DIAGRAMS.

Peter Cawley

POST OFFICE TELEGRAPHS.

CONNECTIONS

OF

TELEGRAPHIC AND TELEPHONIC APPARATUS

AND

CIRCUITS.

GENERAL POST OFFICE,
1898.

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PART I.

TESTING, &c.

Plate 1.

DETECTOR.

A Detector has two coils, called the "Quantity" and "Intensity," or (for shortness) the Q and I coils.

Resistance of I coil is about 100^{ω}
" Q " $0{\cdot}2^{\omega}$

TESTING.

a. For a Disconnection: Have Line put to earth at further end and connect a Battery and Detector between Earth and Line; if no deflection be obtained the Line is disconnected.

b. For an Earth fault: Similar connections to *a*, but Line disconnected at further end. A deflection indicates an earth fault.

c. For Contact: Have the Lines disconnected at further end and connect a Battery and Detector between the two Lines. If a deflection be obtained the Lines are in contact (or both are to earth).

d. To trace a fault along a Line: Connect an earthed Battery to one end of the faulty wire, then walk along the Line, frequently putting the Detector between Line and earth. So long as a deflection is obtained the fault has not been passed.

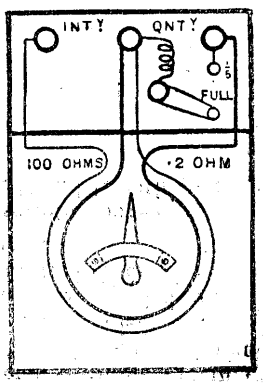
e. To test a Battery: Each cell of a Battery joined through the Quantity coil of the Detector should give, approximately, the same deflection as the whole Battery.

There is a Shunt upon the "Quantity" coil to reduce the deflection to $\frac{1}{5}$th ; that is, the Shunt when brought in circuit by the Switch at the right hand on the top of the case forms a bye-path for $\frac{4}{5}$ths of the current.

The stock description is:—

"Detector, Q and I"

DETECTOR.



DETECTOR WITH TWO SHUNTS.

For General Notes, *see* p. 2.

To meet special requirements in Ireland, especially in connection with the Webb and Thompson Railway Staff System (Plate 62, p. 146), a $\frac{1}{10}$th Shunt is, in some cases, applied to the "Intensity" coil by means of a Switch on the left-hand side of the top of the case.

The stock description is:—

Detector, Q and I, with $\frac{1}{10}$ Shunt.

DETECTOR WITH $\frac{1}{10}$ SHUNT.

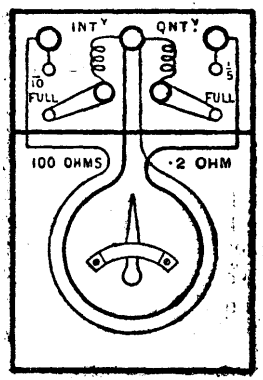


Plate 3.

TANGENT GALVANOMETER.

For full description, *see* Technical Instructions IV., pp. 3 and 25.

The stock description is "Tangent Galvanometer." The ring is double-wound, each Coil having a resistance of 160 ohms. The coils are so connected that when terminals (2) and 3 are joined the Coils are in series between terminals 1 and (4).

The Shunt Coils, giving values of $\frac{1}{5}$th, $\frac{1}{10}$th, $\frac{1}{20}$th, $\frac{1}{40}$th, $\frac{1}{80}$th, $\frac{1}{160}$th, and $\frac{1}{320}$th, can be brought into the circuit of the Coils by the insertion of a plug, and by this means comparatively heavy currents (ranging up to ·8 ampère) can be measured with fair accuracy.

The key is to enable the needle to be readily brought to rest.

The depression of the key short-circuits only one Coil, (2) (4).

The sensitiveness of the needle is greater when the similar poles of the controlling magnet and the needle magnet point in the same direction, and less when they point in opposite directions. Any further adjustment of sensitiveness required can be obtained by raising or lowering the controlling magnet.

The required position can be determined independently of the mark on the N. pole of the controlling magnet and the needle magnet, by

turning the stalk of the former in its socket. If the pointer follows the direction of the controlling magnet, it indicates that the latter is assisting the earth's magnetism, and that consequently the position is the less sensitive. In this case lowering the magnet reduces the sensitiveness. If the pointer should move in the *opposite* direction it shows that the effect of the directive force of the earth's magnetism is being reduced by the controlling magnet, and in this case the lower the magnet the greater the sensitiveness.

In making tests, care must be taken that the pointer stands at zero when no current is flowing, both when the controlling magnet is removed and when it is replaced.

One segment of the dial is engraved with degrees, and the opposite segment with tangent divisions with an outer and inner scale.

The *outer scale* with the "skew" zero gives a greater range, and in some cases increased sensitiveness (T. I., IV., p. 23). The normal adjustment should be such that a "sealed standard cell" in good condition will give about 80 divisions on the outer scale with no shunt. (The actual deflection is marked upon each standard cell.) This will enable exact values of current to be deduced by taking 80 divisions to represent one milliampère. Thus, 120 divisions with the $\frac{1}{10}$th shunt would indicate a current of $\frac{120 \times 10}{80} = 15$ milliampères.

Plate 3—*cont.*

With this adjustment of 80 divisions of the outer scale for one milliampère the following values result from the use of the various shunts :—

Shunts.	Resistance of Galvanometer in Ohms.	Divisions per Milliampère.	Milliampères.	
			Per Division.	Per 200 Divisions.
—	320	80	$\frac{1}{80}$	$2\frac{1}{2}$
$\frac{1}{5}$	64	16	$\frac{1}{16}$	$12\frac{1}{2}$
$\frac{1}{10}$	32	8	$\frac{1}{8}$	25
$\frac{1}{20}$	16	4	$\frac{1}{4}$	50
$\frac{1}{40}$	8	2	$\frac{1}{2}$	100
$\frac{1}{80}$	4	1	1	200
$\frac{1}{160}$	2	$\frac{1}{2}$	2	400
$\frac{1}{320}$	1	$\frac{1}{4}$	4	800

TANGENT GALVANOMETER.

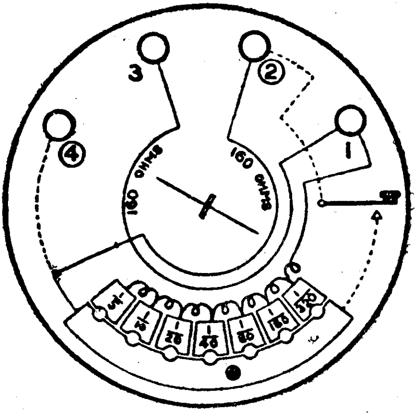


Plate .

TEST-BOX DETECTORS.

The positions of the plugs for ordinary requirements are shown by the separate diagrams :—

"TO SEND A ZINC CURRENT" and "TO RECEIVE A CURRENT" : The Line must be connected to the right-hand front terminal.

NOTE.—*To Receive a Current when the Office at which the test is made is Intermediate*, one section of the Line must be connected to the right hand and the other to the middle terminal. No plugs should be inserted.

"TO TEST FOR CONTACT." One Line must be connected to the right-hand and one to the left-hand terminal.

The Instrument shown is "Test-Box Detector 'A.'"

Another form, "Test-Box Detector 'C.'" is constructed for insertion into a panel of the Test-Box. The description does not include a Switch, which is a separate part, namely, "Test-Box Detector Switch."

A pattern now frequently used consists of—

A "Differential Galvanometer" with coils joined in series (100ω) mounted upon

A "Turntable Bracket for Test Box," and connected with

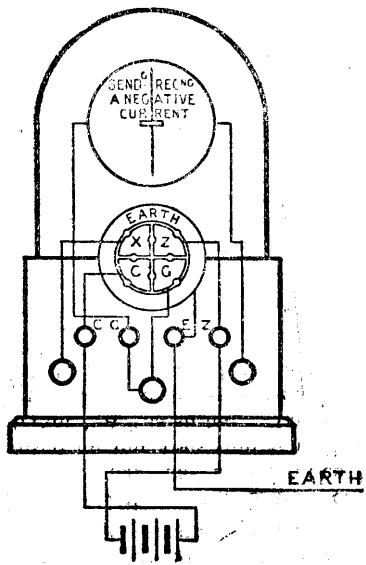
A "7-Testhole Tablet (Circular) 'A'."

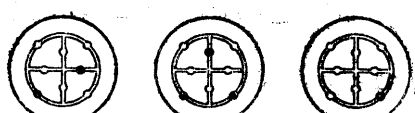
The connections are, of course, as shown in the diagram.

The Testing Battery should consist of 20 Large Daniell Cells, and when underground work is being tested the power should be increased to 100 volts.

TEST-BOX DETECTOR, "A."

(Same connections for "C.")





TO SEND A NEGATIVE CURRENT

TO TEST FOR CONTACT

TO RECEIVE A CURRENT

Plate 5.

TEST-BOX DETECTOR "B."

This is provided for use at Offices where more elaborate Testing Instruments cannot be authorised.

It is fitted with three Coils, of which that connected to the side terminals has a resistance of 100ω, and can be used for purposes similar to those for which the Detector "A." is suited. The other two coils are of low resistance so as to be suitable for the testing of battery cells as described at *e*, page 2.

TEST-BOX DETECTOR "B."

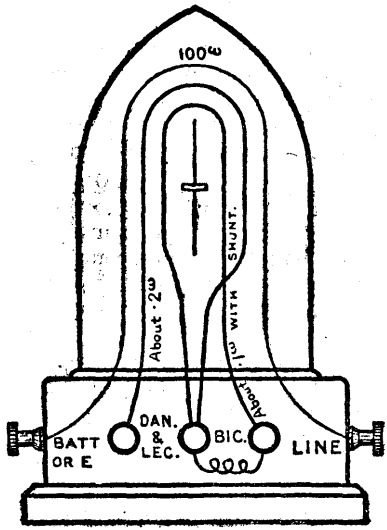


Plate 6.

WHEATSTONE BRIDGE COILS.

The connections in the diagram show the method of testing a Line. In testing for conductivity, put the Line to earth at the further end; in testing for insulation leave it disconnected.

To test a loop, or any resistance of which both ends are accessible, join one end to A and the other to D, and use no earth.

Resistance must always be left in between A and C, and C and B. The resistance in AC, divided by the resistance in CB, and multiplied by that in BD, gives the resistance under test. AC and CB are known as the "ratios" and BD as the "rheostat."

Example:—

If, in the conditions shown in the diagram, a balance is obtained, then the (insulation) resistance of the Line is known to be $\frac{1000 \times 2350}{10} = 235{,}000$ ohms.

The Reversing Switch enables the currents in the Line to be reversed quickly. The two plugs removed for the "ratios" (AC and BC) serve for the purpose. When the plugs are horizontal (as shown) a negative current passes to line, whereas, if the plugs be placed one above the other a positive current passes to line.

These positions are marked respectively "Straight" and "Reversed" (in reference to the two sections of terminals A and D).

The Reversing Switches on new Instruments are of the handle form.

Full instructions as to various special systems of test by Wheatstone Bridge are given in Technical Instructions III.

WHEATSTONE BRIDGE COILS.

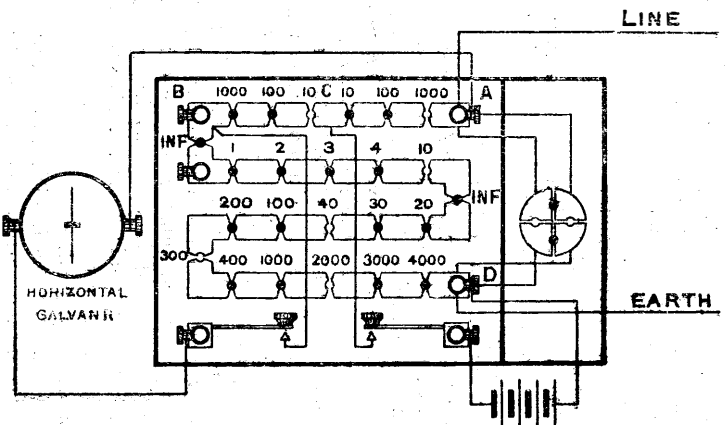


Plate 7.

MORNING TEST APPARATUS.

For full information, *see* Technical Instructions IV.

Morning Test Switch Tablet (wired complete with 8-terminal 4-position Switch; two 7-Test-hole Tablets, circular; Resistance Coils; 4 U-links, &c, as shown in diagram).

6-terminal 2-position Switch.

Press Button D.

Tangent Galvanometer.

Testing Batteries:—

42 Dry Cells. Where Secondary Cells are available (50 volts) only 5 Dry Cells are required.

20 cells. Large Daniell.

The main testing battery usually consists of from 37 to 41 dry cells, depending on the voltage of the cells employed in order to get a deflection of 110 divisions = 55·5 volts. The next cell to those in use is so connected that by means of the U-link on the left-hand tablet it can be added to the testing battery. On no account must it be necessary to use 42 cells permanently to procure the required 55·5 volts.

Where secondary cells are available the negative 50-volt main should be brought to the Test Table and any required number not exceeding 5 dry cells should be added in order to bring the Testing Power to the required E.M.F. of 55·5 volts, one of the cells to be retained for use with the tablet link as above explained.

One-half of the Daniell force available is used for line insulation-resistance localisations with the Tangent Galvanometer, and the whole Daniell force available is used for Wheatstone Bridge measurements, the two 10-cell batteries being so

(*Continued on p.* 18.)

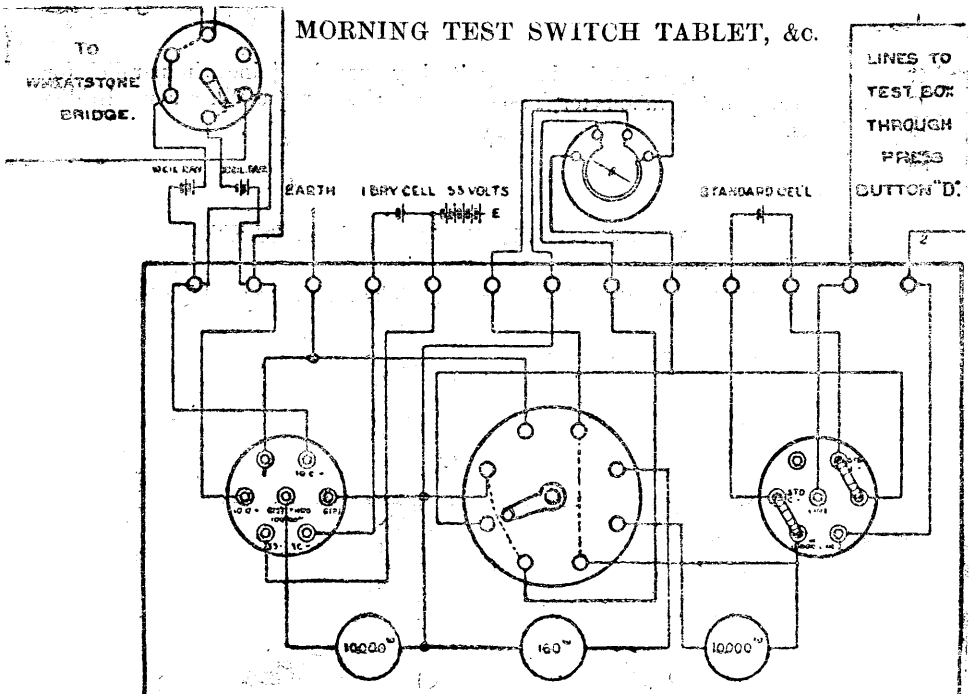
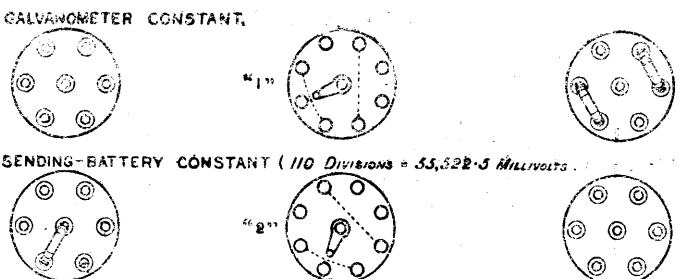

MORNING TEST SWITCH TABLET, &c.
TO WHEATSTONE BRIDGE.
LINES TO TEST BOX THROUGH PRESS BUTTON "D".
EARTH
1 DRY CELL 55 VOLTS
STANDARD CELL
10000
160
10000

Plate 8.

connected to the switch that by it they may be joined in parallel for the Tangent Galvanometer Tests, or in series for the Wheatstone Bridge Tests.

MORNING TEST SWITCH TABLET.

Position of Switch lever and U-links for the several Tests.



MORNING TEST SWITCH TABLET—(*cont.*)

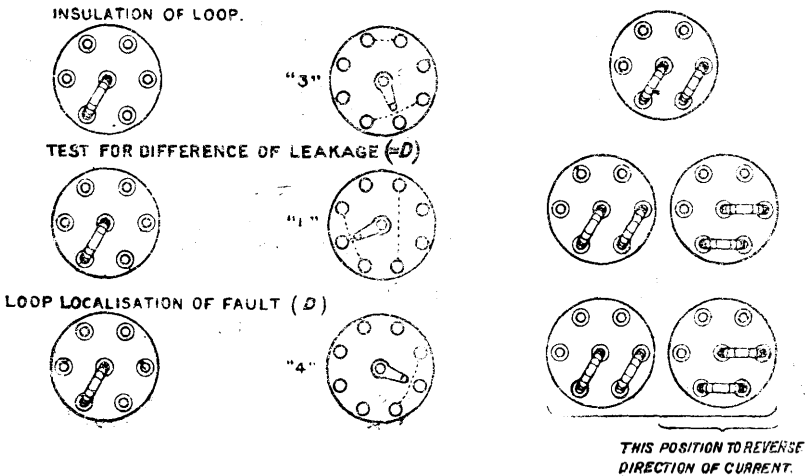
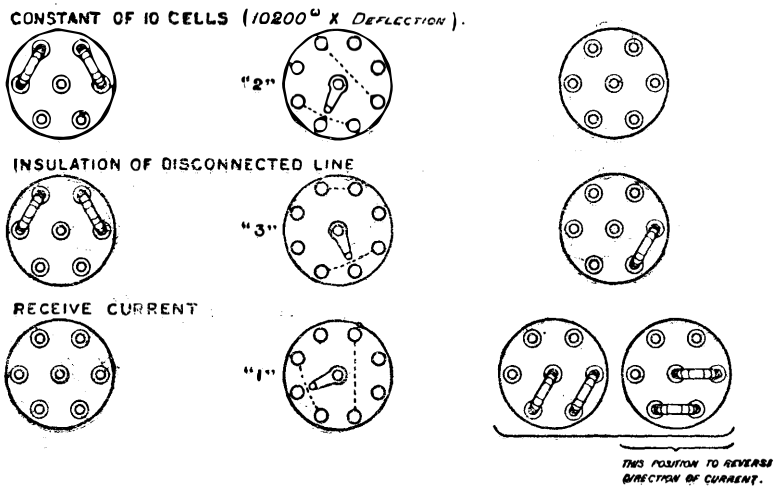


Plate 8—*cont.*

MORNING TEST SWITCH TABLET—(*cont.*)



PART II.

ABC AND SINGLE NEEDLE SYSTEMS

Plate 9.

WHEATSTONE ABC.

Resistance of Communicator	-	800ω
,, Indicator -	-	250ω
,, ,, (Magneto)	-	500ω

These instruments will work through a resistance of 7,000ω.

Every Lineman responsible for the maintenance of these instruments should have an "ABC Testing Coil."

Detailed information regarding the removal of faults, &c., is given in Technical Instructions XI. (pp. 12–18).

ABC COMBINED INDICATOR AND BELL

is now the standard type of Indicator. The coils are double wound so that they can be joined in multiple (250ω) for ordinary use or in series (1000ω) when "leak" working is resorted to. *See* Circular Memo. relating to conditions of use.

If it be required to work on the "leak" principle, disconnect the left-hand terminal of the Communicator from the contact-maker (that is, have it connected to the coils only); join the left-hand terminals of both Communicator and Combined Indicator and Bell to Line, and the two corresponding right-hand terminals to earth. The Indicator coils must be joined in series. All Offices on a circuit connected alike.

WHEATSTONE ABC.

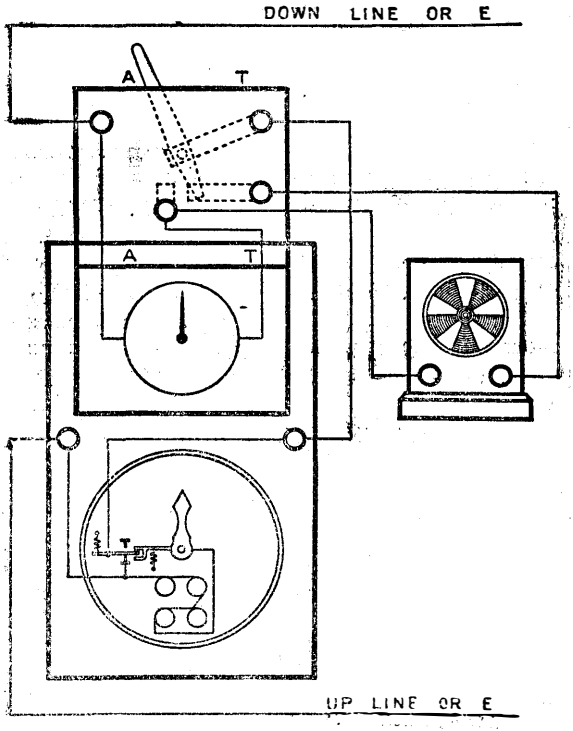


Plate 10.

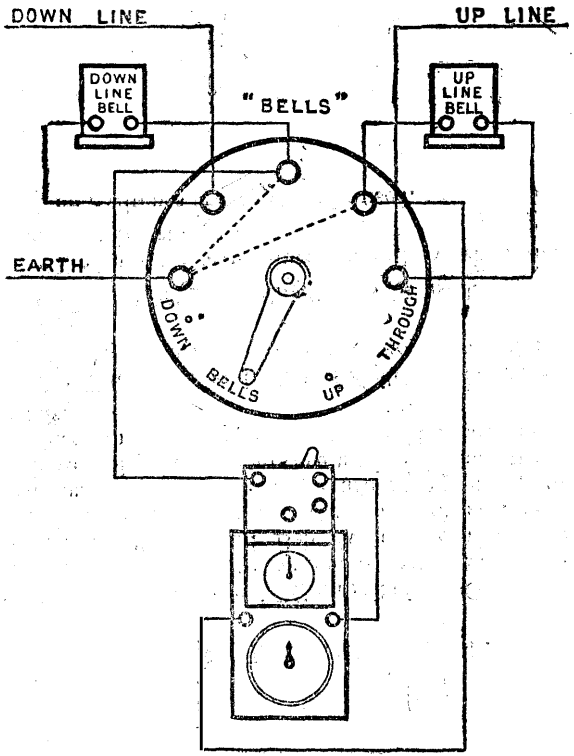
ABC INTERMEDIATE SWITCH.

This Switch enables an Intermediate Office to communicate with either Terminal Office without disturbing the other.

"Bells, ABC Indicating" should be used where two (as for this purpose) or more Bells are required.

"BELLS" is the normal position of this Switch. When the lever is at "THROUGH" the Bells are short-circuited.

ABC INTERMEDIATE SWITCH.



SWITCH CONNECTIONS AT

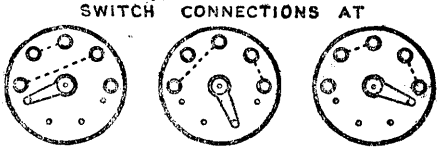


Plate 11.

LINE AND BELL SWITCHES.

Where two or more ABC circuits in an Office are necessarily attended to by one operator the application of a "Line and Bell Switch" obviates the need of a complete set for each circuit. On Departmental circuits these are rarely used, but where such arrangements are made it is more usual to have indicators specially mounted rather than bells.

A "Three-line and Bell Switch" is shown by Plate 11. Other sizes are for two, four, and six Lines.

"Bells, ABC Indicating" must be used.

"Up" and "Down" lines cannot be worked from the same Instrument.

The Switches are now rarely used.

LINE AND BELL SWITCHES.

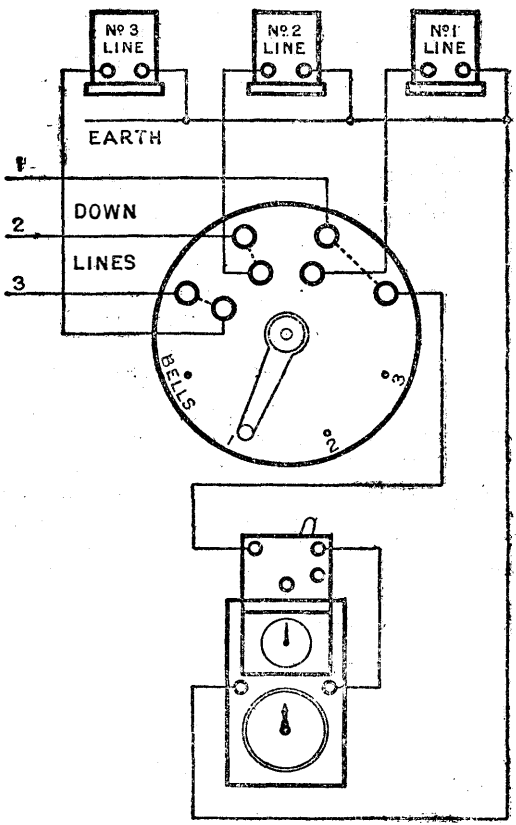


Plate 12.

SINGLE NEEDLE.

Showing standard connections of Commutator.

The connections of the Commutator are so arranged that the Battery cannot be short-circuited by the depression of both tappers at the same time. All Commutators issued from Factory have these connections; and on circuits worked by Universal Batteries (Plate 45), Commutators with the old connections must not be used. The old connections are retained in Plate 13.

Apparatus required:—
Single Needle, which includes:—
SN. Case.
SN. Coil (induced).
Commutator.

2 Sounding Pieces (if required).

Neale's Dials may be used exceptionally in place of the Induced Coil.

Resistance of Coils, 200ω.
Form of Battery, Leclanché (Porous Pot No. 3).
Current required, 15 to 20 milliampères.

SINGLE NEEDLE.

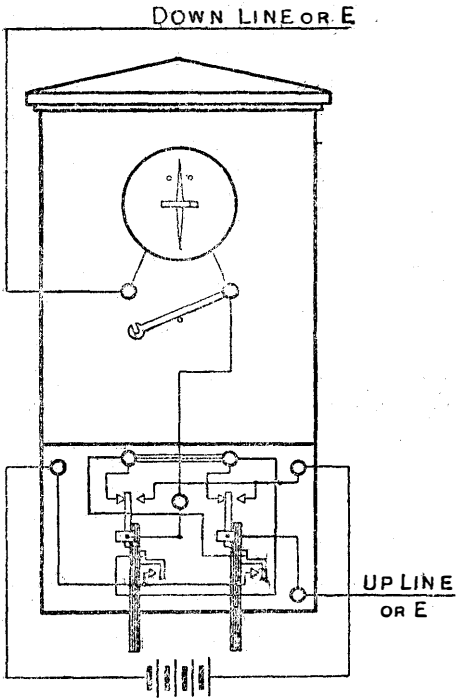


Plate 13.

BRIGHT'S BELL.

Showing old connections of Commutator.

These are now issued fitted with Standard Relays (neutral).

Apparatus required:—

Commutator.
Cover for Commutator
Bright's Bell (which includes Standard Relay "A" or "B" Neutral and two Plate Sounders).
SC. Galvanometer.

Resistance of Relay "A"	100ω
" " "B"	200ω
" " Bright's Relay	200ω
" " Sounder, 20ω " " Shunt (R.) 500ω	19·2ω
" " Sounder (Old Form, without Shunt)	40ω

The connecting hook between the two "Bell" terminals of the Commutator must be released.

Form of Battery, Leclanché (Porous Pot No. 3).
Current required, 15 to 20 milliampères.
Local Battery—3-cell Large Daniell Battery for 20ω Sounders.
" " 5-cell Large Daniell Battery for 40ω Sounders.
" " 2-cell Bichromate may be used.

BRIGHT'S BELL.

(*Note.*—For standard connections of Commutator, *see* Plate 12.)

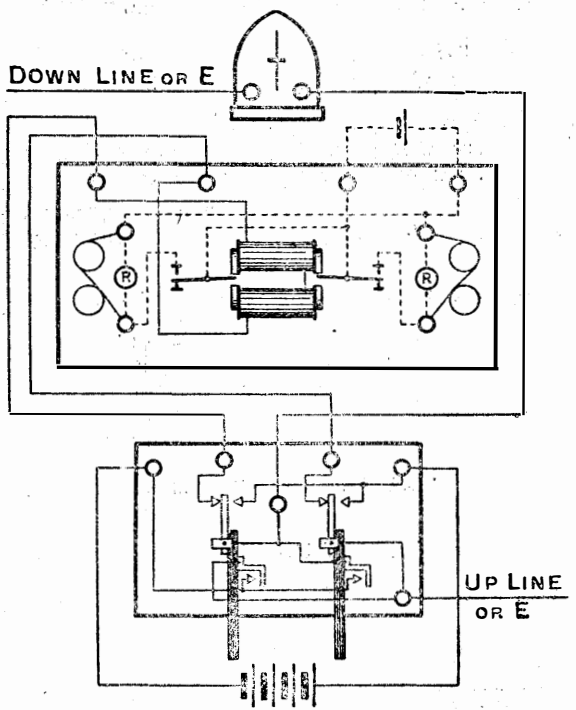


Plate 14.

DOUBLE SOUNDER.

WITH SEPARATE SC. GALVANOMETER.

Apparatus required:—
Commutator.
Cover for Commutator.
Double Sounder with Relay.
SC. Galvanometer.

A "Standard Relay (neutral)" is the form used.

Combined resistance of Sounders, with 500 shunts, 19·2 each.

The connecting hook between the two "Bell" terminals of the Commutator must be released.

Form of Battery, Leclanché (Porous Pot No. 3).

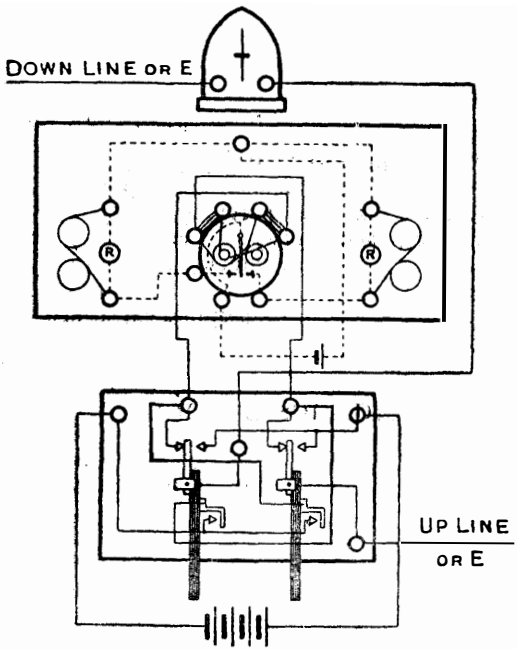
Current required, 14 to 17 milliampères.

