SIGNAL CORPS UNIVERSAL TEST SET, TYPE EE-65

WIRE COMMUNICATION
PAMPHLET NO. 7
(Second Edition)

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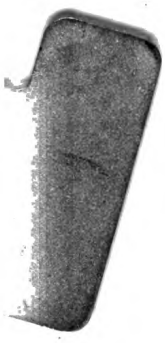

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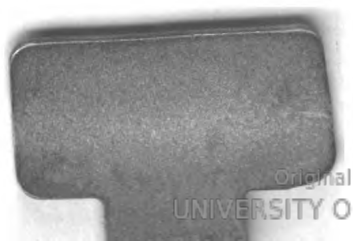


WAR DEPARTMENT,
WASHINGTON, *November 30, 1921.*

The following publication, entitled "Signal Corps Universal Test Set, Type EE–65," Wire Communication Pamphlet No. 7, is published for the information and guidance of all concerned.

[062.1, A. G. O.]

BY ORDER OF THE SECRETARY OF WAR:

JOHN J. PERSHING,
General of the Armies,
Chief of Staff.

OFFICIAL:

P. C. HARRIS,
The Adjutant General.

TABLE OF CONTENTS.

SIGNAL CORPS UNIVERSAL TEST SET, TYPE EE-65.

SECTION I.

PURPOSE OF SET.

1. *Testing equipment.*—This set has been designed to provide a wire chief's testing equipment in a compact, portable form, for use both in the field and in permanent central office installations. The complete testing, signaling, and talking equipment is installed in a substantial case, provided with a shoulder strap, and can easily be transported by one man. No additional equipment is necessary for its successful operation.

SECTION II.

DESCRIPTION OF SET.

2. *Set box.*—The set box consists of a wood case, metal bound, with hinged cover and is provided with a quick-acting latch lock, and in addition has two supports for attaching the carrying strap. The case acts as a support for the testing equipment; the entire set of keys, voltmeter, and generator, ringing and induction coil, together with the necessary wiring, being mounted on a hinged hard-rubber support. Within the case, a battery compartment is provided for the talking and testing batteries. A compartment on the left side of the test panel provides a carrying space for the transmitter and receiver, test cords, and clips. Inside the cover is a support for holding the ground rod and also a diagram of the wiring of the test set.

3. *The test unit.*—The test unit set up in position for service is shown in figure 1. The voltmeter at full scale reads 50 volts. Each space on the scale has the value of 1 volt, every fifth and tenth unit being shown by a longer line on the scale. The upper left-hand binding post is for the ground connection and is designated GND. The next two posts are the line terminals and are designated "L–1" and "L–2," respectively. The thumbscrew directly over the voltmeter locks the front panel in position. At the upper right-hand side are two binding posts for connecting any external source of electromotive force whose value it is desired to find. These posts are designated "BAT TEST," the left-hand one being the positive post.

The transmitter is connected to the two upper binding posts, located at the lower left-hand side of testing panel, and they are designated "TRANS." The testing receiver is connected to the next two binding posts, which are designated "REC." Two-way flexible cords are used for these connections, and in addition there is a supporting strand to take the strain from the terminals. The generator handle is located in the lower center of the panel. The two binding posts at the lower right-hand side of the panel provide terminals for an external testing battery, the upper one of the pair being the positive

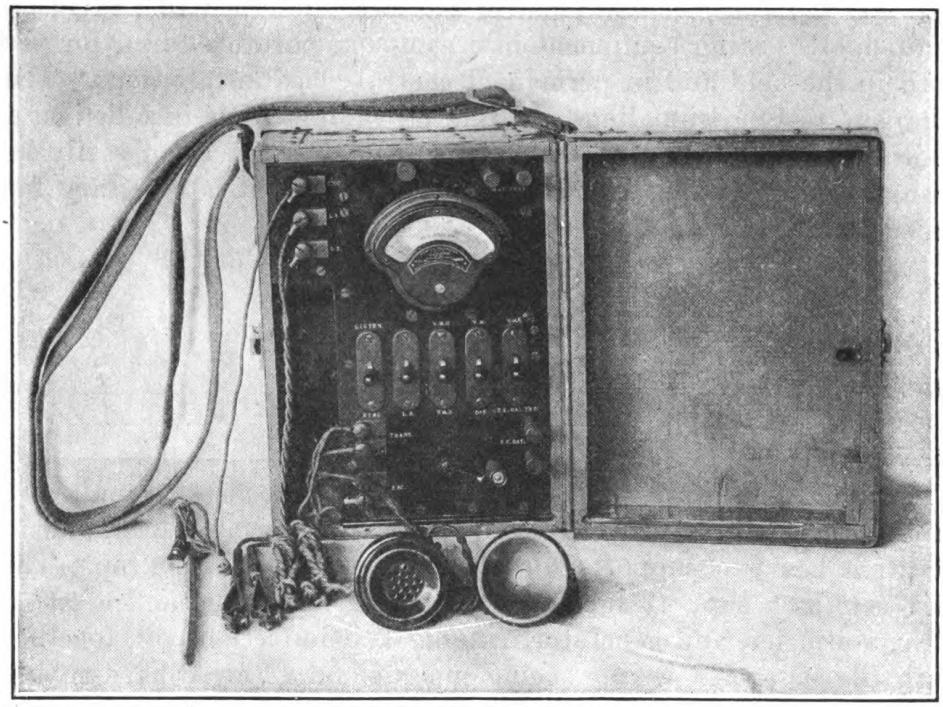


FIG. 1.—Universal test set ready for operation.

terminal. When an external battery is used, the battery within the case must be disconnected.

4. *Test keys and their uses.*—The various talking and testing circuits of the set are controlled by five keys mounted in a row in the center of the testing panel.

Key No. 1 when thrown up (locking position) is used for listening or talking. When pulled downward (nonlocking position) it is used for ringing out on the test leads, the generator crank being turned at the same time. The 80-ohm buzzer provides a signal to show whether or not the line is closed.

Key No. 2 can only be moved to the downward position and is used for reversing the test leads.

Key No. 3 when in the up position grounds the positive side of the test battery and also connects the other side of battery through the

voltmeter to L–1. This key is used when testing for grounds or a grounded foreign battery. When thrown to down position the voltmeter, in series with the testing battery, is connected directly across the test leads for locating crosses or making other resistance tests.

Key No. 4 when in the up position disconnects the testing battery and connects the voltmeter directly across L–1 (with key No. 3 toward "VMG") and ground. With the key in the down position, a means is provided for testing the voltage of the self-contained testing battery.

Key No. 5, in the up position, is used to reverse the terminals of the voltmeter. This relieves the tester from having to change his test leads when measuring external battery. In the down position the voltmeter is connected directly across the "BAT TEST" posts, for measuring any outside potential within the range of the voltmeter.

Various combinations of the above keys provide the necessary testing circuits for the usual magneto or common battery tests.

SECTION III.

GENERAL INSTRUCTIONS FOR USING THE SET.

