WS No. 19 Mark III

FOR OFFICIAL USE.

A.2.

P.W.—A.2.

Post Office Engineering Department

TECHNICAL PAMPHLETS FOR WORKMEN

Subject:

Primary Batteries.

ENGINEER-IN-CHIEF'S OFFICE,
1919.

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PRIMARY BATTERIES.

TABLE OF CONTENTS.

FOR OFFICIAL USE.

PRIMARY BATTERIES

(A.2).

The following pamphlets in this series are of kindred interest:

A.1. Magnetism and Electricity.
G.1. Secondary Cells.

The Leclanché type of primary battery is now used almost without exception for all telephone and telegraph purposes by the Post Office. This pamphlet deals with that type of cell.

1.—SIMPLE CELLS.

If any two different metals be placed in an acid or solution of salts, and the outside end of each piece of metal be joined up to a voltmeter the pointer of the voltmeter will deflect. The extent of the deflection will differ according to the particular combination of metals selected and the nature of the liquid in which the metals are immersed. The following examples will make this clear. If a zinc and a copper rod are immersed in diluted sulphuric acid the voltmeter will show about 1 volt. If a brass rod be substituted for the zinc rod the voltage indicated on the voltmeter will be much less—about $\frac{1}{5}$ of a volt. If a rod of zinc and a rod of carbon be used the voltmeter will show about $1\frac{1}{2}$ volts. If, again, instead of a solution of sulphuric acid, a solution of common table salt be used, different voltages will be registered according as the different metals are tried, but the readings on the voltmeter will generally be lower than when the same two metals are immersed in sulphuric acid. A rod of zinc and a rod of carbon immersed in a solution of salammoniac will produce a voltage reading of about $1\frac{1}{2}$ volts, whilst the same two rods in a solution of manganese chloride will produce a slightly higher voltage reading. In no case will the size of the metals or the amount of liquid used materially affect the extent of the deflection obtained on the usual type of voltmeter.

Any one of these combinations of two metals placed in the solution in a suitable containing vessel forms a "simple cell." The metal by which the current of electricity is led out of the cell is known as the "**positive pole,**" "**kathode**" or "**negative electrode,**" and the metal to which the current returns is known as the "**negative pole,**" "**anode**" *or* "**positive electrode.**" The "Pole" is actually the part of the electrode which is outside the solution. The solution is referred to as the "**electrolyte.**"

A simple cell will furnish a very small current for a long time, and as a properly designed voltmeter takes a very small current, the deflection obtained by joining a simple cell to the voltmeter will remain steady for a considerable time. If, instead of a voltmeter, a low resistance instrument is used, the limitations of the simple cell will soon become apparent.

The "quantity" coil of the P.O. Detector No. 1 or the 500 milliampère coil of the P.O. Detector No. 2 will serve to demonstrate the point.

When a simple cell is joined up to either of these the pointer will be observed to fall rapidly from a large deflection, immediately the cell is connected, to a constantly diminishing value the longer the cell is connected. A low resistance trembler bell connected to a simple cell would give a few beats and then fail. Hence, a simple cell cannot sustain a large current.

This failure is due to the effect known as "**polarisation.**" If the electrodes in the simple cell are closely examined whilst the cell is discharging a large current, bubbles of gas will be observed to accumulate, particularly in the neighbourhood of the negative electrode, and it is the presence of the coating of gas which is the direct cause of polarisation and which prevents the metals maintaining their initial electrical properties.

In order to overcome the difficulty another substance which will absorb the gas is added to the simple cell. That substance is known as the "**depolariser.**" It is a different material in different types of cell. In the Leclanché cell the depolariser is **manganese dioxide.**

2.—THE LECLANCHÉ CELL.

The Leclanché cell consists of:—

(a) A glass or earthenware containing vessel;

(b) A solution of salammoniac or manganese chloride;

(c) A zinc rod;

(d) A quantity of mixture of manganese dioxide and carbon in the form of powder;

(e) A carbon rod;

(f) A porous container.

The carbon rod is placed centrally in the porous container, commonly an unglazed earthenware jar, or a canvas bag, and the mixture of manganese dioxide and carbon powder, after being **slightly** moistened with a solution either of salammoniac or zinc chloride, is placed in the container and punned firmly around the carbon rod.

The electrolyte is placed in the earthenware containing vessel, and a zinc rod and the porous container with the enclosed depolariser and carbon rod are immersed in the liquid.

The Dry Cell.—The usual type of dry cell consists of a central rod of carbon, around which is packed a mixture of manganese dioxide and powdered carbon, the whole being enclosed in a muslin or canvas bag. The latter, with its contents, is placed centrally within a zinc cylinder. The space between the bag and the cylinder is filled with a very fluid paste made up of flour, gum tragacanth, and solutions of salammoniac and zinc chloride. The flour and gum tragacanth serve only to assist in forming the paste. They play no part in the useful chemical reactions.

The zinc cylinder is filled up with a layer of almost 1 in. in depth of sawdust or husks of wheat in order to form an expansion chamber for gases, and the cylinder is finally closed in with pitch compound. To allow of the escape of gas generated within the cell, small holes are left in the sealing compound. The whole is enclosed in a cardboard jacket.

"Inert" Dry Cell.—The "Inert" type of dry cell is made up in the same way as the type just described excepting that the space between the bag containing the depolariser and the zinc cylinder is filled with dry materials, and water must be added through a hole in the sealing compound before the cell can be brought into use.

Chemical Action in a Leclanché Cell.—It will be seen that the dry cell is merely another form of the Leclanché cell. Theoretically, the chemical action is the same, and may be briefly described as follows:—

As the cell is discharging current the zinc rod dissolves in the electrolyte, forming zinc chloride and, with salammoniac solution, ammonia gas. The depolariser gets continually weaker. Finally, the cell fails, due to one or more of the following causes:—

(i) The zinc rod is all dissolved.

(ii) The electrolyte becomes short of salammoniac, or manganese chloride, as the case may be, causing a coating of hard yellowish white salts or crystals to form on the zinc rod and porous container.

(iii) The depolariser becomes exhausted and cannot prevent gas reaching the carbon rod.

Making up a Leclanché Cell.—In making up the depolarising element the essential condition is to pack the mixture of two parts of manganese dioxide and one part powdered carbon into as firm a mass as is possible without breaking the porous container. The powdered carbon increases the conductivity of the manganese which by itself is a bad conductor of electricity. A layer of the slightly moistened mixture should be first placed in the bottom of the porous container, the carbon rod should then be placed centrally in position, and the powder added a little at a time and rammed down frequently with a stick. If the porous jar happens

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to crack it should be tied up with string. The main objects of the porous jar are to hold the contents and to prevent the zinc rod making contact with the carbon. If anything, a cracked porous jar works better than a whole one provided it holds the contents together firmly.

The porous container need not be sealed in if the cell is to be used on the spot. Sealing is only necessary for cells to be transported to a considerable distance. Nor, if sealed in, need the sealing be ventilated by leaving holes in it.