Local Battery—3-cell Large Daniell Battery.

NOTE.—This is not now issued, having been superseded by that shown in Plate 15.

DOUBLE SOUNDER.

WITH SEPARATE SC. GALVANOMETER.



U 9562.

Plate 15.

DOUBLE SOUNDER.

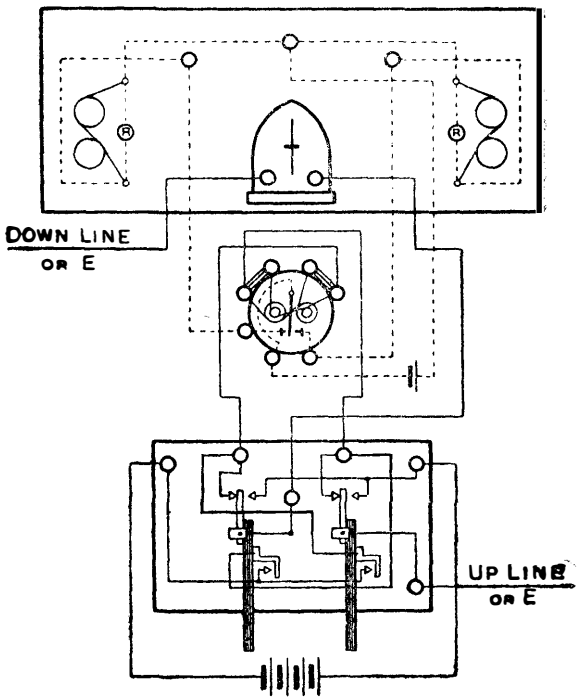
WITH SEPARATE RELAY.

Apparatus required :—
Commutator.
Cover for Commutator.
Double Sounder (which includes Screen on Turntable, fitted with 2 Plate Sounders and a Galvanometer).
Standard Relay A or B (neutral).

See Notes to Plate 14.

DOUBLE SOUNDER.

WITH SEPARATE RELAY.



PART III.

SINGLE CURRENT.

(Including also 6- and 7-terminal 2-position Switches.)

Plate 16.

6-TERMINAL 2-POSITION SWITCH.

("DUPLEX AND SINGLE.")

The upper figure shows the standard pattern (both segmental and spring cam forms), and indicates the relative positions of the terminals as compared with the older pattern with dead contacts, which is shown beneath. The latter is now obsolete.

7-TERMINAL 2-POSITION SWITCH.

("DUPLEX AND SINGLE.")

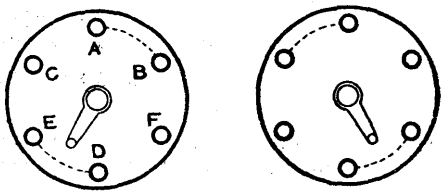
This is used in connection with the "Bridge" method of cable working on the Duplex Automatic System (Plates 28 and 53), also as a Counter Communication Switch (Plates 78 and 79).

6-TERMINAL 2-POSITION SWITCH.

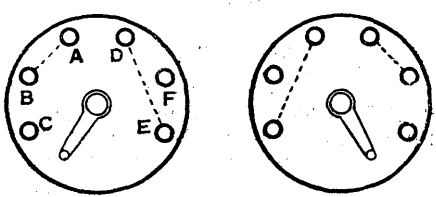
POSITION 1. (or "Duplex.")

POSITION 2. (or "Single.")

NEW FORM.



OLD FORM.



7-TERMINAL 2-POSITION SWITCH.

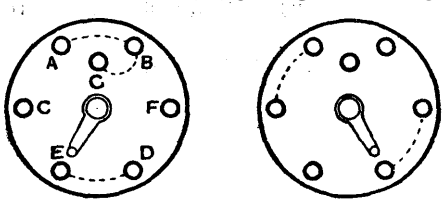


Plate 17.

SINGLE CURRENT.

DIRECT SOUNDER OR INKER.

Apparatus required:—
SC. Key.
SC. Galvanometer, 30ω.
Resistance Coil (various) 5ω (to be fitted as a shunt upon the Galvanometer Coils).

Sounder { Coils 20ω. / Shunt 500ω. } 19·2ω.

or

Local Inker. { Coils 40ω. / Shunt 500ω. } 37ω.

Form of Battery, Small Daniell.
Current required, 90 to 100 milliampères.

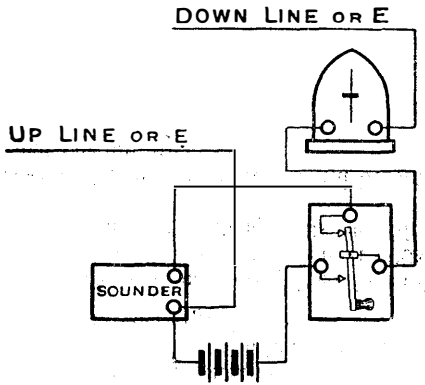
DIRECT WRITER.

This is complete in one piece.
Resistance of Coil, 300ω.
„ of Galvanometer, 30ω.
Form of Battery, Small Daniell.
Current required, 15 to 20 milliampères.

The speed of Slip for Inkers should be between 6 and 7 feet per minute.

SINGLE CURRENT.

DIRECT SOUNDER (OR INKER).



DIRECT WRITER.

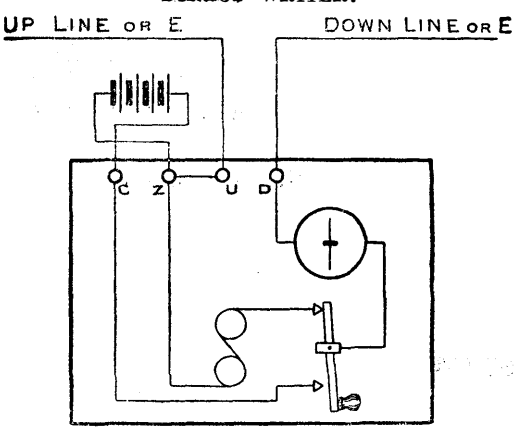


Plate 18.

SINGLE CURRENT.

SOUNDER (OR INKER) WITH RELAY.

Apparatus required:
SC. Key.
Relay
SC. Galvanometer.
Sounder or Local Inker.

Form of Battery, Small Daniell.
Current required, 15 to 20 milliampères.
Local Battery, 5c. Large Daniell.

The Relay Coils should be joined in multiple if the Line resistance does not exceed 1,000Ω. If above that resistance the Relay coils should be in series.

The Speed of Slip for Inkers should be between 6 and 7 feet per minute.

SINGLE CURRENT.

SOUNDER (OR INKER) WITH RELAY.

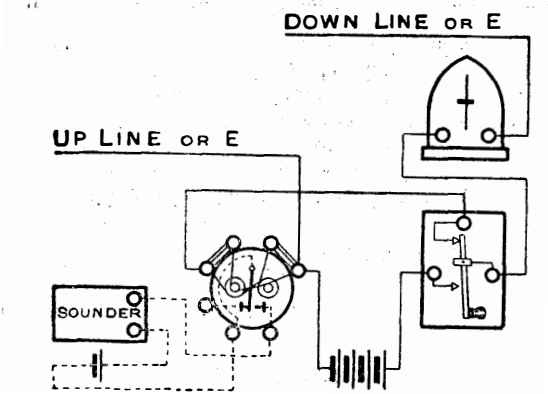


Plate 19.

SINGLE CURRENT.

DIRECT WRITER DUPLEX.

Apparatus required:—

Direct Writer Duplex with Switch (200ω each coil).

Differential Galvanometer { 50ω each coil, 300ω „ shunt } 42·9ω

Rheostat "C" or "Metropolitan."

Resistance Coil (various) (approximately equal to the resistance of the Battery).

Form of Battery, Large Daniell.

Current required, 15 to 20 milliampères.

The "Metropolitan" Rheostat has a maximum resistance of 1,175ω by gradations of 25ω.

Rheostat "C" has a maximum of 8430ω by gradations of 10ω.

The use of single current for Duplex Circuits is not to be encouraged; double current should be adopted for all new Circuits.

SINGLE CURRENT.

DIRECT WRITER, DUPLEX.

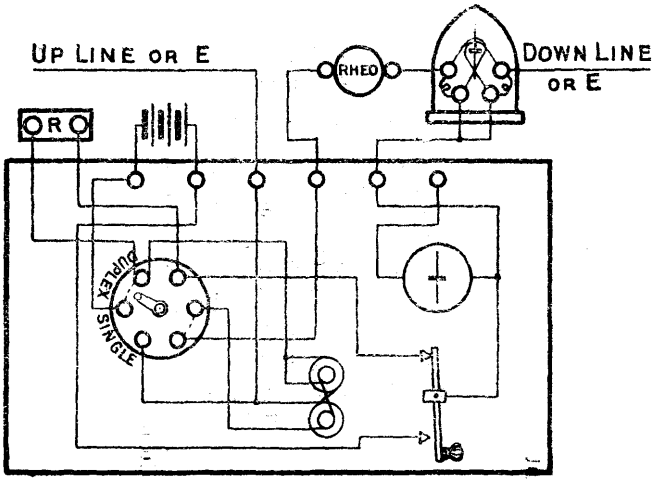


Plate 20.

SINGLE CURRENT.

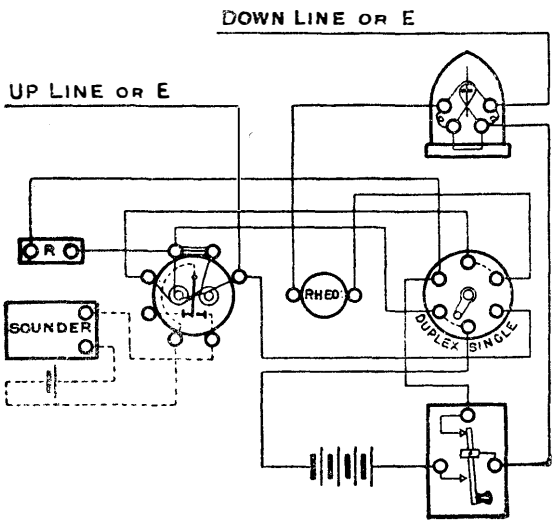
DUPLEX.

Apparatus required :—
SC. Key.
Relay.
Differential Galvanometer.
Sounder (or Local Inker).
6-terminal 2-position Switch.
Rheostat "C" or "Metropolitan."
Resistance Coil (various) (approximately equal to the resistance of the Battery).
Form of Battery, Large Daniell.
Current required, 15 to 20 milliampères.
Local Battery 5c. Large Daniell.

All new Duplex Circuits should be Double Current.

SINGLE CURRENT.

DUPLEX.



PART IV.

DOUBLE CURRENT.

Plate 21.

DOUBLE CURRENT.

SOUNDER (OR INKER) WITH RELAY.

Apparatus required :
DC. Key.
Relay.
SC. Galvanometer.
Sounder (or Local Inker).

Form of Battery, Small Daniell.
Current required, 14 to 17 milliampères.
Local Battery—5c. Largo Daniell.

DOUBLE CURRENT.

SOUNDER WITH RELAY.

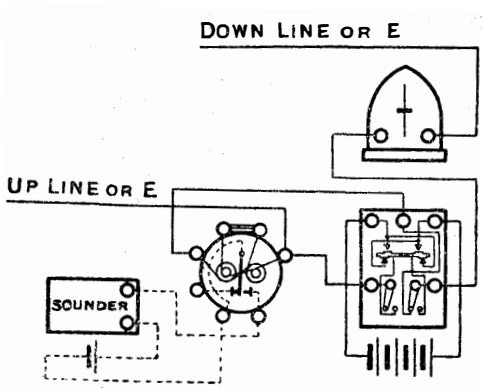


Plate 22.

DOUBLE CURRENT.

DUPLEX.

Apparatus required :—

- DC. Key.
- Differential Galvanometer.
- Relay.
- 6-terminal 2-position Switch.
- Rheostat "C."
- Condenser, $7\frac{1}{4}$ mf. (for Circuits over 100 miles, or when on railway lines, over 120 miles).
- Retardation Coils (for Circuits over 150 miles).
- Resistance Coil (various) 2,000ω (for Circuits over 120 miles).
- Sounder.

NOTES.—The Resistance Coil is to be placed across the divided plate of the Condenser.

For Circuits over 200 miles "Condenser Coils" should be used instead of the "Resistance Coil (various) 2,000ω."

Form of Battery :

For Circuits over 150 *miles in length*, Bichromate.

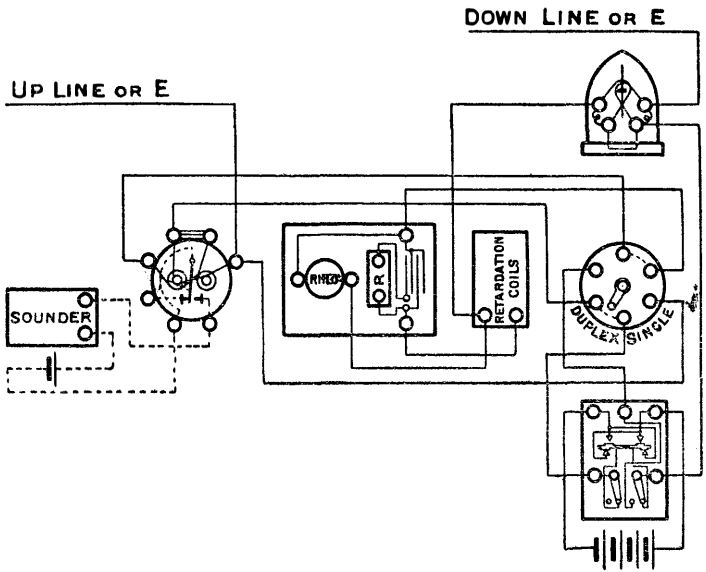
For Circuits less than 150 *miles in length*, Large Daniell.

Current required, 14 to 17 milliampères.

Local Battery, 5c. Large Daniell.

DOUBLE CURRENT.

DUPLEX.



PART V.

AUTOMATIC SYSTEM

Plate 23.

AUTOMATIC SYSTEM.

COMPLETE, FOR TRANSMITTING AND RECEIVING.

Apparatus required :—

DC. Key.
Wheatstone Transmitter.
Receiver Motor.
„ Train.
2 Auto. Weights.
Differential Galvanometer.
Condenser, 7¼ mf. (Reading).
Rheostat "C."
Sounder.

Battery, Bichromate, 100 volts required.

Local Battery, 5c. Large Daniell, or 2c. Bichromate.

AUTOMATIC SYSTEM.

COMPLETE: FOR TRANSMITTING AND RECEIVING.

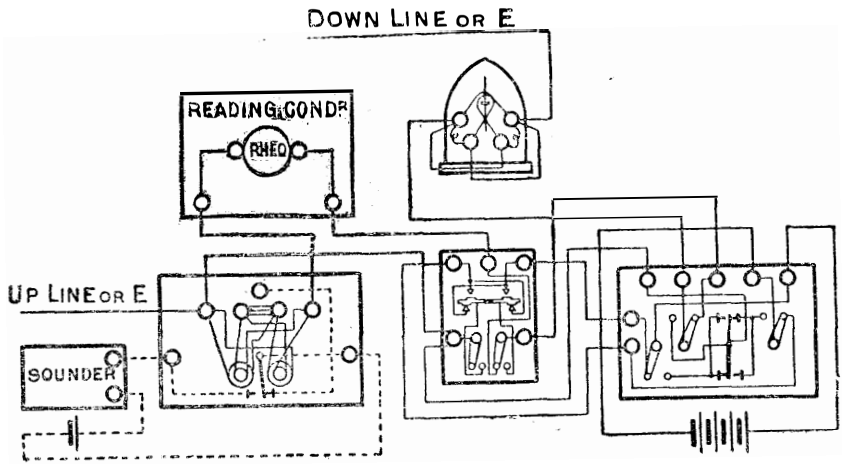


Plate 24.

AUTOMATIC SYSTEM.

"NEWS" ARRANGEMENT, FOR TRANSMITTING ONLY.

Apparatus required :—
- DC. Key.
- Wheatstone Transmitter.
- Auto. Weight.
- Differential Galvanometer.
- Relay.
- Sounder.

Battery, Bichromate, 100 volts required.
Local Battery, 5c. Large Daniell, or 2c. Bichromate.

AUTOMATIC SYSTEM.

"NEWS" ARRANGEMENT, FOR TRANSMITTING ONLY.

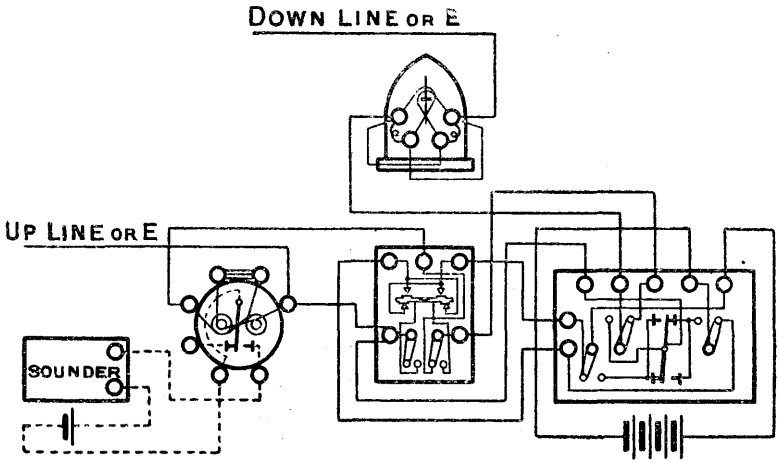


Plate 25.

AUTOMATIC SYSTEM.

"NEWS" ARRANGEMENT, FOR RECEIVING ONLY (INTERMEDIATE STATION).

Apparatus required :—
DC. Key.
Differential Galvanometer.
Receiver Motor.
„ Train.
Auto. Weight.
Sounder.

As a general rule, the Receiver coils should be joined in multiple.

Form of Battery, Leclanché No. 1 with Circular Zincs.
Current required, 14 to 17 milliampères.
Local Battery, 5c. Large Daniell, or 2c. Bichromate.

AUTOMATIC SYSTEM.

"NEWS" ARRANGEMENT, FOR RECEIVING ONLY (INTERMEDIATE STATION).

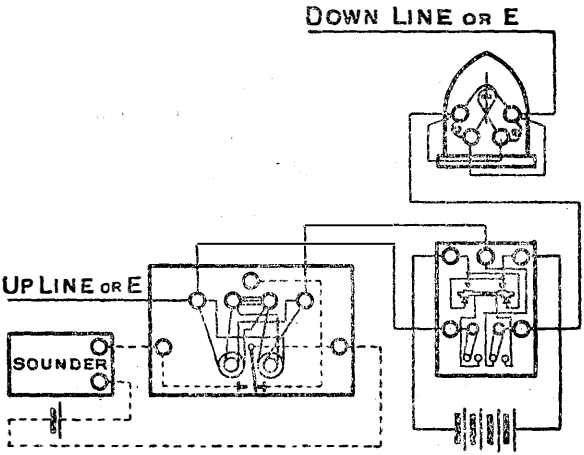


Plate 26.

AUTOMATIC SYSTEM.

"NEWS" ARRANGEMENT, FOR RECEIVING ONLY (TERMINAL STATION).

Apparatus required :—
DC. Key.
Differential Galvanometer.
Receiver Motor.
„ Train.
Auto. Weight.
Condenser, $7\frac{1}{4}$ mf. (Reading).
Rheostat "C."
Sounder.

As a general rule, the Receiver coils should be joined in multiple.

Form of Battery, Leclanché No. 1 with Circular Zincs.
Current required, 14 to 17 milliampères.
Local Battery, 5c. Large Daniell, or 2c. Bichromate.

AUTOMATIC SYSTEM.

"NEWS" ARRANGEMENT, FOR RECEIVING ONLY (TERMINAL STATION).

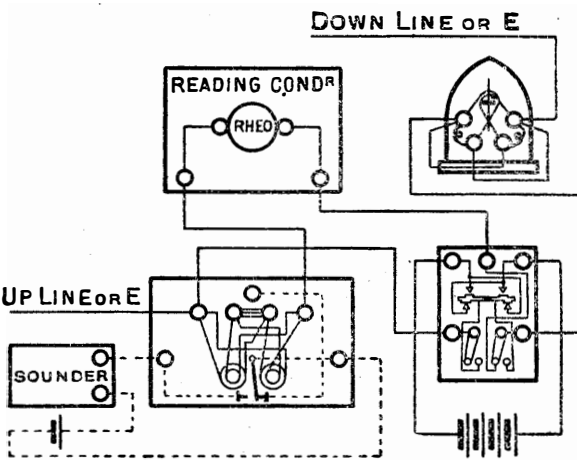


Plate 27.

AUTOMATIC SYSTEM.

DUPLEX.

Apparatus required :—

DC. Key.
Wheatstone Transmitter.
Differential Galvanometer.
Receiver Motor.
„ Train.
2 Auto. Weights.
6-terminal 2-position Switch.
2-way Switch.
Rheostat "C."
Condenser, $7\frac{1}{4}$ mf. or $10\frac{1}{2}$ mf.
Retardation Coils (8 plugs).
Battery Resistance Coils.
Condenser Coils (to be placed across the divided plate of the Condenser).
Sounder.
Battery, Bichromate, 100 volts required.
Local Battery, 5c. Large Daniell, or 2c. Bichromate.

Where the resistance of the line is between 1,000 and 2,000 ohms a "Resistance Coil (various) 1,000 ohms" should be inserted between the Up Terminal of the Receiver and the junction of the two wires connected to that terminal in the diagram. Where the line is 1,000 ohms or less, two Resistance Coils (various) 1,000 ohms should be inserted.

The connections of the Switch are such as to admit of the Condenser being used in "Single" working.

The capacities of the $7\frac{1}{4}$ mf. Condenser are $3\frac{3}{4}$ mf. by gradation of $\frac{1}{4}$ mf. *plus* $3\frac{1}{2}$ mf. by gradation of $\frac{1}{2}$ mf. The corresponding values of the $10\frac{1}{2}$ mf. Condenser are $6\frac{3}{4}$ mf. *plus* $3\frac{3}{4}$ mf. each by gradations of $\frac{1}{4}$ mf.

AUTOMATIC SYSTEM: DUPLEX.

U 9562. E

Plate 28.

AUTOMATIC SYSTEM.

"BRIDGE" DUPLEX: FOR CABLE CIRCUITS.

As different arrangements are made to suit various requirements, Automatic Duplex Circuits should be fitted only after direct communication with the Office of the Engineer-in-Chief.

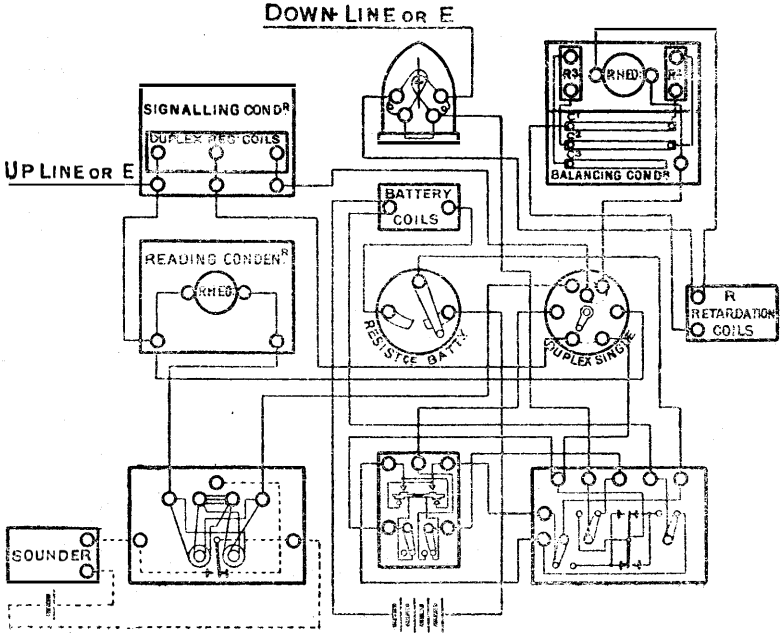
Apparatus required:—

DC. Key.
Wheatstone Transmitter.
Differential Galvanometer.
Receiver Motor.
,, Train.
2 Auto. Weights.
7-terminal 2-position Switch.
2-way Switch.
Rheostat "C."
Triple Condenser.
Signalling Condenser.
Reading Condenser (adjustable).
Retardation Coils (8 plugs).
Battery Resistance Coils.
2 Condenser Coils (R^2 and R^3 on diagram).
Duplex Resistance Coils.
Shunt Coil 14,000 (on Reading Condenser, marked "Rheo").
Sounder.
Battery, Bichromate, 100 Volts required.
Local Battery, 5c. Large Daniell, or 2c. Bichromate.

The connections of the Switch are such as to admit of the Reading Condenser being used in "Single" working.

For internal connections of the Switch in position 2 ("Single") *see* Plate 16, p. 59.

AUTOMATIC SYSTEM. "BRIDGE" DUPLEX: FOR CABLE CIRCUITS, &c.



PART VI.

REPEATERS.

Plate 29.

REPEATERS.

(1.) LINE AND BATTERY BOX CONNECTIONS.

The external connections of Repeater Boards of all forms should be made on the principle shewn in this Diagram. The "Up E" and "Down E" Terminals of the Repeater Board are to be connected respectively to the Up Return Instrument and Down Return Instrument Terminals at the Line Box. The centres of the Main Batteries are also to be connected from the Instrument Room Battery Box to the same two terminals, the centre of the Up Main being connected to the Down Return Instrument Terminal and the centre of the Down Main to the Up Return Instrument Terminal. The "Earth" connection is then made only at the Line Box.

To "LOOP": disconnect the "Earth" at the Line Box and join the Up Return wire to the Up Return Instrument Terminal, and the Down Return wire to the Down Return Instrument Terminal.

The coils of the Non-polarised Indicators are joined in "multiple" (25ω) and have a shunt of 3·4ω, so that the resistance in the Battery lead is increased by 3ω. The Indicators are actuated by the short-circuiting of the Main Batteries, and being of the shutter local-circuit form, the Bell

(*Continued on p. 72.*)

REPEATERS.

LINE AND BATTERY BOX CONNECTIONS.

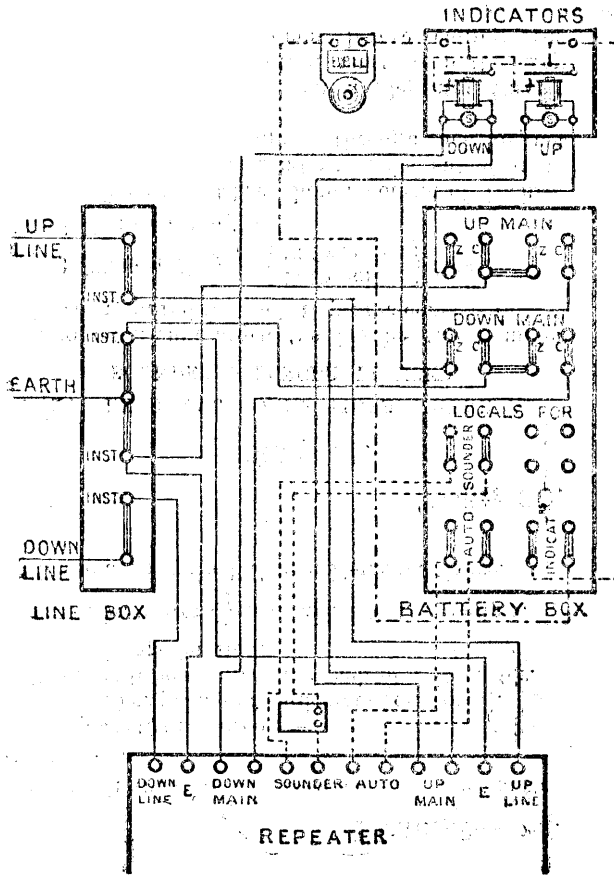


Plate 29—*cont.*

rings until the fault is removed and the shutter replaced.

Apparatus required :—

2 Non-polarised Indicators (old form).

These will be required for each new Repeater.

1 Trembler Bell.

1 Indicator $\frac{0}{N}$ fitted with N 3·4ω shunts.

These are required at each Repeater Office.

Plate 30.

REPEATERS.

(2.) EXTERNAL CONNECTIONS WHERE A SOUNDER SILENCER IS USED.

The additional apparatus besides the Sounder Silencer required for each Repeater consists of—

1 Silencer Magnet $\left\{\begin{matrix}200\omega \text{ coil} \\ 200\omega \text{ shunt}\end{matrix}\right\}$ 100ω.

1 Press-Button "E."

The Silencer Battery should consist of Bichromate (3-pint) or Secondary Cells sufficient to give about 100 milliampères through each Magnet (100ω).

The Terminal Offices on a Repeater Circuit where a Silencer is fitted must keep the Key depressed for 20 seconds before calling the Repeater Office.

NOTE.—The Silencer Magnet is adjusted not to act at 14 seconds, and to bring the Sounder into circuit at 18 seconds.

REPEATERS.

EXTERNAL CONNECTIONS WHERE A SOUNDER SILENCER IS USED.

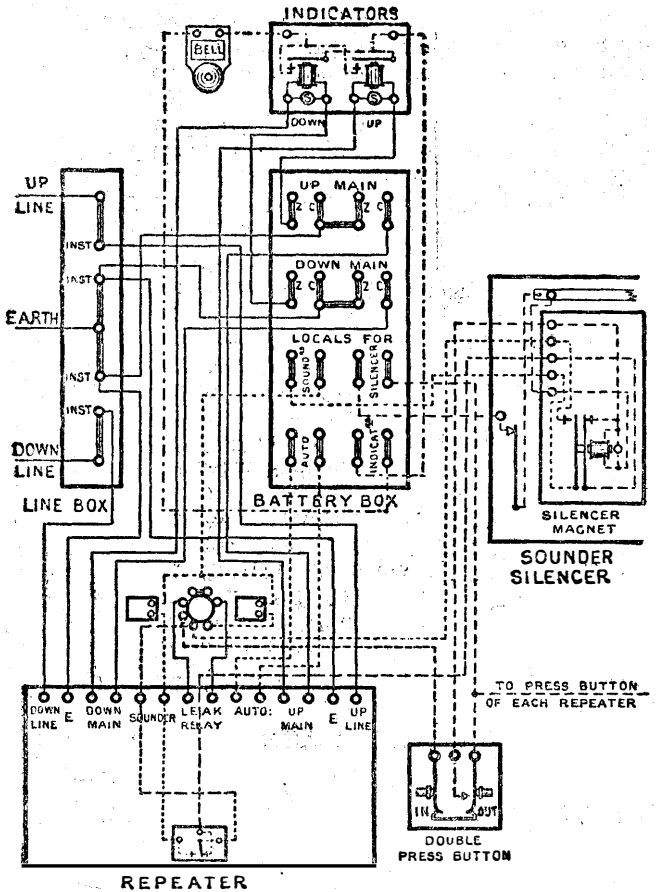


Plate 31.

