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**Two-Way T. P. S. Set**  
**Type SCR-76-A**



**RADIO PAMPHLET No. 19**

**April 20, 1919**

**Signal Corps, U. S. Army**



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## Two-Way T. P. S. Set. Type SCR-76-A.

**T**HE TYPE SCR-76-A SET is a transmitting and receiving set for ground telegraph work (t. p. s. or earth induction), and is therefore to be used at stations where two-way communication is necessary. It is practically an assembly of the type SCR-71 t. p. s. buzzer and the type SCR-72 amplifier (with some important changes in design) into a single unit to facilitate the installation and use of the two when both are required at one location. The set comprises an adjustable frequency power buzzer, a telegraph key for sending, and a two-stage vacuum tube low frequency amplifier for receiving. The power required to operate the buzzer and to light the filaments of the vacuum tubes is derived from a 10-volt storage battery. Provision is made for operating the buzzer from a 20-volt battery should extreme conditions demand a higher output than is possible with the use of a 10-volt battery.

### . Principles and Description.

The principle of operation of the type SCR-76-A set is illustrated in the wiring diagram given herewith, Fig. 1. In general it consists of generating by induction, high potential current of audio frequency, which is caused to flow through the ground between two ground terminals separated by about 500 ft. In flowing through the ground the lines of current spread out in all directions, so that some of them may be intercepted at considerable distances by a suitable receiving device similarly connected to the ground and sensitive enough to respond to the extremely small currents thus received by conduction through the earth. Then by breaking up the pulsating emf. impressed on the ground into dots and dashes, it is possible to read the signals at the receiving station.

In the two-way t. p. s. set, the same ground connections and the same 10-volt storage battery are used for both sending and receiving, this being accomplished by means of a double pole double throw "Transmit-Receive" switch mounted on the panel of the set.

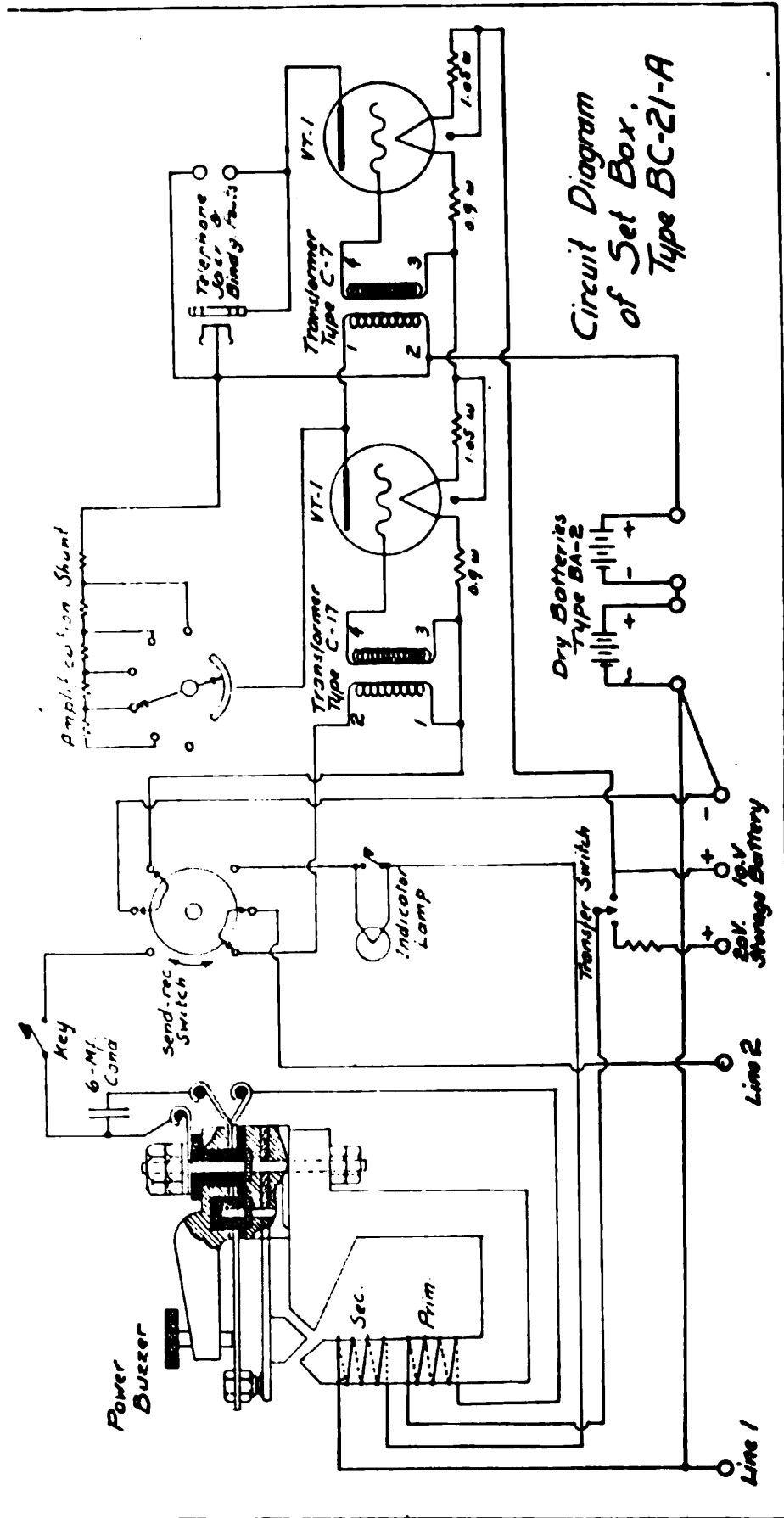


FIG. 1.—Schematic Circuit Diagram of Set Box Type BC-21-A Which Forms a Part of Set Type SCR-76-A.