The electrolyte is made up by dissolving 2 to 4 ozs. of salammoniac or 4 ozs. of manganese chloride in each pint of water. (For use of zinc chloride see under "Points on Maintenance.") "Voltoids" consist of compressed salammoniac, and 16 voltoids weigh 1 oz. The voltoids dissolve quicker in warm water if first crushed. Very hot water should not be used.

It is found that the tendency of crystals to form is much reduced by the presence of a small quantity of zinc chloride in the freshly prepared salammoniac solution. It is now provided for by incorporating zinc chloride and salammoniac in a compressed tablet stamped "Zinkams."

The salammoniac must be stirred in the water until it is dissolved. If it be merely thrown in it lies at the bottom of the liquid and is wasted, for it will not dissolve if left undisturbed. 2 ozs. of salammoniac to the pint is a sufficiently strong solution for lightly worked batteries, and 4 ozs. to the pint for heavily worked batteries. With the stronger solution difficulty may arise owing to the salammoniac creeping out of the solution and over the outside of the cell. If the weaker solution be used for a heavily worked battery crystals will form prematurely on the zinc rod. Manganese chloride is used for lightly worked cells and for cells used in close proximity to secondary cells. Ammonia gas, which is very harmful to secondary cells, is not formed when manganese chloride is used as the electrolyte. On the whole it is not quite so efficient an electrolyte as salammoniac, but the absence of free gas when the cell is discharging enables the cell containing manganese chloride to be wholly enclosed in a box and the evaporation of the solution is thereby considerably retarded.

The charged porous container and the zinc rod are now placed in the outer containing vessel, and the electrolyte is poured in until it is almost level with the top of the porous container. Care should be taken not to wet the brass terminal on the carbon plate, otherwise it will corrode. Some of the electrolyte will gradually soak into the depolariser. The level of the electrolyte should therefore be restored a few hours later.

The cell is ready for use immediately it is made up, provided the depolariser has not been set aside until it has dried. Even in that case good results can be obtained within an hour or two from the time the cell elements are assembled.

3.—TESTING OF CELLS.

The fundamental idea underlying the method of testing cells is **to ascertain the electrical condition of the different elements comprised in a cell.**

A newly made up Leclanché cell, properly constituted, will show at least 1½ volts on a Detector No. 2, and the internal resistance of the cell will be about 1 ohm; whilst a new dry cell will give 1½ volts, with an internal resistance of about ¼ ohm. But it has been shown that a simple cell of zinc-carbon in electrolyte of salammoniac will give 1½ volts. Consequently the fact that a cell gives 1½ volts when first connected to a voltmeter merely shows that the carbon and zinc rods are in order. It does not prove that the cell is capable of yielding a comparatively large current for a prolonged period. The amount of current passed from the cell through the voltage coil of a Detector No. 2 is not sufficient to test the ability of the depolariser for absorbing the gas. If, however, a small resistance—say, 2 ohms—is joined across the terminals of the cell and allowed to remain connected, say, for one minute, the cell will pass a large current, and if the depolariser be acting perfectly, the voltage reading obtained on the Detector No. 2, if it is connected to the cell immediately after the 2-ohm resistance has been removed, will be 1½ volts.

With continued use the depolariser becomes more and more exhausted, and ultimately reaches the stage when it is no longer capable of absorbing the gas fast enough. If, therefore, we take a cell in which the depolariser has become exhausted, and test it after the cell has been idle and the gas generated during a previous discharge has had time to disappear, we should find that, when first connected to the Detector No. 2, the voltage reading obtained may be as high as 1½ volts; but on retesting after applying the 2-ohm resistance for one minute, the voltage reading would be less than 1 volt. Hence it can be said that if a cell will not give 1 volt or more immediately after discharging a current through 2 ohms external resistance for one minute, the depolariser has failed, and fresh manganese dioxide mixture is required (*see* Example 3).

The internal resistance of a Leclanché or a dry cell should not exceed a certain limit, which, for the purpose of this pamphlet, may be taken to be 2 ohms. The internal resistance of a Leclanché cell will be influenced by the following conditions:—

(i) Loose packing of the manganese dioxide mixture.

(ii) Dirty wire contacts on the carbon rod or zinc rod.

(iii) A hard, porous jar, or a container which has become clogged with salts.

(iv) A zinc rod which has become encrusted with salts.

(v) A zinc rod not immersed in the electrolyte.

(vi) Insufficient electrolyte.

That the internal resistance of a cell is not more than 2 ohms may be ascertained in the following manner:—

Connect up the cell to the 5-volt coil of the Detector No. 2. Read the voltage indicated. Now join a 2-ohm resistance directly across the terminals of the cell without disturbing the detector connection. Watch the detector needle. If at the moment the 2-ohm resistance is joined across the cell terminals, the detector indicates a voltage less than one-half the voltage read immediately before the resistance was joined across the cell, the internal resistance of the cell exceeds 2 ohms (*see* Example 2).

Now consider a few practical examples.

EXAMPLE 1.—TEST SHOWING WHEN CELL IS SATISFACTORY.

The voltage of a Leclanché cell when first connected to the 5-volt coil of a Detector No. 2 gave 1·4 volts. Immediately the 2-ohm resistance was joined across the cell terminals the voltage reading became 1·0. Keeping the resistance connected across the cell for one minute, the voltage indicated immediately the resistance was disconnected rose to 1·2 volts.

The following deductions are made:—

(a) The internal resistance of the cell is right, because the second voltage reading is more than half the first voltage reading, and—

(b) The depolariser is in good order, because the third voltage reading is more than 1 volt.

EXAMPLE 2.—TEST SHOWING WHEN INTERNAL RESISTANCE IS DEFECTIVE.

The first voltage reading was 1·4.

The second voltage reading was ·5.

Deduction: The internal resistance of the cell is defective as is shown by the second voltage reading being less than half the first voltage reading and the cell would be examined to see which of the possible causes referred to accounts for the defect.

Seeing that the foregoing tests show that the cell is defective the carrying out of the third test would not be necessary in this case.

EXAMPLE 3.—TEST SHOWING WHEN POLARISATION IS DEFECTIVE.

The first voltage reading was 1·3, the second voltage reading was ·9, and the third voltage reading was ·9.

Deduction:—The depolariser is exhausted as is shown by the third voltage reading being less than 1 volt.

Clearly it would not serve any useful purpose in the case illustrated in example 3 merely to recharge the cell with salammoniac without also replacing the manganese dioxide mixture.

Precisely the same testing procedure applies in the case of the dry cell and the deductions to be made are similar, but, in virtue of the design of the dry cell a new cell must be substituted if the cell tested proves to be defective as regards either internal resistance or polarisation. There is no known means of remedying internal defects in a dry cell other than reconstruction.

The test may be applied to a battery consisting of any number of cells provided the proper coil of the Detector No. 2 be used, and the resistance joined across the terminals of the battery be made equal to the number of cells in the battery multiplied by 2, e.g. 10 ohms for a 5 cell battery, 40 ohms for a 20 cell battery and so on.

The standard instructions relating to the testing of batteries are published in the telephone and telegraph diagram books—Form T. 102 of the loose leaf diagrams.

