DIRECTIONS FOR USING SIGNAL CORPS UNIVERSAL TEST SET

PREPARED IN THE OFFICE OF THE
CHIEF SIGNAL OFFICER

June, 1920

(For inclosure in the Test Set when issued and to remain constantly with the set box. To be issued only as a component part of this set)

WASHINGTON
GOVERNMENT PRINTING OFFICE
'20

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WAR DEPARTMENT
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Office of The Adjutant General

WAR DEPARTMENT,
WASHINGTON, *June 9, 1920.*

The following publication, entitled "Signal Corps Universal Test Set," is published for the information and guidance of all concerned.
[062.1, A. G. O.]

BY ORDER OF THE SECRETARY OF WAR:

W. M. WRIGHT,
Major General, Acting Chief of Staff.

OFFICIAL:
P. C. HARRIS,
The Adjutant General.

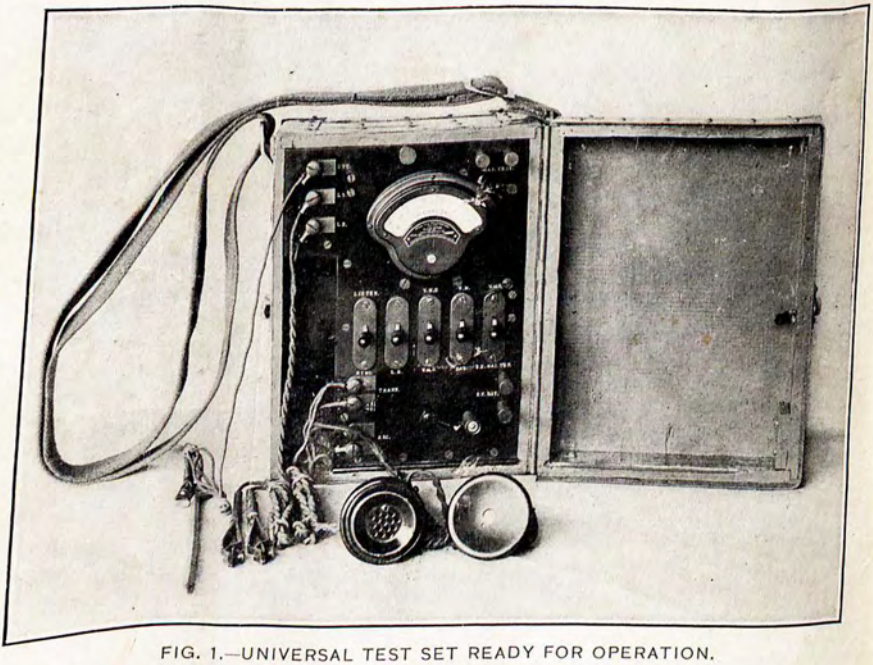

FIG. 1.—UNIVERSAL TEST SET READY FOR OPERATION.

SIGNAL CORPS UNIVERSAL TEST SET.

TYPE EE-65.

This testing set is a condensed wire chief's set and is designed for testing and locating trouble on magneto and common battery lines and apparatus. The complete equipment is mounted in a substantial carrying case provided with a shoulder strap and is intended for use at junction points in the field and any place along the line, as well as for central office work. It is equipped with a hand generator, ringer, transmitter, and receiver, and therefore is entirely independent of any auxiliary talking or ringing apparatus so often necessary with the common form of portable wire chief's sets. If necessary, it may be also used as a line tester.

Testing and locating trouble.

This set is designed for making the following tests on either common battery or magneto lines:

(*a*) Ringing substation or exchange.
(*b*) Talking to substation or exchange.
(*c*) Continuity test.
(*d*) Test of short circuit.
(*e*) Test of ground.
(*f*) Test for crosses on lines carrying current.
(*g*) Test for crosses on other lines.
(*h*) Measuring a voltage of auxiliary battery.

Method of operation.

The set will operate equally well in vertical or horizontal position; therefore, when it is desired to set it up for use, it may be suspended from some point by means of the carrying strap or may be laid flat on the table or some other support. Two test clips with the necessary cord are provided for connecting with metallic lines and a small ground rod with cord for securing the necessary ground connection in case there is no other means of obtaining a ground. Good connections, both line and ground, should always be secured before making any tests, and the ground rod should only be used when a better ground is not available. In case tests are being made on grounded lines, a test clip from terminal marked L–1 should be connected to the line, while the test clip from terminal marked L–2 should be connected to the ground.