KEY REPEATER.

DUPLEX (AND SINGLE).

Apparatus required :—

2 Relays "B" ordinary.
2 „ "B" neutral.
2 Relaying Sounders "A" (60ω coils and 60ω shunts).
2 Pole Changers.
2 DC. Keys with 6 terminals.
1 8-bar Switch.
2 Differential Galvanometers.
2 Rheostats "C."
2 Resistance Coils (various) 2,000ω.
2 Retardation Coils O.F.
2 Quad. Battery Resistance Coils 100ω.
2 7¼ mf. Condensers.
1 Board, with 14 Terminals.
2 Non-polarised Indicators, OF.

Form of Battery, Bichromate.

Current required, 14 to 17 milliampères.

Local Batteries, Large Daniell; ten cells being used for each (that is, thirty cells in all).

The Switch is shown in position for *Duplex* working.

For full external connections, *see* Plate 29 or 30.

When the apparatus is not in circuit the Switch must be turned to *Single*.

KEY REPEATER.

DUPLEX (AND SINGLE).

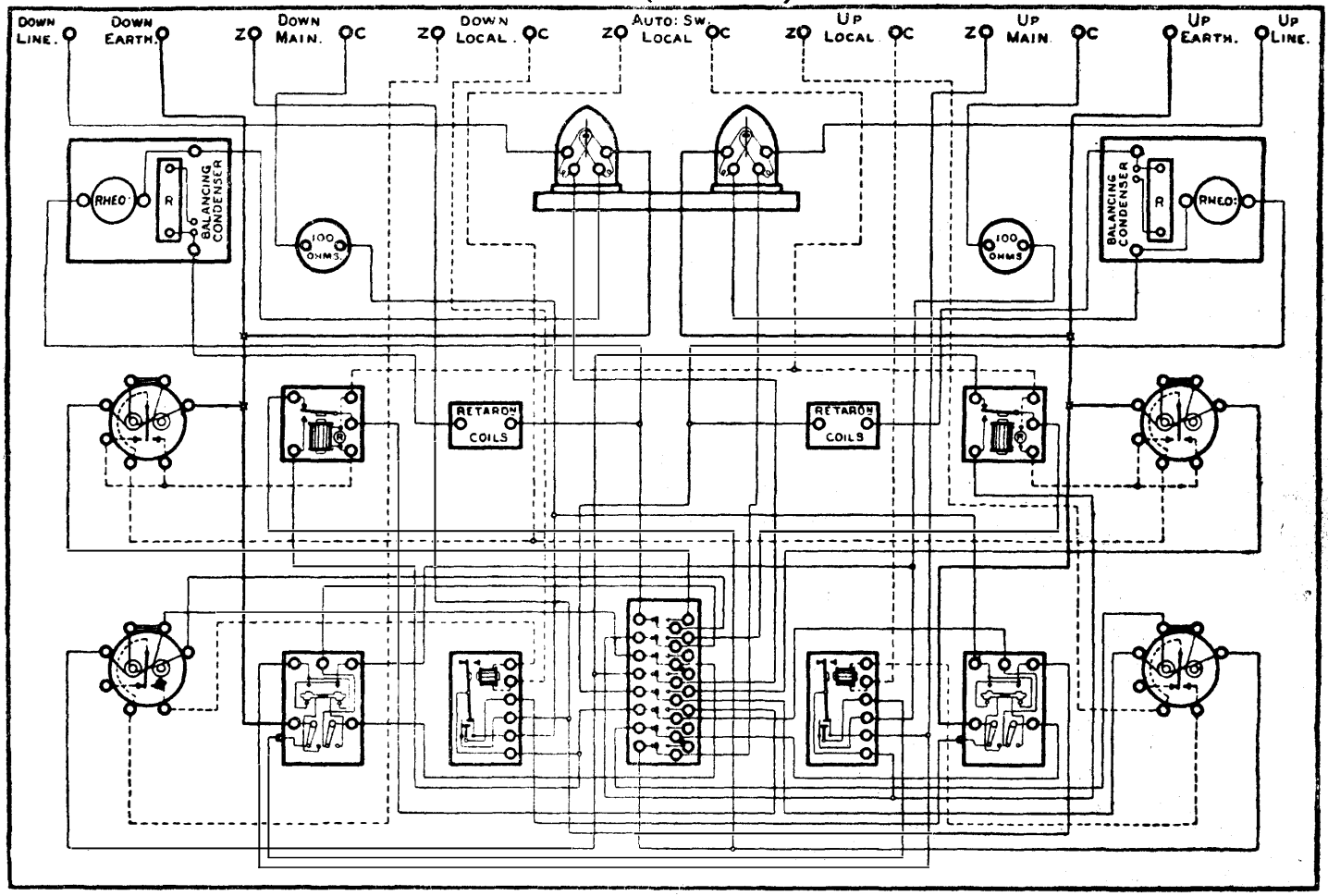


Plate 3

Plate 32.

FAST REPEATER.

SINGLE.

Apparatus required :—

1 Receiver Motor.
1 Receiver Train.
1 Auto. Weight.
2 Relays "B" ordinary.
2 „ "B" neutral.
2 Electro-magnetic Switches.
2 SC. Keys with Switch.
2 Differential Galvanometers.
1 Leak Coil (20,000ω).
2 Rheostats "C."
1 Resistance Coil (various), 2,000ω.
2 7¼ mf. Condensers.
1 Spark (1 mf.) Condenser.
2 On and Off Switches.
1 Board, with 12 Terminals.

1 Sounder.
2 Non-polarised Indicators, O.F.

Battery, Bichromate; 100 volts required.

Local Batteries, Large Daniell; 10 cells being used for the Automatic Switches, and 5 cells for the Sounder local.

For full external connections, *see* Plate 29 or 30.

The Main Batteries can be disconnected from the Transmitting Relays (but not from the Keys) by turning the levers of the corresponding "On and Off" Switches to "Off."

Plate 33.

FAST REPEATER.

DUPLEX (AND SINGLE).

Apparatus required :—

1 Receiver Motor.
1 Receiver Train.
1 Auto. Weight.
2 Relays "B" ordinary.
2 „ "B" neutral.
2 Electro-magnetic Switches.
2 SC. Keys, with Switch.
2 6-terminal 2-position Switches.
1 8-bar Switch.
2 Differential Galvanometers(*see* page 79).
1 Leak Coil (40,000ω).
2 Battery-Resistance Coils.
2 Retardation Coils (8 plugs).
2 Rheostats "C."
2 Condenser Coils.
2 Resistance Coils (various), 2,000ω.
2 7¼ mf. Condensers.
2 Spark (1 mf.) Condensers.
1 Leak Switch and Peg.
1 Board with 14 Terminals.

1 Relay "B" ordinary.
2 Sounders.
2 Non-polarised Indicators, O.F.

Battery, Bichromate, 100 volts required.

Local Batteries, Large Daniell; 10 cells being used for the Automatic Switches, and 5 cells for the Sounder local.

(*Continued on p.* 79.)

FAST REPEATER.

DUPLEX (AND SINGLE).

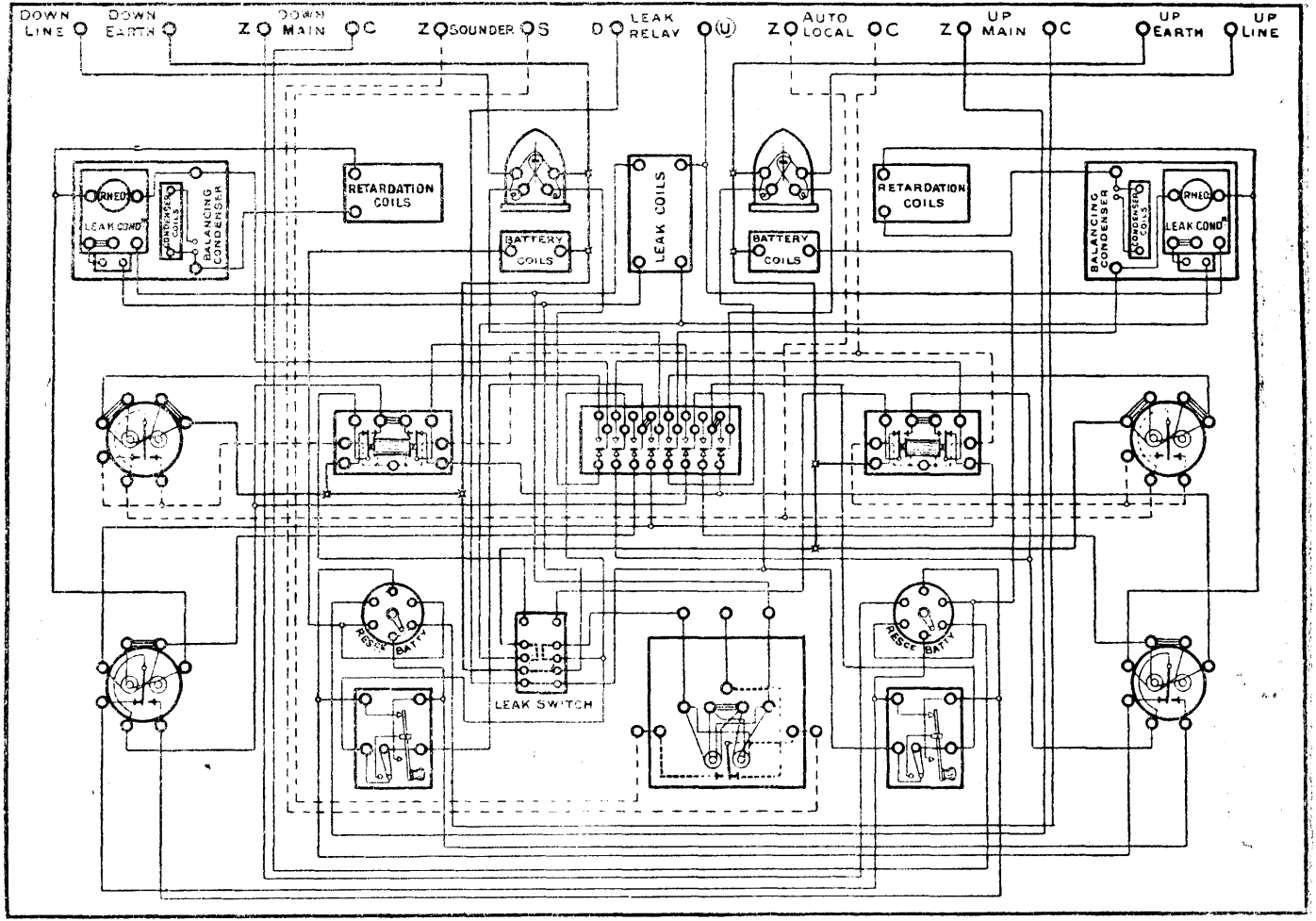


Plate 33.

If the resistance of the Line be between 1,000ω and 2,000ω, one Resistance Coil (various) 1,000ω: If the line be 1,000ω or less two Resistance Coils (various) 1,000ω must be inserted between the line terminal of the Transmitting Relay and the 8-bar Switch. This applies to the *Line* side only in regard to Plates 34 and 35 (that is, the rule applies to "differential" but not to "bridge" duplex working).

Where authorised, and in all new Fast Duplex Repeaters, a Differential Galvanometer (with coils in series) is inserted in the Receiver Leak circuit between the Leak Coils and the connection which is shown as passing direct to the Receiver Terminal D.

For full external connections, *see* Plate 29 or 30.

The Switch is shown in position for *Duplex* working.

The left-hand portion of the Leak Coils is permanently connected to the Receiver, and the right-hand portion to the Relay.

When the apparatus is not in circuit the Switch must be turned to *Single*.

It will be seen that in this case the Resistance-Battery Switches can be utilised as On and Off Switches (Plate 32, p. 76).

Leak Switch. For explanation and connections in all positions *see* Notes on p. 81.

A slight re-arrangement in the order of the terminals is shown in these diagrams (Plates 33, 34, and 35).

The latest pattern Fast Duplex (and Single) Repeater is arranged with the whole of the apparatus on the Board, and the upper tier of apparatus is fitted upon a removeable shelf.

Plates 34 and 35.

FAST REPEATER.

DUPLEX (AND SINGLE), ON CABLE CIRCUITS.

For general notes, *see* pp. 78 and 79.

Apparatus required :—

1 Receiver Motor.
1 Receiver Train.
1 Auto. Weight.
2 Relays "B" ordinary.
2 „ "B" neutral.
2 Electro-magnetic Switches.
2 SC. Keys with Switch.
2 6-terminal 2-position Switches.
1 8-bar Switch.
3 Differential Galvanometers (p. 79).
1 Leak Coil (40,000ω).
2 Battery Resistance Coils.
1 Shunt Coil (14,000ω).
2 Retardation Coils (8 plugs).
2 Rheostats "C."
3 Condenser Coils.
2 Resistance Coils (various), 2,000ω.
1 7¼ mf. Condenser.
1 Condenser (*mf.).
1 Signalling Condenser (*mf.).
1 Triple Condenser (*mf.).
1 Duplex Resistance Coils (3,000ω + 3,000ω).
2 Spark (1 mf.) Condensers.

---

* Resistance and Capacity according to requirements of Circuit.

(*Continued on p.* 81.)

FAST REPEATER.

DUPLEX (AND SINGLE) CABLE ON "UP" SIDE.

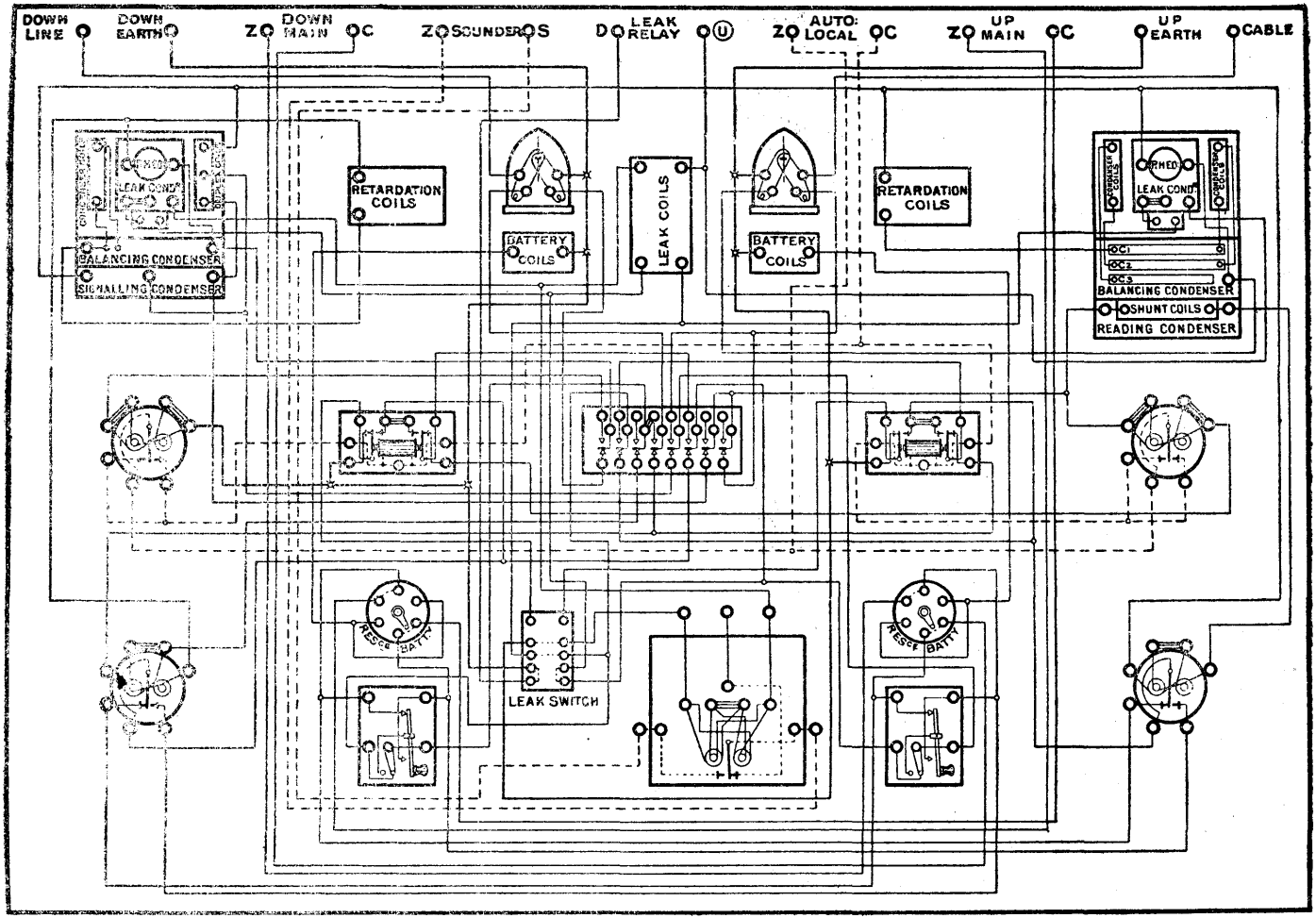


Plate 34.

FAST REPEATER.

DUPLEX (AND SINGLE), CABLE ON "DOWN" SIDE.

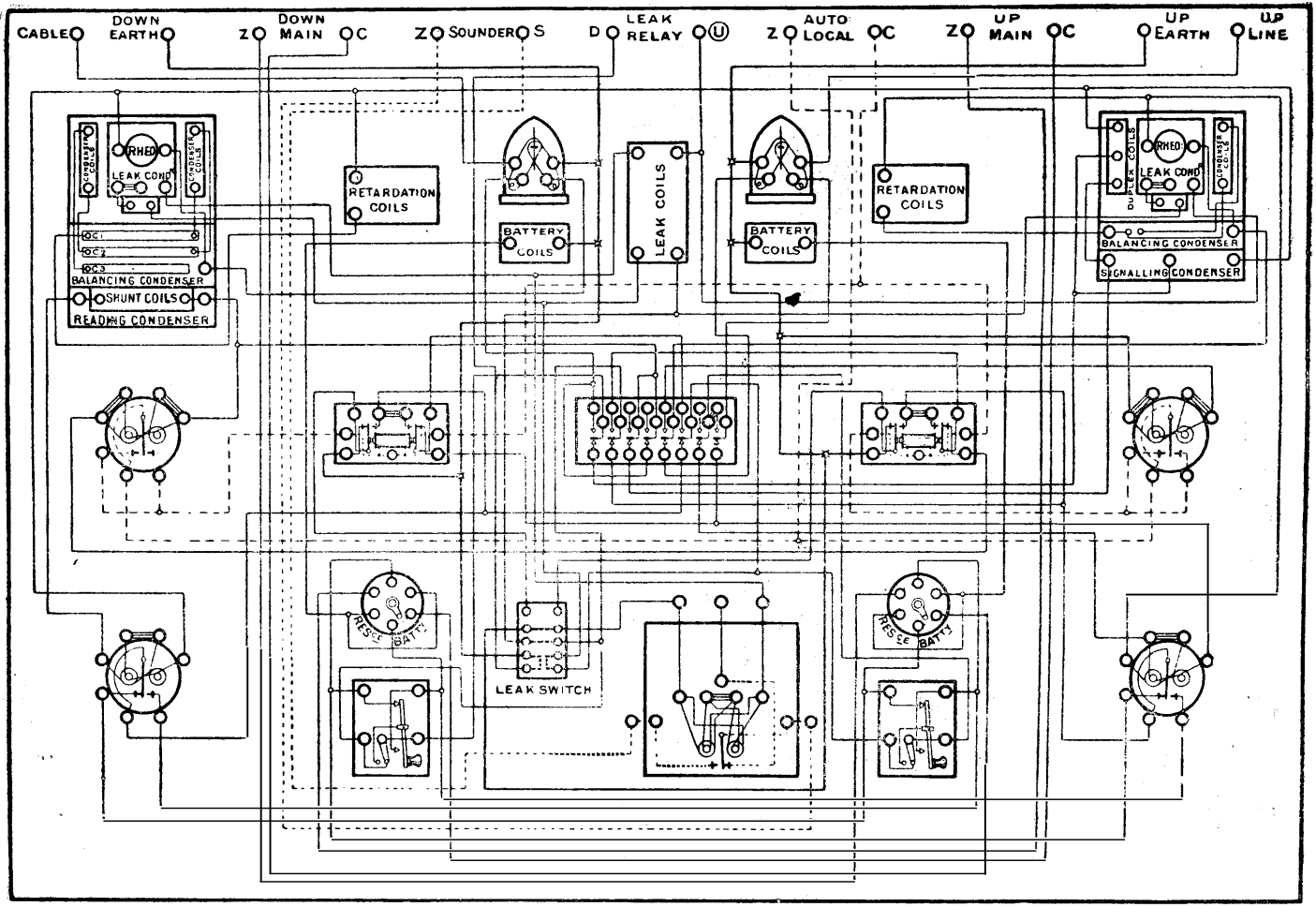


Plate 35.

FORKED "NEWS" REPEATER (WITH REVERSIBLE LEAK).

LEAK SWITCH IS SHOWN IN POSITION 1—CONNECTING LEAK TO NO. 1 DOWN RELAY.

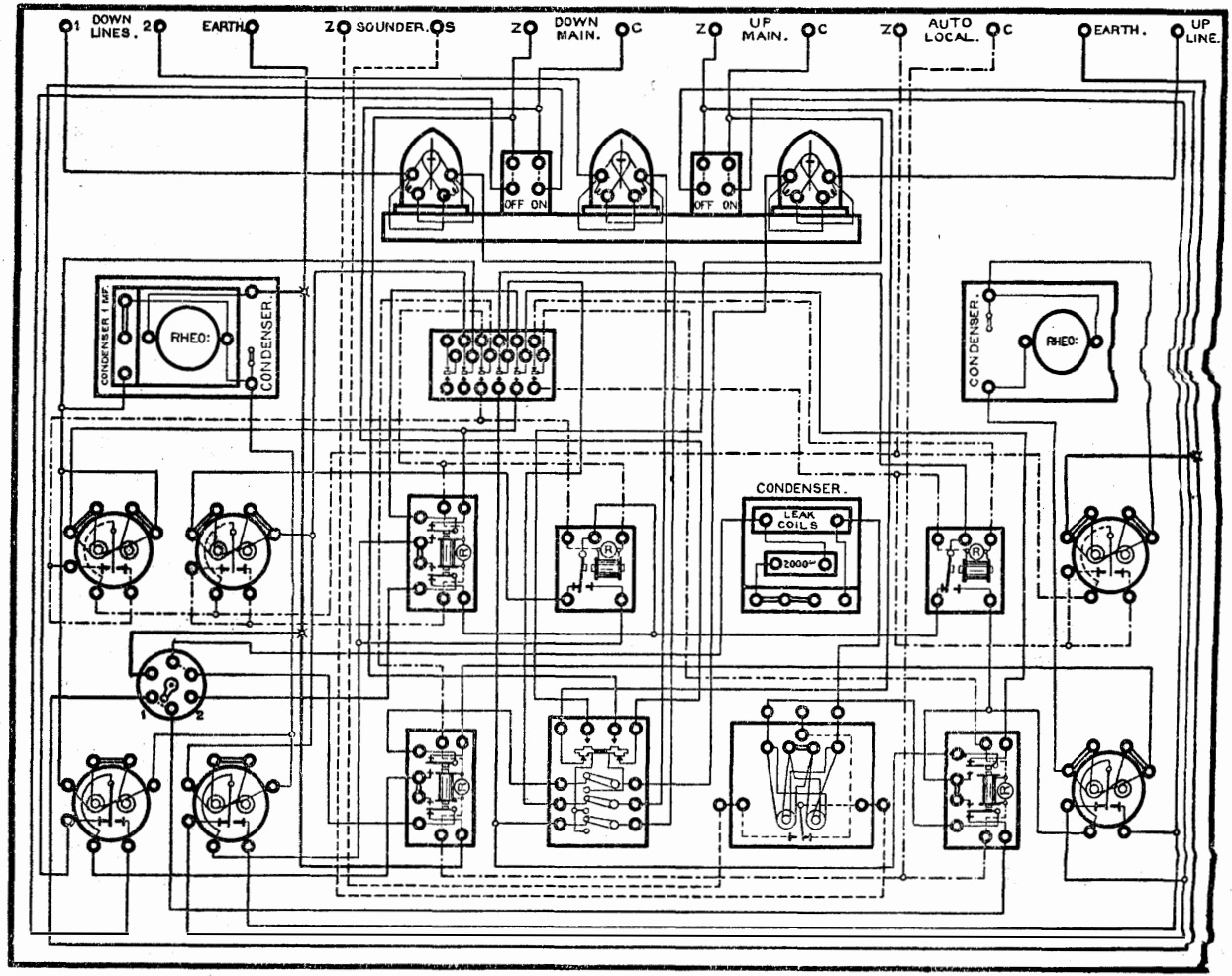


Plate 36a.

Plate 36a.

FORKED "NEWS" REPEATER

WITH REVERSIBLE LEAK (*Standard Pattern*).

For general notes *see* page 76.

Apparatus required :—

1 Receiver Motor.
1 Receiver Train.
1 Auto. Weight.
3 Relays "B" ordinary.
3 „ "B" neutral.
3 Electro-magnetic Switches.
2 Relaying Sounders "A" (60ω coils and 60ω shunts).
1 DC. Key, 10-terminal.
1 Switch, 6-bar.
1 „ 6-terminal, 2-position.
2 „ On and Off.
3 Differential Galvanometers.
1 Resistance Coil, Leak, 20,000ω.
1 „ „ various, 2,000ω.
2 Rheostats "C."
2 Condensers, $7\frac{1}{4}$ mf.
2 „ 1 „
1 Board, with 13 Terminals.
1 Sounder.
2 Non-polarised Indicators, O.F.

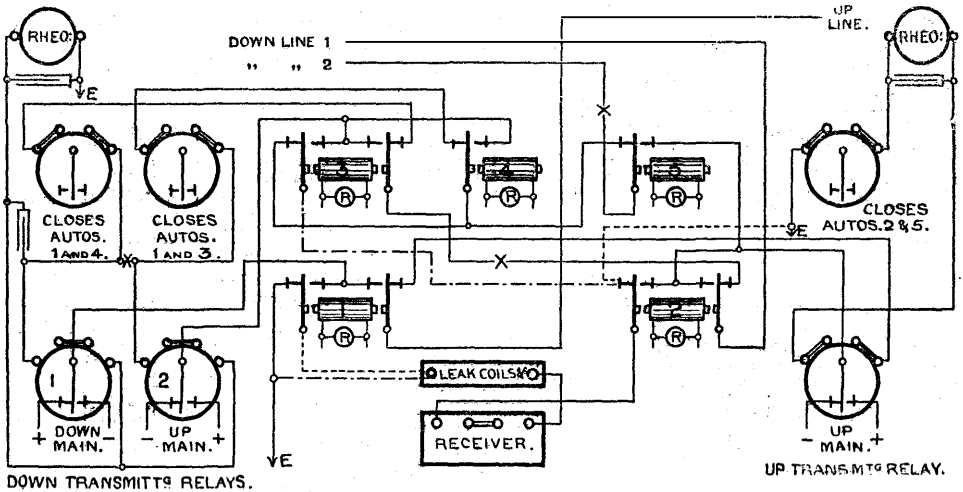
The 6-terminal, 2-position Switch is introduced in order to allow of the Receiver Leak being connected at will to either of the Down Transmitting Relays.

When the Lines have to be LOOPED, the 6-bar Switch must be turned to "Ordinary," and *both* Return Down Lines connected in place of the Earth on the Down Return Instrument Terminal at the Line Box.

The Return Up Line will, of course, be correspondingly connected to the Up Return Instrument Terminal instead of Earth.

FORKED "NEWS" REPEATER (WITH REVERSIBLE LEAK).

THEORETICAL DIAGRAM.—MAIN SWITCH IN "FORKED" POSITION.



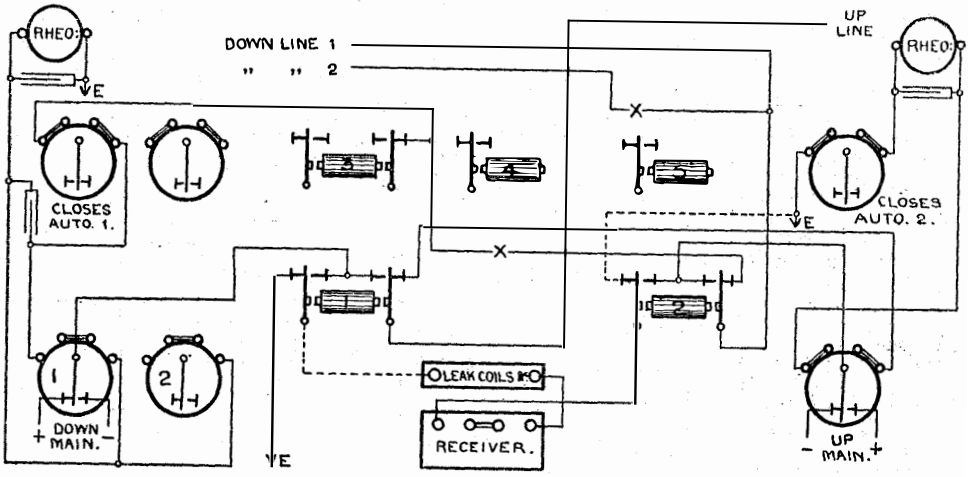
Connections made by Leak Switch in position 1 *are shown as* ----------

" " " " 2 " —·—·—·—

" " *Main (6-bar) Switch are marked* - 'X'

FORKED "NEWS" REPEATER (WITH REVERSIBLE LEAK).

THEORETICAL DIAGRAM.—MAIN SWITCH IN "ORDINARY" POSITION.



Dotted lines show connections made by Leak Switch (POSITION 1.)

Connections made by Main (6-bar) Switch are marked "X"

Plate 37.

HUGHES REPEATER.

SINGLE, CABLE ON "DOWN" SIDE.

For general notes, *see* page 76.

Apparatus required :—

5 Relays "B" ordinary.
2 SC. Keys.
2 Differential Galvanometers.
1 Leak Coil (40,000ω).
1 Resistance Coil (various) 1,000ω.
1 On and Off Switch (3-position).
1 6-terminal 2-position Switch (engraved "DF" and "IQ").
1 2-way Switch (special).
1 Board with 12 terminals.

1 Sounder.
1 Relaying Sounder "B."

HUGHES REPEATER.