5. *Tests.*—This set, as previously stated, has been designed to provide a means of making the usual tests for magneto or common battery requirements. In general the test set can be used either in a vertical or horizontal position. If the voltmeter fails to read "zero" with all keys normal, adjust the screw on the face of the voltmeter. The resistance of the voltmeter is approximately 3,000 ohms, and it is sufficiently sensitive to allow of measuring fairly high resistance.

The set can be used for making any one of several tests, detailed information and the theory involved appearing under the heading "Detailed Instructions for Using the Set."

SECTION IV.

DETAILED INSTRUCTIONS FOR USING THE SET.

6. *To ring substation or magneto exchange.*—Key No. 1 down, generator crank turned at the same time. Party line ringing signals can be made by moving the key from normal to down the required number of times. In this case it may be necessary to reverse the test leads. To signal or ring on a grounded line, L–1 clip should be connected to the desired line wire and L–2 clip grounded. Conditions will then be similar to ringing on a metallic line.

7. *To signal common battery exchange.*—Key No. 1 up. Receiver and secondary induction coil is bridged directly across the line and provides the necessary shunt to operate the central office signal. Care should be observed to see that the test receiver is connected with proper polarity to prevent possible injury to magnets. To test for this polarity, remove the receiver cap while current is flowing through the receiver. If the magnet strongly attracts the receiver diaphragm, the receiver is poled correctly.

8. *To talk to a magneto substation or office.*—Key No. 1 up. Receiver of set is now directly across test leads. To talk and listen, in addition to above, press small button on transmitter which supplies the 3-volt battery to the testing transmitter.

9. *To talk to a common battery station.*—While this set is not wired to supply talking battery to a C. B. substation, it is still possible to do this by wiring the set as follows:

Key No. 1 up as for talking on magneto lines: Connect L–1 and L–2 by pair of wires to external battery posts, in series with a 165-ohm retardation coil, and to the desired line by means of the test clips. This should only be used as an emergency method, as the drain on the test battery is excessive.

10. *Test for continuity of a metallic circuit.*—Key No. 3 down. The voltmeter is then connected in series with the testing battery, the combination being connected directly across the test leads L–1, L–2. The voltmeter reading, as compared with the reading on short circuit, will be a measure of the resistance of the external circuit. The greater the reading of the voltmeter when connected to the external circuit the smaller the value of the resistance being measured. A table will be found in the back of this pamphlet giving voltmeter readings and the equivalent resistance in ohms. An open line will not show any deflection of the voltmeter needle.

11. *Test for continuity of a grounded line.*—Key No. 3 up. Connect the ground post "GND" to a water pipe, or, if using the set

in the field, drive the ground rod in moist earth. Connect the line to the L–1 bending post. If the line is closed the voltmeter will give a reading as in paragraph 10.

12. *Test for a ground on a metallic line.*—Key No. 3 up. Connect L–1 and L–2 to the desired line. Connect post "GND" to ground, or use ground rod, as in paragraph 11. If voltmeter shows a reading the wire connected to L–1 is grounded. Next operate key No. 2 down. If no voltmeter reading shows, the L–2 wire, which has been substituted for the L–1 wire, by the operation of key No. 2, is clear. A case may develop where both sides of the line are grounded, or where the line is crossed and one side grounded. In this case the voltmeter will show a reading when key No. 3 is thrown downward. A partial check on the trouble may be had by carefully observing the difference, if any, of the voltmeter reading when key No. 3 is up and key No. 2 has been moved to the down position. The wire giving the greater reading will in most cases be the grounded wire.

13. *Test for capacity.*—(Such as station with condenser in bell circuit.) Key No. 3 down. Move key No. 2 to down and back to normal, observing the "throw" of the voltmeter needle. The set can be calibrated by reading the deflection on lines having one bell and condenser, two bells and two condensers, and so on. The condenser at the station is charged and then discharged by the opening and closing of the circuit under control of key No. 2.

14. *Test for an open.*—Key No. 3 up. Connect one line wire to L–1 and connect "GND" to ground; move key No. 4 up and back to normal. This measures the capacity between the wire and the earth. (See also paragraph 13.) Change the other line wire to L–1, if a metallic line, and measure that one and observe the reading. The distance can be found approximately by a comparison of these two reading. In the above case, it is assumed that any equipment at the distant end has been disconnected, or that the equipment is known, so that allowance can be made for condensers. It is assumed also that the line is not grounded.

15. *Test for crosses on lines carrying current.*—Key No. 3 up. Connect "GND" to ground. Key No. 4 up. If the foreign line has its battery grounded, such as a common battery telephone line or a telegraph line, a voltmeter deflection will be shown reading directly in volts. The value of this reading will serve to designate the type of circuit that has caused the trouble. If the voltmeter needle tends to move off scale in the reverse direction, move key No. 5 up, to reverse the voltmeter. In making measurements of this nature some knowledge of the potentials that may be present on the line is necessary. The reason for this is the possible injury or burning out of the voltmeter by connecting to lines carrying high voltage.

It should be remembered that many telegraph circuits have an applied voltage in excess of 100 volts. If the needle goes off scale, the tester should immediately restore key No. 3 to normal position to open the voltmeter circuit.

16. *Test for crosses with other lines.*—In addition to tests outlined in paragraph 15, it may be thought that two lines, *a* and *b*, are crossed. In this case L–1 is connected to one side of line *a*, and L–2 to each side of line *b* in turn; key No. 3 down, being used. If no reading shows, change L–1 to the other wire of line *a* and repeat test. A reading of the voltmeter shows a cross. A similar test for crosses with grounded lines may be made, either by grounding L–2 or changing key No. 3 to up and using L–1 and the ground rod as in paragraph 14.

17. *Measuring an external battery voltage.*—Connect the terminal marked "BAT TEST" to the battery whose voltage is desired. Be sure to connect the positive terminal of the battery to the left-hand or plus post. Key No. 5 (down) connects the voltmeter directly across these posts and will read potentials, within the capacity of the instrument. Care should be observed not to expose the voltmeter to potentials outside the range of the instrument.

18. *Ringing tests for crosses or grounds.*—This is a rapid means of testing a number of lines and is especially useful when a new system is being installed. To test for a cross, connect L–1 and L–2 to the desired line. Move key No. 1 down, rapidly turning the generator handle at the same time. If the line is open, the buzzer will not sound and the generator turns easily. If the line is closed—that is, the station bell connected to line—the generator turns readily and the buzzer sounds. A high resistance gives about the same test as a station. If the generator turns hard, the buzzer sounding also, a cross exists on the line under test. The degree of difficulty in turning the generator, and the loudness of the buzzer, may be taken as an estimate of the value of the resistance of the cross. To test for grounds, change L–2 to a ground connection and proceed as above. In making these tests it is best to operate the generator at a constant speed, so that the buzzer having once been adjusted may function correctly. Too high a speed increases the frequency of the alternating current given by the generator; it may be sufficiently high to give an inaccurate test by the non-response of the buzzer.

19. *To determine value of an unknown resistance.*—This method of testing is based on the principle that in any series circuit the various potentials in the circuit are proportional to the different resistances in the circuit. If the resistance of the voltmeter is known, the value of any other resistance may be calculated.