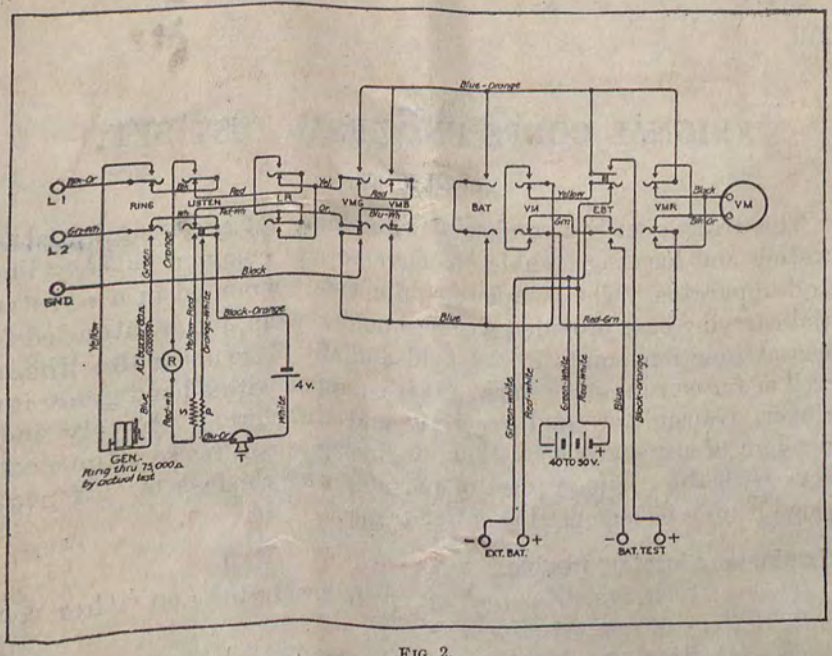
Blue-Orange
L 1
L 2
GND.
RING
LISTEN
L.R.
VMG
VMB
BAT
VM
EBT
VMR
VM
Green
Orange
Black
Blue
Red-Grn
Yellow
Black-Orange
4 v.
GEN.
Ring thru 75 000Δ
by actual test
40 TO 50 V.
EXT. BAT.
BAT. TEST

FIG. 2.

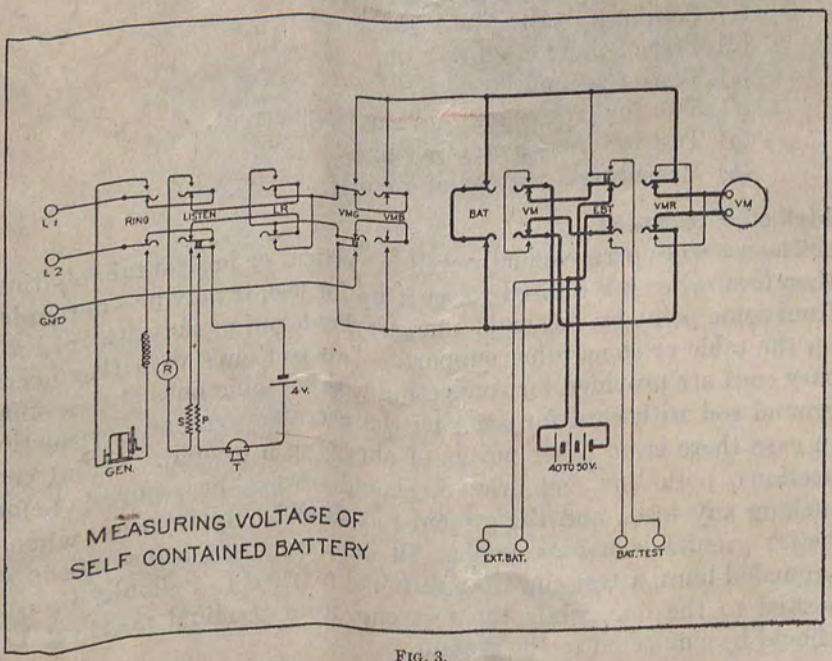
L 1
L 2
GND
RING
LISTEN
L.R.
VMG
VMB
BAT
VM
EBT
VMR
VM
4 v.
GEN.
40 TO 50 V.
EXT. BAT.
BAT. TEST
MEASURING VOLTAGE OF
SELF CONTAINED BATTERY

FIG. 3.