With the switch in the "Transmit" position, the local circuit from the storage battery through the sending key and the primary of the power buzzer is completed and the base line wires are connected directly to the secondary or high potential winding. When the sending key is closed, the vibrator interrupter makes and breaks the current through the primary winding at a frequency which is controlled by means of small weights screwed to the vibrating armature. Six different frequencies are possible, as listed under a later paragraph (par. 9 of "Method of Operating"). The pulsating primary current resulting from the action of the buzzer induces an alternating emf. of high potential in the secondary winding.

The power buzzer is a double winding, closed magnetic circuit, buzzer interrupter, of practically the same construction as the SCR-71 t. p. s. buzzer. As in the SCR-71 buzzer, a condenser is connected across the vibrator contact points to reduce the spark and improve operation. For every change of frequency, the screw on top of the buzzer should be adjusted to give a good clear note, and then locked in position. The adjustment should be made as tight as possible and still give a clear note, as the current into the ground will then be a maximum.

The proper setting of the vibrator adjustment may be obtained by depressing the "Line Lamp" switch on the face of the panel and holding down the key with the "Send-Receive" switch in the "Send" position. The vibrator screw should then be adjusted until the line lamp glows at maximum brilliancy.

When it is desirable to operate the buzzer at 20 volts input, an additional 10-volt storage battery is required. This second battery is connected in series with the first battery without disconnecting the leads used for 10-volt operation (these are necessary for lighting the filaments for receiving), and the positive terminal is connected to the third (rear) binding post on the right side of the set. The transfer switch, located inside the set box on the back of the box is thrown to the right.

**CAUTION.**—Under no condition should 20 volts be applied to two forward battery binding posts, since this would result in burning out the tube filaments when the "Send-Receive" switch is turned to "Receive."

For good operation of the buzzer, the vibrator contact points must be clean, and the surfaces even and parallel. After some time, these contact points may become pitted and require cleaning and truing

up. It is best not to use the file furnished with the set, but to remove the contacts from the vibrator and rub them gently on a piece of emery cloth laid on a flat surface. Only in exceptional cases will it be found necessary to use the file or to replace the contact points with the spare ones furnished with the set.



FIG. 2.—Set Box Type BC-21-A as it Appears Closed Up Ready for Transportation.

With the switch closed in the "Receive" position, the base and 10-volt battery are connected to the amplifier. This is a low frequency, two-stage amplifier, using two type VT-1 three-electrode vacuum tubes connected for cascade amplification by means of two iron core transformers. Jacks and binding posts for connecting telephone receivers are provided in the plate circuit of the last tube. The fila-



ments of the two tubes are connected in series to the 10-volt storage battery. Four fixed resistances having a total value of 3.9 ohms are in series with the filament circuit. These resistances are so con-