Let R = the resistance of the voltmeter.

Let V = the reading of the voltmeter when test leads are short-circuited. (Key No. 4 down.)

Let V' = the reading of the voltmeter when the test leads are connected to the unknown resistance, i. e., the voltage across the voltmeter. (Key No. 3 down.)

Then $V-V'$ = voltage across the resistance.

$$\text{Then } V' : V-V' :: R : X$$

$$\text{or } V'X=(V-V')R$$

$$X=\frac{(V-V')R}{V'} \qquad (1)$$

Example: The voltmeter reads 39.5 volts when the test leads are shorted. When the test leads were connected to a tubular drop, the reading of the voltmeter was 32.5 volts. What is the resistance of the drop? Resistance of voltmeters averages 3,000 ohms. Substituting in (1) above:

$$\frac{(39.5-32.5)\times 3000}{32.5}=\frac{7\times 3000}{32.5}=646 \text{ ohms. Answer.}$$

Example: Suppose it is desired to find the insulation resistance of a certain line. The voltmeter reading on short circuit was 40 volts. When the set was connected to the line, the voltmeter reading was 12 volts. Resistance of the voltmeter is 3,000 ohms. Then substituting in (1) above:

$$\frac{(40-12)\times 3000}{12}=\frac{84000}{12}=7000 \text{ ohms. Answer.}$$

This shows clearly that the smaller the reading of the voltmeter the higher the value of the resistance being measured. As the voltage of the battery falls off with age, frequent checks should be made when making resistance measurements.

20. *To determine the capacity between two wires.*—This method can be used roughly for determining the location of an open or break in the line. This method was referred to in paragraph 13; a simple method being shown for calibrating the set. To calibrate the set more accurately, proceed as follows:

a. Check the voltage of the test battery by operating key No. 4 to down position. Record this result.

b. Connect a 1 m. f. condenser (Type 21–M, Western Electric Co.) to the testing leads L–1, L–2. Move key No. 2 to down and back to normal. Read "throw" of needle and record.

c. A table can then be made as shown below:

Voltmeter battery reading, 39.5:

	1 m. f. = 4.50
Therefore	2 m. f. = 9.00
	3 m. f. = 13.50
	4 m. f. = 18.00

d. An application of the above can best be understood by a practical problem. An unknown condenser was tested, the voltmeter "throw" being 2.25 volts. What is its capacity?

Let C=the value of the standard (1 m. f.)
Let C′=the unknown value
Let D=voltmeter reading on standard
Let D′=voltmeter reading on unknown.
Then C : C′ :: D : D′
(Substituting) 1 : C′ :: 4.5 : 2.25

$$4.5\,C'=2.25$$

$$C'=\frac{2.25}{4.50}=.5 \text{ m. f.}$$

e. This same principle can be applied to the location of an open in a metallic line. If the distance, in feet or miles, between the two stations is known, the location test follows. The equipment at the terminal station must be disconnected. Test circuit for grounds and if clear proceed as follows:

Connect test lead L–1 to one line wire (the good one).

Ground the terminal marked "GND," operate the No. 3 key up.

Move key No. 4 up and back to normal, reading "throw" of voltmeter at the same time. Next change the other line wire to L–1. Read "throw" of voltmeter. Then the distance to the fault can be computed.

Let D=Voltmeter reading on first line wire.
Let D′=Voltmeter reading on second line wire.
Let L=Distance between stations.
Let X=Distance to fault.
Then D : D′=L : X

$$X=\frac{D'\times L}{D}$$

This test determines the capacity between either wire and the earth and is only an approximate location test, since the voltmeter is damped by the springs used to make it dead beat.

SECTION V.

PROCEDURE IN TESTING FOR AN UNKNOWN FAULT.

21. *Line out of order.*—In testing for an unknown fault the original report of the trouble will, in most cases, centralize it under one of the headings given in Section IV (Detailed instructions for using the set). The most difficult case is the report of the line being "out of order." Assume that such a report has been made on a given telephone line, the procedure would be as follows:

a. Make a voltmeter test to see if the line is closed.

b. Test for grounds.

c. Open line at central office protector frame and ring toward the switchboard to see that drop or signal functions.

d. Ring toward stations and try to call subscriber. After ringing, set keys for "Continuity of a metallic circuit" test. Observe voltmeter and if a deflection is shown after ringing, immediately change keys for position "Talk to magneto station." If party does not answer when this test is made, wait a few moments, ring station again, observe voltmeter and if needle is again deflected the trouble is at the station instrument; the most likely place being in the transmitter circuit. If trouble shows on some of the other tests (see *a*, *b*, *c*, above), it is evident that line trouble exists. For efficient testing a very complete record of the cables, lines, and instrument equipment is necessary; and in addition, a general knowledge of outside conditions, foreign wire circuits, pole line layouts, and so forth.

SECTION VI.

CARE AND ADJUSTMENT OF THE SET.

22. *Procedure.*—Figs. 2 and 3 shows the set box open for removal of battery or adjustment of the buzzer. Adjustment of the set to determine that it is in condition for use should be made as follows:

a. Inspect cords and terminals and see that all cords are securely held by their respective binding posts.

b. Connect a 1,000-ohm bell, that is in adjustment, across the test leads L–1, L–2. Operate ringing key No. 1 and turn generator handle, observing action of buzzer. If buzzer and bell do not respond, release ringing key, operate key No. 3 down. This shows whether the test leads are open or closed. A reading of the voltmeter signifies that the trouble is in the ringing key circuit. Key adjustment would be the most likely cause. If the station bell responded and buzzer did not, adjust buzzer by means of the two lock nuts on the vertical supporting posts until buzzer operates satisfactorily.

c. Operate key No. 4 down and read battery voltage. Voltage should be approximately 44 volts when battery is new. When voltage falls to 38 volts, new batteries should be installed. If new BA–2 batteries are not available a temporary external battery can be substituted by connecting 30 reserve dry cells in series and to the posts marked "EX BAT." Before connecting the external battery be sure that the old battery in the test set has been disconnected.

d. Operate key No. 1 up and short circuit the test leads L–1, L–2. Place receiver to your ear, press transmitter button, and blow lightly

into transmitter. If sound is reproduced clearly the BA–1 transmitter battery is in satisfactory condition.

e. Connect three or four cells in series and to the L–1 and L–2 leads. Operate key No. 4 up and if voltmeter shows a reading, this part of the circuit is functioning properly.

