effect of evaporation should be remedied by occasionally pouring in a little water.

Cleanliness is the great secret of good action, and dryness, without undue evaporation, is essential. The batteries should be protected from dust; and rubbish should never be allowed to rest upon them. They should never be placed on the damp ground. They are usually placed on racks or kept in cupboards. If, however, the battery room be damp, the troughs should rest on insulators.

12. A sufficient stock of new plates, porous cells, and sulphate of copper, to maintain the batteries, should be at hand, and should be neatly stored in a clean and dry place. Porous cells *that have once been used* should be kept in water. If they are kept dry the crystals in their pores disintegrate them.

The tanks for cleaning the batteries should be so constructed that no mud can run away with the waste water. The mud settles at the bottom, and it is therefore sufficient if a pipe be inserted in the waste hole, as shown in Fig. 6.

Fig. 6.



13. Besides being tended constantly, the battery must be thoroughly cleaned every two or three months, according to the work it has been doing. The solution in the zinc division is first drawn off by a syringe and placed for further use in a jar, cask, or tub, in which scraps of zinc have been placed to reduce any sulphate of copper that may be present. The solution in the copper division is similarly drawn off and set aside. The crystals of sulphate of copper are then removed, and the plates are taken out and thoroughly scraped and cleaned with hand brushes or "cards," the "mud" scraped off the zinc plate being deposited in a box called the "mudbox." The porous pots must be cleared of copper, the terminals and copper strips well polished, every particle of matter removed from the cells, and the cells well rinsed out. To clean t Daniell battery.

14. The battery is recharged in the same way as a new battery is charged; the plates are replaced, new plates being substituted for those which are found to be imperfect, and the liquid drawn off from the zinc division is restored, but diluted with water. To recharg the Daniell battery.

(*b*) The Small Daniell Battery.

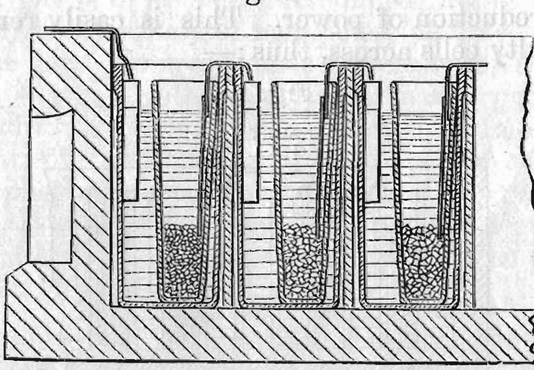
15 This battery is similar in general construction to the large Daniell, the trough is, however, 2 ft. long, 4 in. wide, and $5\frac{1}{2}$ in. deep, and is divided into 10 cells by the slate partitions. The zinc plates are $3\frac{1}{4}$ in. wide by 2 in. deep, and the copper plates $2\frac{1}{4}$ in. wide by $3\frac{1}{4}$ in. deep. The quantity of sulphate of copper required is about 3 ozs. for each cell.

(*c*) The Chamber Daniell Battery.

Fig. 7.

16. A box 2 ft. 2 in. long, 5 in. wide, and $5\frac{3}{4}$ in. deep is made of deal, without any partitions. Ten vessels of ebonite of the shape shown in section at Fig. 8, and forming 10 cells, are fitted into this trough.

Fig. 8.



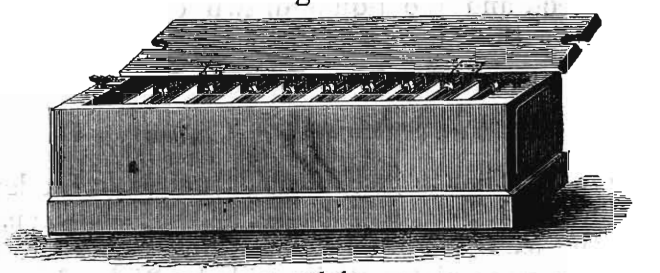
$\frac{1}{3}$ real size.

Into each cell is put a porous earthenware pot, in which the copper plate is placed. The arrangement of the plates, and the mode of fitting, charging, and maintaing the battery, are precisely the same as in the case of the "small Daniell" battery. The zinc plates are $3\frac{1}{4}$ in. wide by 2 in. deep, and the copper plates 3 in. square. In many places the wooden box is dispensed with, and the "chambers" are simply ranged on the shelves or racks of the battery room, but always covered with some protection to check evaporation. This plan of placing the cells without casing on shelves is convenient for increasing battery power, as two, four, six, or any other number of cells can easily be added at any time.