Batteries.

Two sets of batteries are contained within the case. One of these, consisting of one unit, type BA–1, is used for the telephone transmitter, and the other, consisting of two units, type BA–2 in series, is used in connection with all voltmeter tests. These batteries are contained in their proper compartments located in the upper part of the case and are readily accessible for examination or replacement by opening the front of the set. Two binding posts, marked EX. BAT., are provided at the lower right-hand side of the front panel, and an external battery may be used in case the two BA–2 batteries in the case have been removed or are bad. As the maximum range of the voltmeter is only 50 volts, the potential of the external battery should not be above this.

Before carrying the test set in the field or placing it in commission at any point, care should be taken to see that the batteries are in good condition, and if found weak, should be replaced. The BA–1 battery used for the transmitter can be tested by short circuiting the line terminal and throwing key No. 1 to the upper or LISTEN position and tapping on the transmitter with the receiver held to the ear. Should the battery be bad or weak, the tapping on the transmitter would be heard very faintly in the receiver, but a good battery will give a good loud sound. To test the two BA–2 batteries, key No. 4 should be thrown to the lower or BAT position, which places the battery directly across the voltmeter. These batteries, when practically new, should give approximately twenty-two (22) volts per unit, or a total of forty-four (44) volts, and when the voltage has fallen to approximately thirty-eight (38) volts, they should be discarded and replaced by new batteries.

Ringing substation or exchange.

When a telephone or a local battery exchange is to be called, key No. 1 should be thrown to the lower or RING position, and generator crank turned while the key is in this position. There is a small buzzer in series with the generator which will indicate whether or not the line over which the call is being made is closed or open. After the call is made, the key should be thrown to the upper or LISTEN position, when the conversation can be carried on in the usual way. Should the line be of the common battery type, it is only necessary to throw the key in the upper or LISTEN position, which will complete the circuit from the switchboard through the secondary of the induction coil and the telephone receiver, thereby signaling the operator. This, however, is not an ideal position for the telephone receiver in view of the fact that if the current passes through the receiver in a direction tending to demagnetize the poles it will cut down the strength of incoming signals and may have a tendency to permanently demag-

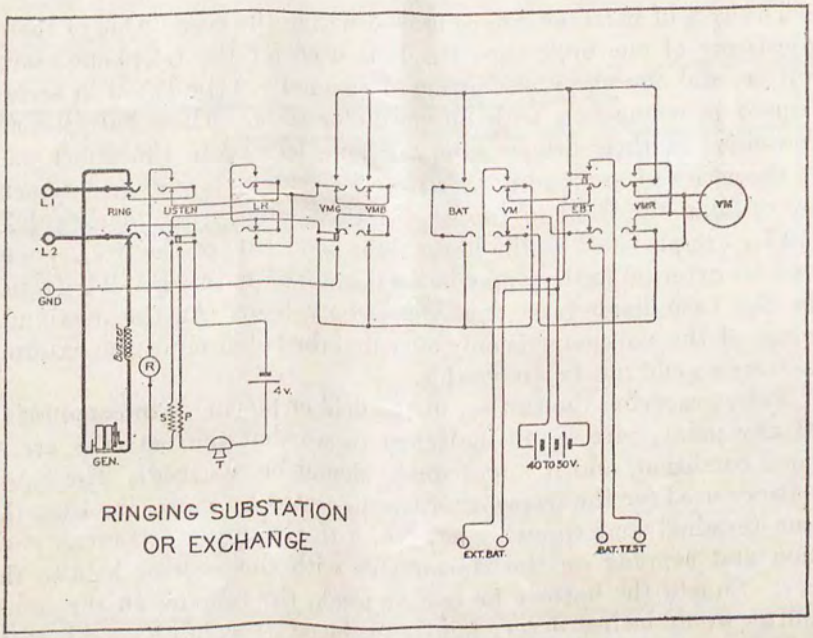
L1
L2
GND
RING
LISTEN
LR
VMG
VMB
BAT
VM
EBT
VMR
VM
Buzzer
R
4 v.
S
P
T
GEN.
40 TO 50 V.
EXT. BAT.
BAT. TEST
RINGING SUBSTATION
OR EXCHANGE

FIG. 4.