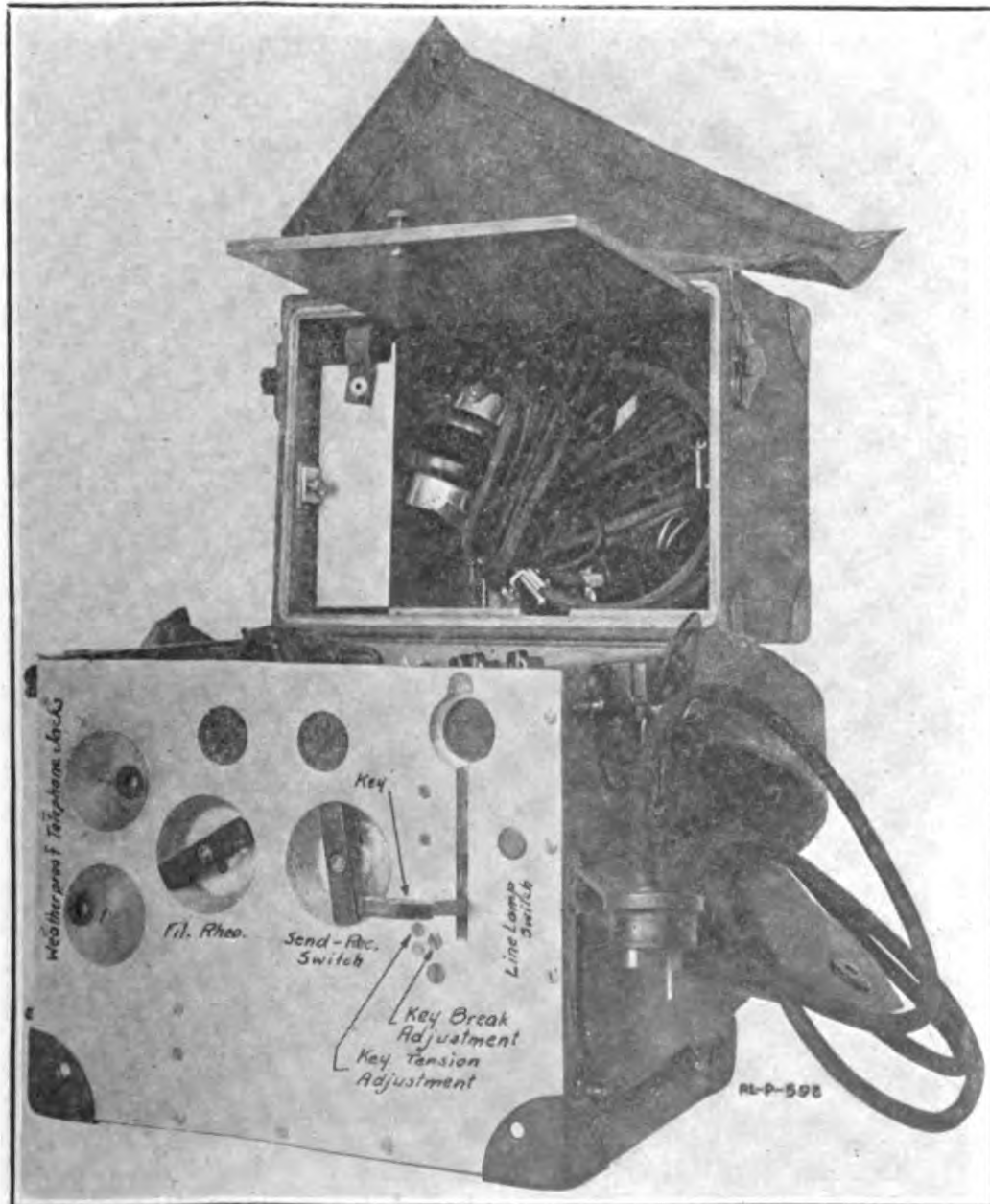


FIG. 3.—Set Box Type BC-21-A Opened to Show Upper Compartment for the Head Sets. This is Normally Closed While Operating and the Panel Exposed by Fastening the Canvas Flap Up.

nected as to allow the substitution of VT-11 or VT-21 tubes for the VT-1 tubes normally furnished with the set, without changing the internal connections of the set. There is no variable resistance in

series with the filament circuit. Variation of amplification is obtained by shunting the primary of the second transformer with a resistance. A switch marked "Amplification" is provided on the face of the panel for this purpose. A plate potential of about 45