4. POINTS ON MAINTENANCE.

Generally speaking, a Leclanché cell is designed so that, with average conditions of use, the zinc, salammoniac, and manganese dioxide become exhausted at the same time. Abnormal conditions of use interfere with the realisation of the design. Large crystals tend to form on the zinc rod, etc., if the discharge current is very high, whilst much finer crystals are formed if currents of a smaller value are maintained for prolonged periods.

It is found that the tendency of crystals to form is much reduced by the presence of a small quantity of zinc chloride in the freshly prepared salammoniac solution. This is now provided for by incorporating zinc chloride and salammoniac in a compressed tablet stamped " Zinkams."

The tendency to form the crystals becomes greater as the salammoniac solution becomes weaker. As already stated, the presence of the crystals results in the cell having a high internal resistance, and, in order to minimise the tendency for the crystals to form, heavily worked cells should be " topped up " with a 4 oz. to the pint solution of salammoniac. In other cases a weaker solution of salammoniac is best, the strength of the topping up solution being regulated by the estimated work done by the cell. As a guide, an average subscriber's telephone speaking battery should be topped up with water, whilst a battery used for lighting lamps on a switchboard should be topped up with the strong solution of salammoniac.

With regard to the use of manganese chloride as the electrolyte difficulties with regard to the salts creeping out or corrosion of terminals do not arise. But there is another difficulty which does arise if the electrolyte be freely exposed to the action of the atmosphere. The difficulty is the coating of the zinc rod with a hard brownish powder which has the same effect on the internal resistance of the cell as the crystals with a salammoniac electrolyte. The remedy is to enclose the cell in a closely fitting box, so as to prevent a circulation of air over the cell. Another way that has been suggested is to float a layer of heavy oil on the top of the electrolyte, in which case the box would not be needed.

Zincs and porous containers should be kept clean by scraping off any encrustation.

Ordinary tap water is suitable for use with Leclanché cells, but in some districts where there is an excess of dissolved salts in the water, it is best to boil the water before using it to make up the electrolyte.

The electrolyte in cells placed in a heated and dry atmosphere evaporates rapidly, and the tendency for the crystals to creep out is very marked. The difficulty due to the latter cause may be materially lessened by coating the inner edge of the outer containing vessel with vaseline.

There will be no difficulty with corrosion of terminals and wire connections of cells provided they are kept dry. Once corrosion is set up, however, it is difficult to eliminate, and should be attempted by carefully scraping only when the corrosion is slight. The lead on carbons which are capped with that metal is very liable to corrosion unless it is well protected by the pitch compound.

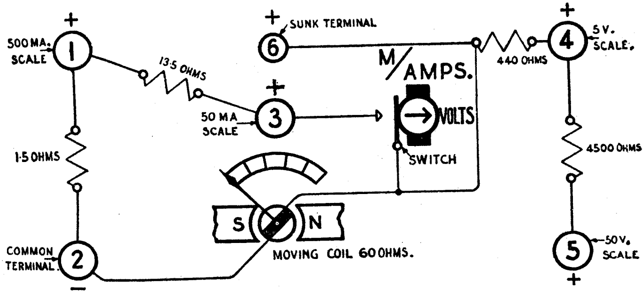
Where white lead makes its appearance on the lead cap it is best to discard the carbon at once, and not to attempt any remedial measures.

Connections should be perfectly clean and tight. The leads from the zinc rods, where two small zinc rods are used instead of one large zinc, in a single cell, should be twisted together before being connected to the terminal of an adjacent cell.

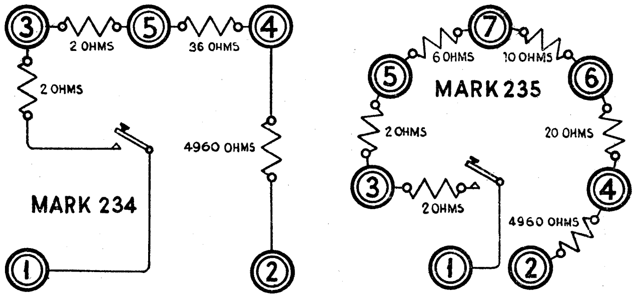
Care should be taken to place batteries on dry wood, or in boxes standing on earthenware feet in situations liable to become wet, floors, for instance; otherwise the current will leak away to earth and the battery will fail prematurely. Cells should always be placed in positions easy of access, in order that the element may be readily lifted out for inspection.

In general, if a battery, even when heavily worked, requires complete renewal of the depolariser or new zincs more frequently than once in two or three months, there is something wrong either with the maintenance, or with the quality of materials used, or it may be that the load on the cells is excessive. In the last case larger cells may be needed, or it may be more economical to use secondary cells.

DETECTOR, No. 2, & COIL, TESTING, No. 1.



The Figure shows the Interna Connections of the Detector, No. 2.



The Figures show the Internal Connections of two types of Coils, Testing No. 1.

PROCEDURE IN MAKING TESTS.

GENERAL NOTES.

In no case should the Detector be permitted to remain in circuit if the full scale deflection is exceeded.

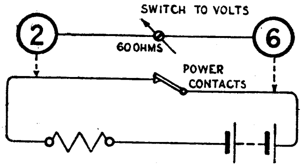
In doubtful cases always test first for a high voltage or heavy current, and thus safeguard the moving coil from being fused.

The Pointer of the Detector can be adjusted to zero by means of the screw at the base of the instrument.

In the explanatory figures which follow the Terminals of the Detector are shown by single circles, and the Terminals of the Testing Coil by double circles.

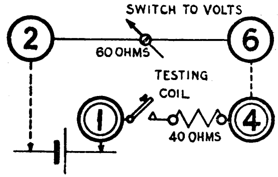
DETECTOR, No. 2, & COIL, TESTING, No. 1.

VOLTAGE TESTS.



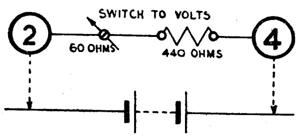
1. 0 *to* 0·6 *Volt.*—Each small division on Detector Scale represents ·012 volt, i.e., 12 millivolts. The reading on the 50 volt scale multiplied by 12 equals millivolts.

Test is suitable for checking conductivity of joints on Power Cables, Switches, &c. To avoid damage to Moving Coil Test (3) should always precede Test (1) and the latter should be made when the voltage in Test (3) is less than ·6 volt, i.e., 6 small divisions.



2. 0 *to* 1 *Volt.*—Each small division on Detector Scale represents ·02 volts, i.e. 20 millivolts.

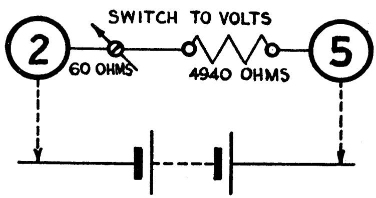
The reading on the 50 volt scale multiplied by 20 equals millivolts.



3. 0 *to* 5 *Volts.*—Each small division on Detector Scale represents ·1 volt.

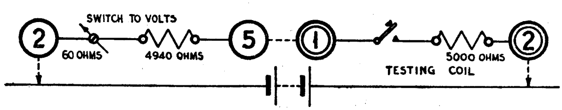
The voltage across the terminals of the Detector is indicated by the reading on the 5 volt scale.