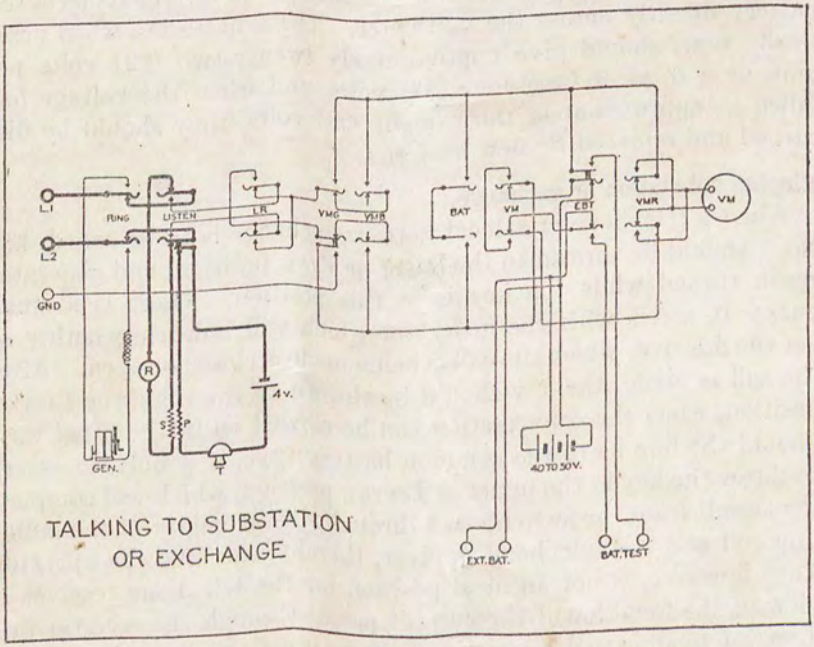
L1
L2
GND
RING
LISTEN
LR
VMG
VMB
BAT
VM
EBT
VMR
VM
R
4 v.
S
P
T
GEN.
40 TO 50 V.
EXT. BAT.
BAT. TEST
TALKING TO SUBSTATION
OR EXCHANGE

FIG. 5.

netize this receiver. Therefore, if it is necessary to connect to a common battery line at any time, the two line clips should be reversed and it should be ascertained at which position the incoming signals are the strongest, and the telephone should be used in this manner. When thus connected, the current will pass through the receiver in the direction that will tend to strengthen the magnets rather than weaken them and have no detrimental effect upon the receiver.

Talking to substation or exchange.

After calling the switchboard or substation or both, they may be communicated with by throwing key No. 1 to the upper or LISTEN position. This connects the receiver and secondary of induction coil directly across the line and by means of an auxiliary contact on the key closes the local circuit, consisting of the primary of induction coil, transmitter, and battery, thus exciting the transmitter. When through talking, this key should always be thrown to its neutral position, thereby saving the transmitter battery as much as possible.

Continuity tests.

To test the continuity of metallic circuit, key No. 3 should be thrown to a lower or V. M. B. position. In this manner the voltmeter in series with the testing battery is placed directly across the line and the amount of deflection as compared with the total voltage of the battery will depend upon the resistance of the line. In case the line is open there will be no deflection, nor will there be any deflection if there is only a telephone across the line which has a condenser in series with the ringer, as in the common battery type. If it is believed that there are such telephones on the line, key No. 3 should be left in the V. M. B. position and key No. 4 operated in the upper or V. M. position several times, which may cause momentary deflections of the voltmeter, due to the charge and discharge of the condenser. Such deflections, however, may also be obtained on long lines having high capacity, such as rubber-insulated cables. A similar test can be made on grounded lines by throwing key No. 3 to the upper or V. M. G. position and proceeding in the same manner as for metallic lines.

A continuity test may also be made by means of the hand generator with key No. 1 in the lower or RING position, the buzzer in series with the generator indicating whether or not the line is open. Should the generator be used, it will be necessary to ground the test clip connected to L–2 when continuity tests are made on grounded lines. As the generator is of the alternating current type, the buzzer will indicate continuous circuits on lines having telephones with condensers in series with the ringer, even though the hook switch may be open.

Tests for short circuits.