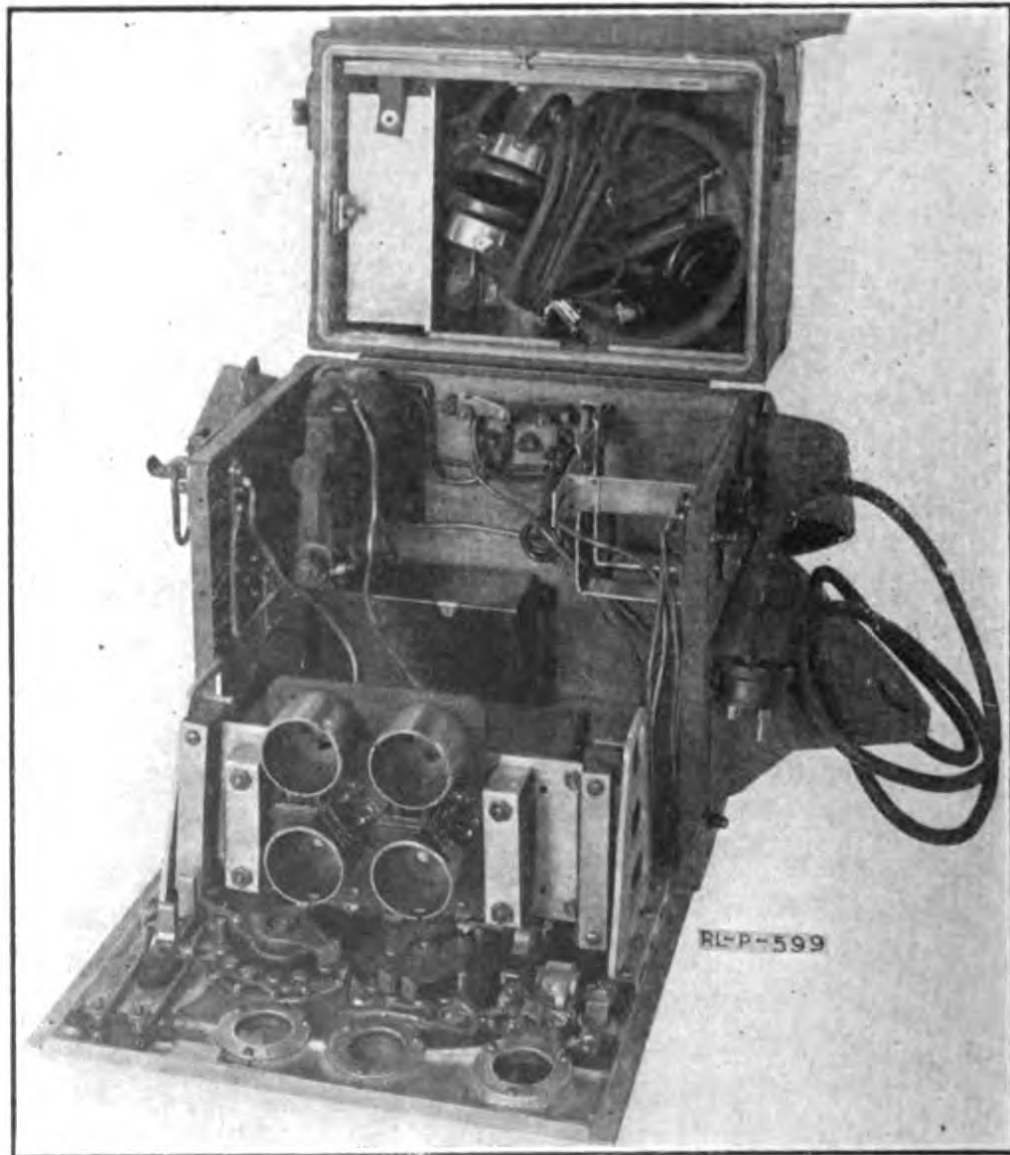


FIG. 4.—Panel of Set Box Type BC 21-A Opened Forward to Show Mounting of Various Apparatus. Note Transfer Switch or Strap on the Back (Top Center) of the Box.

volts is obtained for both tubes by means of two type BA-2 dry batteries connected in series. When the battery voltage has run down to 34 volts (17 volts each) the batteries should be replaced.

When it is necessary to replace the dry batteries of the amplifier circuit, particular care must be taken to see that they are connected

in with the correct polarity. This is essential for the operation of the vacuum tubes. It is also necessary that both vacuum tubes be in good condition, since the amplifier can not operate on one tube only, with the other one broken, burned out, or out of the circuit. If the amplifier does not work properly, this may be due to a poor