SINGLE.

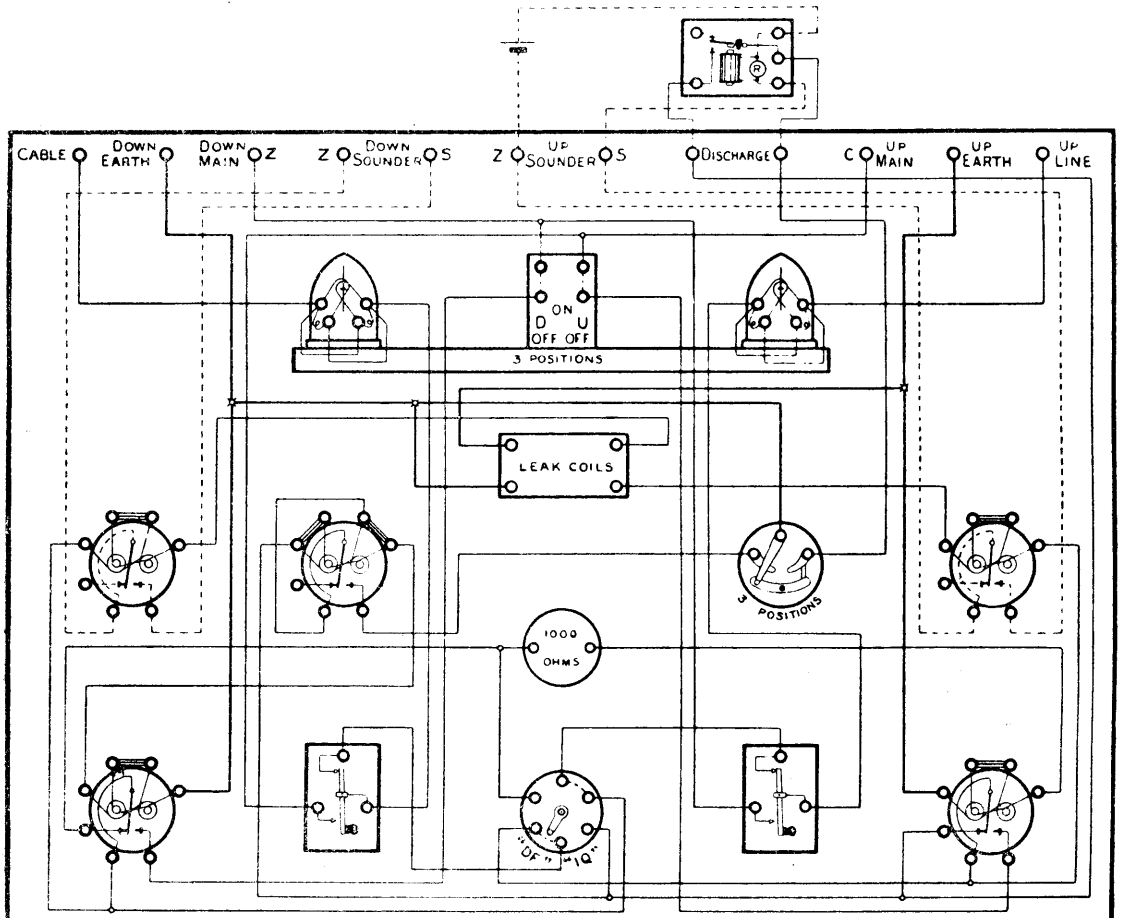


Plate 37.

Plate 38.

HUGHES REPEATER.

DUPLEX (AND SINGLE), CABLE ON "DOWN" SIDE.

For general notes, *see* page 76.

Apparatus required:—

1 Receiver, Spring.
3 Relays "B."
2 SC. Keys with Switch.
1 6-terminal 2-position Switch (engraved "DF" and "IQ").
1 8-bar Switch.
2 Differential Galvanometers.
1 Leak Coil (40,000Ω).
2 Battery Resistance Coils.
2 Retardation Coils (8 plugs).
2 Rheostats "C."
3 Condenser Coils.
1 On and Off Switch (3-position).
1 $7\frac{1}{4}$ mf. Condenser.
1 Triple Condenser.
1 Reading Condenser (if required).
1 Leak Switch and Peg.
1 Short-circuit Piece.
1 Board with 13 terminals.

1 Sounder.
1 Relaying Sounder "B."

HUGHES REPEATER.

DUPLEX (AND SINGLE), CABLE ON "DOWN" SIDE.

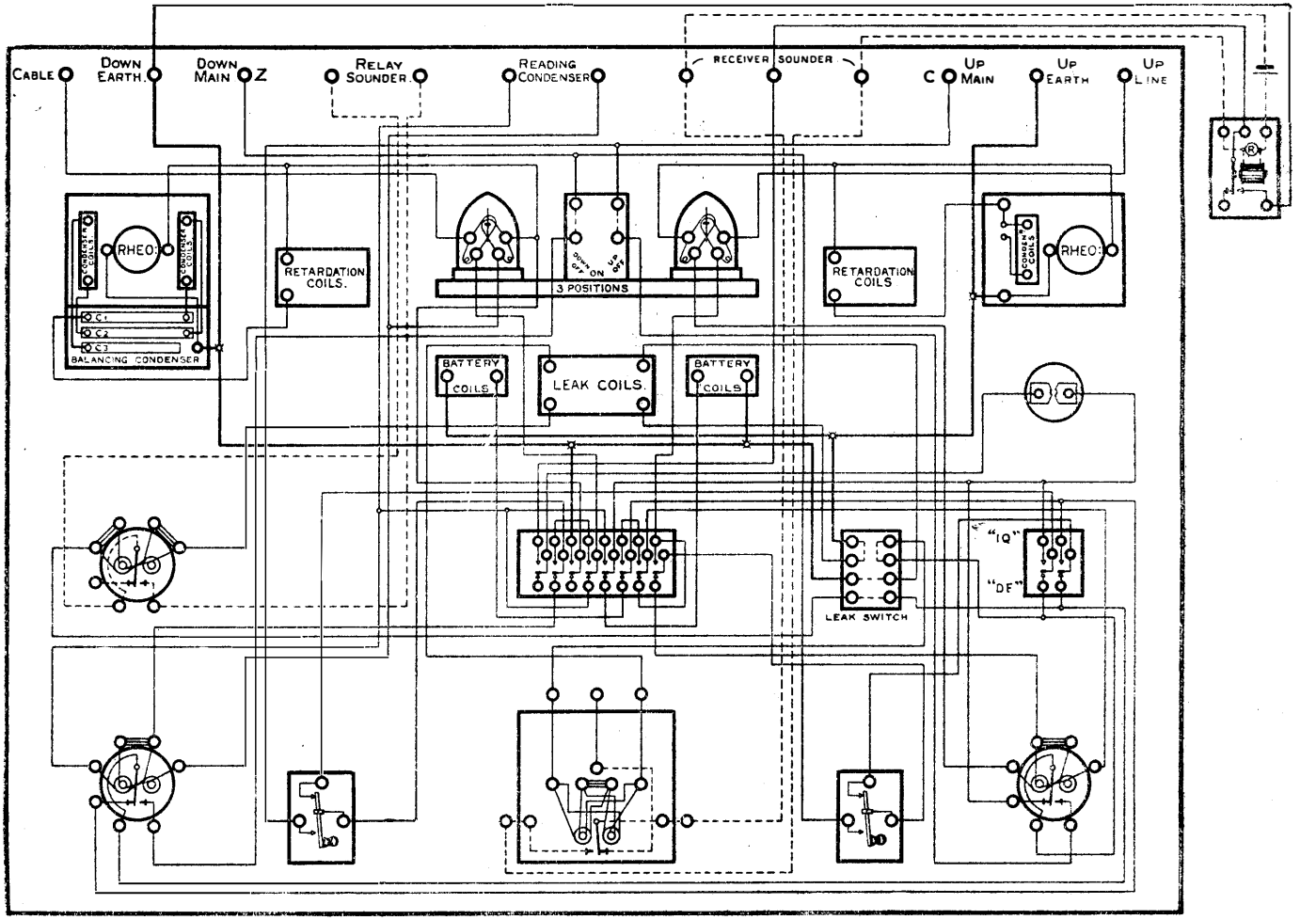


Plate 38.

PART VII.

HUGHES INSTRUMENT.

For Hughes Repeaters, *see* pages 84 to 87.

Plate 39.

HUGHES INSTRUMENT.

ORDINARY.

Apparatus required :—
1 Hughes Instrument (Ordinary).
Driving Weights.
1 Hook.
1 Balance Weight.

For full description, *see* Technical Instructions, VI.

The Line is now usually connected to the Instrument through a Galvanometer (SC). Where night attendance is required the lever and left-hand stud of a two-way switch are inserted on the Office side of the Galvanometer, and the right-hand stud of the Switch is connected to a Non-polarised Indicator with a Bell in its local circuit. This provides a "night-call." A separate Switch must be used for each Instrument, but one Indicator may serve for two or more.

HUGHES INSTRUMENT: Ordinary.

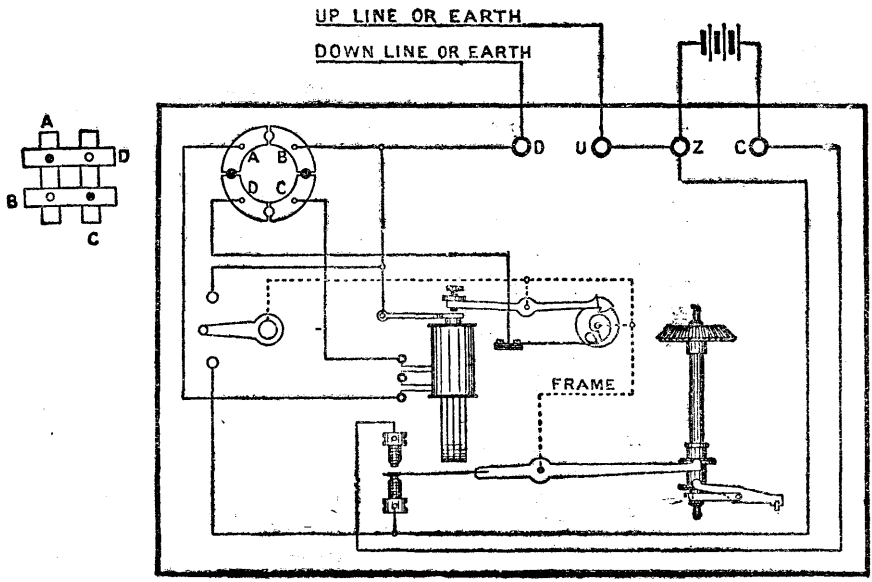


Plate 40.

HUGHES INSTRUMENT.

ELECTRIC.

For general notes, *see* page 90.

Apparatus required :—

1 Hughes Instrument (Electric).
1 Electric-Motor for Hughes.
1 Slide Resistance.

HUGHES INSTRUMENT.

ELECTRIC.

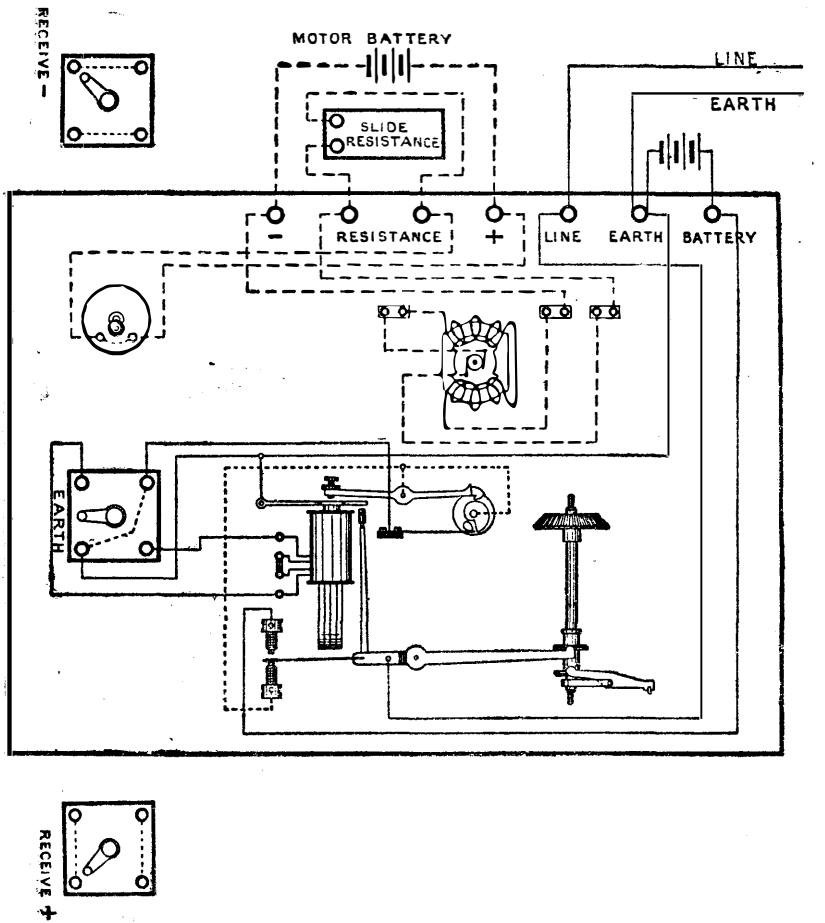


Plate 40.

Plate 41.

HUGHES INSTRUMENT.

ELECTRIC FOR RECEIVING.

This Instrument was introduced for use in connection with Hughes Duplex working. *See* page 96 and Plate 42.

As there is an advantage in employing a complete Instrument so that the sending and receiving instruments may be interchangeable, the issue of this form will be discontinued.

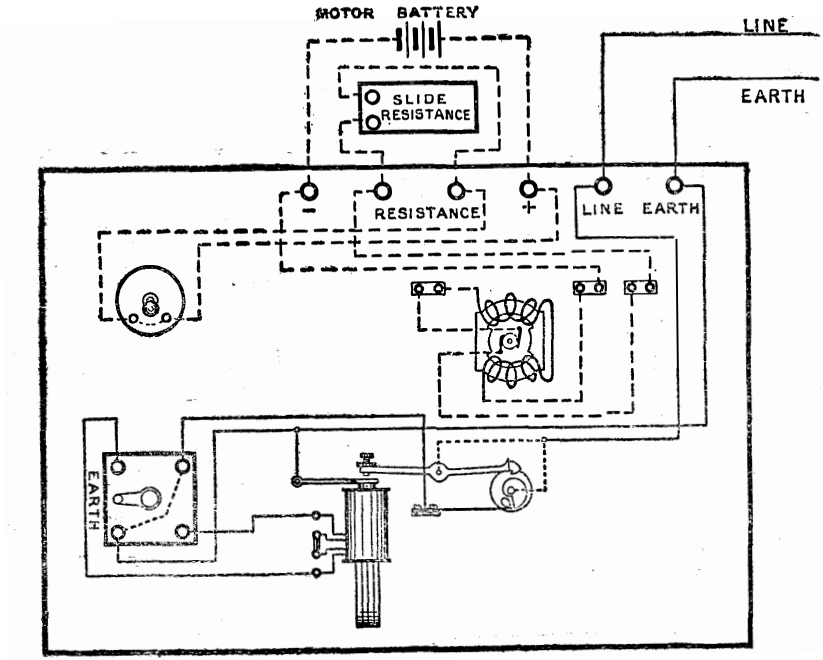

MOTOR BATTERY
LINE
EARTH
SLIDE RESISTANCE
RESISTANCE
LINE EARTH
EARTH

Plate 42.

HUGHES INSTRUMENT.

DUPLEX, FOR INLAND CIRCUITS.

Apparatus required :—

2 Hughes Instruments (Electric).
2 Electric Motors for Hughes.
2 Slide Resistances.
1 Relay "B."
1 SC. Key.
1 Differential Galvanometer.
1 6-terminal 2-position Switch.
1 6 bar Switch.
1 Retardation Coils (8 plugs).
1 Rheostat "C."
1 Condenser Coil.
1 Battery Resistance Coil.
1 $7\frac{1}{4}$ mf. Condenser.
1 Duplex Resistance Coil ($1{,}000_{\omega} + 1{,}000_{\omega}$).
1 Sounder.

For International Lines (relayed to Cable) a Spring Receiver is used instead of Relay "B" and a Triple Condenser with additional Condenser Coil are needed.

Balancing is effected by "Morse" Instrument.

Internal connections of the Hughes Instrument and method of connecting the Slide Resistance are shown by Plate 40, page 93.

HUGHES INSTRUMENT.

DUPLEX, FOR INLAND CIRCUITS.

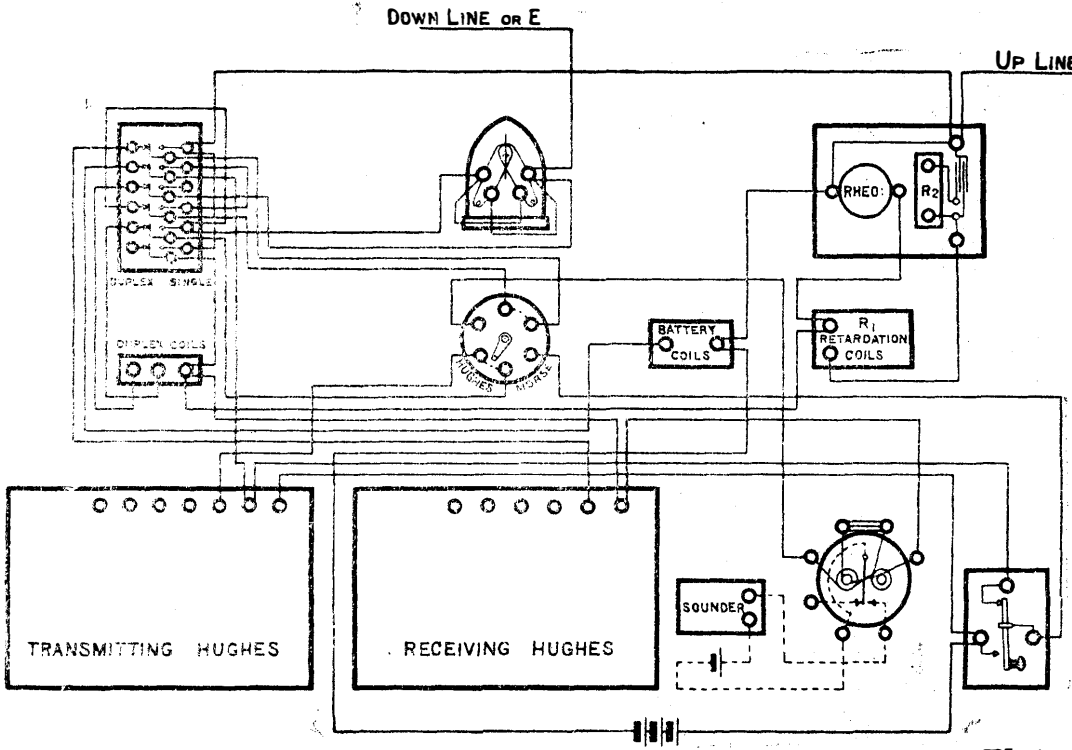


Plate 42.

PART VIII.

QUADRUPLEX MULTIPLEX.

Plate 43.

QUADRUPLEX.

Apparatus required:—

Reversing Key.
Increment Key.
Differential Galvanometer.
Relay, "B" (ordinary).
Non-polarised Relay "B."
Rheostat "C."
Condenser, 7½ mf.
Retardation Coils (8 plugs).
Condenser Coils.
Relaying Sounder, B (40ω and 500ω shunt).
2 Sounders.
2-way Switch.
3 Quad: Resistance Blocks—one (the "Spark" Coil, A) of 100ω resistance, another (B) approximately equal to the resistance of the B side battery and the Spark Coil, and the third (C) approximately equal to the total resistance of the whole Battery and the Spark Coil.

The diagram shows the connections at an Up Office. At a Down Office, reverse the wires on the two upper terminals of the Galvanometer and also the Battery wires on the Reversing Key.

The Line wire must in all cases be on the Galvanometer.

Form of Battery, Bichromate.

Current required—

"A" side, 10 to 15 milliampères.
"B" side, 20 to 30 milliampères.

(The full current is thus 30 to 45 milliampères.)

Relaying Sounder Local. } each 5c. Large
2 Sounder Locals. } Daniell.

Technical Instructions VII. deal with the Quadruplex System.

Reversing Keys are now made with 6 terminals (*see* page 131); and Increment Keys are replaced by Reversing Keys, only one side of the Key being employed.

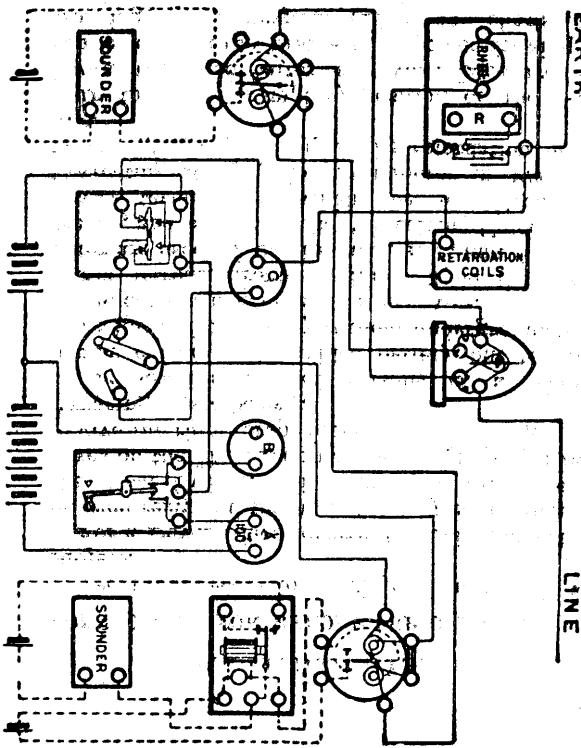


Plate 44.

MULTIPLEX SYSTEM.

CONNECTIONS FOR HEXODE (UP OFFICE).

Technical Instructions IX. deal fully with this subject.

For a Down Office reverse the Coil connections on each relay and the Main Battery connections on the 8-bar Switch. Of course the three "tap" wires on the Main Battery must be properly placed to give the right proportions for "marking" and "spacing" (*see* below).

The usual system of working is, as shown, double current with divided battery, but for very short lines, if practically without underground wire, single current is adopted in some cases.

For tetrode, Groups 1, 2, and 3 on the Distributor are used for the first arm, 4, 5, and 6 for the second, and so on. The "Receiving Correction" (RC.) terminal, to which the wire from the Correcting Relay (below Distributor in Plate 44) is connected, depends upon the retardation of the line.

In the "S" (Simplex) position of the 8-bar Switch the Reed Battery and No. 1 Local are disconnected, and the first arm is joined for simplex working. The diagram (Plate 44) shows the position for Multiplex ("X")

Apparatus required:—

Distributor.
Reed.
Reed Stand.
4 Rubber Rings for Reeds.

(*Continued on p.* 103.)

Reed Coils (4 plugs).
Relaying Sounder "B."
2-way Switch.
8-bar Switch.
Resistance Coil (various) 50ω.
1 „ Quad. Batt. 7ω.
3 „ „ 100ω.
2 Condensers, 5 mf.
– „ 10 mf. (one for each arm).
Relays "C" (one for each arm and one for correcting).
Differential Galvanometers.
7 or 10 terminal SC. Keys (one for each arm).
Sounders (one for each arm).

For tetrode and triode working "10-terminal SC. Keys" are employed, but for hexode "7-terminal S.C. Keys" are used, as shown in the diagram.

The starred circles and thick line show the "earth" connection.

BATTERIES.

Bichromate or secondary cells are used for all batteries but the No. 1 Local, which is Large Daniell.

The *Main Battery* usually consists of 80 cells for "spacing" and 140 cells for "marking," but if the length of the line is only from 50 to 60 miles 50 and 80 cells respectively are sufficient.

The *Reed and Motor Battery* consists of 30 3-pint Bichromate cells; *No. 1 Local* of 2 5-c. Large Daniells joined in multiple and the *Sounder Locals* of 4 Bichromate cells.

MULTIPLEX SYSTEM.

CONNECTIONS FOR HEXODE (UP OFFICE).

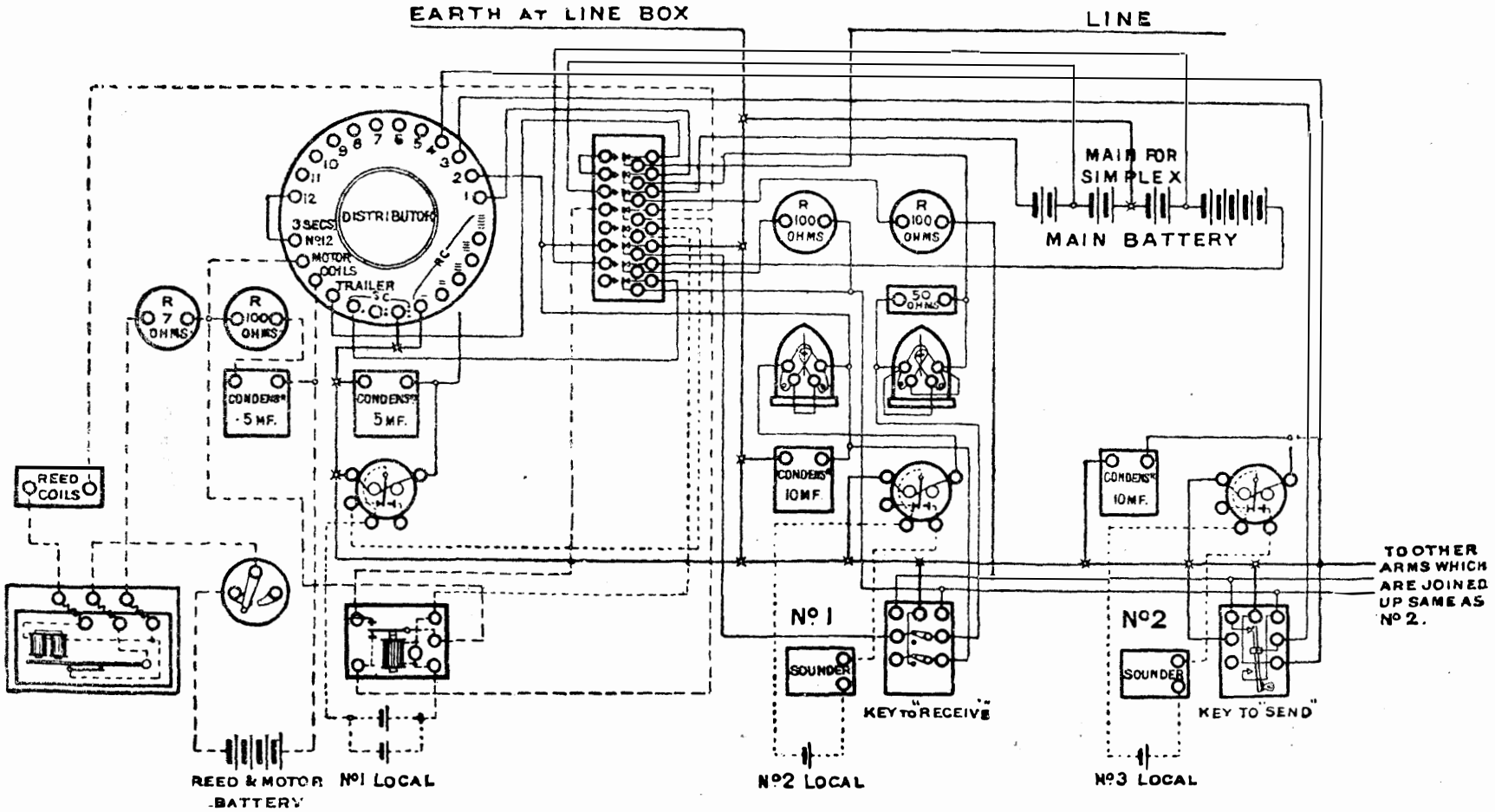


Plate 44.

PART IX.

UNIVERSAL BATTERY SYSTEM.

SECONDARY CELLS.

COMPRISING DIAGRAMS FOR WORKING FROM.

UNIVERSAL BATTERY SYSTEM.

For details as to the principle of the Universal Battery, *see* Technical Instructions IA.

Bichromate Batteries or Secondary Cells to be used except when, for special reasons, authority is given for the use of Leclanché Batteries.

When Primary Batteries are employed the resistance of the different circuits must be approximately equalised by the insertion of Resistance Blocks ◇R◇ in the Battery leads as shown. These are not needed when Secondary Cells are used.

The Battery should be put to earth at the Battery Box.

A *double* set of Batteries is required for SN. or similar systems and for Double Current.

SECONDARY CELL WORKING.

When an office is worked throughout by means of Secondary Cells the whole system must be carefully planned on a basis, full details of which will be supplied from the Office of the Engineer-in-Chief for each particular case.

A 1-ampère Fuse is placed in each Battery lead at every Circuit.

As stated above, equalising Resistance Blocks are not needed in the Battery leads of the Circuits, but *Line* equalising Coils must be employed at Intermediate Offices as usual (*see* page 116).

The maximum electromotive force ordinarily available from Secondary Cells at any office is 100

volts, which is not sufficient for Multiplex and some other Circuits, (the ordinary connections for Multiplex, page 102, are correct for this system). At offices having such Circuits, therefore, two sets of Supplementary Bichromate Cells must be provided, and these must be sufficient to increase the 100 volts of Secondary Cells to the higher value required. "Spares" for maintenance purposes must also be provided.

On SN., Double Current or Automatic Circuits where the Office is intermediate, as well as on each Multiplex Circuit and for each Repeater the short-circuiting of the Cells must be provided against by the insertion in the Battery leads to such Circuits of two special Resistances (called "Vacuum Resistances"). For Quadruplex Circuits *four* such Resistances are required.

Similar provision must be made for each "spare" or other set that is liable to be used Intermediate.

Spare sets liable to be used as "Up," "Down," or "Intermediate" need to be connected accordingly. The necessary changes are effected by means of a Spare Set Reversing Switch in the case of Duplex or Automatic apparatus, but for more simple sets the changes must be made as required at the Terminals.

Single Current Duplex Circuits should not be fitted.

Plate 45.

UNIVERSAL BATTERY SYSTEM.

SINGLE NEEDLE.

Commutators used with Universal Batteries must have the connections shown in Plate 12. These connections are so arranged that the Battery cannot be short-circuited when both tappers are depressed at the same time.

The connections for "Up," "Intermediate," and "Down" offices are shown.

For intermediate offices no alteration of the commutator is required, but for up and down offices the following alterations are necessary:—

(1.) Raise the contact-screw from the left-hand tapper.

(2.) Put a plug under the right-hand portion of the back spring to prevent the right-hand tapper from making contact with it when the tapper is depressed.