The Chamber battery, although still in use, is an obsolete pattern, and no more new ones of the kind will be supplied.

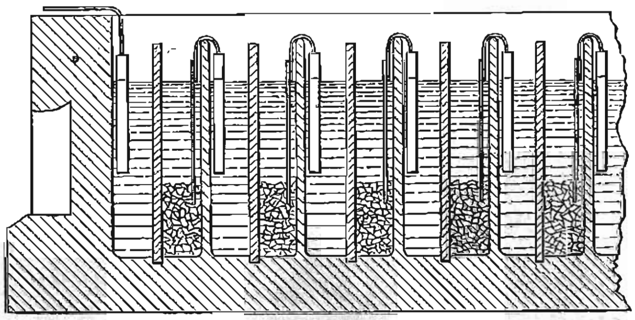
(*d*) THE ORDINARY DANIELL BATTERY.

Fig. 9.



$\frac{1}{10}$ real size.

Fig. 10.



$\frac{1}{4}$ real size.

17. A trough, Fig. 10, 2 ft. long, 4 in. wide, and $5\frac{1}{2}$ in. deep, is made of teak and divided into 10 cells by slate partitions; to make it water-tight it is coated internally with marine glue; each cell is then subdivided by a porous partition of unglazed porcelain, about $\frac{1}{4}$ inch thick, which is fixed while the marine glue is hot. Zinc and copper plates of the same description as those used in the "small Daniell" and "Chamber" batteries are placed in the cells (Fig. 10), and the latter are charged, &c. in precisely the same way as in the case of the "small Daniell" and "Chamber" battery.

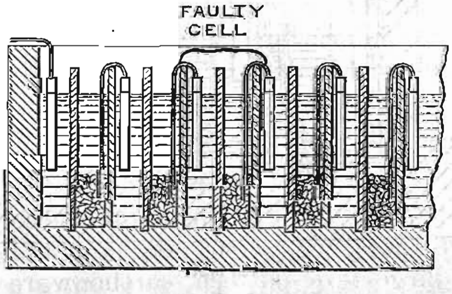
Like the "Chamber" battery, the "Ordinary" is an obsolete pattern, though a large number are still in use.

Prevalent faults in Daniell batteries.

18. The principal faults likely to occur in a Daniell battery are enumerated below:—

(*a*.) *Leaky cells.*—The marine glue chips off, and the joints fail, one cell leaking into another; or the porous jar itself is cracked. The result is complete loss or great reduction of power. This is easily remedied temporarily by bridging the faulty cells across, thus:—

Fig. 11.



(*b.*) *The porous pot or partition sometimes becomes so hard* as to offer sufficient resistance to the current to reduce it greatly. The remedy is the same as in the last case.

(*c.*) *The porous pot is occasionally too soft*, and causes an unequal diffusion of the liquids, so that the liquid in the copper division becomes higher than that in the zinc division. If time fails to work a cure the pot should be changed.

(*d.*) *Dirty connections* are the most frequent source of failure, and cleanliness is the only cure.

(*e.*) *The zinc plate becomes much corroded at the level of the liquid.* This is due to the presence of too much free sulphuric acid, the result of some local action. This, however, is a very rare fault, and one that soon ceases.

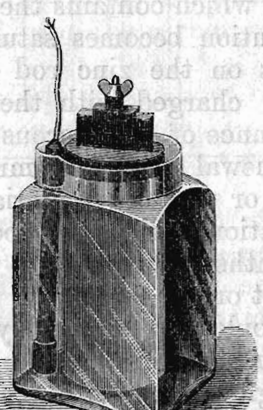
(*f.*) *Local action works out one cell before all its neighbours.* The copper division is found to be full of clear water. It should at once be supplied with crystals. Indeed the liquid should always be blue.

(*g.*) *Occasionally a battery makes earth on a damp support*, but this can always be guarded against by care.

THE LECLANCHÉ BATTERY.

19. The Leclanché battery, which is shown by Fig. 12, is made up in the following manner:—

Fig. 12.