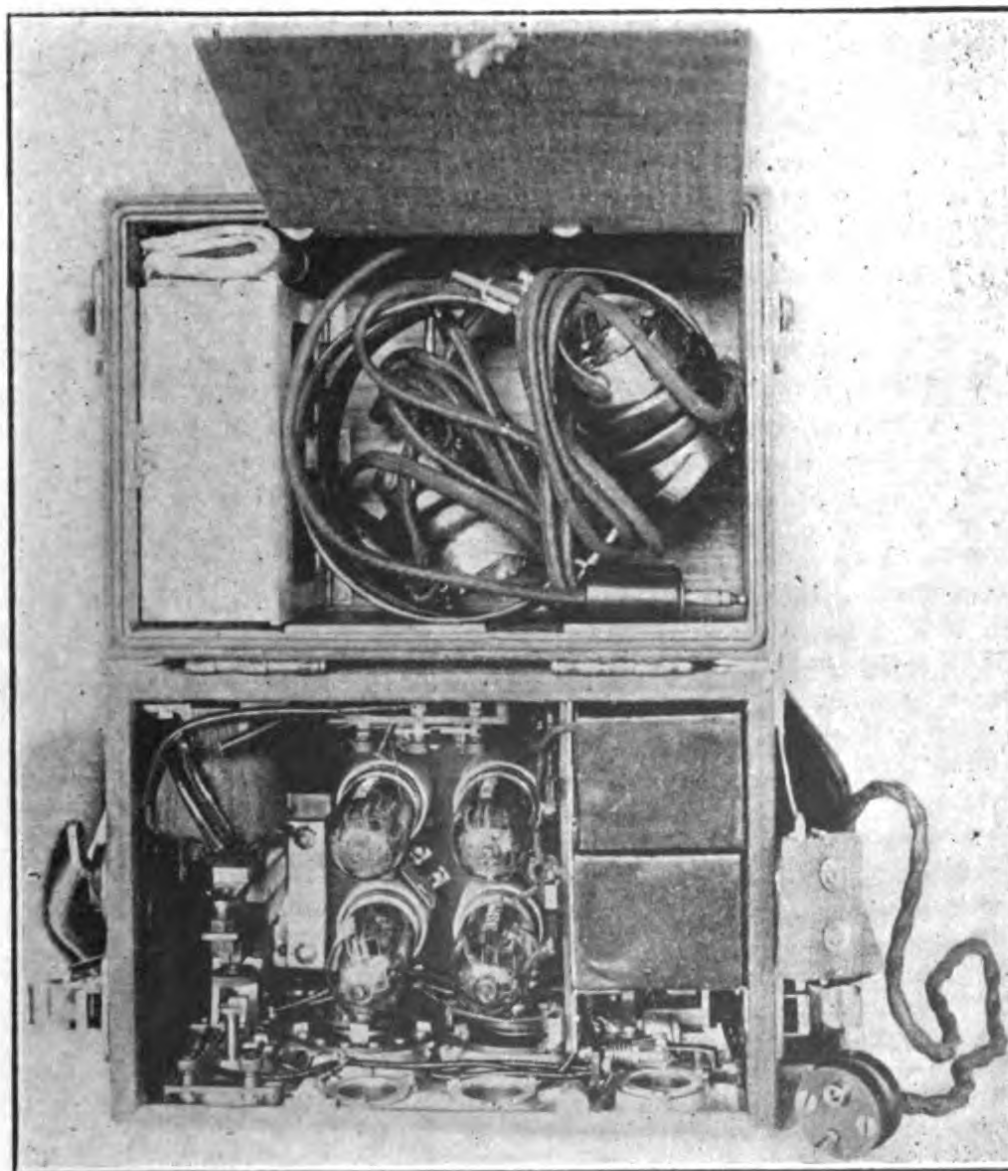


FIG. 5.—Looking Down on the Top of Set Box Type BC-21-A with Top Compartment Opened.

telephone connection, or to a wrong connection of either the storage or the dry batteries, or to the failure of one of the tubes.

When the set is not in use, the transmit-receive switch should be in the "Off" position, as this will avoid any possibility of unnecessarily running down the storage battery.



**Mounting of the Set.**—The set is mounted in a rugged canvas covered wooden case, having the overall dimensions of  $12\frac{1}{2}$  in. x  $10\frac{1}{2}$  in. x  $7\frac{1}{2}$  in. This case is provided with one lid which closes against a rubber gasket and is held tightly by two strong toggle latches. The panel is protected by a canvas cover which buckles over the face of the set. This construction makes the set fairly waterproof, especially if care is taken to keep the rubber gaskets clean and free from dirt or mud before clamping the lid shut.

The lid carries two Headsets, Type P-11, two Batteries, Type BA-2, and a tool roll containing tools, vibrator weights, and spare parts for the buzzer. The two spare vacuum tubes are carried on the same tube base mounting that carries the operating tubes. Two spare line lamps are carried in sockets located below the transfer switch. The battery cord for standard 10-volt operation of the set is permanently connected to the battery binding posts and is carried in the pocket on the outside of the set. This cord is provided with a standard plug for making battery connection.

**Opening a Station.**—To open a station, the base line, approximately 500 ft. long, is established in accord with the rules laid down below, and connected to the line binding posts on the left hand end of the set. The battery cord is removed from the pocket and connected to the battery. The canvas cover over the panel is then unbuckled and catches released so that the lid may be thrown back. The telephones are then removed from the lid and inserted in the telephone jack. The lid should now be closed to protect the set. This operation is of especial importance, particularly during bad weather. By moving the switch to "Receive" and setting the "Amplification" switch to "Max," the set is ready for receiving signals. If it is desired to send a message, the switch is thrown to "Send" and the key is revolved down in the operating position. Should the buzzer require adjusting, it will be necessary to open the lid. This is also necessary in the case of changing tubes or "B" batteries, but under all other conditions the lid should remain closed.

**How to Lay Out the Base Lines.**—When laying out the base lines of various stations communicating with each other, it is very important to follow the general rule of arranging them so that the imaginary straight line joining the centers of the base lines of the stations will make equal angles with the two base lines, the angles considered being taken on the same side of that imaginary line and between the base lines. The best position is that in which the two base lines are parallel to each other and the line joining their centers makes right angles with them. This arrangement is indicated in the first drawing of Fig. 6. The other two drawings show the applica-