Tests for short circuits are made by observing the deflection of the voltmeter when key No. 3 is thrown to the lower or V. M. position. The smaller the resistance of the short circuit the greater will be the deflection. In all cases the voltmeter reading has the same ratio to the voltmeter resistance that the difference between this reading and the testing battery voltage has to the line resistance; therefore before making these tests it is necessary that the exact voltage of the testing battery should be known, which can be obtained by throwing key No. 4 to the lower or BAT position and noting the reading. The line resistance may then be found by dividing the difference between the testing battery voltage and the voltmeter reading when con-

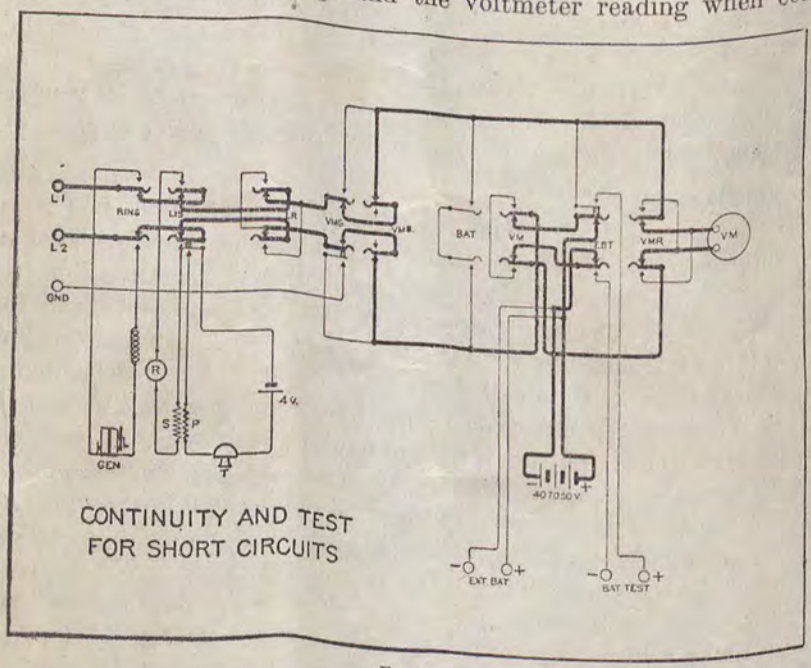

FIG. 6.

nected to line by the last-named reading and multiplying the result by the resistance of the voltmeter, which is approximately 3,500 ohms. As an example, should the voltmeter show the testing battery to have a potential of 42 volts and the reading of the voltmeter be 25 volts when connected to the line, the line resistance will be $\frac{42-25}{25} \times 3{,}500 = 238$ ohms. A set of curves may be prepared for each test set, from which the resistance of the line may be read direct. As the voltage of the test battery will vary slightly with age, it would be necessary to prepare several curves representing different voltages, and in reading the resistance from any of these the curve representing the actual battery voltage as shown by the voltmeter reading when

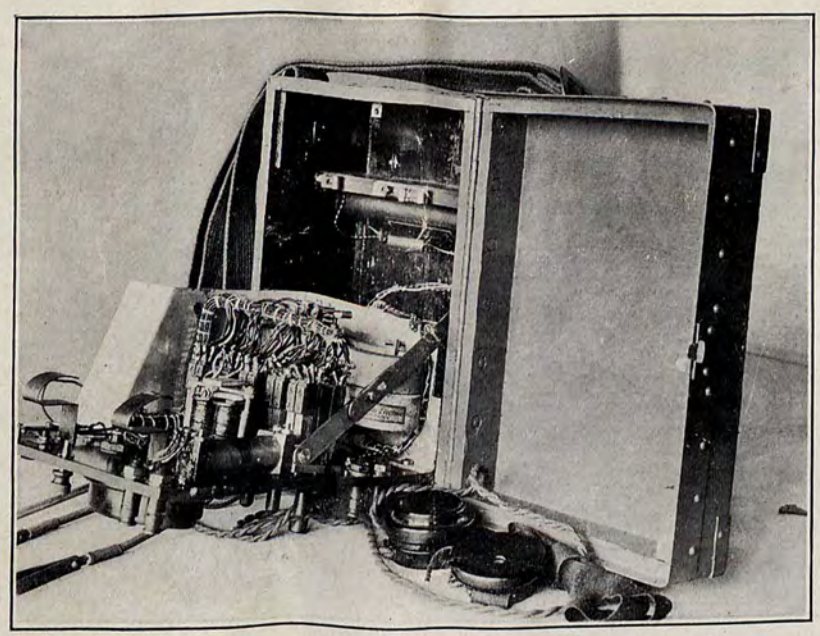

FIG. 7.