Into a glass jar a solution of the ordinary commercial sal ammoniac (which is a combination of hydrochloric acid and ammonia) is poured. A zinc rod, into which a connecting tinned iron wire has been cast, is then placed in the solution; this rod has broad india-rubber rings fitted at its lower and upper ends, to prevent the metal from coming in contact with the porous pot; a plate of carbon, surrounded by a mixture of broken gas-carbon (or coke) and peroxide of manganese, is fixed in a small porous pot at the top of the jar. To make an attachment for the terminal the top of the carbon plate is capped with lead, which makes good metallic contact with the carbon, and is not liable to be attacked by ammonia, as brass would be. The upper part of the carbon plate is dipped in melted paraffin to fill up its pores and to check the ascension of the liquid by capillary action.

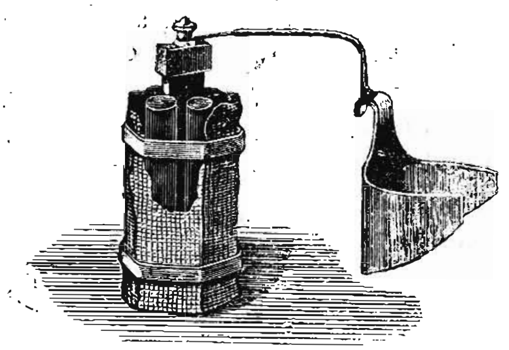
Lastly, the wire, the top of the zinc rod, and the lead cap of the carbon plate are covered with pitch, ozokerit, marine glue, or some other compound, to protect them from local action.

20. The Leclanché batteries of the foregoing description in use by the Department are of two sizes, viz., with porous pots $6\frac{1}{4}$ ins. and $4\frac{3}{4}$ ins. high respectively. In the large size pattern, earthenware instead of glass jars are used.

THE AGGLOMERATE LECLANCHÉ.

In the form of Lechanché battery known as the "Agglomerate" (Fig. 13), the porous pot is dispensed with, and cylindrical prisms of a compressed mixture of carbon and manganese, placed round a central carbon rod, are used. The prisms are kept tight against the central rod by rubber rings, a piece of canvas sacking being first wrapped round the whole set of prisms. A cylinder of zinc surrounds the combination, and a sal ammoniac solution is used, as in the ordinary form of Leclanché.

Fig 13.



The action of the Leclanché battery.

21. The action of the battery is to dissolve the zinc and form zinc chloride, and some other salts of zinc which are soluble in an aqueous solution of sal ammoniac; to reduce the peroxide of manganese to a lower oxide; and, when the battery is heavily worked, to form ammonia, which is given off as a gas. Thus, after a time, new zinc will be required, the sal ammoniac must be replaced, and the porous cell which contains the peroxide of manganese must be renewed. When the solution becomes saturated with the zinc salts, they form themselves in crystals on the zinc rod and porous pot, and if the solution become too highly charged with these salts (supersaturated) the crystals form in the substance of the porous pot and crack it. This is prevented by a periodical renewal of the sal ammoniac solution.

There is no local action or waste of material when the battery is not in action, so that if the evaporation of the liquid be prevented, it may be allowed to remain untouched for months without losing power. The time the battery will last is entirely dependent on the amount of work it has to do.

The porous pot forms should not be employed for local battery purposes, for double current circuits, or for circuits where permanent currents are used, but, in exceptional cases, agglomerate cells, or large size dry cells, may be used for local or permanent current work.

To charge the Leclanché battery.

22. For use at offices where the battery may be without attention for a considerable period, but where the current required is not great, charge the glass jar with a sufficient quantity of sal ammoniac solution to bring the level of the liquid to about two-thirds of the height of the jar when the porous pot and zinc rod are set in their places. The sal ammoniac solution is to be made by dissolving as much sal ammoniac in clean water as the latter will take up, filtering the same through cotton wool, and then adding to the saturated solution so obtained about one-tenth of its bulk of plain water.

Where the battery is likely to be hard worked a supply of undissolved sal ammoniac should however always be available in the glass jar, although this generally results in the deposition of sal ammoniac at the surface of the liquid and general deterioration, unless frequent attention is given to the battery.

Pour a little water into the porous cell through the holes in the top, to moisten the manganese mixture and to establish a conducting medium between the different sections of the battery.

In the case of the smaller size cells, fit an india-rubber ring carefully on the upper part of the porous pot, so as to prevent evaporation.