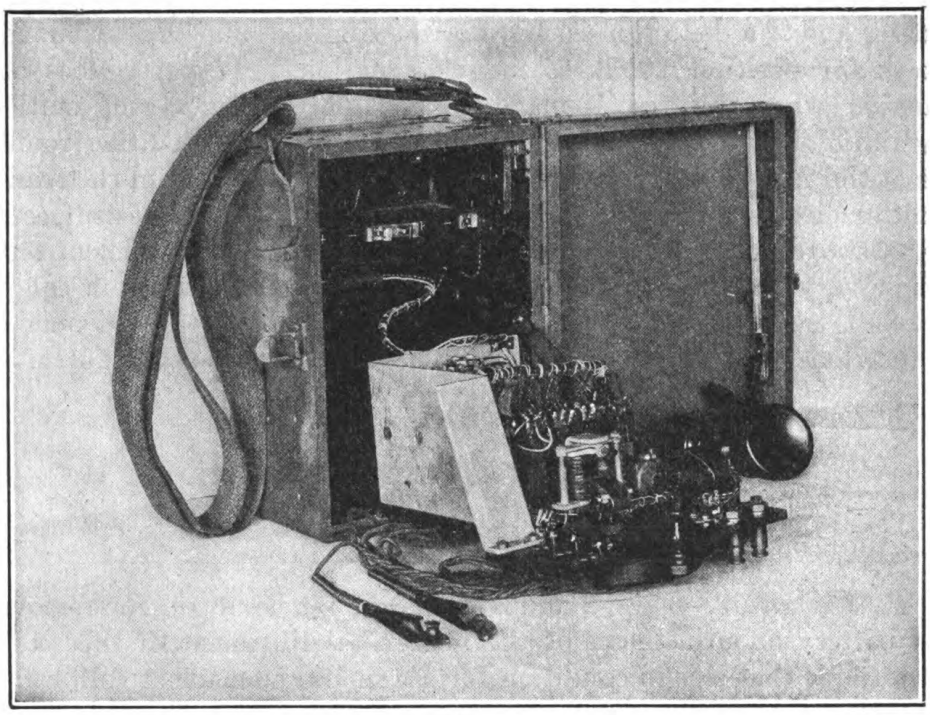


FIG. 2.—View of the interior of the test set.

f. Connect ground rod to L–1 test lead. Operate key No. 3 up. If circuit is working properly the needle should show a full scale reading on the voltmeter. This completes the check tests on the set and only occasional tests of this nature should be necessary. The most probable troubles that will develop in the set are battery and cord troubles. Care should be used to see that no strain is placed on the cord terminals, by using the reinforcement provided for this purpose.

SECTION VII.

TEST SET CIRCUITS.

23. *Theory.*—In figure 4 is shown the general wiring scheme of the set. These circuits will be discussed in detail in the following paragraphs. From the wiring diagram and the corresponding key designations the actual physical position of the equipment in the set and their electrical position in the various testing circuits can readily be seen.

a. Figure 5 shows the circuit when key No. 1 is in the down or ringing position. The trace of the circuit starts at L–1, through the long spring on L–1 side, through made spring (key No. 1 being operated), through automatic switch on generator shaft, generator, low-resistance buzzer, L–2 side made spring, long spring to L–2 post. This shows a series circuit, containing the magneto generator and buzzer, connected to the L–1, L–2 terminals.

b. Figure 6 shows the talking and listening circuits controlled by key No. 1 in the up position. Trace of circuit is from L–1 to long spring on "ringing" side of key, to inside of made spring, to long spring on "listen" side of key, to outside made spring, and to one

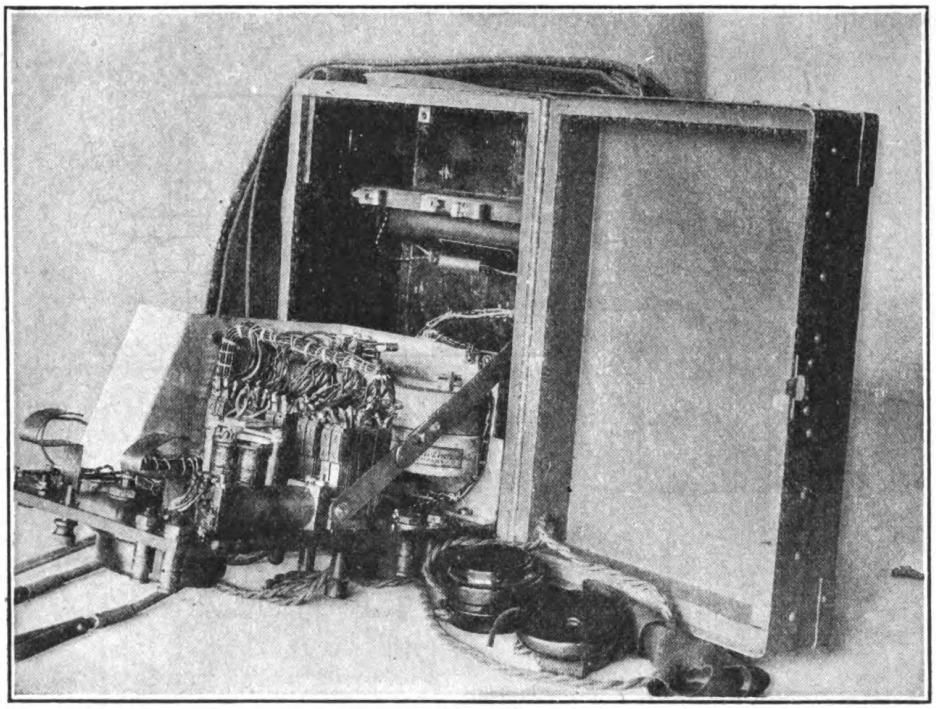


FIG. 3.—View of the interior of the test set.

side of receiver. From L–2 to long spring key No. 1 through made spring of key, to long spring, to outside made spring, to one side of secondary of induction coil, through coil to other side of receiver. The transmitter circuit starts at the positive side of 3-volt battery, through a pair of springs that are caused to make, whenever the key No. 1 is in the "listen" position, to "primary" of induction coil, to transmitter and the cut-out button (not shown), through transmitter to the negative side of the transmitter battery. The varying currents, set up by the transmitter, are impressed on the secondary side, through the action of the induction coil.

c. In figure 7 the circuit for measuring the potential or voltage of the testing battery is shown. Key No. 4 (down) opens the circuit

toward L–1, L–2, and places a short circuit across the remaining section of the test wires. The necessity for disconnecting the self-contained battery when an external testing battery is used is clearly shown in this diagram. The trace of the circuit for this test is from the positive terminal of the 40-volt battery to the inside spring of key No. 5 on the "EX BAT TEST" side, through the long spring to inside made spring on key No. 4 (VM side), through long spring on L–1 side of same key, through made spring of key No. 4, "BAT" side, through the long spring to corresponding pair of springs, L–1 side, to long spring key No. 5 (VMR), through inside made spring to voltmeter. The other side starts at the negative terminal of bat-