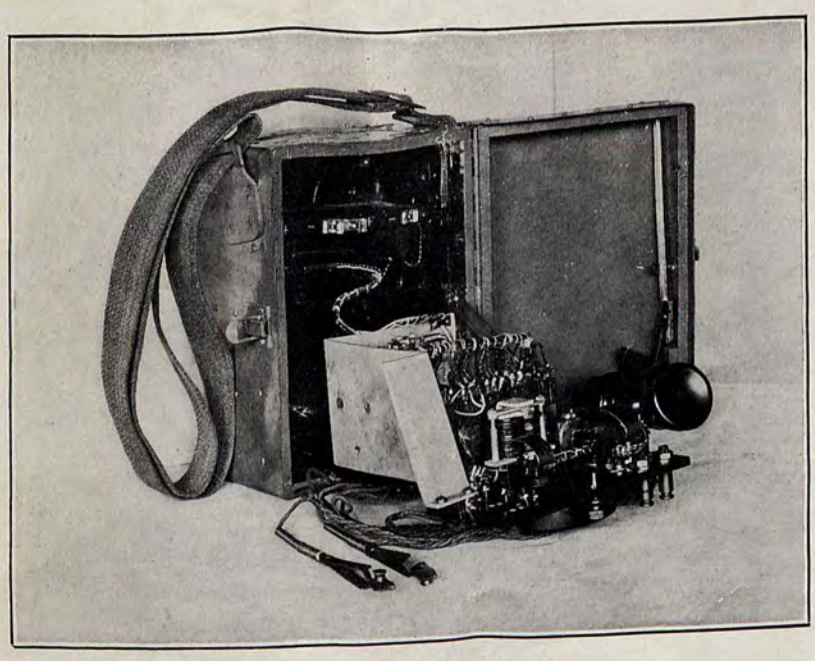

FIG. 8.

INTERIOR VIEWS SHOWING WORKING PARTS OF UNIVERSAL TEST SET.

key No. 4 is thrown to the BAT position should be used. By measuring the resistance in this manner it is easy to distinguish between the short circuit and a line having one or more bells bridged across it without condensers in series. While no fixed rules can be given for making location tests in this manner, operators may, after some experience and knowing the line conditions, determine the approximate location of the trouble. The size and the kind of wire in the circuit as well as the number of telephones bridged across the line and whether or not any of these telephones may have the hook closed, thus placing the receiver and secondary of induction coil directly across the line, will have to be taken into consideration. Telephones having condensers in series with the receiver will only show the resistance of the ringer circuit across the line when making this test, even though the hook switch may be closed.

The table given on page 14, showing the weights and resistance of the several types of wire more commonly used by the Signal Corps for line and field purposes, will probably be of great assistance to the tester in making location tests or short circuits and other tests of this kind.

Tests of grounds.

To test a line for ground, the test clips should be attached to the line in the usual way and a good ground secured by means of the ground connection of the test set. Key No. 3 should be then thrown to the upper or V. M. G. position, and if line No. 1 is grounded it will be indicated by a deflection of the voltmeter. Key No. 2 should then be thrown to the lower or L. R. position, thus reversing the connections to L–1 and L–2. A deflection of the voltmeter would then indicate that ground is on L–2. In making these tests, if no deflection is shown on the voltmeter in either case it will indicate that both lines are clear; however, there may be instances where a service buzzer or the telegraph set may be using the ground return, in which case a deflection will be observed upon the voltmeter. In case it is desired to measure the resistance of the ground, it may be done as explained under "*Tests for short circuits.*"

Tests for crosses on lines carrying current.

In tests for crosses with lines carrying current, such as telegraph lines, or common battery telephone lines, connections should be made in the same manner as the test for grounds. Key No. 3 should be thrown to the upper or V. M. G. position and key No. 4 to the upper or V. M. position. This will place the voltmeter directly in the circuit between L–1 and the ground and will show by a deflection of the voltmeter whether or not this wire is crossed with a grounded circuit line carrying current. By throwing key No. 2 to the lower or L. R. position the same test is made upon the wire in connection with L–2

instead of L–1. Care should be taken in making this test, for if the potential of the foreign current is greater than the voltage of the testing voltmeter, there is danger of injuring the voltmeter; therefore should the needle pass beyond the limit of the scale the instrument should be disconnected at once. In this test, should the voltmeter read in the wrong direction it may be reversed by throwing key No. 5 to the upper or V. M. R. position.