Take care that neither water nor sal ammoniac solution remains on the terminals, otherwise local action and corrosion will set in.

See that no portion of the protecting compound about the top of the battery has been knocked off. In this event, the exposed portion must be varnished or covered afresh with the compound. A cement composed of three parts by weight of ozokerit and one part of Chatterton's compound is that which is generally used.

23. To allow the ammonia to escape into the air the lid of the trough in which the battery cells are placed should always be slightly raised. The care of the Leclanché battery.

The battery must be kept dry and clean. It should not be fixed in a warm place, otherwise evaporation takes place too rapidly; nor in too exposed a place, otherwise it might be frozen.

It should be examined periodically, according to the amount of work it has to do.

The solution should be bright and clear. If cloudy it is an indication that sufficient sal ammoniac is not present to dissolve the zinc salts. *All* the solution should then be drawn off and the cell again charged, as at first, with a fresh supply of sal ammoniac solution.

The porous pot and zinc rod should then be thoroughly scraped and cleaned. The crystals which have formed on the porous pot are best removed with a damp cloth. When the pot shows signs of cracking it must be replaced by a sound one. The zinc rod, when reduced to half its original size, should be renewed.

The connecting wire should be carefully examined, and any portion of the metal which may have become bare should, after being thoroughly cleaned, be well covered with the cement above described.

If there be none of the cement at hand, a piece of tallow well laid on will prevent corrosion for some time, but no time should be lost in procuring a supply of the cement. The terminals should be thoroughly cleaned and burnished.

If any white deposit be observed between the lead cap and the carbon plate a fresh porous pot and plate should be substituted, as the white deposit will eventually insulate the lead from the carbon and stop the action of the battery.

Sal ammoniac should not be left loose about offices or stores. It rapidly destroys metals with which it may be brought in contact, and for this and other reasons it should be put into casks or jars, which should always be kept covered, and perfectly dry.

24. In addition to the exhaustion of the battery material the following faults are not infrequent:— Leclanché battery faults.

(*a.*) The cracking of the porous pot, due to the formation of crystals in its pores.

(*b.*) The corrosion of the connecting iron wires, due to the action of ammonia.

(*c.*) The disconnection of the connecting wire of the carbon plate, due either to the lead cap making imperfect contact with the carbon or to the formation of salts of lead between the lead and the carbon.

(*d.*) The cracking of the glass jar, due to imperfect annealing.

25. A form of Leclanché known as a "dry cell" is frequently employed in offices where it is desirable to avoid the necessity for recharging, or where it is desired to transport the cells from one office to another for immediate use.

This form of cell may be described as an Agglomerate Leclanché without any perceptible liquid excitant.

Amorphous manganese dioxide and finely powdered carbon is made into a paste, in the centre of which the carbon block is placed. This arrangement fulfills exactly the same purpose as the Agglomerate blocks in that form of battery.

The circular zinc of the Agglomerate cell forms in the case of the dry cell the outer containing vessel, and the space between the inside of the zinc cylinder and the carbon and manganese mixture is filled with a paste consisting of sal ammoniac solution, lime, glycerine, and frequently plaster-of-Paris.

The force of this element is similar to that of the Agglomerate and (chiefly owing to the use of amorphous manganese) is less than the porous pot form of Leclanché, but the larger sizes of dry cell are quite equal to the Agglomerate form of battery where constant attention cannot be given.

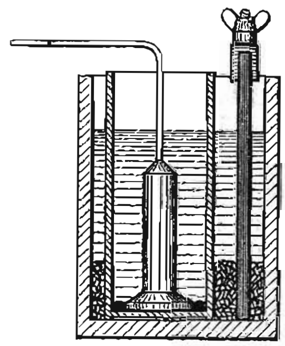
Great care should, however, be taken to keep these cells in a cool place and to prevent the outer cases from touching each other.

It is almost unnecessary to add that this form of cell ceases to be of any practical value when it becomes actually dry.

THE BICHROMATE BATTERY.

26. Each cell consists of a glass or stoneware jar, of a quart size. Inside this jar is placed a porous pot; the zinc is placed in the porous pot, and the negative plate, which is of carbon, is placed in the outer jar; the zinc is of the special shape shown in Fig. 14. It is *cast* on to a stout copper wire, and both are well amalgamated.

Fig. 14.



To charge the Bichromate battery.