The up and down sections of line from an intermediate office must not be very unequal as regards resistance. The resistance of the down line includes the coil (200ω).

For full connections, *see* page 28 and Plate 12, and for notes on details as to universal working, *see* pages 106 and 107.

BRIGHT'S BELL.

DOUBLE SOUNDER.

These are, of course, dealt with on the same principle as Single Needle.

UNIVERSAL BATTERY SYSTEM.

SINGLE NEEDLE.

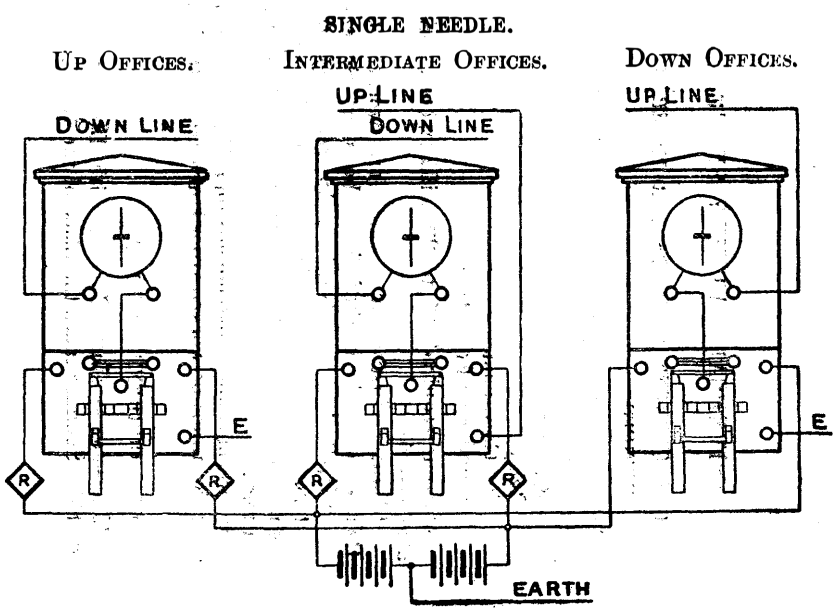


Plate 46.

UNIVERSAL BATTERY SYSTEM.

SINGLE CURRENT SOUNDER (OR INKER): UP OFFICES.

For general notes, *see* pages 106 and 107.

Apparatus required:—

SC. Key.
Relay.
SC. Galvanometer.
Sounder or Local Inker.

Current required, 15 to 20 milliampères. *See* also page 42.

"Down" Instruments which are worked by Relays cannot be worked from the same Battery as "Up" Instruments; but, *by reversing the battery wires*, Direct Writer "Down" Instruments can be worked from an "Up" Universal Battery.

"Intermediate" Instruments on a Single Current Circuit cannot be worked from Universal Batteries.

SINGLE CURRENT: DIRECT.

The same as Single Current with Relay, except that the Sounder takes the place of the Relay.

UNIVERSAL BATTERY SYSTEM.

SINGLE CURRENT: UP OFFICES.

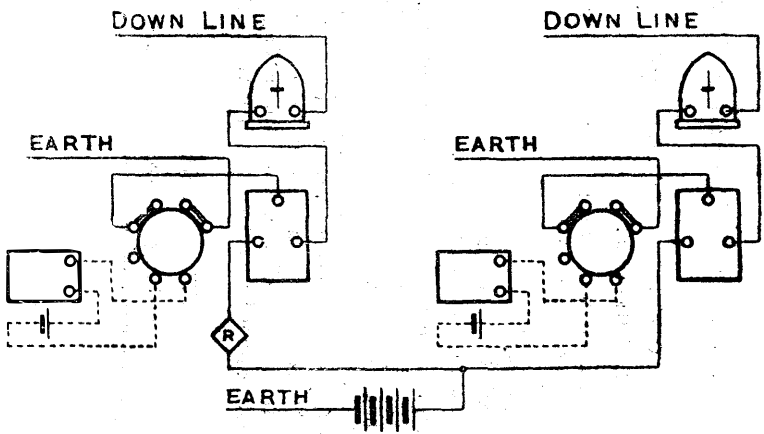


Plate 47.

UNIVERSAL BATTERY SYSTEM.

SINGLE CURRENT SOUNDER (OR INKER) DOWN OFFICES.

For general notes, *see* pages 106 and 107.

Apparatus required:—

SC. Key.
Relay.
SC. Galvanometer.
Sounder or Local Inker.

Current required, 15 to 20 milliampères.

"Up" Instruments which are worked by Relays cannot be worked from the same Battery as "Down" Instruments; but, *by reversing the Battery wires*, Direct Writer "Up" Instruments can be worked from a "Down" Universal Battery.

"Intermediate" Instruments on a Single Current circuit cannot be worked from Universal Batteries.

SINGLE CURRENT: DIRECT.

The same as Single Current with Relay, except that the Sounder takes the place of the Relay.

UNIVERSAL BATTERY SYSTEM.

SINGLE CURRENT: DOWN OFFICES.

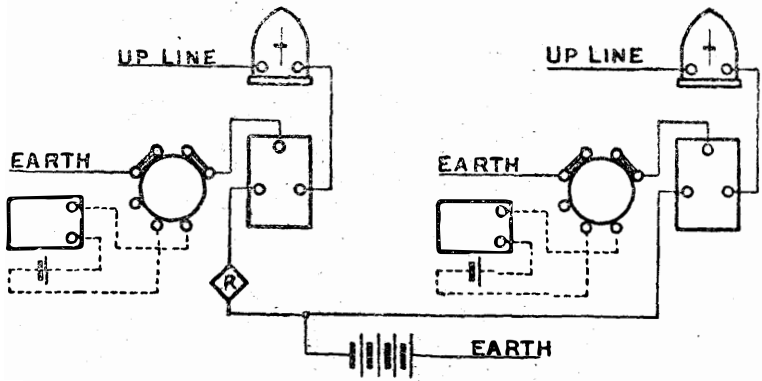


Plate 48.

UNIVERSAL BATTERY SYSTEM.

DOUBLE CURRENT: UP AND DOWN OFFICES.

For general notes, *see* pages 106 and 107.

The Diagram shows the connections for both "Up" and "Down" Offices.

Apparatus required:—

SC. Key with Switch.
Relay.
SC. Galvanometer.
Sounder (or Local Inker).

Current required, 14 to 17 milliampères.

"Intermediate" Offices can be worked from the same Battery as "Up" and "Down" Offices, *see* Plate 49.

UNIVERSAL BATTERY SYSTEM.

DOUBLE CURRENT: UP AND DOWN OFFICES.

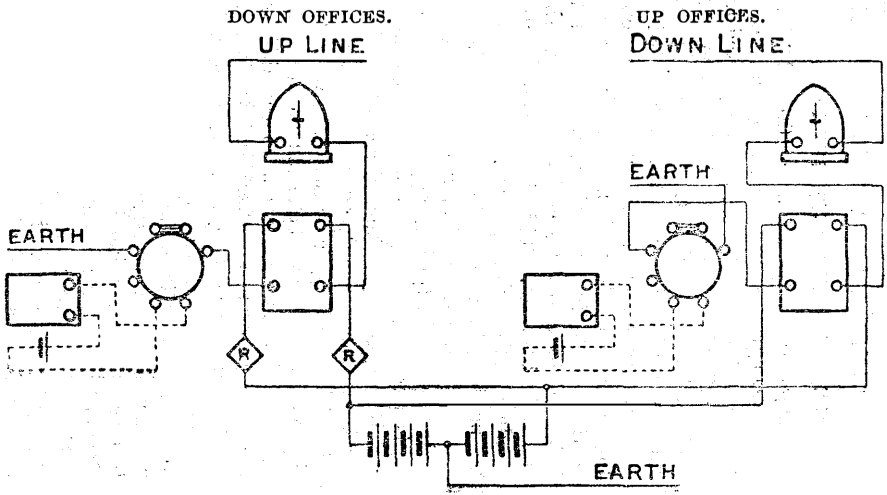


Plate 49.

UNIVERSAL BATTERY SYSTEM.

DOUBLE CURRENT: INTERMEDIATE OFFICES.

For general notes, *see* page 106 and 107.

The Diagram shows the connections for "Intermediate" Offices. These can be worked from the same set of Batteries as "Up" and "Down" Offices, but a Double Current Key is required instead of a Single Current Key with Switch.

If the resistance of the "Up" section of the line should be less than that of the "Down" section (including the Galvanometer) it may be balanced by a resistance R_1, placed as shown in the right-hand set. This is, of course, quite independent of the balancing-up resistance coil (if such be needed) in each Battery lead. (*See* note on "Vacuum Resistance" p. 107.)

If the two sections be approximately equal, then R_1 is not required, and the terminals of the Key and Relay must be joined direct.

If, on the other hand, the resistance of the "Up" section be greater than that of the "Down," the connections must be as shown in the left-hand set; and R_1 must be equal to the difference between the resistance of the "Up" section, including the Galvanometer (30ω) and the "Down" section.

When the "Intermediate" Office Circuits are grouped with "Terminal" Offices it must be remembered that the resistance of *each section* of the former must approximately equal that of the whole Circuit from a "Terminal" Station.

Of course two "line" terminal groups must be appropriated to each intermediate circuit in the proper positions on the Test Board for the two line wires.

To prevent misunderstanding when circuits are to be looped, the Terminal Office should instruct the Intermediate to "loop by connecting the centre " of battery to the through return wire instead of " to earth."

UNIVERSAL BATTERY SYSTEM.

DOUBLE CURRENT: INTERMEDIATE OFFICES.

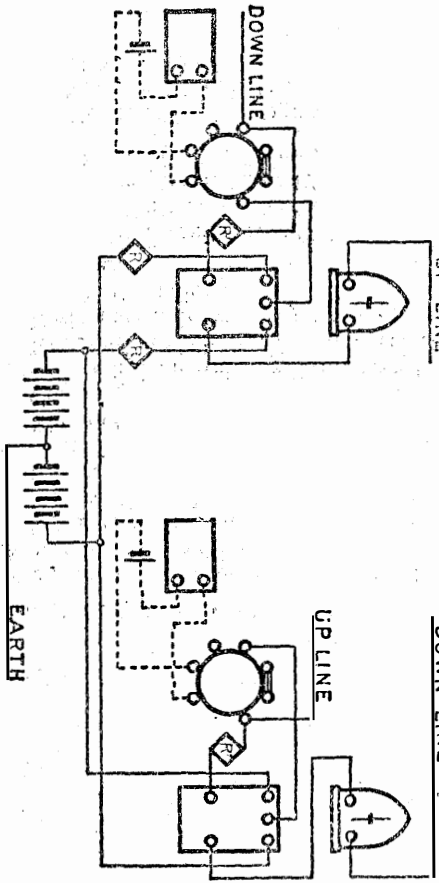


Plate 50.

UNIVERSAL BATTERY SYSTEM.

DOUBLE CURRENT DUPLEX: UP OFFICE.

For general notes, *see* pages 106 and 107.

Apparatus required :—

SC. Key with Switch.
Differential Galvanometer.
Relay.
6-terminal 2-position Switch.
Rheostat "C."
Condenser, $7\frac{1}{4}$ mf. (for Circuits over 100 miles or, when on Railway lines, over 120 miles).
Retardation Coils (for Circuits over 150 miles).
Resistance Coil (various) 2,000ω (for Circuits over 120 miles).
Sounder.

NOTE.—For Circuits over 200 miles use "Condenser Coils" instead of the 2,000ω Coil.

Current required, 14 to 17 milliampères.
Local Battery, 5 c. Large Daniell.

For a DOWN Office the connections on U and D of the Relay, and the Battery connections on the Key, must be reversed.

UNIVERSAL BATTERY SYSTEM.

DOUBLE CURRENT DUPLEX : UP OFFICE.

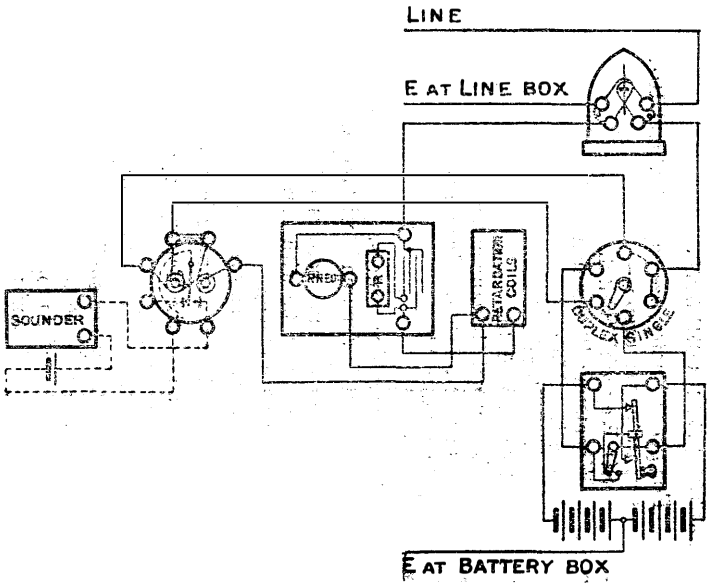


Plate 51.

UNIVERSAL BATTERY SYSTEM.

AUTOMATIC : COMPLETE.

For general notes, *see* pages 106 and 107.

Apparatus required:—

SC. Key with Switch.
Wheatstone Transmitter.
Receiver Motor.
„ Train.
2 Auto. Weights.
Differential Galvanometer.
Condenser, 7¼ mf. (Reading).
Rheostat "C."
Sounder.
2 Vacuum Resistances.
Stand for 2 Vacuum Resistances.

The upper contact screws of the Transmitter contact-lever must be withdrawn sufficiently to be quite clear of the lever.

The connections shown are for an Up Office; for a Down Office the connections on (U) and D of the Receiver and the Battery connections on the Key must be reversed.

"News" for transmitting only and "News" for receiving only are similar, except that for the former a Relay is substituted for Receiver Motor and Train and one Auto. Weight and for the latter the Transmitter is omitted. (*See* pages 58 to 63.)

The Notes *re* Intermediate Offices at page 116 are generally applicable here, and reference should also be made to page 126.

UNIVERSAL BATTERY SYSTEM.

AUTOMATIC : COMPLETE.

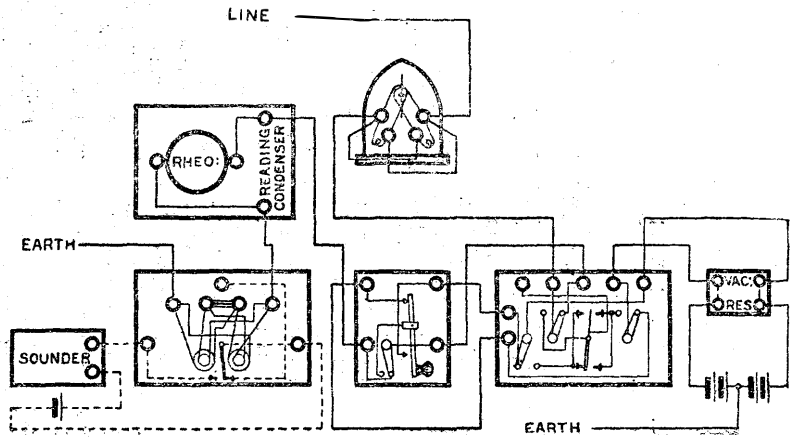


Plate 52.

UNIVERSAL BATTERY SYSTEM.

AUTOMATIC: DUPLEX.

For general notes, *see* pages 106 and 107.

Apparatus required:—

SC. Key with Switch.
Wheatstone Transmitter.
Receiver Motor.
„ Train.
2 Auto. Weights.
Differential Galvanometer.
2 6-terminal 2 position Switches.
Rheostat "C,"
Condenser, $7\frac{1}{4}$ mf. or $10\frac{1}{2}$ mf.
Retardation Coils (8 plugs).
Battery Resistance Coils.
Condenser Coils (to be placed across the divided plate of the Condenser).
Sounder.
2 Vacuum Resistances.
Stand for 2 Vacuum Resistances.

If the resistance of the line be between 1,000ω and 2,000ω one "Resistance Coil (various) 1,000ω" and if the resistance of the line be 1,000ω or less, two "Resistance Coils (various) 1,000ω" should be inserted between the "line" terminal of the Receiver and the Duplex and Single Switch.

The connections of the Switch are such as to admit of the Condenser being used in "Single" working.

The upper contact-screws of the Transmitter lever must be withdrawn (*see* page 120).

The connections shown are for an Up Office; for a Down Office reverse the connections on (U) and D of the Receiver and the Battery connections on the Keys.

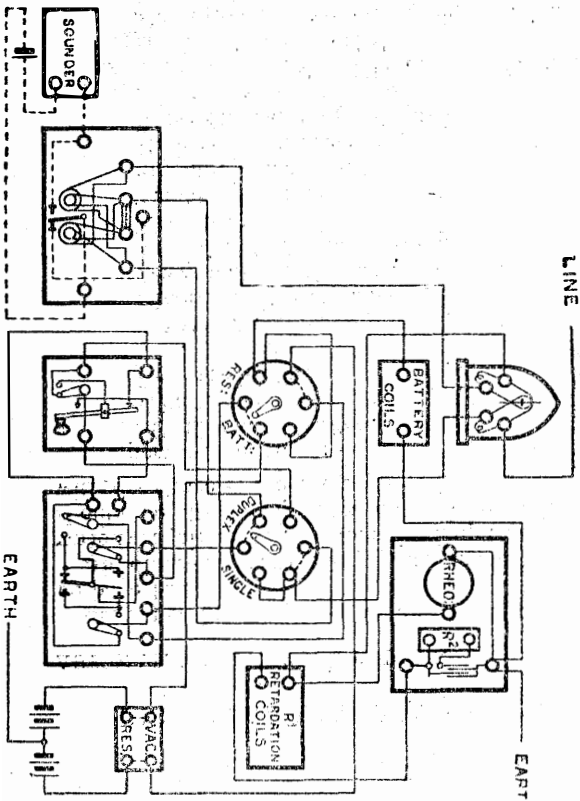


Plate 53.

UNIVERSAL BATTERY SYSTEM.

AUTOMATIC "BRIDGE" DUPLEX.

See general notes, pages 106 and 107; also notes on page 124.

As different arrangements are made to suit various requirements, Automatic Duplex Circuits should be fitted only after direct communication with the Office of the Engineer-in-Chief.

Apparatus required:—

SC. Key with Switch.
Wheatstone Transmitter.
Receiver Motor.
„ Train.
2 Auto. Weights.
Differential Galvanometer.
7-terminal 2-position Switch.
6 terminal 2-position Switch.
Rheostat "C."
Triple Condenser.
Signalling Condenser.
Reading Condenser (adjustable).
Retardation Coils (8 plugs).
Battery Resistance Coils.
2 Condenser Coils (R^2 and R^3 on diagram).
Duplex Resistance Coils.
Shunt Coil 14,000ω (on Reading Condenser).
Sounder.
2 Vacuum Resistances.
Stand for 2 Vacuum Resistances.

For internal connections of the Switch in position 2 ("Single") *see* Plate 16, page 39.

UNIVERSAL BATTERY SYSTEM. AUTOMATIC "BRIDGE" DUPLEX.

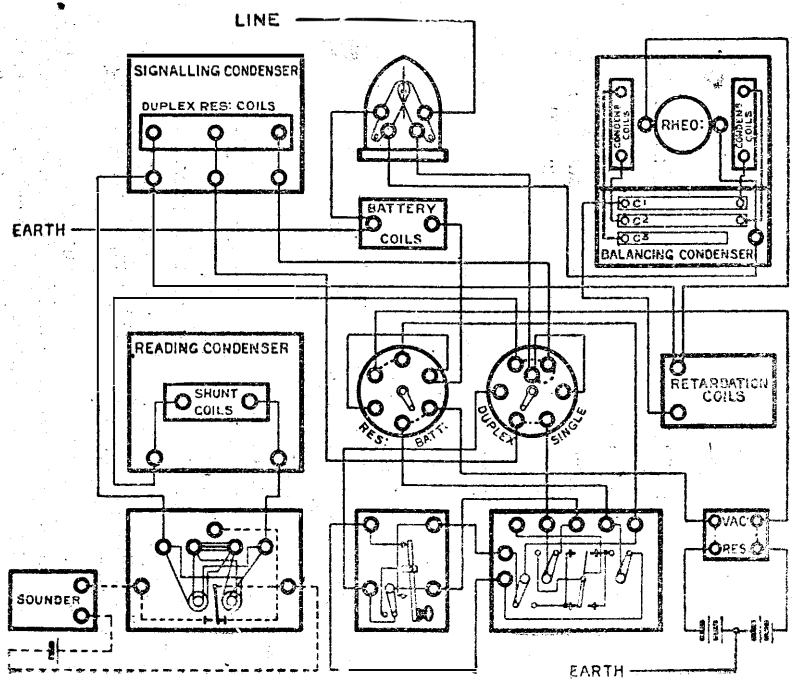


Plate 54.

UNIVERSAL BATTERY SYSTEM.

AUTOMATIC, COMPLETE, *for Special Sets.*

For general notes, *see* pages 106 and 107; *see* also note as to "News" Circuits on page 120.

Apparatus required:—
DC. Key.
Wheatstone Transmitter.
Receiver Motor.
" Train.
2 Auto. Weights.
Differential Galvanometer.
Condenser, 7¼ mf. (Reading).
Rheostat "C."
Sounder.
Condenser Coil.
Spare-set Reversing Switch and Peg.
2 Vacuum Resistances.
Stand for 2 Vacuum Resistances.

Battery power (Secondary) according to requirements put on at Distributing Box at end of Instrument Table.

The Condenser Coil is for equalising the resistance of the two sections of Line when the apparatus is Intermediate. Together with the pair of terminals and the link it should be placed at the Line Box adjacent to the Terminals of the Special Instrument set.

The Peg of the Spare-set Reversing Switch must be turned to left or right to suit the Line upon which the apparatus is to be used.

UNIVERSAL BATTERY SYSTEM.

AUTOMATIC, COMPLETE, *for Special Sets.*

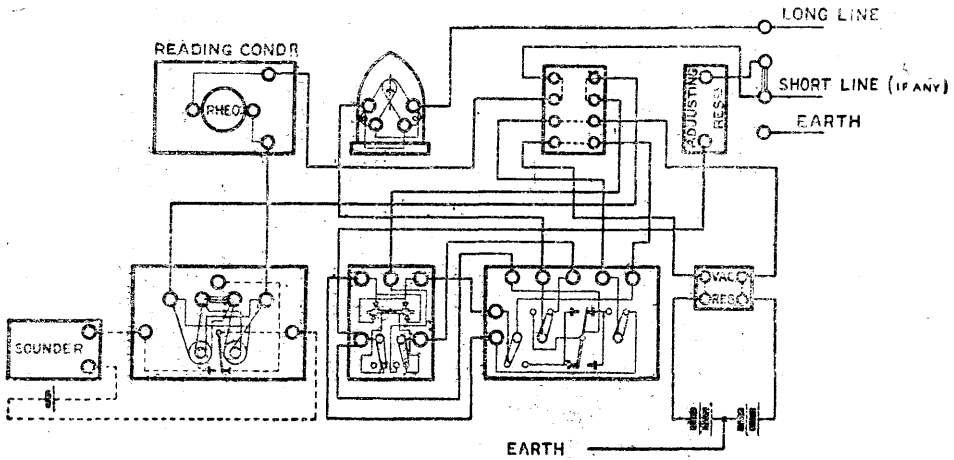


Plate 55.

UNIVERSAL BATTERY SYSTEM.

AUTOMATIC, DUPLEX, *for Special Sets.*

For general notes, *see* pages 106 and 107; *see* also notes as to Battery power and use of second Condenser Coil (adjusting Resistance), &c. on page 126.

Apparatus required:—

DC. Key.
Wheatstone Transmitter.
Receiver Motor.
,, Train.
2 Auto. Weights.
Differential Galvanometer.
2 6-terminal 2-position Switches.
Rheostat "C."
Condenser, $7\frac{1}{4}$ mf. or $10\frac{1}{2}$ mf.
Retardation Coils (8 plugs).
Battery Resistance Coils.
2 Condenser Coils.
Sounder.
Spare set Reversing Switch and Peg.
2 Vacuum Resistances.
Stand for 2 Vacuum Resistances.

UNIVERSAL BATTERY SYSTEM.

AUTOMATIC, DUPLEX, *for Special Sets.*

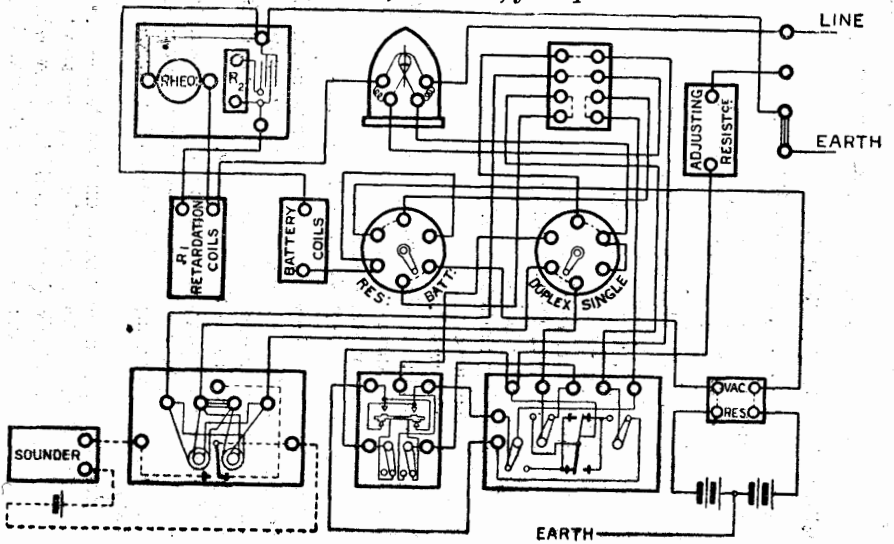


Plate 56.

UNIVERSAL BATTERY SYSTEM.

QUADRUPLEX, UP OFFICE.

For general notes, *see* pages 106 and 107.

Apparatus required :—

- Reversing Key, with 6 terminals.
- Increment Key.
- Differential Galvanometer.
- Relay, "B" (ordinary).
- Non-polarised Relay "B."
- Rheostat "C."
- Condenser, $7\frac{1}{4}$ mf. or $10\frac{1}{2}$ mf.
- Retardation Coils (8 plugs).
- Condenser Coils.
- Relaying Sounder "B."
- 2 Sounders.
- 2-way Switch.
- 1 Quad: Resistance Block (A) of 100w resistance.
- 4 Vacuum Resistances.
- 2 Stands for 2 Vacuum Resistances.

The diagram shows the connections at an Up Office. At a Down Office, reverse the wires on the two lower Terminals of the Galvanometer and also the Battery wires on the "A" Key.

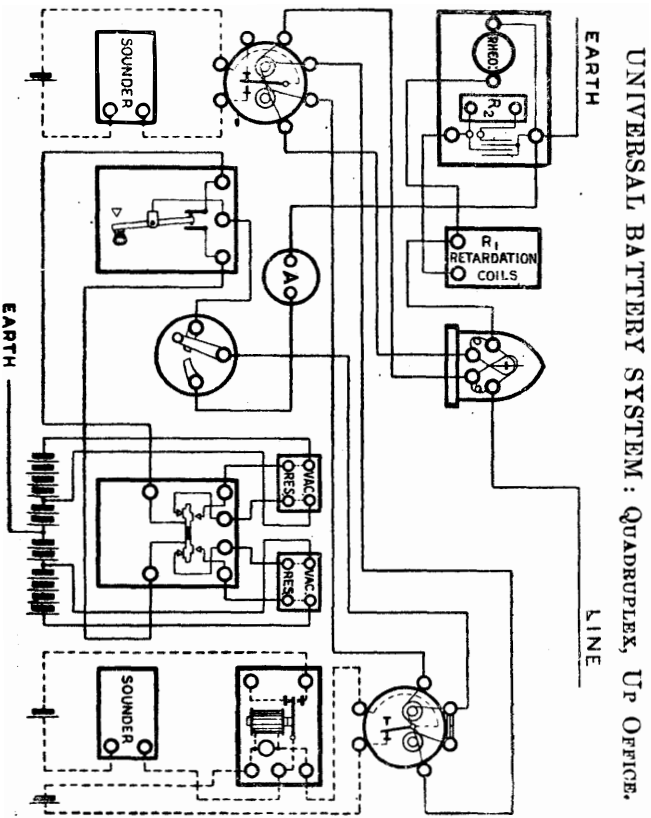
It may be remarked that on this System the "Increment" Key is used for reversing the current and the "Reversing" Key is used for increasing only.

For working on the DECREMENT System—

(*a*) Reverse the connections on the two left-hand back Terminals B side (Reversing) Key and the two right-hand back Terminals.

(*b*) Omit the Uprighting Sounder.

(*c*) Put the contact pointed screw of the Non-polarised Relay to marking instead of to spacing, and connect the Sounder in the Relay Local Circuit in the usual way.



UNIVERSAL BATTERY SYSTEM: QUADRUPLEX, UP OFFICE.

PART X.

RAILWAY BLOCK INSTRUMENTS.

PREECE'S SINGLE WIRE (4-TERMINAL) BLOCK INSTRUMENT.

Form of Battery —Leclanché (No. 1 Porous Pot), with Circular Zincs.

Current required for—

Old Form 60 to 70 milliampères.
New Form 45 to 50 do.

Resistance of Coils of—

M_1	Old Form	10ω	New Form	50ω
M_2	,,	10ω	,,	50ω
M_3	,,	50ω	,,	120ω

The levers are all pivotted upon the brass plate of the instrument, and are electrically connected to the left-hand terminal.

(*continued.*)

Plate 57—*cont.*

Normal Position. *Line Blocked.* Switches to "ON"; Discs to "ON"; Semaphore Arms *Up*.

To get *Line Clear*. Move Switch to "OFF," and depress the Plunger of K. This sends a negative current to line, which passes through the coils of M_3 at the distant station, closing the local bell-circuit and moving over the polarised armature of M_3, thus unlocking the semaphore arm and breaking the short-circuit of the coils of M_2. The arm at the distant station is now held up only by the detent fixed on the armature axle of M_2. The sending of the acknowledgment signal by the depression of the Plunger of K at the distant station causes a current to pass to line through M_2. This (positive) current releases the semaphore arm at the station sending the acknowledgment and at the home station actuates only the non-polarised armature of M_3, which closes the local bell-circuit and (as the switch is to "OFF") moves over the Indicator to "OFF," so that the *Indicator* of the station at which the call originates shows the same as the *Arm* of the distant station.

To restore to *Line Blocked.* Put the Switch to "ON" and depress Plunger. The positive current which then passes to line rings the distant bell and, by attracting the polarised armature of M_3 to the left, short-circuits M_2, and raises the semaphore, which is again caught by the detent. When the distant station acknowledges the signal, the local (positive) current which passes through M_1 of the home instrument restores the Indicator to "ON." The line is now blocked.