Test for crosses on other lines.

In making a test for a cross between two lines, a ground connection of the test set should be connected to the line which is suspected to cross with the line under test and test made in the same manner as

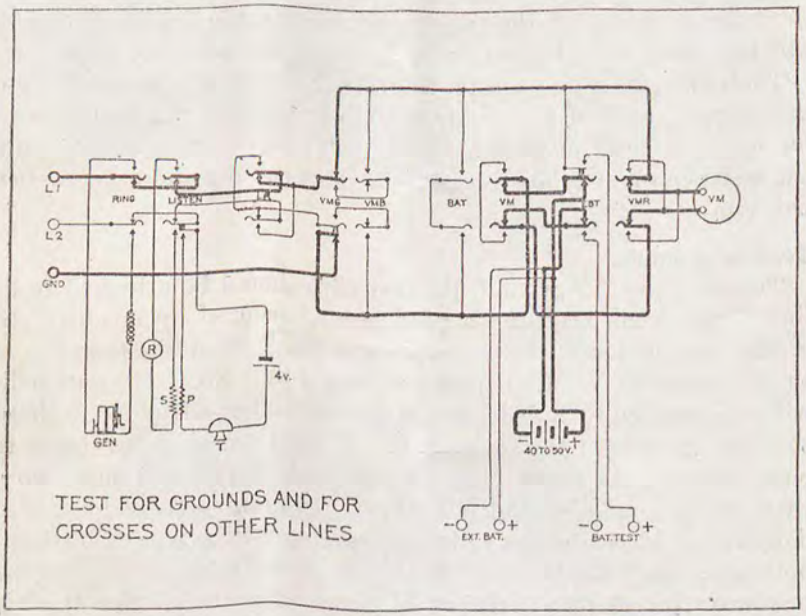

FIG. 9.

in "*Tests of grounds.*" After testing the line with key No. 3 in the upper or V. M. G. position and key No. 2 in its central or normal position, the latter key should be thrown to the lower or L. R. position, which will reverse the connections to L–1 and L–2, and the test repeated for L–2. If no deflection is observed on the voltmeter in either case, it will indicate that there is no cross between the line under test and the one suspected. If it is still believed that the line under test is crossed with some other line, it will be necessary to move the ground connection of the set from line to line and the test repeated on each of the other suspected lines. If a reading is obtained and is in the wrong direction, the voltmeter may be reversed by key No. 5 as in the previous test.

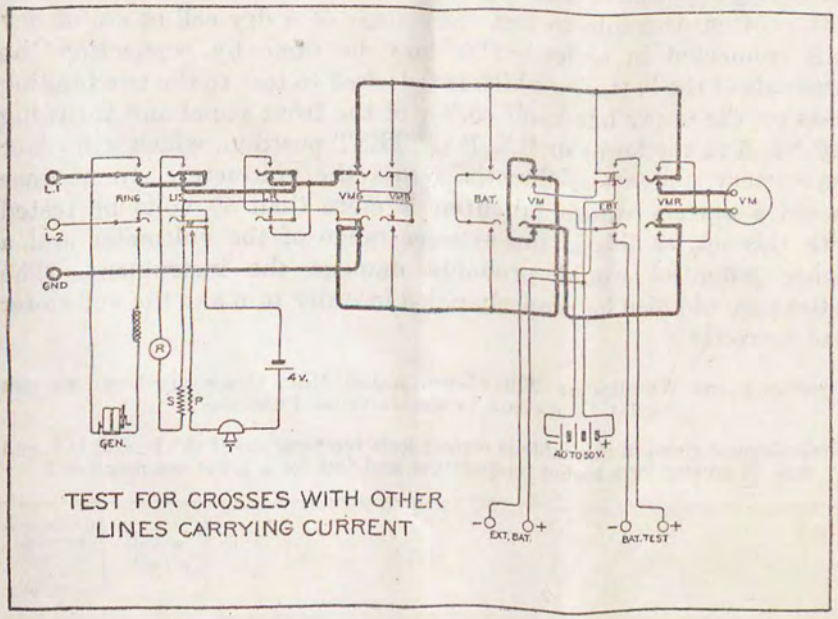
L1
L2
GND
RING
LISTEN
ER
VMG
VMR
BAT.
VM
TEST
VMR
VM
R
4 V.
S
P
GEN.
T
40 TO 50 V.
EXT. BAT.
BAT. TEST
TEST FOR CROSSES WITH OTHER
LINES CARRYING CURRENT

FIG. 10.