To test Relay or Night Bell Contacts for resistance connect Terminals (2) and (4) across same. No resistance is indicated by no deflection when current is flowing through contacts.



4. 0 *to* 50 *Volts.*—Each small division on Detector Scale represents 1 volt.

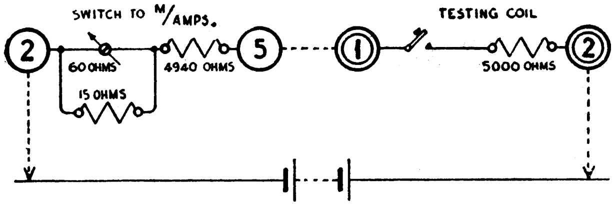
The voltage across the Terminals of the Detector is indicated by the reading on the 50 volt scale.



5. 0 *to* 100 *Volts.*—Each small division on the Detector Scale represents 2 volts. The reading on the 50 volt scale multiplied by 2 gives the voltage across Detector and Testing Coil.

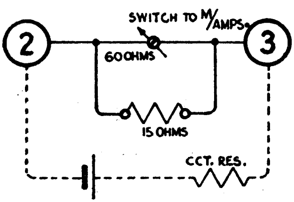
DETECTOR, No. 2, & COIL, TESTING, No. 1.

VOLTAGE TESTS—*continued.*

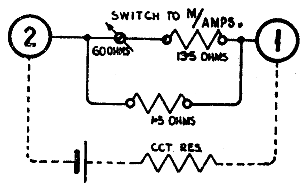


6 0 *to* 250 *Volts.*—Each small division on Detector Scale represents 10 volts. The reading on the 50 volt scale multiplied by 10 gives the voltage across the Detector and Testing Coil. *In making this test current must be left on continuously. If reading exceeds* 25 *small divisions Detector should be discontinued at once.*

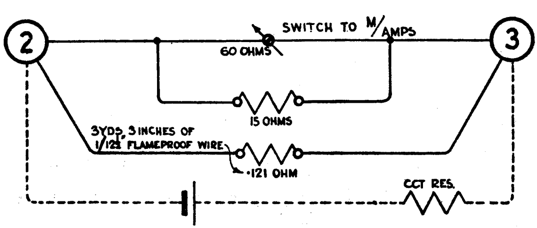
CURRENT TESTS.



7. 0 *to* 50 *Milliamperes.*—Each small division on Detector Scale represents 1 milliampere. The current flowing through the Detector is indicated by the reading on the 50 milliampere scale. The resistance of the Detector is 12 ohms.



8. 0 *to* 500 *Milliamperes.* Each small division on the Detector Scale represents 10 milliamperes. The current flowing through the Detector is indicated by the reading on the 500 milliampere scale. The resistance of the Detector is 1·47 ohms.

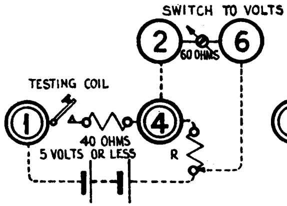


9. 0 *to* 5 Amperes.—Each small division on the Detector Scale represents ·1 ampere The reading on the 5 volt scale may be regarded as representing amperes. The resistance of the Detector is ·12 ohm.

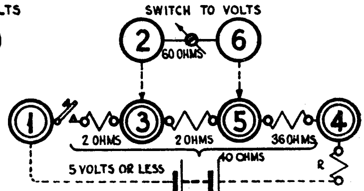
DETECTOR, No. 2, & COIL, TESTING, No. 1.

RESISTANCE TESTS.

(i)



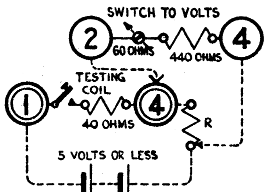
(ii)



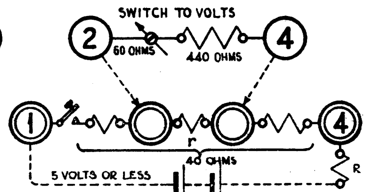
10. 0 *to* 5 Ohms.—Connect up as in (i). Note reading on 50 volt scale = V_1.
Connect up again as in (ii). Note direct reading on 50 volt scale = V_2.

Unknown resistance $R = \frac{2 V_1}{V_2}$

(i)



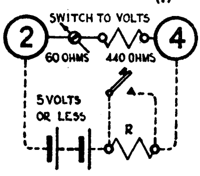
(ii)



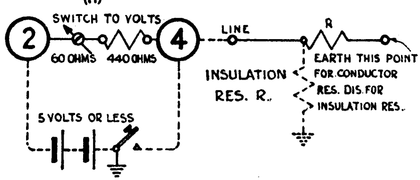
11. 0 *to* 500 *Ohms.*—Connect up as in (i). Note direct reading on 50 volt scale = V_1.
Connect up again as in (II) selecting terminals on Testing Coil so that resistance r as near as possible to the unknown resistance R. Note direc reading on 50 volt scale = V_2.

Unknown resistance $R = \frac{r V_1}{V_2}$

(i)



(ii)



12. 0 *to* 24,500 *Ohms*. Connect up as in (i) or (ii) Short-circuit R and note direct reading on 50 volt scale = V_1.
Remove short-circuit and again note direct reading on 50 volt scale = V_2.

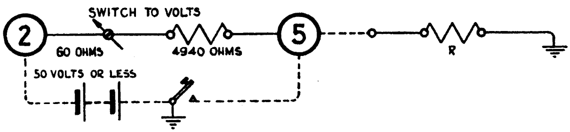
Unknown resistance $R = \frac{500 (V_1 - V_2}{V_2}$

The value of R can be ascertained from the Table on Sheet 10 when V_1 is from 18 to 25 divisions or 36 to 50 divisions.

Test (ii) *is more suitable or measuring low resistances.*

DETECTOR, No. 2, & COIL, TESTING, No. 1.

RESISTANCE TESTS—*continued.*

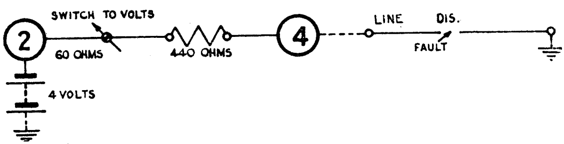


13. 0 *to* 245,000 *Ohms.*—Short circuit R and note direct reading on 50 volt scale = V_1 Remove short circuit and again note direct reading on 50 volt scale = V_2.

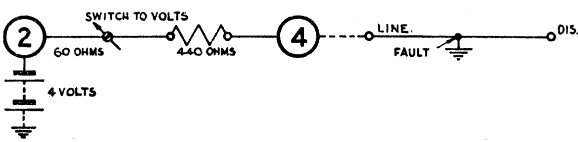
Unknown resistance $R = \frac{5,000\ (V_1 - V_2)}{V_2.}$

The value of R can be ascertained from the Table on Sheet 10 when V_1 is from 18 to 25 divisions or 36 to 50 divisions.

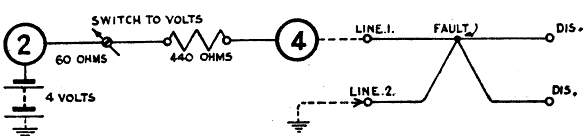
LINE TESTS.