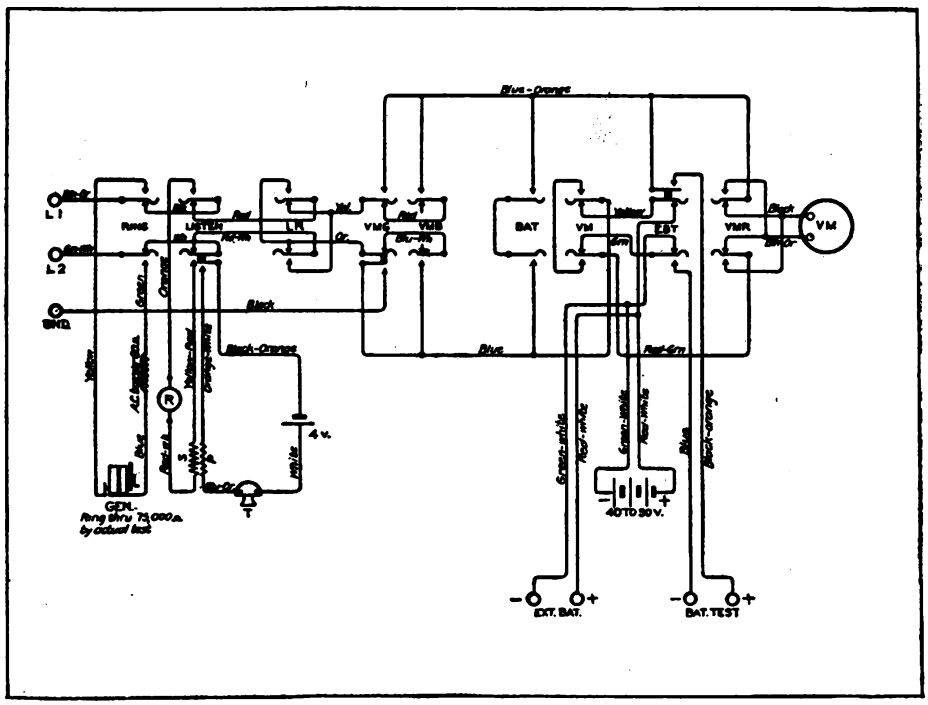


FIG. 4.

tery, through inside key No. 5 (EX BAT TEST), through long spring to inside spring key No. 4 (VM), to corresponding long spring, to long spring key No. 5 (VMR), through corresponding inside made spring to voltmeter. This key circuit serves to connect the voltmeter directly across the test battery and therefore measures the potential of the battery.

d. Figure 8 shows the circuit for testing the continuity of a circuit, or the resistance of any metallic circuit. The trace of the circuit for these tests is from L–1 to the long spring L–1 side of key No. 1 (ring), through the inside made spring to the long spring, same key (listen), to the inside made spring, to long spring key No. 2 (LR), through inside made spring, to long spring, key No. 3 (VMG), to inside made

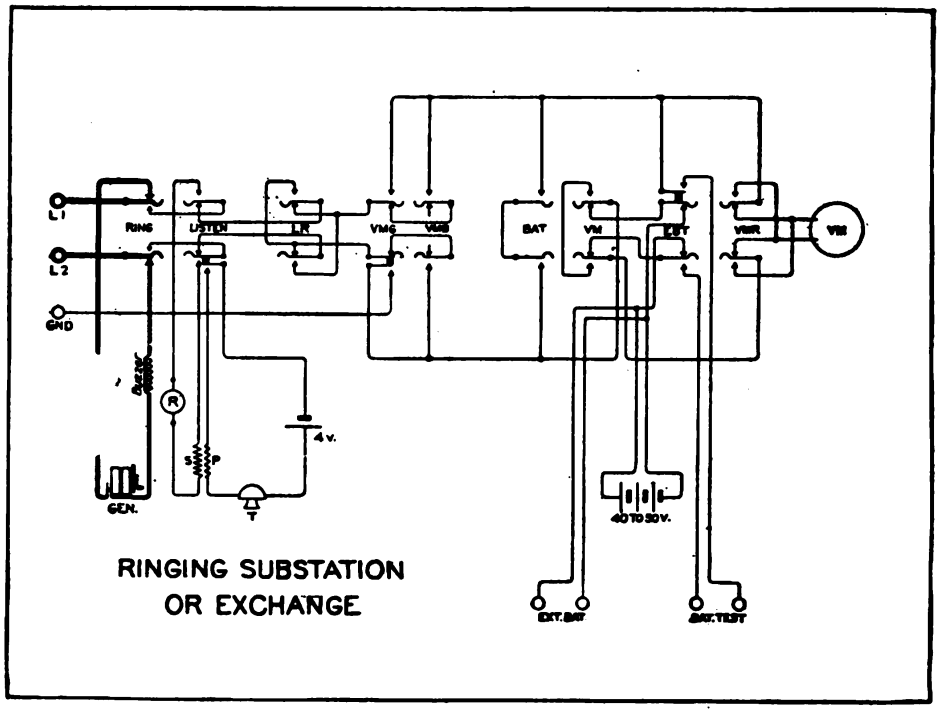


FIG. 5.

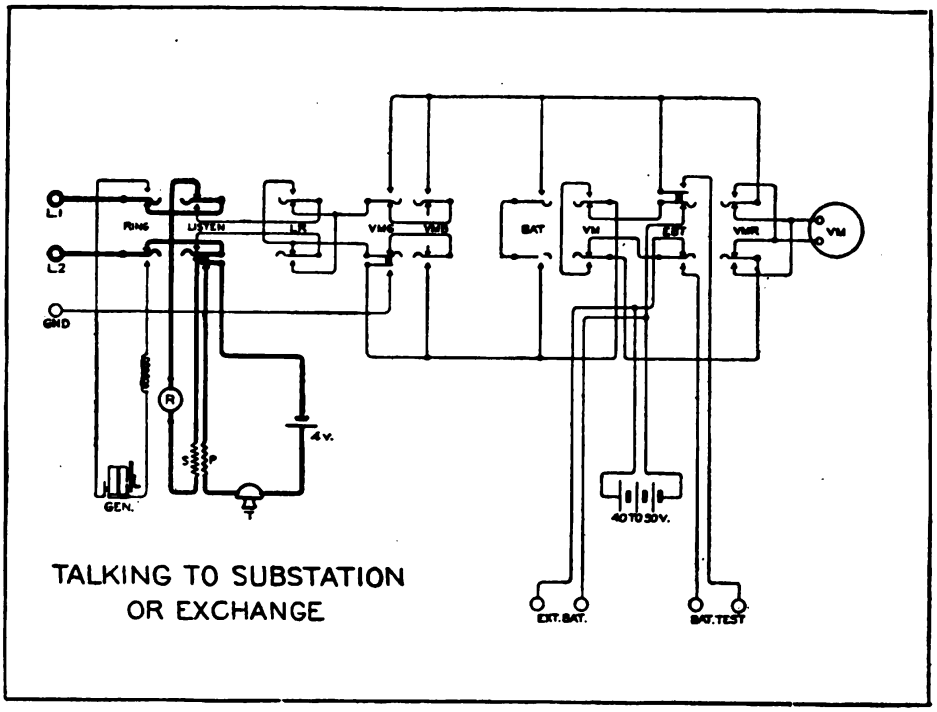


FIG. 6.