27. In the outer jar are placed four ounces (or one scoopful*) of bichromate of potash.

In the porous pot are placed two ounces (or two measures†) of mercury. Both the outer jar and the porous pot are then filled up to within two inches of the top, the former with water to which four ounces (or one measure†) of sulphuric acid are added and the latter with water, a quarter of an ounce of acid is then added in the porous pot.

The proportions of acid and water in the outer jar are therefore as one to four and in the porous pot as one to forty.

The action of the Bichromate battery.

28. When the plates are connected the sulphuric acid attacks the zinc and forms sulphate of zinc, while the hydrogen reduces the bichromate of potash to a lower form. The mercury keeps the zinc perfectly amalgamated, so that local action is reduced to a minimum; there is secondary action in the battery when the solutions become saturated, which results in the formation of dark violet crystals of "chrome-alum" on the carbon plate. This is a double salt, a sulphate of chromium and potassium, and is an evidence of inefficient maintenance.

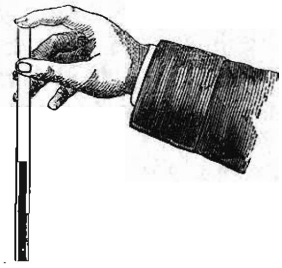
29. The secondary action just referred to is only to be prevented by the occasional withdrawal of some of the liquid and its replacement by fresh sulphuric acid and water, an operation which should be performed immediately the deposition of crystals is detected. The crystals themselves should of course be removed.

As long as the colour of the bichromate solution remains *orange* little need be done, but if *blue* fresh bichromate of potash should be added; when the colour remains orange, and yet the battery fails, some fresh sulphuric acid must be added. At the same time half of the solution in the porous pot should be replaced with water. The colour of the bichromate solution can be ascertained by dipping a strip of white paper into it, but the better plan is to

* Scoops are supplied for this purpose. † Measures are supplied for this purpose.

insert an open glass tube to a depth of an inch or two, and then by stopping up the end of the tube with the forefinger, thus :—

Fig. 15.



the tube can be withdrawn for examination.

The zinc should remain bright and clear with mercury and uncoated with any deposit. It should always be covered with the solution.

30. Some difficulty is frequently experienced in keeping the internal resistance of this form of battery within the limits authorised by the Department, and although in many cases this difficulty is caused by unsuitable porous pots or solutions, this fault is often produced by working the battery too hard.

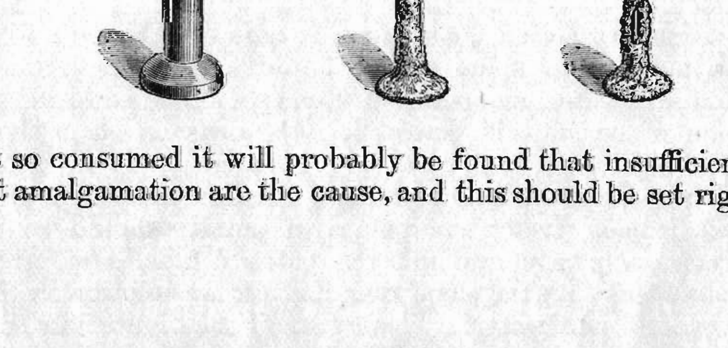
In such cases it will be noticed that the battery resistance increases while working, and decreases during the periods of rest.

To clean the Bichromate battery.

31. With a moderate amount of work this battery will last three or four months without being touched, but when worked hard it must be examined about once a week.

When the solution becomes blue, notwithstanding the presence of a sufficiency of bichromate of potash, and the zinc becomes dirty and coated with deposit, the battery must be entirely cleaned. In doing this great care should be taken not to waste the mercury either in the pot or on the zinc. The best plan is to insert the pot and its zinc undisturbed in an open jar, and place them under a water tap. The whole of the solution in the pot, together with the deposit, will then be washed away, but the mercury will remain behind. The carbon and the outer jar simply need washing in water; the battery can then be charged as before. Crystals that remain in the cells unchanged in colour can be used again, but all others must be rejected. The zinc can be used as long as any portion remains. In a good working battery the zinc should be consumed gradually from the top downwards, as shown in Fig, 16.

Fig. 16.



If it be not so consumed it will probably be found that insufficient mercury and imperfect amalgamation are the cause, and this should be set right without delay.