14. *Disconnection.*—Have line earthed at distant end. No deflection on Detector indicates line is disconnected.



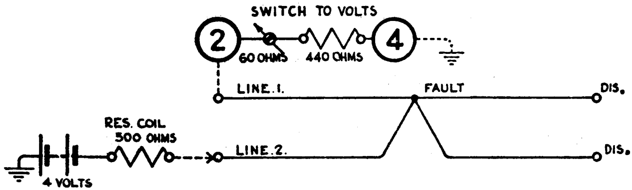
15. *Earth.*—Have line disconnected at distant end. A deflection on Detector indicates line is to earth.



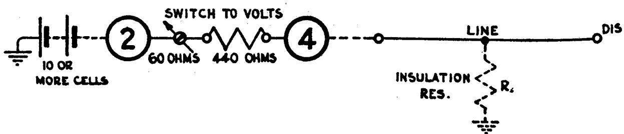
16. *Contact.*—(Exchange testing practice). Have lines disconnected at distant end. Disconnect earth from Line 2 and re-connect. A deflection or an alteration to the deflection on Detector following each connection of "earth" to Line 2 indicates a contact.

DETECTOR, No. 2, & COIL, TESTING, No. 1.

LINE TESTS—*continued.*



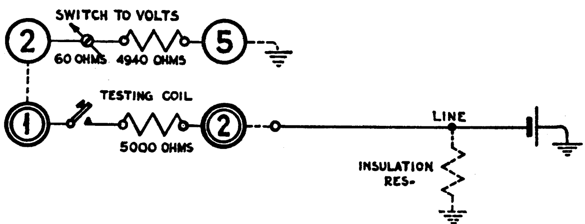
17. *Contact.*—Have lines disconnected at distant end. Disconnect battery and reconnect. A deflection on Detector following each application of the battery indicates a contact.



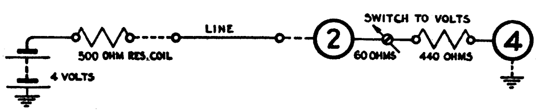
18. *Insulation Resistance.*—Have line disconnected at distant end. Deflection on 50 milliampere scale divided by 5 gives current C in milliamperes.

$$\text{Insulation resistance } R = \frac{\text{Voltage of cells } V \times 1{,}000}{\text{Current } C \text{ (in milliamps)}} - 500.$$

Test 12 *or* 13 *may be taken as an alternative.*



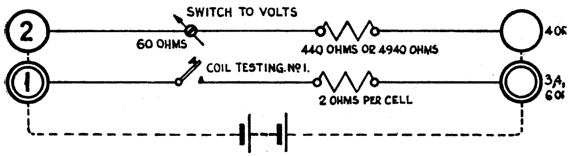
19. *Approximate Voltage at end of Line.*—The reading on the 50 volt scale multiplied by 2 gives the approximate voltage. This test is suitable for testing voltages on "permanent current" circuits when line resistance not unduly high and leakage normal.



20. *To send or receive a current.*—Connect power to line through a resistance as shown *in order that Loading Coils, etc., may not be damaged by a heavy current.*

DETECTOR, No. 2, & COIL, TESTING, No. 1.

PRIMARY BATTERY TESTS.



21. *Battery Testing.*—Connect up as in figure using Terminals (2) and (4) if voltage less than 5, and (2) and (5) if voltage greater than 5 but less than 50.

Note voltage = V_1.

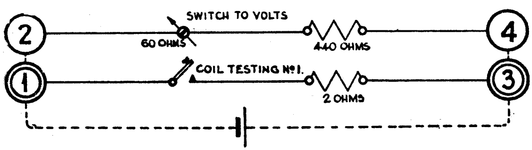
Depress Testing Coil Key and note voltage immediately = V_2.

Keep Key depressed for 1 minute, then release it and note voltage immediately = V_3.

If the battery is in a satisfactory condition :—

V_3 will be not less than 1 volt per cell.

V_2 will be not less than one half V_1 for No. 0 and No. 1 Leclanche Cells, and Dry Cells, NOT less than one third V_1 for No. 2A Leclanche Cells. If these conditions are not met test the separate cells as described in 22



22. *Separate Cell Testing.* Connect up as in figure.

Note voltage = V_1.

Depress Testing Coil Key and note voltage immediately = V_2.

Keep Key depressed for one minute, then release it and note voltage immediately = V_3.

(1) If, in the case of Leclanche Cells, V_3 be less than 1 volt, clean the cell and change the porous pot or sack element. In the case of Dry Cells withdraw the cell from service.

(2) For No. 0 and No. 1 Leclanche Cells, and Dry Cells, if V_3 be above 1 volt, and V_2 be less than half V_1, clean Leclanche Cells and refill with fresh Chloride of Ammonium solution.
Withdraw Dry Cells from service.

(3) For No. 2A Leclanche Cells, if V_3 be above 1 volt, and V_2 be less than one third V_1, clean the cell and refill with fresh solution of Chloride of Manganese or Chloride of Ammonium.

Leclanche Cells must be re-tested after treatment.

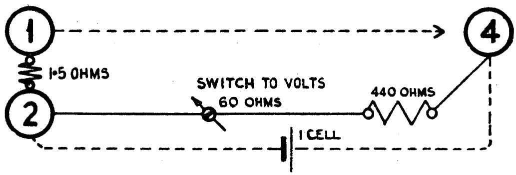
The internal resistance of a battery or cell may be calculated from the readings obtained under tests 21 *or* 22 *by using the following formula :—*

$$\text{Internal Resistance } r = \frac{S\,(V_1 - V_2)}{V_2}$$

Where S = The Testing Coil Resistance used.

DETECTOR, No. 2, & COIL, TESTING, No. 1.

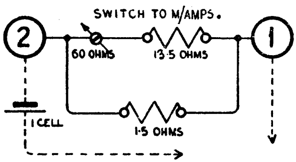
PRIMARY BATTERY TESTS—*continued.*



23. *Cell Test for use in exceptional cases when Testing Coil not available.*—The principle of Test 22 can be applied by connecting up the Detector as above. To obtain V_2 reading connect Terminal (1) to Terminal (4), and disconnect after 45 seconds for V_3 reading.

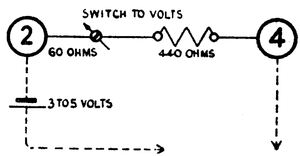
The test must not be applied to more than a single cell.

MISCELLANEOUS TESTS.

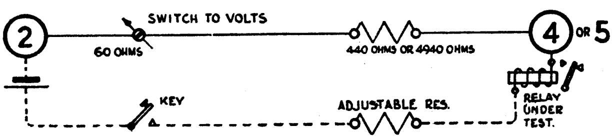


24. *Point to Point Testing.*—Use Terminals (2) and (1) and a single cell.

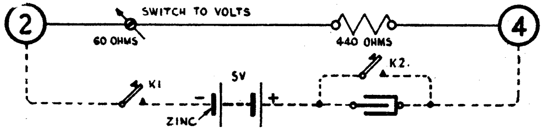
Use Test 25 for tapping out on loaded cables.