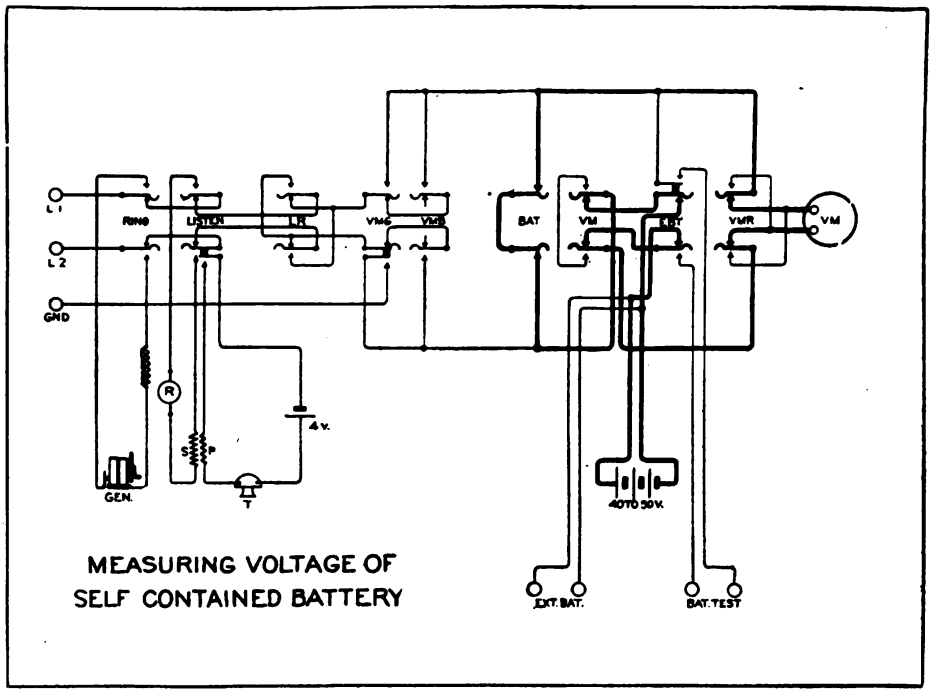


FIG. 7.

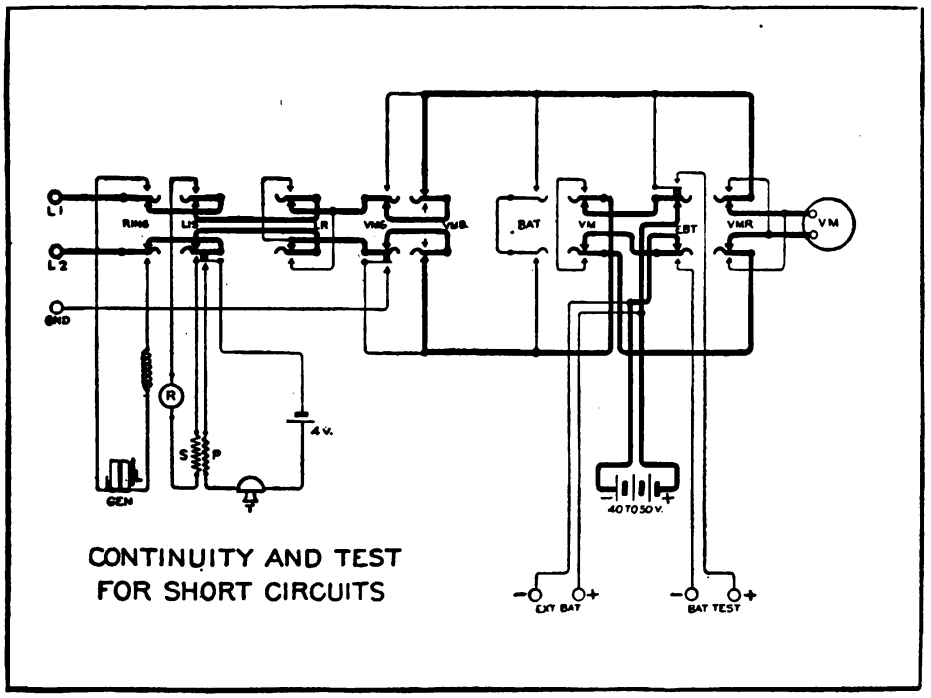


FIG. 8.

spring, to long spring, same key operated to down position (VMB), to outside made spring, to long spring, key No. 5 (VMR), through inside made spring, to one side of the voltmeter. From L–2 to long spring, key No. 1 (ring), to inside made spring, to long spring, same key (listen), to inside made spring, to long spring, key No. 2 (LR), through made spring to long spring, key No. 3 (VMG), to inside made spring, to long spring, same key (VMB) operated to down position, through outside made spring, to long spring, key No. 4 (VM), through inside made spring, to long spring, to L–1 side key No. 5 (EX BAT), through inside made spring, to positive side of 40-volt battery. From the negative side of battery to inside made

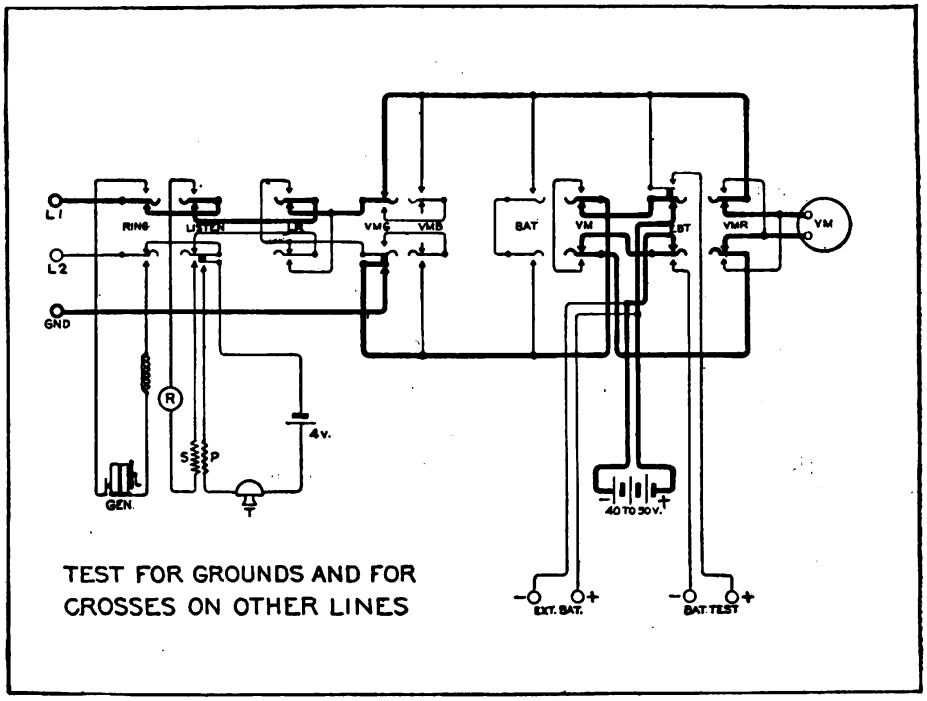


FIG. 9.

spring, key No. 5 (EX BAT), through long spring, same key, to inside spring key No. 4 (VM), to long spring, to long spring key No. 5 (VMR), through inside made spring, same key, to remaining voltmeter terminals. This circuit as previously explained connects the battery and voltmeter in series and across the L–1, L–2 leads.