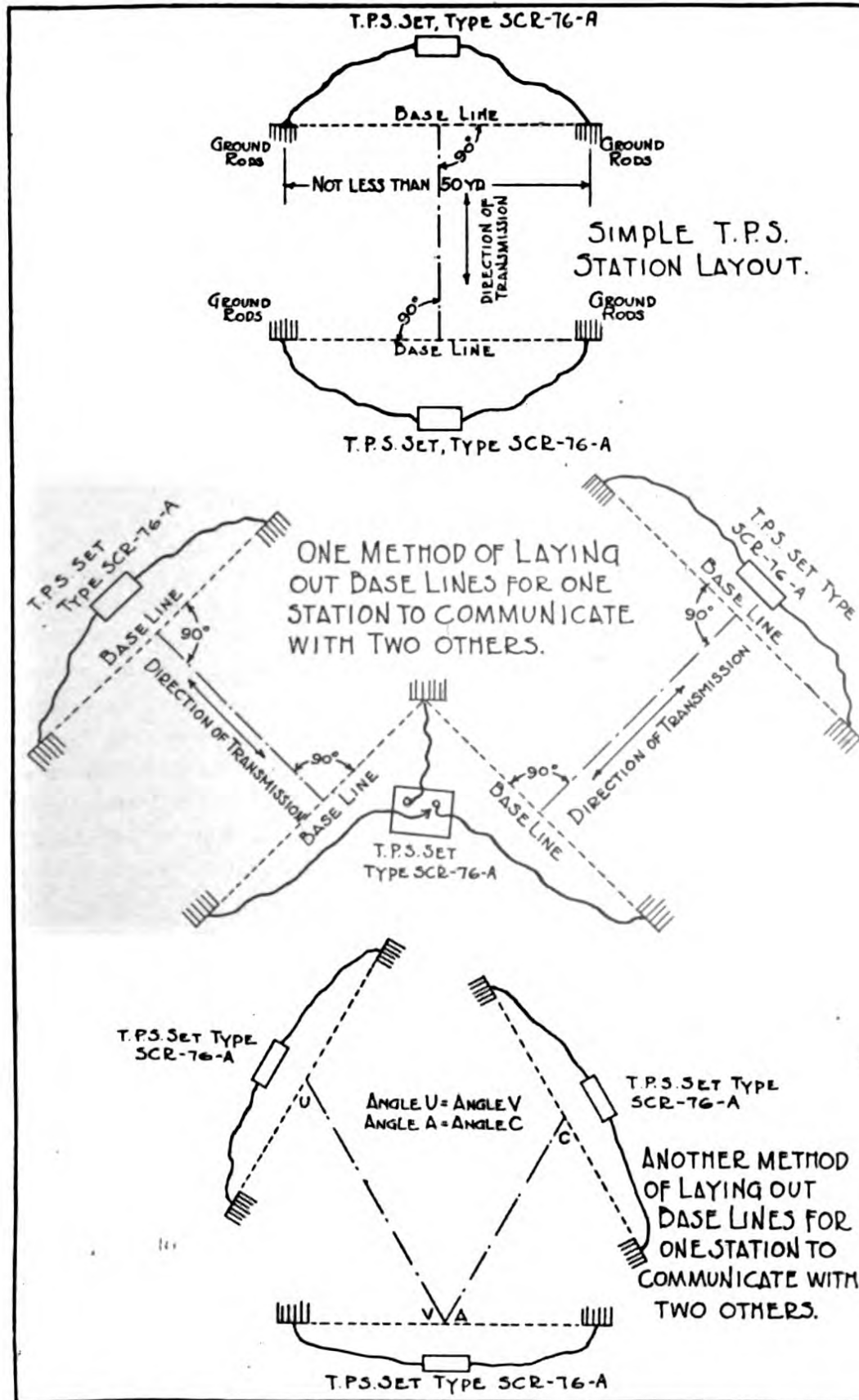


FIG. 6.—Methods of Laying Out a Simple T. P. S. Station, and One Station to Communicate with Two Others.

tion of the above rule by two different methods to the case of one station communicating with two others.

If one station is to communicate with a number of different stations, best results are obtained by providing at that one station a number of base lines, laid out radially around the station in positions at right angles, respectively, to the lines joining that base line to each of the other station base lines. A selector switch then enables the connection of the central station to any desired base line.