25. *Tapping out on Loaded Cables.*—Terminals (2) and (4) of the Detector are used in order that a heavy current may not flow to line and damage the Loading Coils.



26. *Operating Current when less than* 10 *milliamperes required. See also Test* 39. Connect up as in figure using suitable voltage. Each small division on Detector Scale represents ·2 milliampere. The reading on the 50 milliampere scale divided by 5 gives current in milliamperes.

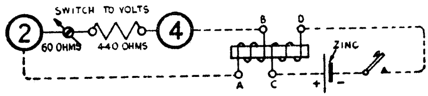


27. *To prove a Condenser.*—Depress Key K1. If Condenser in working order momentary deflection on Detector will be to right; if disconnected, no deflection; if short-circuited, permanent deflection. Release Key K1 and depress Key K2 to discharge condenser before repeating test.

DETECTOR, No. 2, & COIL, TESTING, No. 1.

MISCELLANEOUS TESTS—*continued.*

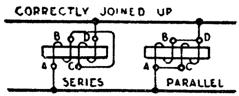
(i)



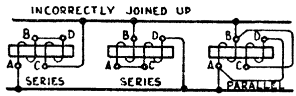
28. *Test to determine correct method of joining u Relays, Bridging Coils, etc., that are double-wound, in order to obtain maximum magnetic effect or impedance.*—Arrange the connections so that momentary deflection on Detector is to left when key depressed and to right when key released. When this is the case :—

Regard Terminal of Coil connected to Terminal (2) of Detector as A
" " " " " " " (4) " " as B.
" " " " " " positive pole of Battery as C.
" " " " " " negative " " " as D.

(ii)



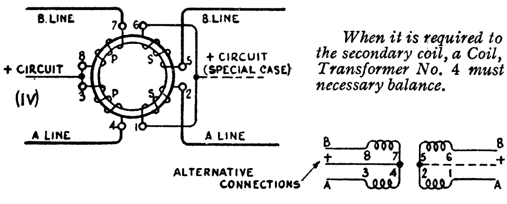
(iii)



Then if the apparatus under test is joined across a telephonic loop in accordance with either arrangement shown in figure (ii) it will offer considerable impedance. If arranged as shown in figure (iii) the ringing and speaking efficiency will be reduced considerably.

This test is also suitable for verifying the direction of the individual windings of a Repeating Coil or Transformer. Figures (iv) (v) and (vi) show the correct methods of joining up such apparatus under different conditions.

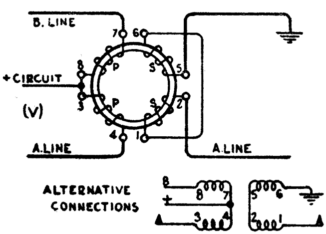
Repeating Coil used as a Transformer on a looped circuit.

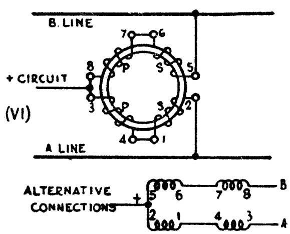


When it is required to take a + circuit from the secondary coil, a Coil, Repeating 4006A, or a Transformer No. 4 must be used to obtain the necessary balance.

Repeating Coil used as a Transformer on an earthed circuit.

Repeating Coil used as a Bridging Coil.





DETECTOR Nº 2, & COIL, TESTING, Nº 1.

TABLE FOR USE WITH TESTS 12 AND 13.

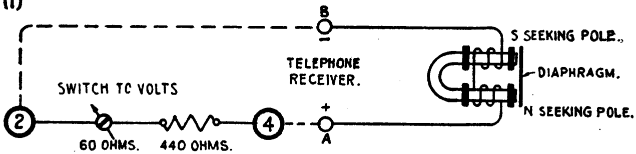
THE FIGURES, AT THE POINT WHERE THE HORIZONTAL ROW (V_2 READING) AND THE VERTICAL COLUMN (V_1 READING) INTERSECT, REPRESENT THE VALUE OF THE UNKNOWN RESISTANCE R IN TEST 12, AND WHEN MULTIPLIED BY 10 ITS VALUE IN TEST 13.

V_2	V_1: 50	48	46	44	42	40	38	36	V_2
	V_1: 25	24	23	22	21	20	19	18	
1	24500	23500	22500	21500	20500	19500	18500	17500	½
2	12000	11500	11000	10500	10000	9500	9000	8500	1
3	7835	7500	7165	6835	6500	6165	5835	5500	1½
4	5750	5500	5250	5000	4750	4500	4250	4000	2
5	4500	4300	4100	3900	3700	3500	3300	3100	2½
6	3665	3500	3335	3165	3000	2835	2665	2500	3
7	3070	2930	2785	2645	2500	2355	2215	2070	3½
8	2625	2500	2375	2250	2125	2000	1875	1750	4
9	2275	2165	2055	1945	1835	1720	1610	1500	4½
10	2000	1900	1800	1700	1600	1500	1400	1300	5
11	1775	1680	1590	1500	1410	1320	1225	1135	5½
12	1585	1500	1415	1335	1250	1170	1085	1000	6
13	1425	1345	1270	1195	1115	1040	960	885	6½
14	1285	1215	1145	1070	1000	930	860	785	7
15	1165	1100	1035	965	900	835	765	700	7½
16	1060	1000	940	875	815	750	685	625	8
17	970	910	850	795	735	675	615	558	8½
18	890	835	780	720	665	610	555	500	9
19	815	765	710	655	605	553	500	448	9½
20	750	700	650	600	550	500	450	400	10
21	690	645	595	545	500	452	405	357	10½
22	635	590	545	500	454	409	364	318	11
23	587	543	500	456	413	369	326	282	11½
24	542	500	458	417	375	333	292	250	12
25	500	460	420	380	340	300	260	220	12½
26	461	422	384	346	307	269	230	192	13
27	426	389	352	315	278	241	204	166	13½
28	392	357	322	286	249	214	178	143	14
29	362	328	293	259	224	190	155	121	14½
30	333	300	267	233	200	167	133	100	15
31	306	274	242	210	177	145	112		15½
32	281	250	219	188	156	125	94		16
33	258	228	197	167	136	106			16½
34	235	206	177	147	118	88			17
35	214	186	157	129	100				17½
36	194	167	139	111	83				18
37	176	149	122	95					18½
38	158	132	105	79					19
39	141	115	90						19½
40	125	100	75						20
41	110	86							20½
42	95	72							21
43	81								21½
44	68								22

DETECTOR, No. 2, & COIL, TESTING, No. 1.

MISCELLANEOUS TESTS—*continued.*

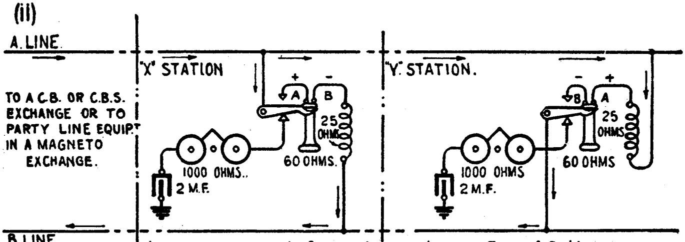
(i)



29. *To join up a telephone receiver so that exchange current augments magnetic field o its polepieces.* Arrange connections as in (i) so that momentary deflection on detector is to left when diaphragm removed, and to right when diaphragm replaced. When this is the case :—

Regard terminal of receiver connected to terminal 4 of detector as A.
,, ,, ,, ,, ,, ,, ,, 2 ,, ,, ,, B.