PREECE'S

SINGLE WIRE (4-TERMINAL) BLOCK.

[FROM THE FRONT.]

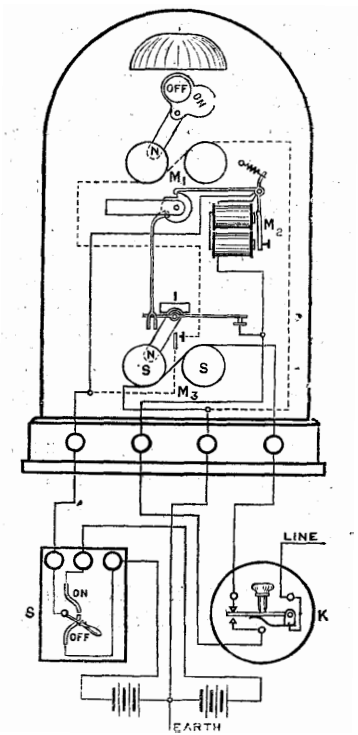


Plate 58.

PREECE'S SINGLE WIRE (5-TERMINAL) BLOCK INSTRUMENT.

Form of Battery.—Leclanché (No. 1 Porous Pot), with Circular Zincs.

Current required 45 to 50 milliampères.

Resistance of Coils of		M_1	50ω
Do.	do.	M_2	50ω
Do.	do.	M_3	120ω
Do.	do.	I	11ω to 18ω

The swinging armature, N, of M_3 is polarised by the Inducing Electro-magnet, I, whenever the unpolarised armature is attracted. This Inducing Electro-magnet takes the place of the permanent magnet, I, in the 4-terminal instrument, and constitutes the difference between the two forms.

The method of working is the same as for the 4-terminal Instrument (see Notes).

The three-position Switch enables the Signalman to distinguish, for his own information, whether the line is merely *Blocked* (normal), or whether there is actually a *Train on Line.* The electrical connections are the same for these two positions.

PREECE'S
SINGLE WIRE (5-TERMINAL) BLOCK.

[FROM THE FRONT.]

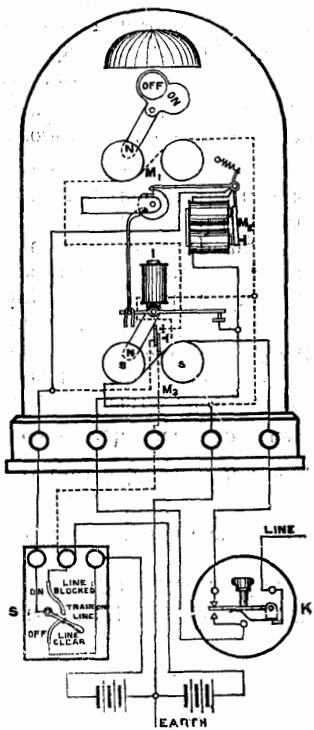


Plate 59.

HARPER'S SINGLE-PLUNGER BLOCK INSTRUMENT.

Form of Battery.—Leclanché (No. 1 Porous Pot), with Circular Zincs.

Current required, 60 to 70 milliampères.

Resistance of each Electro-magnet, 14$^{\omega}$ to 15$^{\omega}$.

When the Indicator shows "ALL CLEAR" the depression of the Plunger actuates the right-hand springs; when as shown in the diagram, or to "TRAIN ON LINE," the Plunger actuates the left-hand springs. Normally, the long springs are joined to the contact-blocks, but when the Plunger is depressed one long spring is joined to the short spring beneath it and the two other springs are connected together by the insulated cross-piece fixed on the long spring.

All outgoing currents pass through the *lower* electro-magnet, and all incoming currents pass through the *upper*.

Pressing the Plunger in all cases rings the Bell at the distant station.

Three cells only are required for the Bell circuit.

NOTE.—The Three-Plunger Block Instrument is electrically the same.

HARPER'S
SINGLE PLUNGER BLOCK.

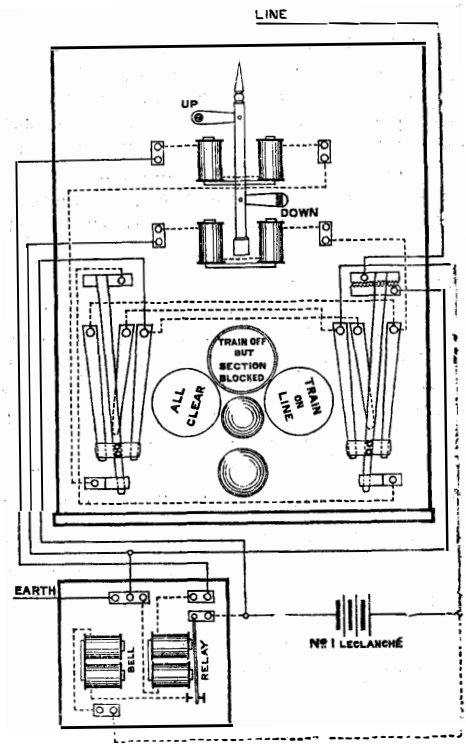


Plate 60.

TYER'S SEMAPHORE BLOCK INSTRUMENT.

Form of Battery.—Leclanché (No. 1 Porous Pot), with Circular Zincs.

Current required 100–110 milliampères.

Resistance of Coils of each Semaphore—about 15ω
" " Relay " 18ω
" " Magnetising coils " 3ω

In the normal position of the Plunger the right-hand spring is connected to the contact-piece A and the other springs are disconnected.

The incoming currents pass through the *upper* electro-magnets and the Relay coils. The magnetising coils M_1 M_2 and the Bell coils are brought into circuit by the Relay.

When the Indicator shows "LINE CLEAR" the depression of the Plunger connects the two left-hand springs and the two right-hand springs, sending to Line a positive current through the lower Semaphore coils. When the Indicator is, as shown, to "TRAIN ON LINE" a negative current passes. These outgoing currents pass through the *lower* electro-magnets and the magnetising coils M_1, M_2.

TYER'S SEMAPHORE BLOCK.

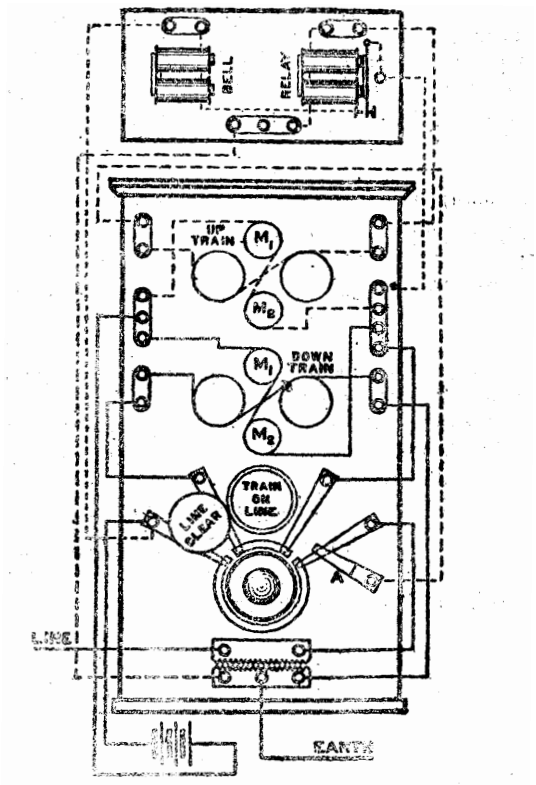


Plate 61.

FLETCHER'S COMBINED BLOCK INSTRUMENT (3-WIRE).

Form of Battery.—Leclanché (No. 1 Porous Pot), with Circular Zincs.

Current required 16 to 20 milliampères

Resistance of each Indicator 160ω.
do. Bell Coils 40ω.

Three Lines are used with each Instrument—one for *incoming* signals, which actuate the upper Semaphore; one for *outgoing* signals, which actuate the lower Semaphore and one for *Bell* signals.

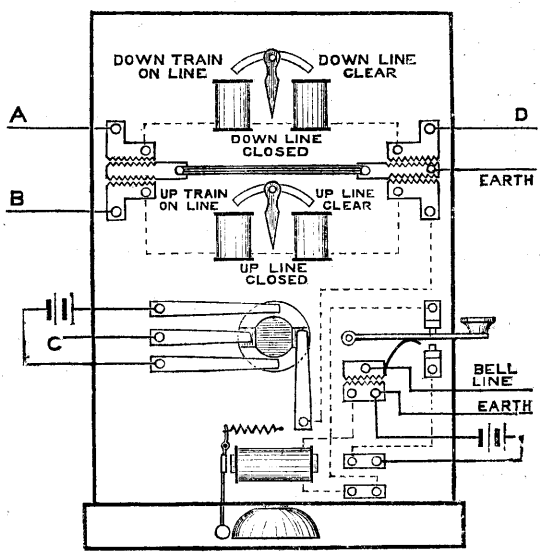
The connections are as follows:—

UP LINE *Down Instrument* A; *Up Instrument* C.
DOWN LINE do. B; do. D.
EARTH do. C & D; do. A & B.

The BELL-LINE and EARTH connections are always as shown in the Diagram.

The Diagram shows a DOWN Instrument: in an UP Instrument the dials are printed for the upper part to be for *Up* signals and the lower part for *Down* signals. In later Instruments the dials are fitted with movable plates in slides, so that any Instrument can be made UP or DOWN.

FLETCHER'S COMBINED BLOCK (3-WIRE)



U 9562. K

Plate 62.

WEBB AND THOMPSON'S ELECTRICAL TRAIN STAFF APPARATUS FOR WORKING SINGLE LINES.

Approximate Resistance of		"Line" Coils	90Ω
Do.	do.	"Local" Coils	60Ω
Do.	do.	Galvanometer Coils	6Ω
Do.	do.	Bell Coils	40Ω

Form of Battery.—Leclanché (No. 1 Porous Pot), with Circular Zincs.

Local Battery 7 cells.

The Batteries are to be kept under lock and key the key being in the charge of the Lineman.

Current required with the Line Coils and Galvanometer in circuit 130 to 150 milliampères.

The several Signal Stations are provided as usual with an instrument for each section; terminal stations having one instrument and intermediate stations two. The instruments and sets of staffs are of two different forms, and are arranged in pairs for alternate sections, so that on a line with stations A, B, C, D, &c., a staff sent by A cannot be used by B in the instrument for the B–C section.

METHOD OF WORKING.

Assume that a train is ready to start from A.

A calls B by depressing the key K once. This actuates the "Bell" switch-lever and causes a current to pass through the Galvanometer to Line and through the Galvanometer and Bell at B.

B acknowledges with one stroke of the bell.

A gives (by code) description of train to be sent, which B acknowledges.

A then gives the code signal and turns the right-hand pointer to "FOR STAFF." This actuates the "Local Lock" and the "Line Lock" switch-levers as shown in the diagram, so that a current passes through the "Local" coils of the electro-magnet from the local battery, while the "Line" coils are connected through the galvanometer to Line.

B permits the withdrawal of a staff by depressing his key and keeping it depressed until he gets the signal showing that a staff has been withdrawn. The current thus sent by B deflects his galvanometer needle and passes through the "Line" coils at A in a direction to assist the "Local" coils. As soon as A observes the deflection of the galvanometer, he lifts a staff up the channel C so raising the lever E upon which the electro-magnet is fixed. The currents in the "Line" and "Local" coils impart sufficient attractive force to the central pole-piece to ensure that the detent-lever D shall follow the electro-magnet lever E. This releases the detent-disc L and leaves it and three other discs free to be turned through a quadrant by the completion of the withdrawal of the staff. A then at once turns the left-hand pointer to "UP STAFF OUT" or "DOWN STAFF OUT," as the case may be, pressing it *hard down* until (by breaking the circuit at *a*), the galvanometer needles at both stations return to zero. A also restores the right-hand pointer to "BELL." B on seeing his galvanometer needle go to zero, releases K and sets his

Plate 62—*cont.*

left-hand pointer to "UP STAFF OUT" or "DOWN STAFF OUT," as the case may be.

It may be observed that even a very excessive current passing through only one pair of coils—either the "Local" or "Line" coils—will not permit of the lever D being raised by the lifting of a staff.

The staff withdrawn by A is given to the engine-driver, who is to pass it on to B.

The quarter revolution of one of the locking discs actuates the two "Reverser" switch-levers through a lever indicated by R. This reverses the LINE and EARTH, so as to throw the A instrument out of unison with the B instrument, and consequently no staff can be obtained from either instrument until that originally taken from A is received and placed in the instrument at B. As placing the staff in the instrument effects a quarter revolution of the discs at B the two instruments are again in unison. On inserting the staff, B gives the *Line Clear* code and turns his left-hand pointer to "STAFF IN."

A acknowledges the signal, and turns his left-hand pointer to "STAFF IN." Both instruments are now again in normal position, and a train may be despatched from either end as desired.

Replacing a staff in the instrument from which it has been taken will also restore the two instruments to unison.

WEBB AND THOMPSON'S
ELECTRICAL TRAIN STAFF SYSTEM.

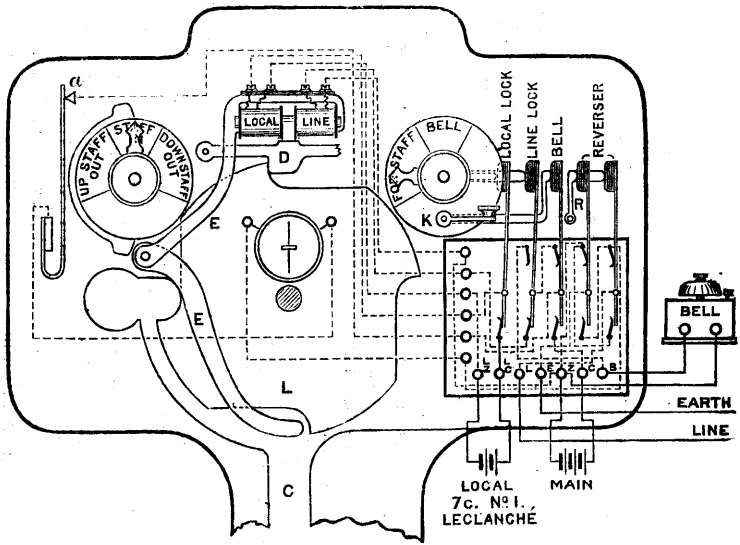


Plate 62—*cont.*

EQUALISATION OF SUPPLY OF TRAIN STAFFS.

In the event of the supply of Staffs at one end of the section becoming so reduced as to leave two only, owing to more Trains having been despatched in one direction than the other, the following Regulations must be carried out:—

(*a.*) The key which opens the lid of the instrument is in all cases to be kept in charge of the Telegraph Lineman, and no one else, and he alone is to open the same when required for any purpose.

(*b.*) If, on a section worked by Signal Boxes A and B, Staffs accumulate at B, the Stationmaster, or other Officer named by the Railway Company as in charge of A, shall communicate by telegraph or in writing with the Inspector and Lineman, requesting that the Lineman may proceed to A, who on his arrival shall accompany him to B, where (after the Train Staff of their Train has been handed to the Stationmaster at B and restored to the Train Staff Instrument there in the usual way) the Lineman will be requested by the Stationmaster of A (in the presence of the Stationmaster of B) to unlock the cover of the instrument and permit the Stationmaster of B to withdraw, mechanically, the requisite number of Staffs. It is to be specially noted here that this number must always be even (2, 4, 6, 8, &c.) to leave the apparatus in its normal electrical condition. An entry must then be made in the diary

at B to the effect that so many Staffs have been withdrawn by the Stationmaster of B, and this entry must be signed by the Stationmasters of A and B respectively, by the Lineman, and by the Signalman at B.

(*c.*) The Staffs withdrawn by the Stationmaster of B should be tied together, and be handed by him to the Stationmaster of A, who with the Lineman will then return to A by the next Train (which will, of course, be sent on in the usual way with a Staff withdrawn at B by electrical permission of A, and given by the Signalman of B to the Engine-driver, as in other cases).

(*d.*) On arrival of the Stationmaster (of A) and the Lineman at A, and after the Staff which has brought on the Train by which they travelled has been placed in the Instrument at A, the Stationmaster at A should then, in the presence of the Signalman at A and of the Lineman, put in the number of Staffs be brought from B.

(*e.*) When this is done, an entry of the transaction must be made in the diary at A, and signed by the Stationmaster of A, the Lineman, and the Signalman of A.

(*f.*) The transaction is then complete, and a special Report thereof must be sent by the Stationmaster at each end to the Manager's Office.

PART XI.

TELEPHONES.

TELEPHONES.

There are now two standard forms issued from the Factory, namely:—

(*a.*) Post Office Telephone for Single Receiver. [Plate 63a.]

(*b.*) „ „ Two Receivers. [Plate 63b.]

(*a.*) requires two "Bell Receivers"; (*b.*) requires only one Receiver. The Receivers are a separate item. When issued the Telephones are fitted with flexible cords for Receivers.

The Gower type of pencil Transmitter is employed in these Telephones, but if "for Granular Transmitter" be added the cover provides for the attachment of a "Deckert Transmitter," which constitutes a separate stock item.

(*c.*) "Post Office Telephone with Silence Cover" is a Single Receiver Instrument for Granular Transmitter.

Recognised forms that will remain in full use until the Instrument needs to be returned to the Factory are—

(*d.*) Gower-Bell Telephone (with flexible tubes).

(*e.*) „ „ (incomplete).

In all these cases the internal connections are so arranged as to provide for any ordinary conditions under which it is desired to use this Instrument.

No alteration of internal connections is required, but when a relay is placed in the Telephone case the coil ends must be connected to the two pillars marked "Relay," the base-plate to the pillar to which one end of the Receiver coils is also con-

nected, and the contact block to the disconnected wire. When no Relay is used the two pillars so marked must be connected across by a wire.

BATTERIES.

Speaking Battery.—For ordinary circuits two No. 1 Leclanché cells with circular zincs.

For circuits communicating with a Public Exchange two six-block Agglomerate Leclanché cells are to be employed.

For ordinary circuits which are exceptionally long and underground, or which are in continuous use, authority will be given for the use of six-block Agglomerate cells. (*See* Circular E., 137 IX.)

In the diagrams the speaking battery is marked "two cells."

Ringing Battery.—This includes the two cells for speaking. The remainder of the battery at offices where a total of not more than nine cells is needed should consist of No. 1 Leclanché cells; where more than nine cells are required all but the speaking cells should be No. 3 Leclanché.

If on an Exchange circuit, the whole remainder of the permanent current battery must consist of No. 1 Leclanché cells with circular zincs.

No. 1 size cells are issued in boxes for 2, 3, 4 and 5; No. 3 size 6, 8, and 10.

Boxes required to contain cells of different forms are to be described as "combination," for example :—

1 5c. Combination Lec. Battery No. 1 and CZ., and
1 4c. „ „ „ Agg. and CZ.

mean a Battery Box of the size described, containing respectively—

2 No. 1 Cells with circular zincs, and 3 No. 1 Cells, ordinary,

and

2 6-block Agg. Cells, and 2 No. 1 Cells with circular zincs.

For purposes of estimating battery power the electromotive force of a Leclanché cell may be taken as 1·08 volt and its resistance as 4 ohms. (*See* Table VIII., page 224.)

Local Battery.—The local ringing battery where a Relay is used must consist of two cells. Ordinarily the connections provide for the use of the speaking battery for the purpose.

If the user of a Telephone can hear well and cannot be heard (indicating a fault in the microphone circuit) he should endeavour to speak through the receiver.

INDUCTION COILS.

—	Gower-Bell Telephone.	Post Office Telephone.		
		(*a*)	(*b*)	(*c*)
	ohms.	ohms.	ohms.	ohms.
Primary -	·5	·5	1	1
Secondary -	250	150	25	250

The coils (*b*) are the standard pattern for Post Office Telephones; they may be identified by the fact that their resistance will be stamped upon one coil-cheek.

Telephones fitted with granular transmitters are to have (*b*) coils; otherwise (*a*) and (*b*) forms are to be used interchangeably. (*c*) is for Trunk Line working.

In most of the following diagrams the Gower-Bell Telephone is shown. It will be understood that the connections are precisely similar for the other recognised forms of Telephone.

TREMBLER BELLS.

Bells are fitted with small plates for joining the coils either in "multiple" or in "series." The coils should invariably be joined in series for direct working; and in multiple when the Bell is used in connection with a Relay.

Current required with coils in series (100ω) 25 milliampères.

Circular E. 130 deals fully with the authorised arrangement of Telephone lines, including the uses of the various forms of Relay, the recognised symbols for circuit plans; the method of calculating battery power for the "bridge" and "leak" systems, &c.

Circulars E. 134 and 137 deal more particularly with special telephonic apparatus, including their treatment for stock purposes.

In cases where a Table Telephone is required either form of Post Office Telephone may be used fitted upon a "Stand for Telephone." The Telephone may be fitted upon one side of the stand, and the Trembler Bell upon the other. The flexible connection between the table and the wall or other

point to which the rigid connections are to be brought should be used with—

{ 1 Ebonite Strip for flexible cord, with Base.
{ 1 " " "
{ — yards 7-wire flexible cord.

If bracketted (as shown) on requisitions the two strips will be sent properly connected. The strip without base is for the stand.

Separate instructions will be issued respecting a standard type of TABLE TELEPHONE.

RELAYS.

The conditions of the use of Relays are indicated in the Notes to subsequent Plates. If Relays are required to be fitted under the Telephone cover the two items should be bracketted thus :—

{ 3 Telephones, P.O. for 2 Receivers.
{ 3 Telephone Relays, unmounted.

Current required :—

Relays, 100ω	-	16 milliampères.
" 1,000ω	-	7 "

INTERMEDIATES.

At an Intermediate Office *both* "A" lines are connected to one line terminal and *both* "B" lines to the other line terminal. If it be a single wire circuit then the lines on each side are connected to the terminal marked for the "A" line, and the terminal marked for the "B" line is connected direct to earth.

LIGHTNING PROTECTORS.

All telephone circuits must be fitted with Protectors.

A Protector "$\frac{1}{1}$ C" should be used at each office on a single-wire circuit; and a Protector "$\frac{2}{2}$ C"

at each office on a double-wire circuit. At Intermediate Offices *where a switch is used* two Protectors are required on each side of the Office ("$\frac{4}{4}$ C").

INSTRUCTIONS FOR WORKING.

The following Cards are printed and will be supplied to Superintending Engineers on application to the Engineer-in-Chief.

INSTRUCTIONS FOR WORKING TELEPHONES.

(*a*.) Telephone Intercommunication System.

(*b*.) Telephone Intercommunication System; Open-circuit Working.

(*c*.) Private Wires.

(*d*.) Single Receiver Telephone on Public or Private Wires.

(*e*.) Transmitting Telegrams.

(*f*.) Counter-communication Switch.

A suitable Card must be placed at every Instrument wherever there is a possibility of Instructions being required and Sectional Engineers should ensure that such Cards are kept in good condition and renewed when necessary.

Plate 63a.

POST OFFICE TELEPHONE FOR SINGLE RECEIVER.

POST OFFICE TELEPHONE FOR TWO RECEIVERS.

Plate 63b.

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Plate 64.

TELEPHONE.

CONNECTIONS FOR "SIMPLE."

For general notes, *see* pages 154–159.

Note.—Connect relay-coil pillars inside the Telephone.

Join Bell coils in series.

Apparatus required :—
Telephone.
2 (or 1) Bell Receivers.
Trembler Bell.

To be used—

(*a.*) On direct circuits which have a line resistance of less than 200 ohms.

(*b.*) On circuits with *three* offices, provided that the joint resistance of the ringing circuit from any telephone does not exceed 150ω.

(*c.*) On circuits with *more* than three offices, provided that the line resistances between the offices be fairly uniform and do not exceed (say) 20ω in each section.

Where a balancing resistance is required it must be inserted between terminal 1 and the right hand terminal of the Bell. (*See* Circular E. 130, fig. 1.)

TELEPHONE.

CONNECTIONS FOR "SIMPLE."

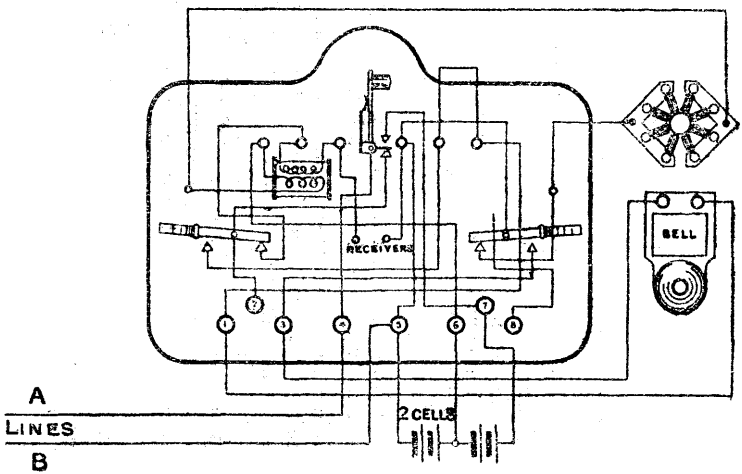


Plate 65.

TELEPHONE.

WITH RELAY INSIDE CASE.

For general notes, *see* pages 154–159.

Apparatus required :—
Telephone.
Telephone Relay 100ω or 1,000ω (unmounted).
2 (or 1) Bell Receivers.
Trembler Bell.

For lower limits for the use of a Relay (100ω) *see* Notes (*a*), (*b*) and (*c*), page 162.

When there are more than three offices on a circuit and the resistance in the section between the second offices from each end is more than 50ω then 1,000ω Relays should be used. They should also be used upon circuits connected with Exchanges used for message traffic where any one or more of the circuits concerned has more than one office.

If a balancing resistance be required it must be inserted between terminals 1 and 2 of the Telephone.

Fuller details are given in Circular E. 130.

TELEPHONE.

WITH RELAY (UNMOUNTED).

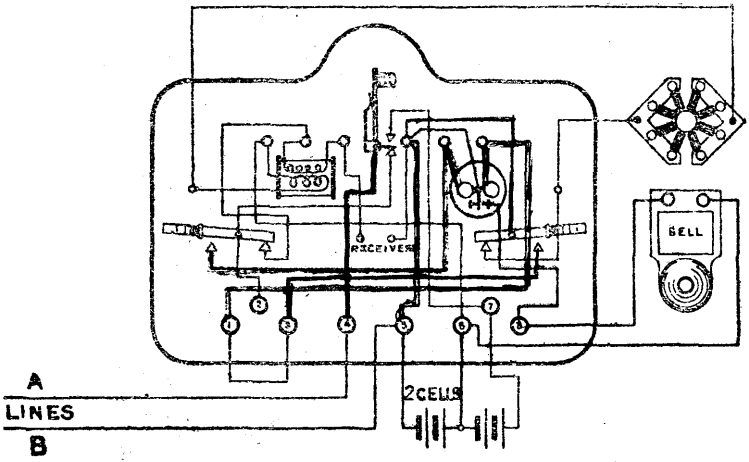


Plate 66.

TELEPHONE.

WITH NON-POLARISED INDICATOR RELAY.

For general notes, *see* pages 154–159.

Apparatus required :—

Telephone.
Non-polarised Indicator Relay B. 100ω or 1,000ω.
2 (or 1) Bell Receivers.
Trembler Bell.

For conditions of use, &c. *see* notes to Plate 65.

If a balancing resistance be required it must be inserted between terminal 1 of Telephone and the Relay.

This is to be considered an exceptional requirement. A preferable arrangement is to have a Telephone with Relay (Plate 65) and a "Telephone Galvanometer" placed in "bridge" or in "leak" direct on the line (*see* Circular E. 134, p. 2 and added slip).

TELEPHONE.

WITH INDICATOR RELAY.

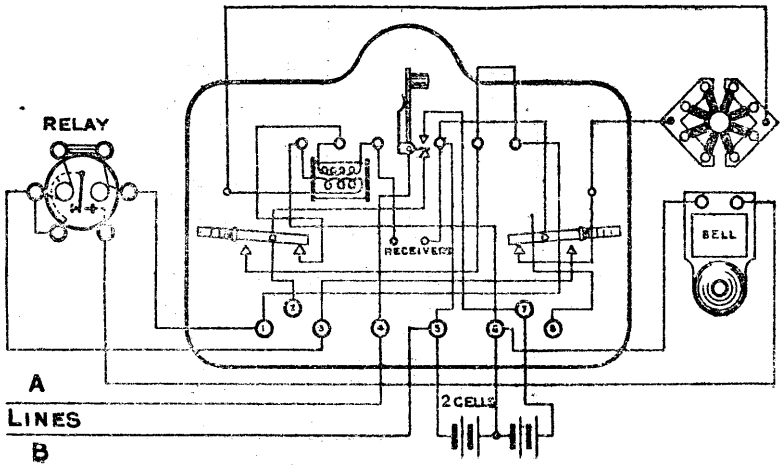


Plate 67.

TELEPHONE.

FOR "EXCHANGE" WORKING.

For general notes, *see* pages 154–159.

Apparatus required :—

Telephone.
Telephone Relay 1,000ω unmounted.
2 Bell Receivers.
Trembler Bell.

The Relay is adjusted with a "bias" sufficient to prevent its responding to the permanent current from the Battery.

Permanent current 4 milliampères.

To call the Exchange, repeatedly depress the press-button; then remove the Receivers and speak.

TELEPHONE.

"EXCHANGE" (PERMANENT CURRENT) WORKING.

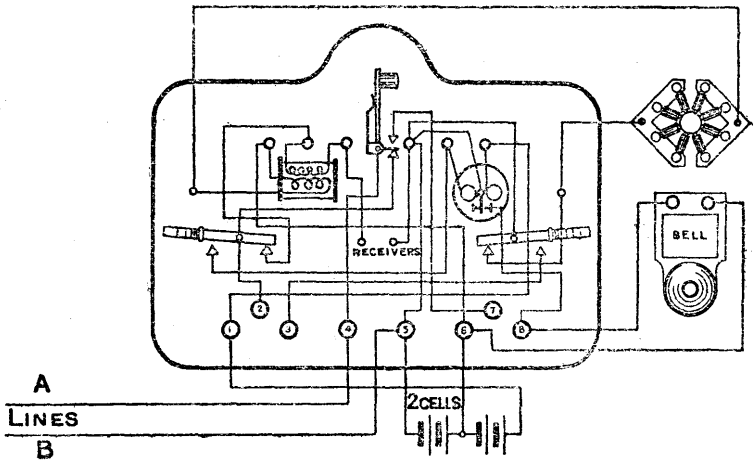


Plate 68.

TELEPHONE.

FOR "EXCHANGE" WORKING WITH AUGMENTING BATTERY.

For general notes, *see* pages 154–159.

Apparatus required:—

Telephone.
Telephone Relay 1,000ω (unmounted).
2 Bell Receivers.
Trembler Bell.