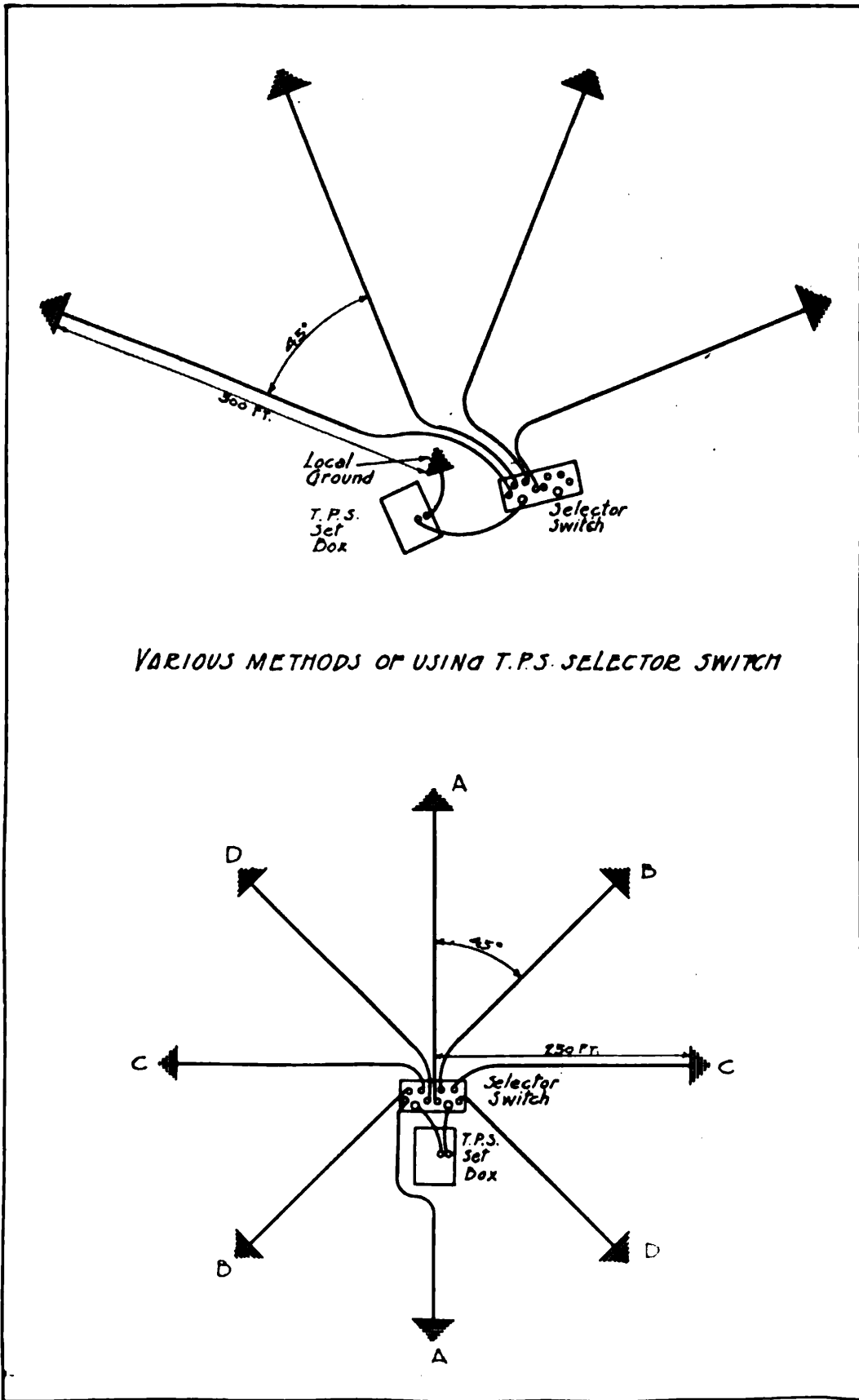
The installation of such a central station may be made in a number of different ways. Two methods are illustrated in Fig. 7, making use of Switch Type SW-16. By the method shown in the upper drawing, any one of the four outer ground terminals may be used with the local ground to make four different base lines, these covering closely almost any direction. By the method shown in the lower drawing, the two switches will usually be placed to make A and A, or B and B, etc., the ends of the base line in use. However, the terminals D and B on opposite switches might be used as the pair of ground terminals if they were laid out the proper distance apart. This gives an idea of the various combinations possible.

The first method is preferable, it being easier to install and operate. There are only five grounds to establish, and one-half of the selector switch only is used. In the second method, both sides of the switch are used and there are eight grounds to establish.

When a station having a single line is to communicate with a central station having the choice of a number of base lines, the single station will establish its base perpendicularly to the line joining the two stations. The central station then selects the one of its bases which is nearest perpendicular to the line joining the two stations.

The best method for laying out the base lines is to use a compass, by means of which the direction of the bases of the various stations can be determined accurately. A number of types of compasses are in use, which makes it impossible to give definite rules as to their use in this connection.

Another important consideration is the method of grounding the far ends of the base line wires. Twelve ground rods are furnished with the set. At least four rods should be driven into the ground in a straight line at each end of the base, and at a distance apart of not less than 2 ft. They should be driven at least 1 ft. into the ground. It is well to moisten the ground around the rods after they have been driven in.



*VARIOUS METHODS OF USING T.P.S. SELECTOR SWITCH*

FIG. 7.—Methods of Laying Out Central T.P.S. Station.

Special care should be taken to use only line wires having perfect insulation for connecting the ground rods to the set box. These line wires may be buried in the ground if desired in order to protect them somewhat from shell fire. This, however, may increase the difficulties in case it is necessary to repair the wire after it has been cut by a shell. Inspect the line wires frequently to see that they are in good condition. If splices have to be made, insulate them carefully. Never use lead covered cable for these wires.

In order to make ground connections of low resistance, it is often useful to bury tin cans, shell cartridges, pieces of pipe, etc., in addition to the ground rods, or in place of them in cases of emergency. All these metallic masses should be carefully interconnected and connected to the line.

For more complete details on the theory of ground telegraphy and the methods of laying out ground stations, see Radio Pamphlet No. 10. For details of the listening-in service and the means of coping with interference, see Radio Pamphlet No. 18.

### **Method of Setting Up and Operating.**

**Installation of the Grounds.**—After the direction of the base line has been determined, a ground connection is made at each end of the base, the grounds being separated by a distance of approximately 500 ft.

1. The base line wire is run out from the set box by means of the breast reel, on which is wound 500 ft. of wire. One end of the wire is connected to the set box, as explained below. At the other end drive four to six ground stakes as deep as possible into the ground, in a straight line coinciding with the line of the base, and with at least 2 ft. separation between adjacent stakes. All the stakes are connected together by means of a wire which is then spliced to the line wire.

2. Near the set box, drive another group of four to six stakes into the ground and interconnect them similarly. This ground is connected to the other line wire from the set box. If possible, moisten the ground around each ground connection by pouring some water over the ground stakes after they have been driven in.