(ii)

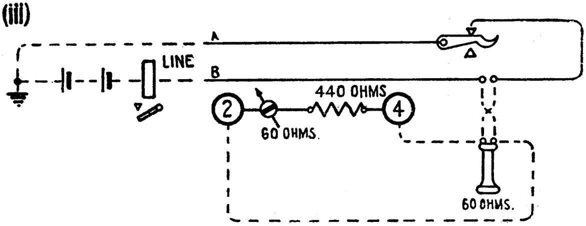


Arrows show current flowing to negative or Zinc of Battery.

The receiver should then be joined up so that the exchange current flows through its coils from Terminal A to Terminal B as shown in (ii), i.e., Terminal A should be connected to the A line and Terminal B to the B line. The receiving efficiency of a receiver is considerably reduced when it is joined up incorrectly.

Terminals A and B are marked + and − respectively in modern receivers

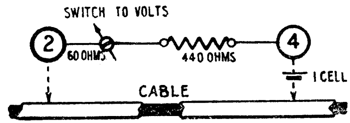
(iii)



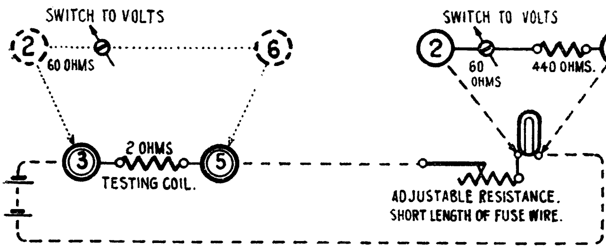
To test receiver in position.—With detector connected as in (iii) obtain reading. Press down switch hook. If receiver is joined up correctly, kick on the detector will be to left when diaphragm is removed, and to right when diaphragm is replaced. If opposite deflections are observed, reverse receiver leads and repeat test.

DETECTOR, No. 2, & COIL, TESTING, No. 1.

MISCELLANEOUS TESTS—*continued.*



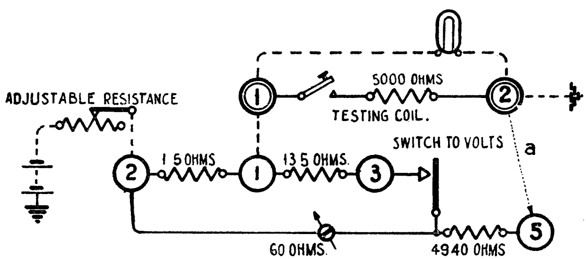
30. *To demonstrate existance of induced alternating current in cable sheath.*—With connections shown, a current of about 50 periods will be indicated by the pointer vibrating.



31. *Current taken by a switchboard lamp rated at* 5 *volts or less.*—Adjust E.M.F. and resistance so that reading on Detector agrees with rated voltage of lamp. When this is so, disconnect Detector and using terminals 2 and 6, connect it across 2 ohm resistance in Testing Coil.

Note deflection in small DIVISIONS = D.
Current flowing through lamp in mAs = 6D.

$$\text{Resistance of lamp when glowing} = \frac{\text{Rated voltage of lamp} \times 1{,}000}{6\text{D.}}$$



32. *Current taken by a switchboard lamp rated from* 5 *to* 50 *volts.*—With detector switch to volts, adjust E.M.F. and resistance so that reading on detector agrees with rated voltage of lamp. When this is so disconnect lead "a," turn Detector switch to mAs and depress key of Testing Coil.

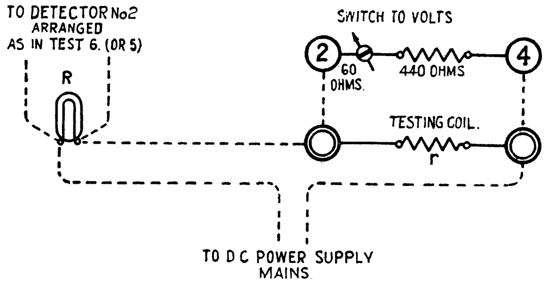
Note current shown on the 0·500 mA. scale = C

Current I in mAs flowing through lamp $= C - \frac{V}{5}$ where V = Rated voltage of lamp.

Resistance of lamp when glowing = *Rated Voltage of lamp* × 1,000.

DETECTOR, No. 2, & COIL, TESTING, No. 1.

MISCELLANEOUS TESTS—*continued.*



33. *To ascertain current flowing through and resistance of a lamp when glowing and power supply is direct current. See also Test* 34.—Using Test 3 adjust resistance "r" to give a convenient deflection.

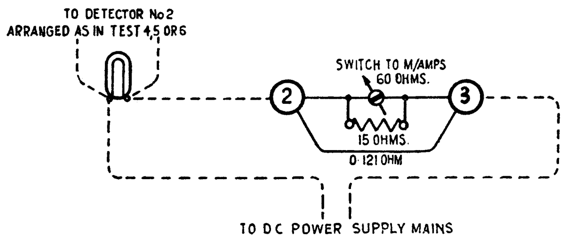
Note deflection in volts = V.

The value of r. to give a deflection of approximately 3 volts can be calculated. Multiply the "rated voltage" of the lamp by 3 and divide the result by the "rated wattage" of the lamp.

Current C, flowing through lamp in mAs, $= \frac{1{,}000\ V}{r}$

Using Test 6 (or 5 if suitable), ascertain voltage across lamp = E.

Resistance R of lamp when glowing $= \frac{1{,}000\ E.}{C}$



34. *In the case of lamps of* 75 *ohms or less resistance or which carry a current of more than* 2·5 *amps, apply this Test instead of Test* 33.

Ascertain current flowing in amperes by Test 9 = C

Ascertain voltage across lamp by Test No. 4, 5 or 6 = E

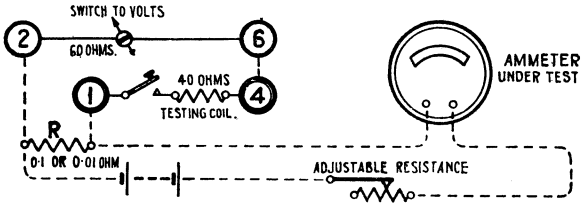
Resistance of lamp when glowing $= \frac{E}{C}$

To calculate the resistance of a lamp glowing at its rated voltage:—Multiply "rated voltage of lamp" by "rated voltage of lamp" and divide by "rated wattage of lamp."

To calculate the current carried by a lamp at its rated voltage:—Divide "rated wattage of lamp" by "rated voltage of lamp."

DETECTOR, No. 2, & COIL, TESTING, No. 1.