The Relay is adjusted with a "bias" sufficient to prevent its responding to the permanent current from the Battery.

This system is required only when two Subscribers desire to be connected (through the Exchange) for communication independent of the Exchange. The Augmenting Battery, which is provided for each Office, enables each to gain the attention of the other without calling the Exchange. This is principally applicable to cases where a Subscriber having two distinct lines, wishes them to be connected through at night.

Current required for permanent current, 7 to 8 milliampères.

Current required for augmenting (whole battery), 14 to 16 milliampères.

To call the Exchange, repeatedly depress the press-button; then remove the Receivers and speak.

To call distant Office (when through), depress the button.

NOTE.—The press button must have a prolonging spring to prevent breaking the circuit when it is depressed. All P.O. Telephones are so arranged.

TELEPHONE.

"EXCHANGE" WORKING WITH AUGMENTING BATTERY.

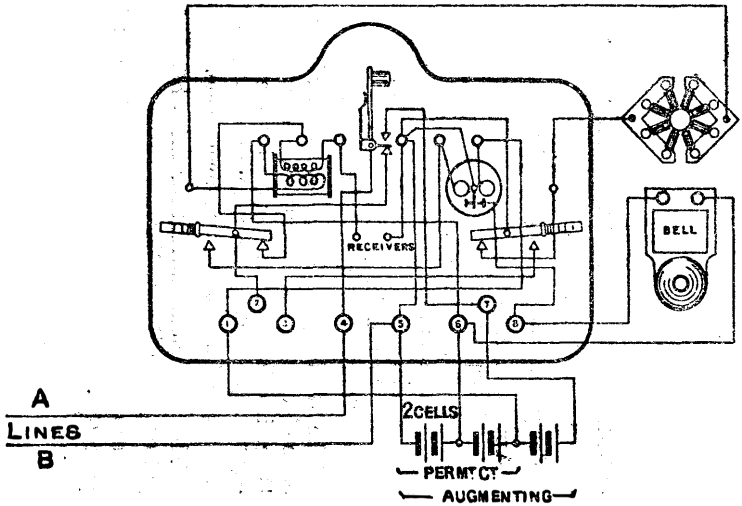


Plate 69.

TELEPHONE.

CONNECTIONS AT DOWN OFFICE (EXCHANGE INTERMEDIATE).

For general notes, *see* pages 154–159.

Apparatus required :—

Telephone.
2 Bell Receivers.
Press-button "C."
Polarised Indicator Relay "B." (Coils in "multiple.")
Trembler Bell with Indicator.

The Exchange is called by repeated depression of the Telephone Press-button. The Intermediate Office is called by *twice* depressing the press-button "C." This indicates to the "Intermediate" Office that the call is from the "Down" side.

The permanent current for the whole circuit is put on at the Down Office.

For connections at the Intermediate Office, *see* page 186.

DOWN OFFICE ON EXCHANGE INTERMEDIATE CIRCUIT.

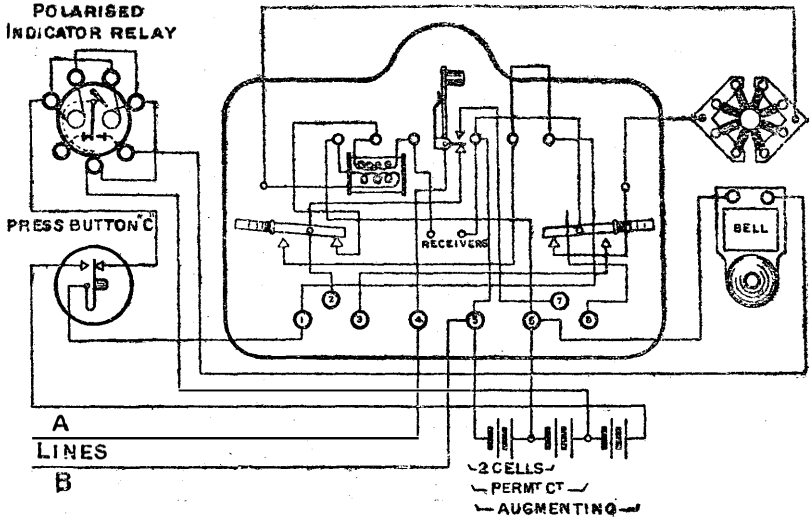


Plate 70.

GOWER-BELL TELEPHONE.

(SIX-TERMINAL PATTERN.)

As there are a few of these instruments still in use this diagram and Plate 71 are given to avoid confusion. It should, however, be understood that this pattern of G.B. Telephone must be used only on unimportant circuits.

SIMPLE.

For instructions as to conditions of use, *see* page 162.

Leclanché Batteries (Porous pot No. 1) must be used.

Two cells must be used for speaking and these must be fitted with circular zincs.

For general notes, *see* pages 154–159.

GOWER-BELL TELEPHONE.

(SIX-TERMINAL PATTERN.)

SIMPLE.

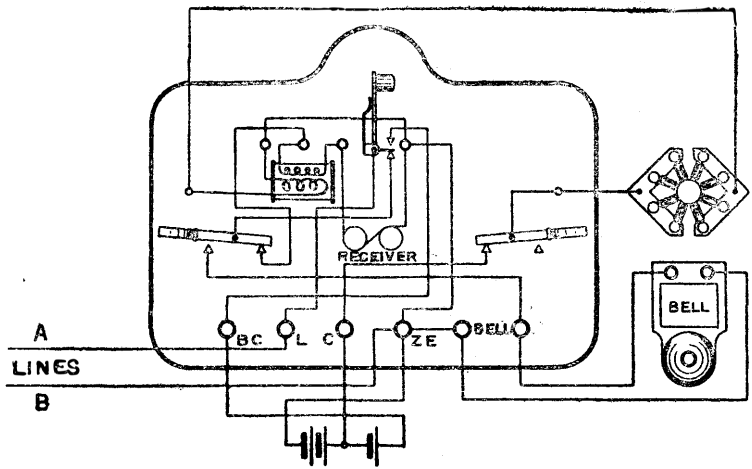


Plate 71.

GOWER-BELL TELEPHONE.

(SIX-TERMINAL PATTERN.)

WITH RELAY.

For general notes, *see* pages 154–159.

These instruments must be used only on unimportant circuits. (*See* notes, page 164.)

GOWER-BELL TELEPHONE

(SIX-TERMINAL PATTERN.)

WITH RELAY.

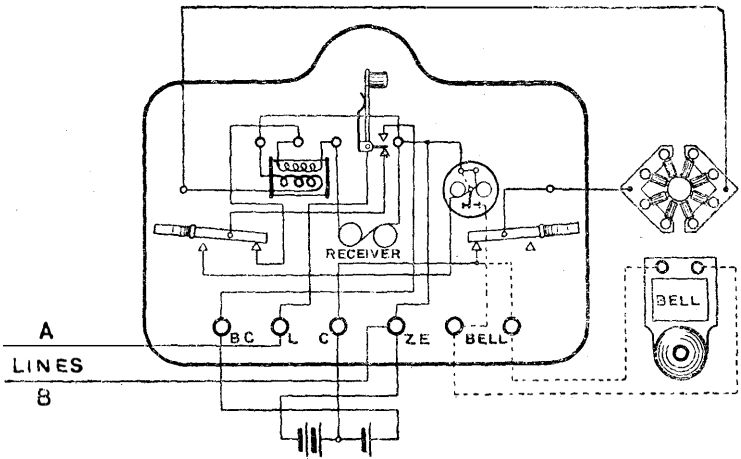


Plate 72.

TELEPHONE.

WITH MAGNETO GENERATOR AND BELL.

Magneto calling apparatus may be used upon Coastguard and Public Office (Message) single wire circuits.

The continuous ringing of ordinary trembler bells by earth currents, which, in some districts, is of frequent occurrence, will thus be avoided. If, during the prevalence of earth currents, the attention of any Office cannot be secured, opportunity should be taken to call when the Telephone Galvanometer (which will still be used) shows that the conditions are temporarily normal.

Magneto apparatus is also authorised in exceptional cases where the ringing circuits are very disproportionate.

Formal application for authority to use this apparatus must at present be made to the Engineer-in-Chief in all cases where less than six Leclanché cells would be required for ringing under the battery system.

Not more than six offices may be placed upon a circuit without special authority. (*See* Circular E. 137. § xi.)

Apparatus required:—

Telephone.
Telephone Galvanometer.
Magneto Generator or Bracket Generator.
Magneto Bell.

(*Continued on p.* 180.)

TELEPHONE.

WITH MAGNETO GENERATOR AND BELL.

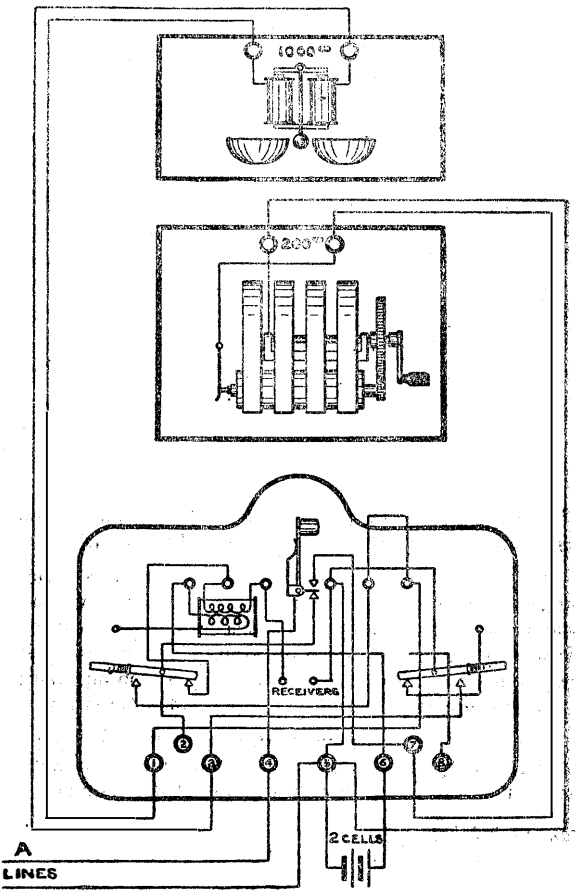


Plate 72—*cont.*

When used, the Telephone Galvanometer is connected between terminals 4 and 5, that is, in "bridge" (or leak) direct on the line.

To ring, depress the Telephone Press-button, and turn the crank handle of Generator continuously. If intermittent signals be required, turn the handle continuously and regulate signals by the Press-button. Jerking the handle of the Generator is liable to damage the gearing.

Magneto apparatus is not suitable for circuits connected with permanent current Exchanges.

PART XII.

TELEPHONE SWITCHES.

Plates 73a andb.

BRIDGE INTERMEDIATE SWITCH (T.B.I.).

For general notes, *see* pages 154–159.

Apparatus required :—

Bridge Intermediate Switch.
Telephone.
Telephone Relay, 100ω or 1,000ω (unmounted).
2 (or 1) Bell Receivers.
2 Trembler Bells with Indicator.
Resistance Coil (various) R.

The use of a Balancing Resistance Coil R. and of a Relay must be determined by the conditions laid down by Circular E. 130, §§ 7, 8, and 9.

This resistance is placed between terminals 1 and 3 of the Telephone, so that it may be in the call-receiving circuit only, and not in circuit for either ringing or speaking. If a Resistance Block is not required the two terminals must be joined direct.

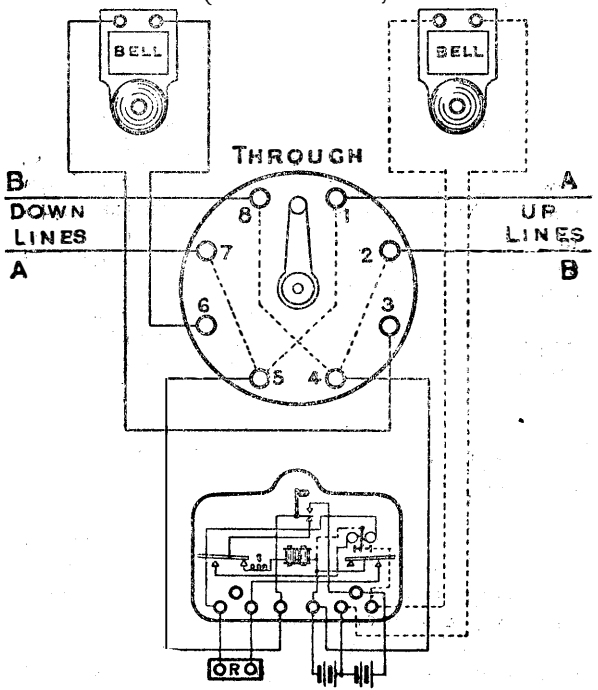
When a Switch is used, if the Intermediate Office is off the main line, and has to be reached by a branch, the branch line must be a loop; that is, it must consist of two wires for a single-wire circuit, and of four wires for a double-wire circuit. The same rule applies to leading-in wires in every such case. (*See* Circular E. 130, § 6.)

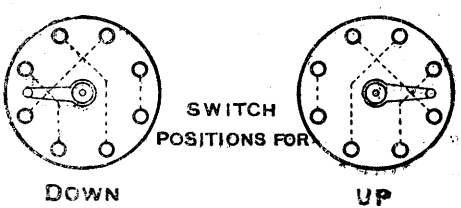
In the through position the Telephone is placed in the circuit in "bridge."

(*Continued on p.* 184.)

BRIDGE INTERMEDIATE SWITCH.

(OLD PATTERN.)





Plates 73a and b—*cont.*

The same form of Switch is used for single wire circuits.

It is sometimes desired that the intermediate office Telephone may for purposes of privacy not be in circuit when the line is "through." In such case the *Telephone* and the left-hand *Bell* connections on the Switch may be interchanged so that the Bell may be in circuit when the Switch is at "through." In this case the Relay (mounted) should be used in the Bell instead of in the Telephone circuit. The balancing resistance R. (if any) must also be placed in the Bell Relay circuit instead of in the position shown.

Plate 73b.

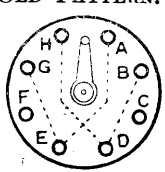
BRIDGE INTERMEDIATE SWITCH (T.B.I.).

(NEW PATTERN.)

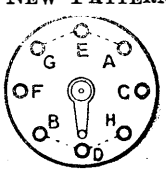
The Notes to Plate **73a** apply in every respect in this case. The two patterns of Switch are to be used indifferently.

It must be noted, however, that the relative positions of the connections on the two patterns do not correspond, but the following figures, in which corresponding terminals are similarly lettered, will provide for cases where it becomes necessary to exchange one pattern for the other.

OLD PATTERN.

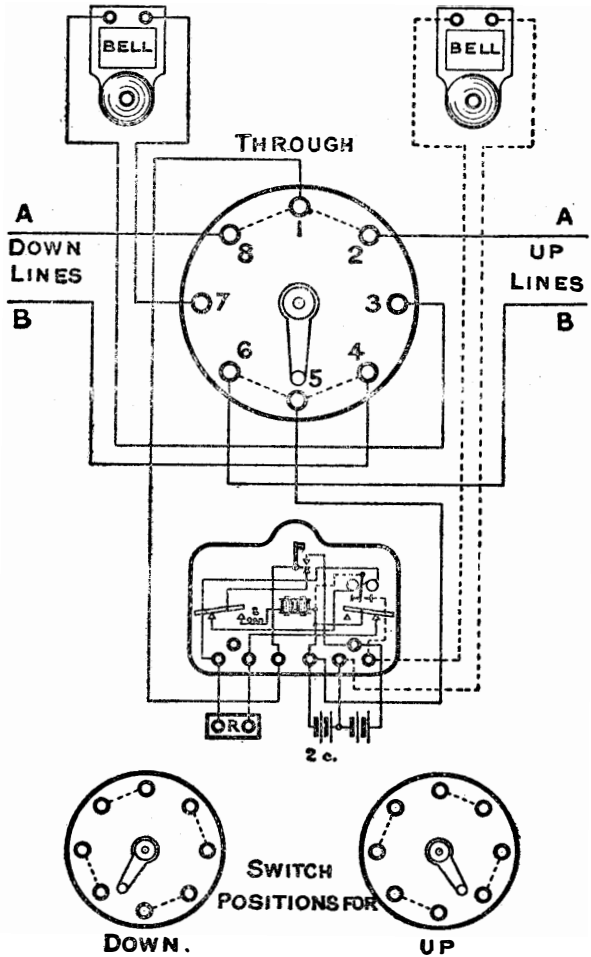


NEW PATTERN.



BRIDGE INTERMEDIATE SWITCH.

(New Pattern.)



Plates 74a and b.

EXCHANGE INTERMEDIATE SWITCH (E. I.).

Apparatus required :—
Exchange Intermediate Switch.
Telephone.
2 Bell Receivers.
Telephone Relay 100Ω
Polarised Indicator Relay 1,000Ω.
Trembler Bell.

Four leading-in wires (or branch wires) are required for an Intermediate Office where a Switch is used.

"Exchange" is the normal position.

The Intermediate Office gains the attention of the Exchange by repeated depression of the Telephone Press-button, and calls the Down Office by turning the Switch to "Down" and also depressing the Press-button.

The internal connections of the Switch in the two positions are shown at the lower part of the figure.

EXCHANGE INTERMEDIATE SWITCH (E. 1.).

(OLD PATTERN.)

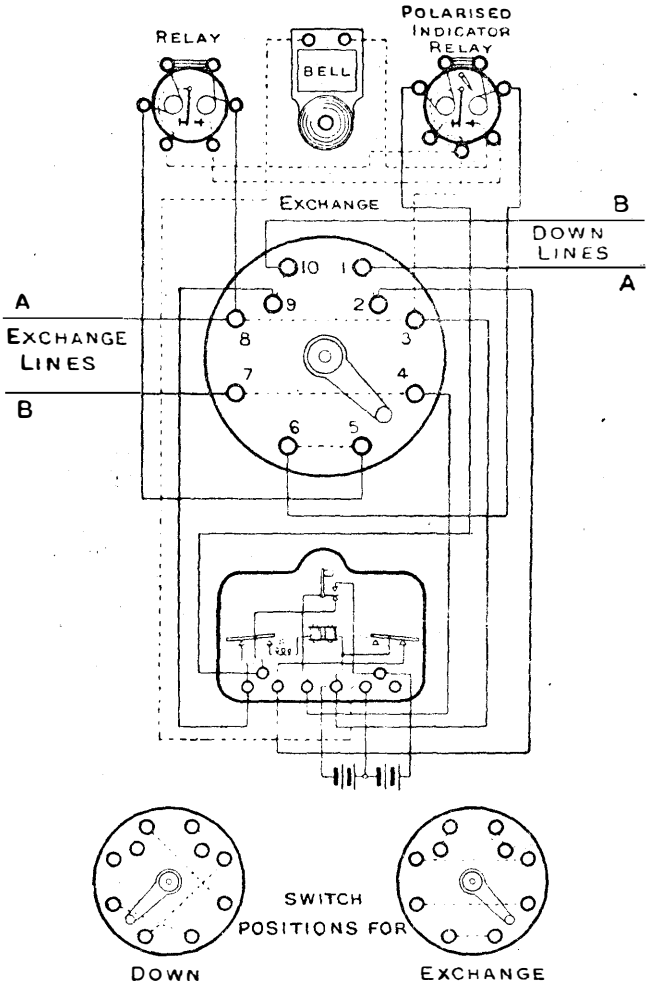


Plate 74b.

EXCHANGE INTERMEDIATE SWITCH (E. I.)

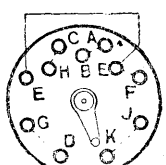
(NEW PATTERN.)

The Notes to Plate **74a** apply in every respect in this case. The two patterns of Switch are to be used indifferently.

It must be noted, however, that the relative positions of the connections on the two patterns do not correspond, but the following figures, in which corresponding terminals are similarly lettered, will provide for cases where it becomes necessary to exchange one pattern for the other.

OLD PATTERN.

NEW PATTERN.



Two terminals (marked "E" above, and "2" and "8" in Plate **74b**) are connected together direct. This is necessitated by the fact that in the new pattern Switch provision is made for the special requirements of the Multiple Switch System adopted for Newcastle-on-Tyne. The old pattern Switch requires special alteration for this purpose.

EXCHANGE INTERMEDIATE SWITCH.

(New Pattern.)

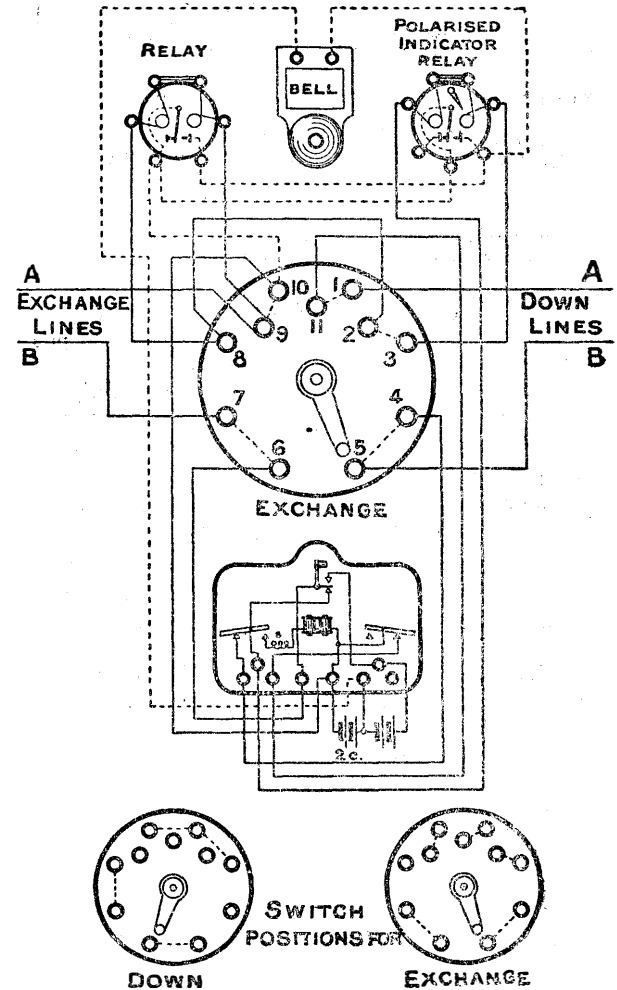


Plate 75.

TELEPHONE EXCHANGE SWITCH.

ORDINARY CONNECTIONS FOR PERMANENT CURRENT OR FOR PRIVATE EXCHANGE.

The several positions of the Switch are shown.

The Polarised Indicators used on the permanent current system should be so connected that the needles normally deflect to the right.

The ordinary sizes of Switches and of Indicator Tablets are for 2, 4, 6, 9, 12, 16, 20 and 25 circuits.

For Stock purposes they are described respectively, thus :—

— hole Telephone Switch,

and

— Polarised Indicator "B" $\frac{\text{No. of Indicator.}}{\text{No. of Spaces on Tablet.}}$

or

— Non-polarised Indicators $\frac{\text{No. of Indicator.}}{\text{No. of Spaces on Tablet.}}$

Thus—

3 Polarised Indicators "B" $\frac{12}{16}$

would mean 3 Indicator Tablets for 16 Indicators each fitted with 12 Polarised Indicators "B."

Either form of Indicator can be fitted on the Tablets.

Separate Indicators are described as such, for instance :—

12 Polarised Indicators "B."

TELEPHONE EXCHANGE SWITCH.

ORDINARY SYSTEM.

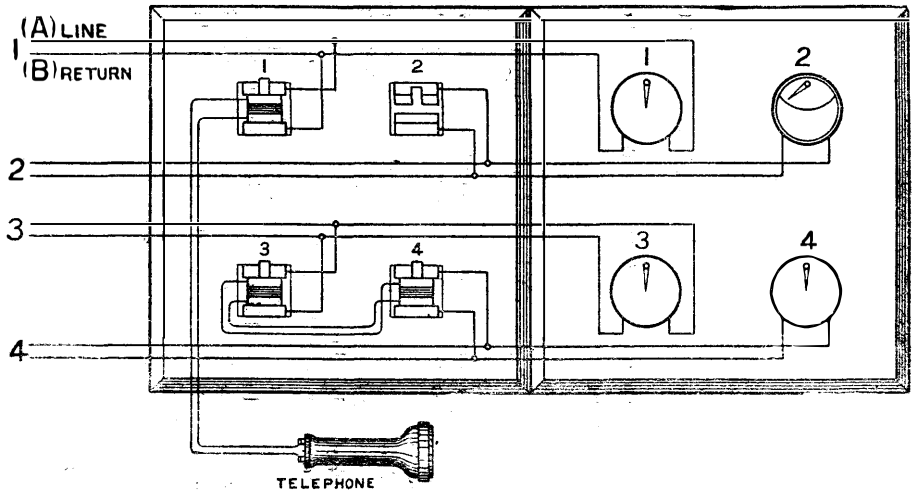


Plate 76.

TELEPHONE EXCHANGE SWITCH.

CONNECTIONS FOR (SINGLE WIRE) TELEGRAPH CIRCUITS.

See notes, page 190.

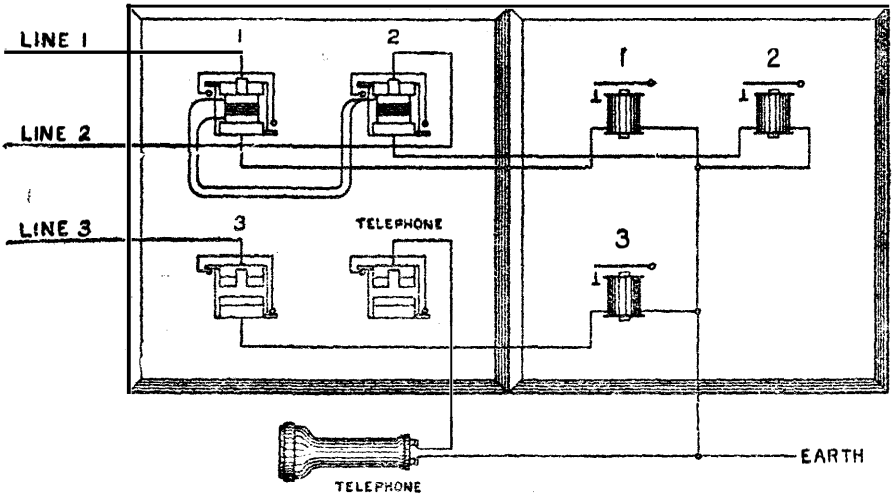
In some cases where several Telephone Circuits used for public messages are connected to one Office it is convenient to group them on a Switch or an Exchange, so that they can intercommunicate as well as speak direct to the Transmitting Office. When this is so the connections shown arrange that only one Indicator is left in "leak." This is effected by the connection of *both* conductors to the upper side of one of each pair of pegs.

Whenever any circuit on the Exchange has an Intermediate Office upon it, the whole system should be fitted with 1,000Ω Telephone Relays; and 1,000Ω Non-polarised Indicators should be fitted at the Exchange.

See also Circular E. 130, page 6.

TELEPHONE EXCHANGE SWITCH.

SINGLE WIRE TELEGRAPH CIRCUITS.



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PART XIII.

WALL BOARDS.

Plates 77a, b, and c.

WALL BOARDS.

For fuller details, *see* Circular E. 138, § XV.

Wall Boards of four standard forms are issued from the Instrument Factory.

(*a.*) The stock description is—
"Wall Board."

Such boards may be used where necessary on ordinary Telephone circuits, but it is not intended that "Desks" shall be supplied to any but Departmental (Message) circuits. If a Desk be required it must appear as a separate item on the Requisition as—

Desk, Writing with Paper Clip.

(*b.*) and (*c.*) The stock description is—
"Wall Board (fitted)."

Eight screw-head terminals are fitted as shown.

The diagrams will serve as a guide for arranging the apparatus, not only for the two actual cases shown (that is, the "Down" and "Intermediate" offices on an Exchange circuit), but also for ordinary Intermediate offices and for special cases.

In some circumstances it is desirable to fix Wall Boards when the apparatus cannot be grouped; for such cases—

(*d.*) "Wall Board (Small)" and
(*e.*) "Wall Board (for Bell),"

provide respectively for fixing a Telephone (of either form) and a Bell.

Requisitions should include 4 2½" No. 12 Brass Screws for fixing each Board or a supply should be kept.

Plate 77a.

ARRANGEMENT OF APPARATUS ON WALL BOARD AT A SUB-POST OFFICE.

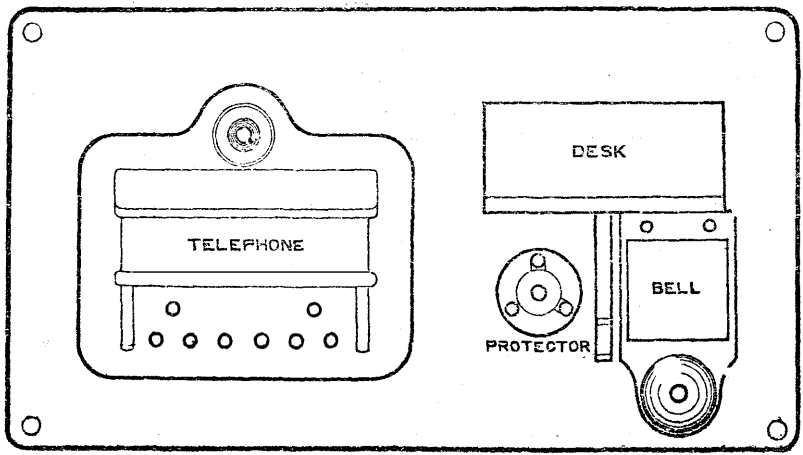


Plate 77b.

ARRANGEMENT OF APPARATUS ON WALL BOARD (FITTED) AT A "DOWN" OFFICE. (*See* Plate 69.)