e. Figure 9 shows the circuit for testing for grounds or crosses with other lines. The trace of the circuit starts at the L–1 terminal, to long spring of key No. 1 (ring), through inside made spring, to long spring, same key (listen), through the inside made spring, to long spring, key No. 2 (LR), through the inside made spring, same key, to the long spring, key No. 3 (VMG), to the outside made spring (the key being operated in the up position), to the long spring, key No. 5 (VMR), through inside made spring, to one terminal of the voltmeter. The trace of the other side of the circuit starts at the "GND"

post, through the outside made spring, key No. 3 (VMG) (the key being operated), through the insulated spring, to the long spring, key No. 4 (VM), through the inside made spring, through the long spring, same key (EX BAT), through the inside made spring, to the positive terminal of the battery. From the negative terminal of the battery the circuit is continued to the inside made spring, key No. 4 (EX BAT), through the long spring, to the inside made spring, same key (VM), through the long spring, to the long spring, key No. 5 (VMR), through the inside made spring, to the other terminal of the voltmeter. The circuit connects the testing battery in

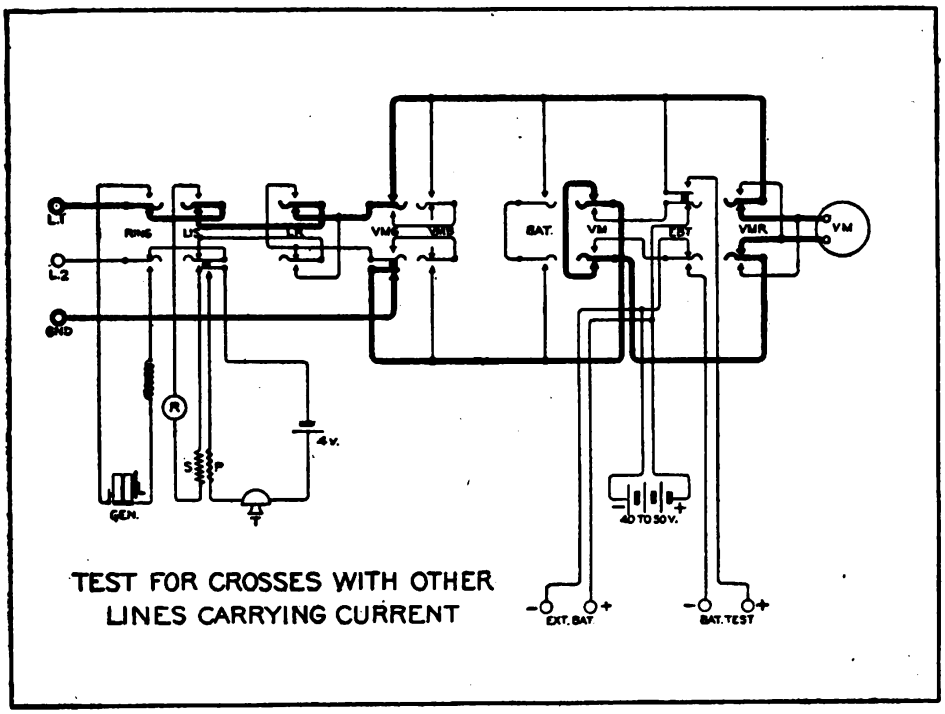


FIG. 10.

series with the voltmeter and across the L–1 and "GND" terminals. It is similar to the circuit shown for resistance tests.

f. Figure 10 shows the circuit for crosses with lines carrying current. The trace of the circuit is similar to the circuit in *e* above, except that key No. 4 has been operated to the up position (VM), in addition to key No. 3 given in *e*. This change cuts off the test battery and closes the voltmeter circuit directly across the L–1 and "GND" terminals. Therefore a foreign potential can be measured by the voltmeter.

g. Figure 11 shows the circuit for measuring the voltage of any source of current that may be connected across the "BAT TEST" posts. The trace of the circuit is from the left hand "BAT TEST" post (positive) to the L–1 side of outside made spring, key No. 5 (EX BAT TEST) (the key being operated in the down position),

through the insulated made spring to the long spring, same key (VMR), through the inside made spring to one terminal of the voltmeter. From the negative "BAT TEST" post to the outside made spring, key No. 5 (EX BAT TEST), through the long spring to the inside made spring, key No. 4 (VM), through the long spring to the long L–2 side spring, key No. 5 (VMR), through the inside made spring, to the other voltmeter terminal. This circuit connects the voltmeter across the "BAT TEST" posts and, at the same time,

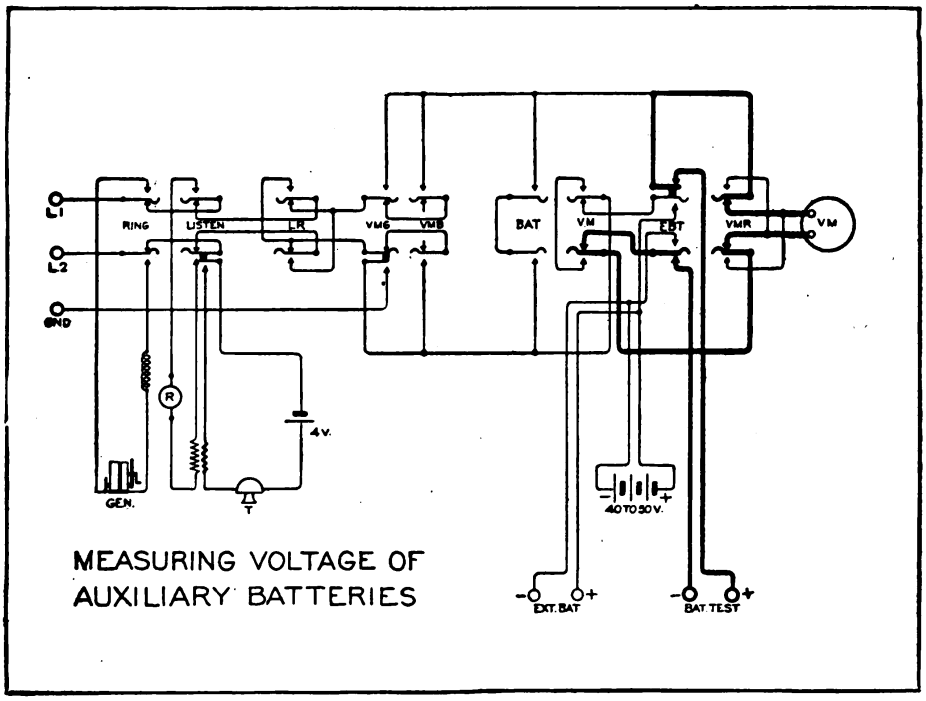


FIG. 11.

disconnects it from the test terminals and the testing battery. Care should be used to keep the potentials, whose values are to be determined, within the range of the voltmeter. Also see that the positive terminal of the desired battery is connected to the positive terminal of the set. Excessive battery voltages may injure the voltmeter and a reversed battery may bend the needle, thus causing it to become inaccurate.

SECTION VIII.

USEFUL TABLES.