MISCELLANEOUS TESTS—*continued.*

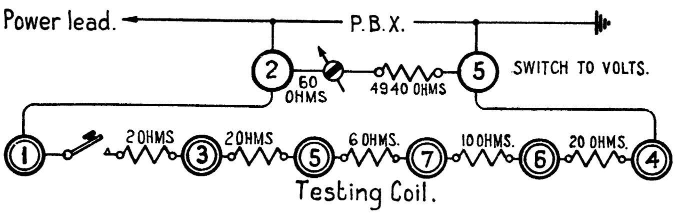


35. *To verify accuracy of, or calibrate an ammeter.*

0–10 *Amperes.* With connections as shown, the resistance R being 0·1 ohm, the ammeter should record 0·2 amp. of current for each division the detector needle is deflected.

0–100 *Amperes.* With connections as shown, the resistance R being 0·01 ohm, the ammeter should record 2 amps. of current for each division the detector needle is deflected.

The 0·1 or 0·01 resistance can be made from " Wire, Flameproof, 1/12½," 2 six-yard lengths being joined in parallel for 0·1 resistance, and 20 six-yard lengths for the 0·01 resistance. The wires, when paralleled, should be tested for resistance by making a Wheatstone Bridge Test, and shortened if necessary.



36. *To ascertain resistance of B.P.X. Power Lead.*

Take detector reading *without* key of coil depressed. Call this V_1.

" " " *with* " " " " " " V_2.

Release the key and if owing to some change in load on power lead, the detector does not return to the previous reading for V_1, the tests should be repeated until consistent results are obtained.

$$\text{Power lead resistance} = \frac{Er\,(V_1 - V_2)}{V_1\,V_2}.$$

when E = P.D. of Main Exchange Bus-Bars.

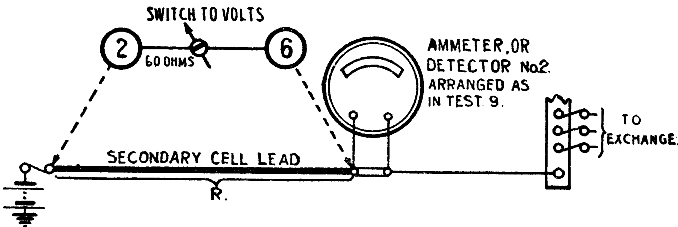
r = Resistance used on Testing Coil No. 1.

V_1 & V_2 Readings obtained as above

Refer to Loose-Leaf Diagram sT.110 to T.114 for furthe information regarding the practical application of this test.

DETECTOR, No. 2, & COIL, TESTING, No. 1.

MISCELLANEOUS TESTS—*continued.*

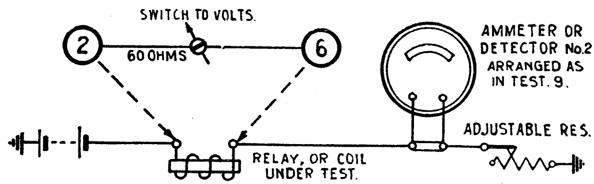


37. *To ascertain the resistance of an exchange power lead.*—Note the current flowing to the exchange in amperes as shown on the Ammeter = C.

At the same time note the reading on Detector, in small divisions =D.

$$\text{Resistance of lead } R = \frac{12D}{1{,}000C}$$

The detector leads should be of very low resistance.



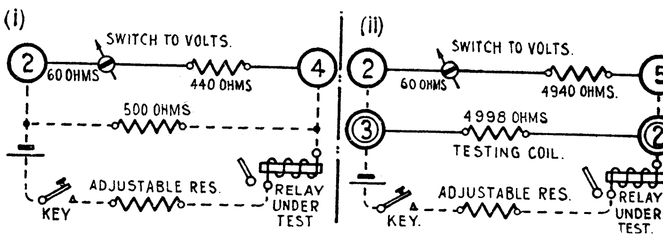
38. *To ascertain resistance of a relay, or coil.*—If resistance is over 1 ohm, use Test No. 10, 11, 12 or 13, but if less than 1 ohm, connect up as in figure.

Adjust E.M.F. and resistance so that current of ·5 to 5 amps (according to current carrying capacity of coil under test) is indicated on Ammeter.

Note reading on Ammeter, in amps, = C.

At the same time note the reading on Detector in *small divisions* = D.

$$\text{Resistance } R = \frac{12D}{1{,}000C.}$$

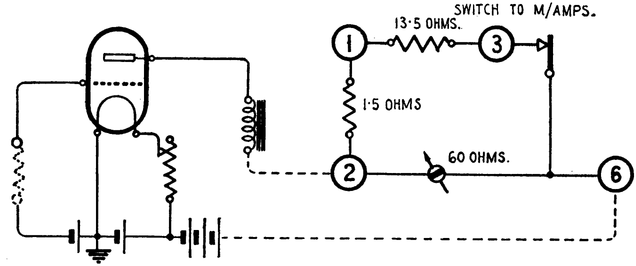


39. *Operating current when less than* 20 *mAs are required.*—Connect up as in (i) or ii), using suitable voltage. The reading on the 50 mA. scale multiplied by 2 and divided by 5 gives current flowing through relay in mAs.

If less than 10 mAs required Test 26 will give greater accuracy.

DETECTOR, No. 2, & COIL, TESTING, No. 1.

MISCELLANEOUS TESTS—*continued.*



40. *To observe current flowing in plate circuit of a thermionic valve.*

0–500 mAs. Connect Detector in circuit using terminals 2 and 1, switch to **M/AMPS.** and read direct.

0–50 mAs. Connect Detector in circuit using terminals 2 and 3, switch to **M/AMPS.** and read direct.

0–10 mAs. Connect Detector in circuit using terminals 2 and 6, as shown in figure. If deflection is less than 10 small divisions, turn switch to **VOLTS**. Each small division on Detector scale then represents $^1/_5$th of a mA.

NOTES.

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Technical Pamphlets for Workmen

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1. Magnetism and Electricity.
2. Primary Batteries.
3. Technical Terms.
4. Test Boards.
5. Protective Fittings.
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GROUP B.

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3. Wheatstone. Morse Keyboard Perforators.
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4. Magneto Exchanges—Non-Multiple Type.
5. Magneto Exchanges—Multiple Type.
6. C.B.S. No. 1 Exchanges—Non-Multiple Type.
7. C.B.S. Exchanges—Multiple Type.
8. C.B. Exchanges—No. 9 Type.
9. C.B. Exchanges—No. 10 Type.
10. C.B. Exchanges—No. 12 Type.
11. C.B. Exchanges—22 Volts.
12. C.B. Exchanges—40 Volts.
13. Trunk Telephone Exchanges.
14. Telephone Exchange Maintenance.
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16. Routine Testing for Telephone Exchanges.
17. Internal Cabling and Wiring.
18. Distribution Cases, M.D.F. and I.D.F.
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20. Superposed Circuits, Transformers, etc.
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(Continued.)

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1. Subscribers' Apparatus C.B.
2. Subscribers' Apparatus C.B.S., Part I—C.B.S., No. 1 System.
3. Subscribers' Apparatus Magneto.
4. Private Branch Exchange—C.B.
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GROUP G.

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3. Maintenance of Power Plant for Telegraph and Telephone Purposes.
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9. Electrolytic Action on Cable Sheaths, etc.
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