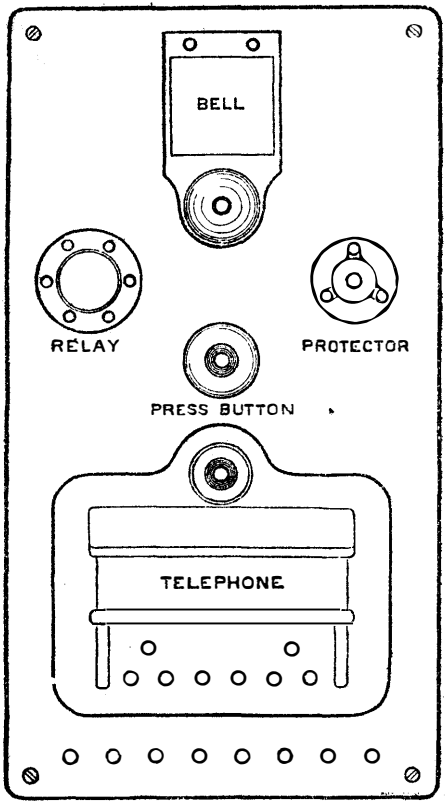
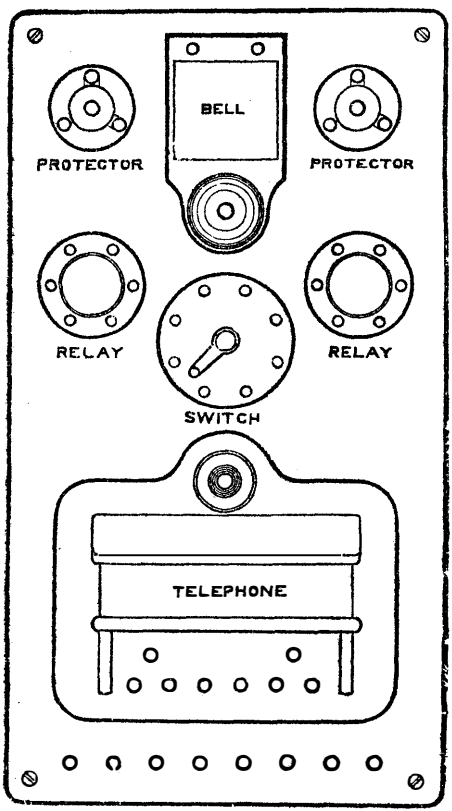


Plate 77c.

ARRANGEMENT OF APPARATUS ON WALL BOARD (FITTED) AT AN "INTERMEDIATE" OFFICE. (*See* Plate 74.)



PART XIV.

CALL OFFICES.

Plate 78.

CALL OFFICE SYSTEM.

WITH TWO TELEPHONES.

For full explanation of the conditions of use, *see* Circular E. 137, § X.—"Counter Communication Switches."

At each Call Office one or more Silence Cabinets are required, into which callers are admitted for the purpose of communicating with their correspondents.

Apparatus required :—

- PO. Telephone for Single Receiver.
- Bell Receiver.
- Non-polarised Indicator Relay 1,000ω.
- 7-terminal 2-position Switch.
- Trembler Bell.
- Resistance Coil (various) 100ω.
- Wall Board (fitted).

The above will be supplied from Instrument Factory fully connected under the stock description of :—

"Counter Communication Switch for One Cabinet."

It is to be fixed in some position convenient for use by the Counter Clerk alone.

- P.O Telephone for Granular Transmitter.
- Deckert Transmitter.
- Telephone Relay 100ω (unmounted).
- 2 Bell Receivers.
- Trembler Bell.

These to be fitted within the Silence Cabinet.

(*Continued on p.* 204.)

CALL OFFICE SYSTEM.

WITH TWO TELEPHONES.

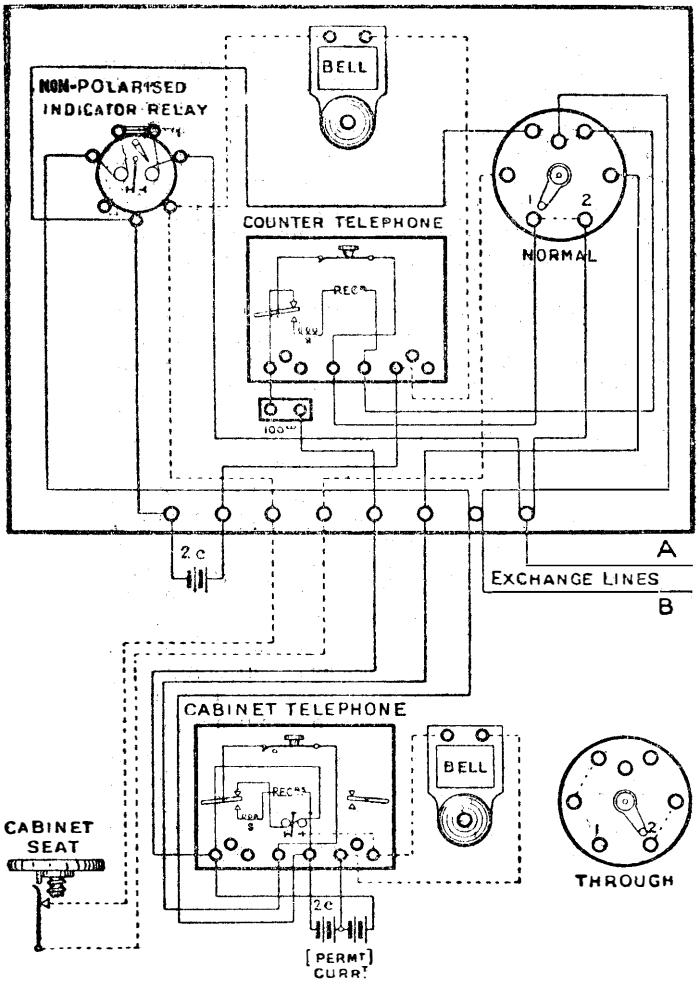


Plate 77—*cont.*

The 100ω Resistance in connection with the Counter Telephone is introduced into the Battery circuit when (in Position "1") the coils of the Cabinet Telephone Relay are not in; otherwise the Battery alone would practically short-circuit the coils of the Indicator Relay.

In cases where the Call Office is not in the same building as the Telephone Exchange, it is generally necessary to use a "Telephone Relay 1,000ω (unmounted)" in the Cabinet Telephone, and to join the coils in multiple (250ω). The Resistance Coil (various) must then be correspondingly increased to 250ω. Also the Permanent-current Battery, which is normally 4 cells, must be increased to 7 cells.

When the Switch is at position 2, the Switch Clerk is able in case of need to call the subscriber direct.

Normally the Telephone in the Silence Cabinet is disconnected, so that unauthorised persons obtaining access to the instrument unobserved are unable to effect communication with the Exchange.

The Cabinet seat (as to the use of which *see* Circular E. 137, § II.) is arranged to disconnect the circuit of the Counter Bell when the seat is in use. This bell circuit is complete only when the switch is turned to "2" and the seat is not depressed. The Counter Clerk by this device secures a signal when a caller rises to leave the Cabinet, in case any question as to the length of conversation is to be raised and to secure the replacement of the Switch to its normal position ("1").

Both Counter and Cabinet Relays must be adjusted against the permanent current.

As the Indicator Relay is permanently in "bridge" across the lines the attention of the Counter Clerk can always be obtained from the Exchange irrespective of all conditions at the Call Office. The Indicator is normally deflected to the right.

The Black Peg and corresponding Ringing Key must be used at the Exchange, two rings being given for the Counter and one for the Cabinet.

A Card of Instructions for working the Counter Communication Switch should be posted at each Switch by the local Engineering Officer. These Cards are supplied on application to the Engineer-in-Chief.

Special instructions will be given as to the Switch to be used when two or more Silence Cabinets are in use at a Call Office.

Plate 79.

CALL OFFICE SYSTEM.

WITH ONE TELEPHONE.

For general Notes, *see* pages 202 to 205.

For fuller explanation of the conditions of use, *see* Circular E. 137, § X.

At Call Offices where there is not sufficient space for the Counter Communication Switch shown in Plate 78, in addition to the Silence Cabinet provided for public use, the Counter Clerk has to use the Cabinet Telephone. In such cases the Silence Cabinet must be so placed that while the public are not admitted behind the Counter the Clerk does not leave the Counter unprotected when using the Telephone.

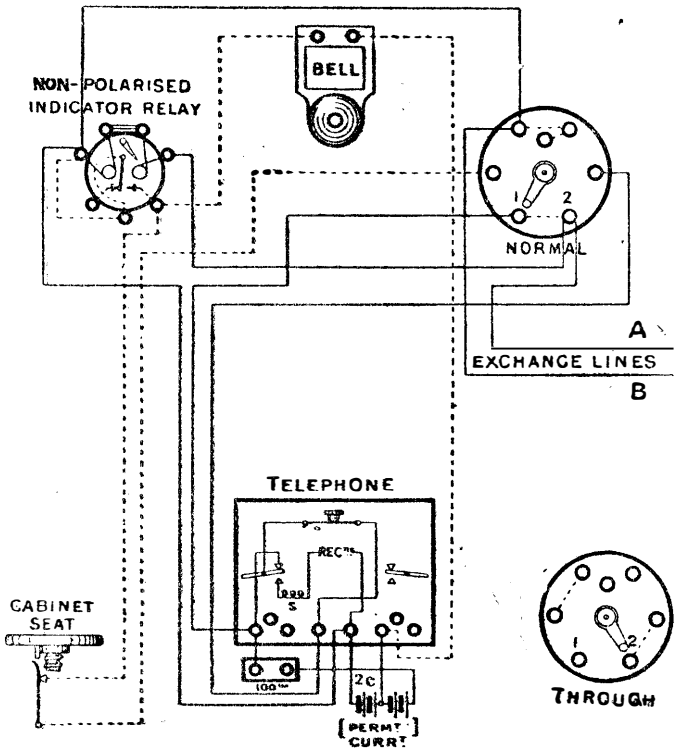
The Switch must be fitted in a position inaccessible to the public.

Apparatus required—

P.O. Telephone for Granular Transmitter.
Deckert Transmitter.
2 Bell Receivers.
Non-polarised Indicator Relay, 1,000ω.
7-terminal 2-position Switch.
Trembler Bell.
Resistance Coil (various), 100ω.

CALL OFFICE SYSTEM.

WITH ONE TELEPHONE.



PART XV.

MISCELLANEOUS.

GREENWICH TIME CURRENT.

ARRANGEMENT OF APPARATUS.

Plate 80.

GREENWICH TIME CURRENT.

This represents the ordinary requirements for sending Greenwich Time Signals to one subscriber in a provincial town.

Apparatus required:—
2-bar Switch (3 positions).
Siemens' Relay.
2 SC. Galvanometers.

The current to Renter's Instrument must always be sent from 10 cells Leclanché (Porous Pot No. 3).

The resistance of the Renter's Instrument should in all cases be approximately 200Ω.

GREENWICH TIME CURRENT.

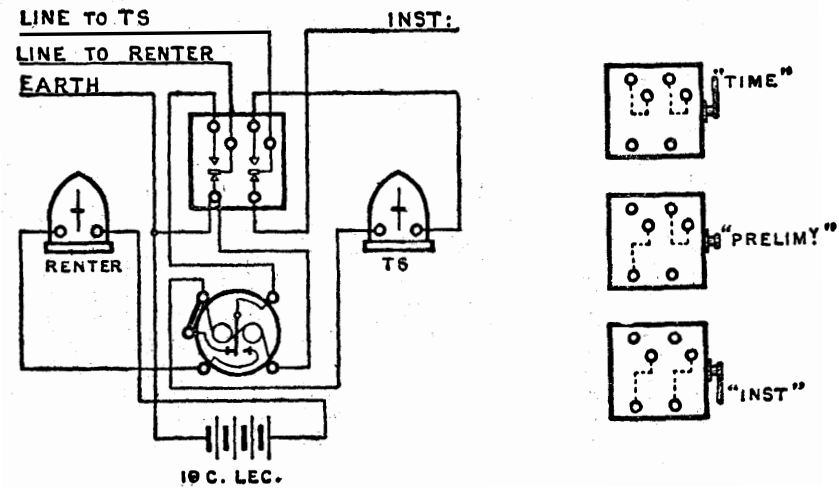


Plate 81.

APPARATUS ON INSTRUMENT TABLES.

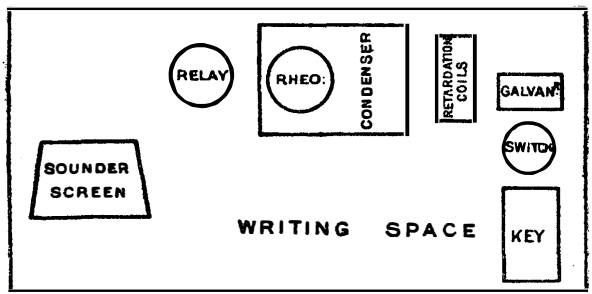
The standard width of Instrument Tables is 2 feet.

Length required:	
A B C. - - -	2 ft. 0 ins.
S.N. - - - -	2 „ 0 „
BRIGHT'S BELL or DOUBLE SOUNDER - - -	3 „ 0 „
SIMPLEX (including writing space) - - - -	3 „ 0 „
DUPLEX (including writing space) - - -	5 „ 0 „
AUTOMATIC (excluding writing space) - - - -	4 „ 0 „
REPEATERS (excluding writing space) - - -	5 „ 0 „
HUGHES INSTRUMENT - -	5 „ 4 „
„ DUPLEX - -	10 „ 8 „
QUADRUPLEX - - -	9 „ 0 „
MULTIPLEX:—	
Distributor, &c. - -	4 „ 6 „
Each Arm (additional) -	2 „ 3 „
CONCENTRATOR SYSTEM:—	
SWITCH - - -	3 „ 0 „
Apparatus, each set - -	2 „ 3 „

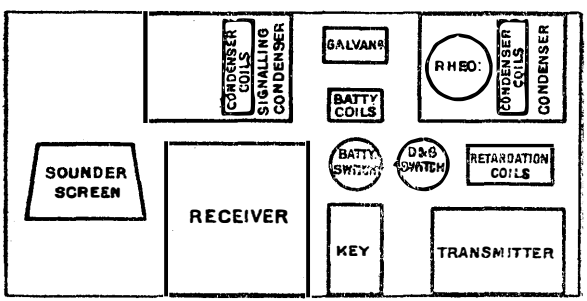
Each Puncher, also, should be allowed 2 feet length of Table space, and for Automatic, "News," and Repeaters an additional length of 2 ft. 3 ins. should be allowed for each Writer.

ARRANGEMENT OF APPARATUS ON INSTRUMENT TABLES.

KEY DUPLEX.



AUTOMATIC DUPLEX.



PART XVI.

TABLES.

Table I.

SPEED TABLE.

TABLE for ascertaining the ACTUAL SPEED of TRANSMISSION on AUTOMATIC CIRCUITS.

Directions.—Pass 10 feet of Perforated Slip (representing 50 average words) through the Transmitter, and observe the time occupied.

NOTE.—3,000 divided by the time *in seconds*, will give the number of words per minute.

Time.	Words per Minute.	Time.	Words per Minute.	Time.	Words per Minute.
seconds.		seconds.		min. sec.	
5	600	23½	127	0 54	56
5½	545	24	125	0 55	55
6	500	24½	122	0 56	54
6½	462	25	120	0 57	53
7	429	25½	117	0 58	52
7½	400	26	115	0 59	51
8	375	26½	113	0 60	50
8½	353	27	111	1 1	49
9	333	27½	109	1 3	48
9½	316	28	107	1 5	47
10	300	28½	105	1 6	46
10½	285	29	103	1 7	45
11	273	29½	101	1 9	44
11½	262	30	100	1 10	43
12	250	31	97	1 12	42
12½	240	32	94	1 13	41
13	231	33	91	1 15	40
13½	222	34	88	1 17	39
14	214	35	86	1 20	38
14½	207	36	83	1 21	37
15	200	37	81	1 23	36
15½	195	38	79	1 25	35
16	188	39	77	1 28	34
16½	182	40	75	1 30	33
17	177	41	73	1 35	32
17½	172	42	71	1 37	31
18	167	43	70	1 40	30
18½	162	44	68	1 43	29
19	158	45	66	1 47	28
19½	154	46	65	1 51	27
20	150	47	64	1 55	26
20½	146	48	62	2 0	25
21	143	49	61	2 5	24
21½	140	50	60	2 10	23
22	136	51	59	2 16	22
22½	133	52	58	2 23	21
23	130	53	57	2 30	20

TABLE II.—Wood-Screws suitable for fixing various forms of Instruments.

Instruments.	Screws.	
	Number.	Length.
		inches.
Lugs of most current Apparatus	5	½
Automatic Transmitters and Receivers, corner pieces for (round headed)	9	¾
Bells, Trembler	10	1½
Block Instruments, Pneumatic	8	1½
Cut-outs, P.O.	6	¾
Ebonite Strips for flexible cord	8	1
Galvanometers, SC. and Telephone	8	1¼
Keys, SC.	10	1½
„ with Switch	10	2
„ other Standard Patterns	10	2½
Magneto Generators and Bells	10	1½
Numbering Machines	12	1
Press Buttons	7	1
Protectors "C"	6	⅝

Instruments.	Screws.	
	Number.	Length.
		inches.
Relays, Standard, "C" and Siemens	8	1½
Relays, other current Patterns	8	1¼
Resistance Coils, 2,000ª	6	1¼
„ „ various	7	1
„ „ Quad. Batt.	10	2½
Rheostats	6	1¾
„ Metropolitan	6	1½
Single Needle Commutator	8	1¼
„ „ Case	10	2
Sounders	8	1¼
Switches, Two-way	6	1¼
„ 6 and 7 terml. 2 posn.	8	1¾
„ TelephoneIntermediate	10	2
Telephones, P.O.	8	2
„ G.B.	10	2
Turntables	10	

Table III.

TABLE III.—STANDARD WIRE GAUGE, showing Areas of Circular Wires in square inches.

No. S. W. G.	Diameter.		Area in square inches.	No. S. W. G.	Diameter.		Area in square inches.
	Mils. (·001 inch.)	Millimetres.			Mils. (·001 inch.)	Millimetres.	
7/0	500·	12·70	·1963	23	24·	·610	·000452
6/0	464·	11·78	·1691	24	22·	·559	·000380
5/0	432·	10·97	·1466	25	20·	·508	·000314
4/0	400·	10·16	·1256	26	18·	·457	·000254
3/0	372·	9·45	·1087	27	16·4	·417	·000211
2/0	348·	8·84	·0951	28	14·8	·376	·000172
0	324·	8·23	·0824	29	13·6	·345	·000145
1	300·	7·62	·0707	30	12·4	·315	·000121
2	276·	7·01	·0598	31	11·6	·295	·000106
3	252·	6·40	·0499	32	10·8	·274	·0000916
4	232·	5·89	·0423	33	10·0	·254	·0000785
5	212·	5·38	·0353	34	9·2	·234	·0000665
6	192·	4·88	·0290	35	8·4	·213	·0000555
7	176·	4·47	·0243	36	7·6	·193	·0000454
8	160·	4·06	·0201	37	6·8	·173	·0000363
9	144·	3·66	·0163	38	6·0	·152	·0000282
10	128·	3·25	·0129	39	5·2	·132	·0000212
11	116·	2·95	·0106	40	4·8	·122	·0000181
12	104·	2·64	·0085	41	4·4	·112	·0000152
13	92·	2·34	·00665	42	4·0	·102	·0000126
14	80·	2·03	·00503	43	3·6	·0914	·0000102
15	72·	1·83	·00407	44	3·2	·0813	·00000804
16	64·	1·63	·00322	45	2·8	·0711	·00000616
17	56·	1·42	·00246	46	2·4	·0610	·00000452
18	48·	1·22	·00181	47	2·0	·0508	·00000314
19	40·	1·016	·00126	48	1·6	·0406	·00000201
20	36·	·914	·00102	49	1·2	·0305	·00000113
21	32·	·813	·000804	50	1·0	·0254	·000000785
22	28·	·711	·000616				

TABLE IV.—STANDARD SCREW GAUGE.

No.	Nominal Dimensions in Thousandths of an Inch.			Absolute Dimensions in Millimetres.	
	Diameter.	Pitch.	Threads per Inch.	Diameter.	Pitch.
25	10	2·8	353	0·25	0·072
24	11	3·1	317	0·29	0·080
23	13	3·5	285	0·33	0·089
22	15	3·9	259	0·37	0·098
21	17	4·3	231	0·42	0·11
20	19	4·7	212	0·48	0·12
19	21	5·5	181	0·54	0·14
18	24	5·9	169	0·62	0·15
17	27	6·7	149	0·70	0·17
16	31	7·5	134	0·79	0·19
15	35	8·3	121	0·90	0·21
14	39	9·1	110	1·0	0·23
13	44	9·8	101	1·2	0·25
12	51	11·0	90·7	1·3	0·28
11	59	12·2	81·9	1·5	0·31
10	67	13·8	72·6	1·7	0·35
9	75	15·4	65·1	1·9	0·39
8	86	16·9	59·1	2·2	0·43
7	98	18·9	52·9	2·5	0·48
6	110	20·9	47·9	2·8	0·53
5	126	23·2	43·0	3·2	0·59
4	142	26·0	38·5	3·6	0·66
3	161	28·7	34·8	4·1	0·73
2	185	31·9	31·4	4·7	0·81
1	209	35·4	28·2	5·3	0·90
0	236	39·4	25·4	6·0	1·00

Table IV.

Table V.

ELECTRICAL AND MECHANICAL QUALITIES OF LINE WIRES USED BY THE DEPARTMENT.

Weight per Mile (lbs.)			Approximate Standard Wire Gauge.	Diameter (inches).			Resistance in Standard ohms, per mile at 60° F. of Standard size.	Minimum Breaking Stress. lbs.
Standard.	Max.	Min.		Standard.	Max.	Min.		
IRON WIRE.								
800	833	767	3½	**·242**	·247	·237	**6·66**	2,480
600	629	571	5	**·209**	·214	·204	**8·88**	1,860
450	477	424	6½	**·181**	·186	·176	**11·84**	1,390
400	424	377	7½	**·171**	·176	·166	**13·32**	1,240
200	213	190	10½	**·121**	·125	·118	**26·64**	620
60	65	55	16	**·066**	·063	·069	**88·8**	
HARD DRAWN COPPER WIRE.								
800	820	780	4½	**·224**	·226	·2205	**1·098**	2,400
600	615	585	6	**·194**	·196	·191	**1·464**	1,800
400	410	390	8	**·158**	·16025	·1555	**2·195**	1,250
200	205	195	11½	**·112**	·11325	·1105	**4·391**	650
150	153¾	146½	13	**·097**	·098	·0955	**5·855**	490
100	102½	97½	14	**·079**	·080	·078	**8·782**	330
***37**	—	—	18	**·048**	·049	·047	**23·740**	120
***28**	—	—	19	**·042**	·043	·041	**34·340**	—
†198	212	184	7/19	—	—	—	**4·866**	630
†111⅛	115	108	3/18	—	—	—	**7·870**	350

*Single Conductor for Strand Wire. † Strand.

NOTES ON TABLES VI–IX.

NUMBER OF CELLS of various forms of Battery required to give specified "WORKING CURRENTS" through various EXTERNAL RESISTANCES.

The Tables are calculated upon the basis of the *Minimum* E.M.F. and the *Maximum* Resistance allowed for the various forms of Cell. Therefore no further margin is necessary.

To use the Tables the "Working Current" required and the total Resistance of the Circuit external to the Battery being known, consult the Table referring to the form of Battery authorised for that particular use, and take the number of Cells indicated against the nearest (higher) Resistance to that concerned. For instance, for a Single Needle circuit with a line resistance of 240ω and fitted with three Instruments (that is 600ω), consult Table VIII. The range of current allowed (page 28) is 15 to 20 milliampères and the total external Resistance is 840ω. It is seen that 11 cells will give barely 15 milliampères, so that 12 cells (which will give 16 milliampères through 852ω) should be used.

Although the resistances of different forms of Leclanché Cells vary very considerably, for purposes of calculating the Battery power to be fixed it is permissible to assume them all to be the maximum.

Table VI.

TABLE VI.—DANIELL (SMALL).

The EXTERNAL RESISTANCE in the Table through which the various Numbers of Cells will give the specified CURRENT in Milliampères is calculated on the basis of each Cell having an ELECTROMOTIVE FORCE of ·96 volts and a RESISTANCE of 8 ohms.

No. of Cells.	Specified Current in Milliampères through External Resistance in Ohms.				No. of Cells.	Specified Current in Milliampères through External Resistance in Ohms.			
	14	15	17	20		14	15	17	20
6	363	336	291	240	30	1817	1680	1454	1200
8	484	448	388	320	32	1938	1792	1551	1280
10	606	560	484	400	34	2059	1904	1648	1360
12	727	672	581	480	36	2180	2016	1745	1440
14	848	784	678	560	38	2301	2128	1842	1520
16	969	896	775	640	40	2423	2240	1939	1600
18	1090	1008	872	720	42	2544	2353	2035	1680
20	1211	1120	969	800	44	2665	2463	2132	1760
22	1332	1232	1066	880	46	2786	2573	2229	1840
24	1454	1344	1163	960	48	2907	2684	2326	1920
26	1574	1456	1260	1040	50	3028	2795	2423	2000
28	1696	1568	1357	1120	60	3634	3356	2908	2400

TABLE VII.—BICHROMATE. DANIELL (LARGE).

ELECTROMOTIVE FORCE, 1·82 volts; RES. 4 ohms. EMF., 96; RES., 4.

No. of Celts.	BICHROMATE. Specified Current in Milliampères through External Resistance in Ohms.							DANIELL (Large). Specified Current through External Resistance.				No. of Cells.
	10	14	15	17	20	25	30	14	15	17	20	
5	890	630	586	515	435	344	283	323	300	262	220	5
10	1780	1260	1173	1030	870	688	566	645	600	524	443	10
15	2670	1890	1760	1546	1305	1032	850	968	900	787	660	15
20	3560	2520	2346	2061	1740	1376	1133	1291	1200	1049	880	20
25	4450	3150	2933	2576	2175	1720	1416	1614	1500	1311	1100	25
30	5340	3780	3520	3091	2610	2064	1700	1937	1800	1574	1320	30
35	6230	4410	4106	3607	3045	2408	1983	2260	2100	1836	1540	35
40	7120	5040	4693	4122	3480	2752	2266	2582	2400	2098	1760	40
45	8010	5670	5280	4637	3915	3096	2550	2905	2700	2361	1980	45
50	8900	6300	5866	5152	4350	3440	2833	3228	3000	2623	2200	50
55	9790	6930	6453	5668	4785	3784	3116	3551	3300	2885	2420	55
60	10680	7560	7040	6183	5220	4128	3400	3874	3600	3148	2640	60
65	11570	8190	7626	6698	5655	4472	3683	4197	3900	3410	2860	65
70	12460	8820	8213	7213	6090	4816	3966	4520	4200	3672	3080	70
75	13350	9450	8800	7729	6525	5160	4250	4843	4500	3935	3300	75
80	14240	10080	9386	8246	6960	5504	4533	5166	4800	4197	3520	80

Table VIII.

TABLE VIII.—LECLANCHÉ.

The EXTERNAL RESISTANCE in the Table through which the various Numbers of Cells will give the specified CURRENT in Milliampères is calculated on the basis of each Cell having an ELECTROMOTIVE FORCE of 1·08 volts and a RESISTANCE of 4 ohms.

No. of Cells.	Specified Current in Milliampères through External Resistance in Ohms.							No. of Cells.	Specified Current in Milliampères through External Resistance in Ohms.						
	7	10	14	15	16	20	25		7	10	14	15	16	20	25
2	300	208	146	136	127	100	78	14	2104	1456	1024	952	889	700	548
3	451	312	219	204	191	150	118	15	2254	1560	1096	1020	952	750	588
4	601	416	291	272	254	200	156	16	2405	1664	1170	1088	1016	800	628
5	751	520	365	340	317	250	196	17	2554	1768	1243	1156	1079	850	666
6	902	624	439	408	381	300	236	18	2105	1873	1317	1224	1143	900	716
7	1052	728	511	476	444	351	274	19	2855	1976	1389	1292	1206	950	744
8	1202	832	585	544	508	400	314	20	3005	2080	1463	1360	1270	1000	784
9	1352	936	657	612	571	450	353	21	3155	2184	1536	1428	1334	1050	824
10	1503	1040	731	680	635	500	392	22	3306	2288	1609	1496	1397	1100	862
11	1654	1144	804	748	699	550	432	23	3456	2392	1682	1597	1461	1150	902
12	1803	1248	877	816	762	600	472	24	3606	2496	1755	1632	1524	1200	940
13	1954	1352	918	884	826	650	513	26	3908	2704	1902	1768	1651	1300	1020

TABLE VIII. (*continued*).—LECLANCHÉ.

No. of Cells.	Specified Current in Milliampères through External Resistance in Ohms.							No. of Cells.	Specified Current in Milliampères through External Resistance in Ohms.						
	7	10	14	15	16	20	25		7	10	14	15	16	20	25
28	4208	2912	2048	1904	1778	1400	1098	52	7814	5408	3803	3536	3302	2600	2038
30	4508	3120	2194	2040	1905	1500	1176	54	8114	5616	3949	3672	3429	2700	2116
32	4808	3328	2340	2176	2032	1537	1254	56	8415	5824	4096	3808	3556	2896	2196
34	5109	3536	2486	2312	2159	1700	1332	58	8716	6032	4242	3944	3683	2900	2274
36	5410	3744	2633	2448	2286	1800	1412	60	9016	6240	4389	4080	3810	3000	2352
38	5711	3952	2779	2584	2413	1900	1490	62	9317	6448	4534	4216	3937	3100	2430
40	6011	4160	2926	2720	2540	2000	1568	64	9617	6656	4681	5352	4064	3200	2508
42	6312	4368	3072	2856	2667	2100	1646	66	9919	6864	4828	4488	4191	3300	2588
44	6612	4576	3217	2992	2794	2200	1724	68	11357	7072	4973	4624	4318	3400	2666
46	6913	4784	3365	3128	2921	2300	1804	70	10519	7280	5120	4760	4445	3500	2744
48	7213	4992	3511	3264	3048	2400	1882	80	12023	8320	5851	5440	5080	4000	3136
50	7514	5200	3656	3400	3275	2500	1960	90	13525	9360	6583	6120	5715	4500	3528

Table IX.

TABLE IX.—SECONDARY CELLS.

The "Number of Volts" is the Nominal ELECTROMOTIVE FORCE.

No. of Volts.	Specified Current in Milliampères through Resistance in Ohms.								No. of Volts.
	10	14	15	17	20	25	30	100	
2	200	143	133	117	100	80	66	20	2
4	400	285	266	235	200	160	133	40	4
6	600	428	399	353	300	240	200	60	6
10	1000	714	666	588	500	400	333	100	10
14	1400	1000	933	823	700	560	466	140	14
24	2400	1714	1600	1411	1200	960	800	240	24
30	3000	2142	2000	1764	1500	1200	1000	300	30
40	4000	2857	2666	2352	2000	1600	1333	400	40
50	5000	3571	3333	2941	2500	2000	1666	500	50
60	6000	4285	4000	3530	3000	2400	2000	600	60
70	7000	5000	4666	4117	3500	2800	2333	700	70
76	7600	5428	5066	4470	3800	3040	2533	760	76
86	8600	6142	5733	5059	4300	3440	2866	860	86
100	10000	7143	6666	5882	5000	4000	3333	1000	100

INDEX.

Morse Alphabet

a	·–	n	–·
b	–···	o	–––
c	–·–·	p	·––·
d	–··	q	––·–
e	·	r	·–·
f	··–·	s	···
g	––·	t	–
h	····	u	··–
i	··	v	···–
j	·–––	w	·––
k	–·–	x	–··–
l	·–··	y	–·––
m	––	z	––··