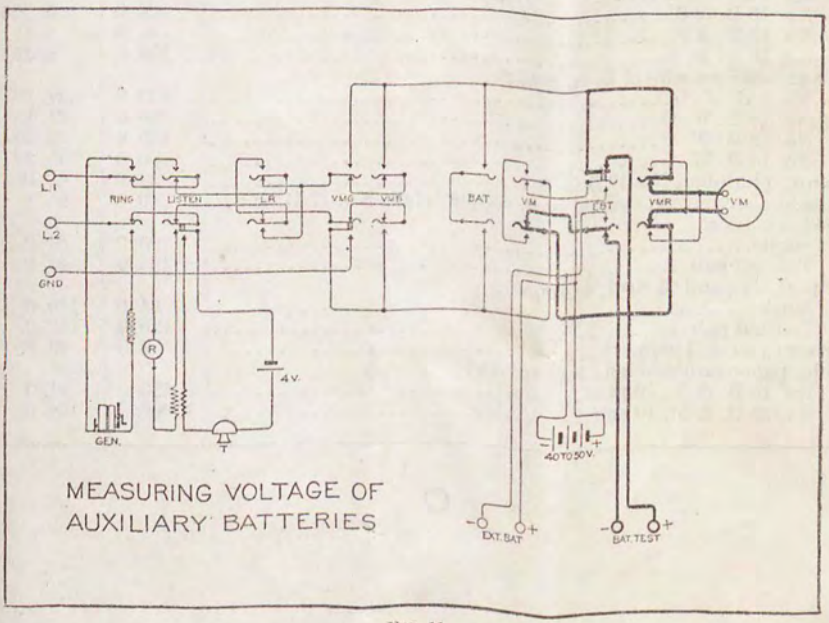
L1
L2
GND
RING
LISTEN
ER
VMG
VMR
BAT.
VM
TEST
VMR
VM
R
4 V.
GEN.
T
40 TO 50 V.
EXT. BAT.
BAT. TEST
MEASURING VOLTAGE OF
AUXILIARY BATTERIES

FIG. 11.

Measuring a voltage of auxiliary battery.

It is often desirable to test the voltage of a dry cell or set of dry cells connected in series. This may be done by connecting the terminals of the batteries which it is desired to test to the two binding posts on the upper left-hand corner of the front panel and throwing key No. 5 to the lower or EX. BAT. TEST position, which will place the battery under test directly across the voltmeter. In no case should a battery whose potential is more than 50 volts be tested with this set, as this is the extreme range of the voltmeter and a higher potential would probably damage the instrument. The battery should also be properly poled in order to make the voltmeter read correctly.

RESISTANCE AND WEIGHTS OF WIRES AND CABLES MOST COMMONLY USED BY THE SIGNAL CORPS FOR COMMUNICATION PURPOSES.

[The resistance given in this table is correct for a temperature of 68° F. (20° C.), and will be greater for a higher temperature and less for a lower temperature.]

	Weight per mile.	Resistance per mile of single wire, in ohms.
Hard-drawn bare copper wire:		
No. 8 B. & S.	264.0	3.31
No. 9 B. & S.	209.3	4.173
No. 10 B. & S.	166.0	5.264
No. 12 B. & S.	104.5	8.37
No. 14 N. B. S.	104.5	8.37
Galvanized-iron wire of B. B. grade:		
No. 9 B. W. G.	320.0	17.19
No. 10 B. W. G.	260.0	21.15
No. 12 B. W. G.	165.0	33.33
No. 14 B. W. G.	96.0	57.29
Bronze, phosphor, No. 17 B. & S.	33.0	42.0
Outside distributing, twisted pair, copper, clad, No. 17 B. & S.	240.0	95.1
Field, 11 strand:		
Single	90.0	51.0
Twisted pair	183.0	52.0
Outpost, 7 strand (3 steel, 4 bronze):		
Single	64.0	140.0
Twisted pair	130.0	142.0
Buzzer (2 steel, 1 copper)	7.0	40.8
Cable, paper insulated and lead covered:		
No. 19 B. & S., 10 pair	5,610.0	44.0
No. 22 B. & S., 10 pair	3,000.0	88.0