24. *Wire.*—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 degrees F. (20 degrees 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.
	Pounds.	*Ohms.*
Hard-drawn bare copper wire:		
No. 8, B. & S.	264.0	3.310
No. 9, B. & S.	209.3	4.173
No. 10, B. & S.	166.0	5.264
No. 12, B. & S.	104.5	8.370
No. 14, N. B. S.	104.5	8.370
Galvanized-iron wire of B. B. grade:		
No. 9, B. W. G.	320	17.19
No. 10, B. W. G.	260	21.15
No. 12, B. W. G.	165	33.33
No. 14, B. W. G.	96	57.29
Bronze, phosper, No. 17, B. & S.	33	42.0
Outside distributing, twisted pair, copper clad, No. 17, B. & S.	240	95.1
Field, 11 strand:		
Single	90	51.0
Twisted pair	183	52.0
Outpost, 7-strand (3-steel, 4-bronze):		
Single	64	140.0
Twisted pair	130	142.0
Buzzer (2-steel, 1-copper)	7	32.0
Cable, paper insulated and lead covered:		
No. 19, B. & S., 10 pair	5,610	44.0
No. 22, B. & S., 10 pair	3,000	88.0

Average number of feet per ohm in No. 22 gauge lead-covered cable, allowance being made for spiraling:

Number of pairs.	At 60 degrees F.	At 80 degrees F.
10 to 50 pairs	62.76	60.19
100 pairs	62.58	60.00
200 pairs	62.14	59.58

25. *Insulation resistance.*—Value of V' with corresponding values of X (resistance) with test battery at 40 volts. (See par. 10.) The resistance of the volt meter is *assumed* to be 3,000 ohms.

When V' equals 1, then X equals 117,000 ohms.
When V' equals 2, then X equals 57,000 ohms.
When V' equals 3, then X equals 37,000 ohms.
When V' equals 4, then X equals 36,000 ohms.
When V' equals 5, then X equals 21,000 ohms.
When V' equals 6, then X equals 17,000 ohms.
When V' equals 7, then X equals 14,140 ohms.
When V' equals 8, then X equals 12,000 ohms.
When V' equals 9, then X equals 10,330 ohms.
When V' equals 10, then X equals 9,000 ohms.
When V' equals 11, then X equals 7,900 ohms.
When V' equals 12, then X equals 7,000 ohms.
When V' equals 13, then X equals 6,230 ohms.

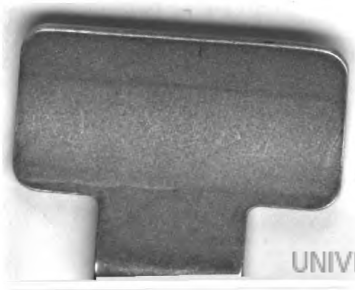
When V' equals 14, then X equals 5,570 ohms.
When V' equals 15, then X equals 5,000 ohms.
When V' equals 16, then X equals 4,500 ohms.
When V' equals 17, then X equals 4,050 ohms.
When V' equals 18, then X equals 3,660 ohms.
When V' equals 19, then X equals 3,320 ohms.
When V' equals 20, then X equals 3,000 ohms.
When V' equals 25, then X equals 1,500 ohms.
When V' equals 30, then X equals 1,000 ohms.
When V' equals 35, then X equals 428 ohms.
When V' equals 40, then X equals 0 ohm.

SECTION IX.

PARTS LIST.

26. Parts list—

1 battery, type BA–1, for transmitter.
2 batteries, type BA–2, for test set.
1 buzzer, alternating current, 80 ohms.
1 case, carrying, 6 inches deep by 8¼ inches wide by 10⅞ inches high; weight, complete, 14 pounds.
2 clips, test, with cord and terminals.
1 generator, hand, with handle.
1 ground rod, with cord and terminals.
1 induction coil, local battery.
5 keys, test, with red rubber handles.
1 receiver, hand, with head strap, cords, and terminals, No. 84–B.
1 strap, carrying.
1 transmitter, complete with cut-out button, cords, and terminals, local battery.
1 voltmeter, Weston, Model 280, 0–50 volts, D. C., back connected.



SIGNAL CORPS PAMPHLETS.

(Corrected to Feb. 1, 1921.)

SIGNAL CORPS PAMPHLETS.

(Formerly designated radio pamphlets.)

No.
1. Elementary Principles of Radio Telegraphy and Telephony (edition of 4–28–21) (WDD 1064).
2. Antenna Systems.
3. Radio Receiving Sets (SCR–54 and SCR–54–A) and Vacuum Tube Detector Equipment (Type DT–3–A).
5. Airplane Radio Telegraph Transmitting Sets (Types SCR–65 and 65–A).
9. Amplifiers and Helerodynes (WDD No. 1092).
11. Radio Telegraph Transmitting Sets (SCR–74; SCR–74–A).
13. Airplane Radio Telegraph Transmitting Set (Type SCR–73).
14. Radio Telegraph Transmitting Set (Type SCR–69).
17. Sets, U. W. Radio Telegraph (Types SCR–79–A and SCR–99) (WDD No. 1084).
20. Airplane Radio Telephone Sets (Types SCR–68; SCR–68–A; SCR–114; SCR–116; SCR–59; SCR–59–A; SCR–75; SCR–115).
22. Ground Radio Telephone Sets (Types SCR–67; SCR–67–A) (WDD No. 1091).
23. U. W. Airplane Radio Telegraph Set (Type SCR–80).
24. Tank Radio Telegraph Set (Type SCR–78–A).
25. Set, Radio Telegraph, Type SCR–105 (WDD No. 1077).
26. Sets, U. W. Radio Telegraph, Types SCR–127 and SCR–130 (WDD No. 1056).
28. Wavemeters and Decremeters (WDD No. 1094).
30. The Radio Mechanic and the Airplane.
40. The Principles Underlying Radio Communication (edition of May, 1921) (WDD No. 1069).

WIRE COMMUNICATION PAMPHLETS.

(Formerly designated electrical engineering pamphlets.)

1. The Buzzerphone (Type EE–1).
2. Monocord Switchboards of Units Type EE–2 and Type EE–2–A and Monocord Switchboard Operator's Set Type EE–64 (WDD No. 1081).
3. Field Telephones (Types EE–3; EE–4; EE–5).
4. Laying Cable in the Forward Area (formerly designated Training Pamphlet No. 3).
6. Trench Line Construction (formerly designated Training Pamphlet No. 6–a).
7. Signal Corps Universal Test Set, Type EE–65 (WDD No. 1020) (2d edition).
10. Wire Axis Installation and Maintenance Within the Division (WDD No. 1068).

TRAINING PAMPHLETS.

1. Elementary Electricity (edition of 1–1–21) (WDD No. 1055).
4. Visual Signaling.
7. Primary Batteries (formerly designated Radio Pamphlet No. 7).
8. Storage Batteries (formerly designated Radio Pamphlet No. 8).

FIELD PAMPHLETS.

1. Directions for Using the 24–CM Signal Lamp (Type EE–7).
2. Directions for Using the 14–CM Signal Lamp (Type EE–6).