**Connecting up the Set.**—While the base line is being established, the set box can be connected up in the following manner:

3. Connect the free ends of the base line wires to the two binding posts on the left hand side of the set box.



4. Open the canvas pocket on the right hand side of the box and connect the 10-volt storage battery to the terminals in that pocket, using the battery plug or ordinary connection wires. If under exceptional circumstances it is desired to increase the range, 20 volts may be used for energizing the buzzer. In this case, connect one 10-volt battery between the "0" and "10 V" binding posts, with the positive pole of the battery to the "10 V" binding post, and connect another 10-volt battery to the "10 V" and "20 V" binding posts, with the positive pole of the battery to the "20 V" binding post.

5. Unbutton the front curtain covering the operating panel of the box and open the cover of the box to remove the telephone receivers. At the same time, check up that the two vacuum tubes in use are in good shape. These are the two tubes which are mounted directly in back of the operating panel of the box. Also check up that the two dry batteries are connected up with the proper polarity.

6. See that the line lamp is in good condition. This is the small lamp mounted in back of the opening in the front panel, which is ordinarily covered by the telegraph key when the latter is folded flush with the panel.

7. Three small binding posts are mounted inside the box, on the rear wall, above the spare line bulbs, and a strap fastened to the center post may be made to connect across either pair. If 20 volts are to be used for energizing the buzzer, connect the metal strap between the two right hand binding posts. If a 10-volt battery only is to be used, connect the strap between the two left hand binding posts.

**Adjustments for Transmitting.**—8. Place the right hand switch of the operating panel in the "Send" position.

9. Open the top of the box and by means of the special wrench to be found in this cover, fasten the desired weight to the power buzzer armature, according to the frequency at which it is desired to transmit. The following frequencies may be obtained by attaching the weight indicated:

	Cycles per second.
Large weight out.....	630
Large weight in.....	700
2 small weights out.....	830
1 small weight out.....	980
1 small weight in.....	1150
No weights.....	1380

10. Unlock the buzzer adjusting screw. Straighten out the telegraph sending key and depress it so that the buzzer will vibrate. Hold the key down and adjust the buzzer adjusting screw until a good clear note is obtained, then lock the screw in this position. As the current input into the ground is greater, the tighter the adjustment, the screw should be turned in as far as possible and retain a clear tone. If the tone is ragged, it is very difficult to eliminate interference at the receiving station.

11. Close the top cover. The set is now in operating condition for transmitting.

12. In order to test whether the base line wires are in good condition, and whether the proper current is flowing into the ground, depress the small black push button at the right of the key, and observe that the small line bulb is glowing. If it fails to light or glow, the base line must be broken or the buzzer is poorly adjusted.

13. The gap and tension of the sending key may be adjusted by means of the two screws located on the panel at the left of the stem of the key, the upper screw being the gap adjustment, the lower screw being the tension adjustment.

**Adjustments for Receiving.** 14.—Place the right hand switch of the operating panel in the "Receive" position.

15. Observe that both vacuum tubes are glowing by looking through the mica covered openings in the operating panel.

16. Open the cover of the box, check up the polarity of the dry batteries, and close the cover again.

17. Insert the telephone receiver plug into one of the jacks.

18. In order to vary the intensity of the received signals, such as for minimizing interference, operate the "Amplification" switch of the panel (left hand switch marked "Filament Rheostat" in Fig. 3).

19. While waiting for signals, check up frequently that the filaments of both vacuum tubes are glowing, as an assurance that the set is in operating condition and that nothing is being missed.

### Precautions.

When the set is not in use, the transmit-receive switch must be placed in the "Off" position, so that there will be no possibility of running down batteries unnecessarily.

Always keep the set box dry and waterproof. Keep the rubber gaskets on the cover clean so that they will keep moisture out of the box. In case of rain, cover the operating panel of the set with the canvas curtain furnished for this purpose.

Do not operate the set on run down batteries. Check up the voltage of the storage battery (10 volts) and of each dry battery separately (20 volts) by means of the voltmeter furnished with the set. The lower limit of working voltage for the dry batteries is 17.5 volts per battery.

It is impossible to operate the set for receiving messages with only one vacuum tube inserted, or with one tube broken or burned out. Two good tubes in place are essential. At least two spare tubes should be kept on hand at all times. This will be a sufficient supply to take care of the requirements between times of getting new supplies from the depot.

Take note that the contact points on the buzzer vibrator are clean and not pitted or burned. If they require cleaning or truing up, remove them by means of the wrench, and gently rub them against some emery cloth on a plane surface. Do not use the file unless absolutely necessary. Replace the contacts carefully, with their surfaces in plane contact. Be sure to place the upper contact on the upper armature and the lower one on the lower armature. Do not interchange them.

Keep the connection leads as dry as possible. Frequently inspect the base line wires, as they may be broken by shell fire and this makes communication impossible.

While sending, another check on the condition of the line wires is obtained by means of the small line lamp, as explained in the operating instructions. Care should be taken that this lamp does not remain in the circuit while sending messages, and that the push button springs back in position when not used, short circuiting the lamp filament.

It is important to check up the connection of the three binding posts on the back wall inside the set box, and see that the position of the connection strap is correct for the storage batteries being used with the set.

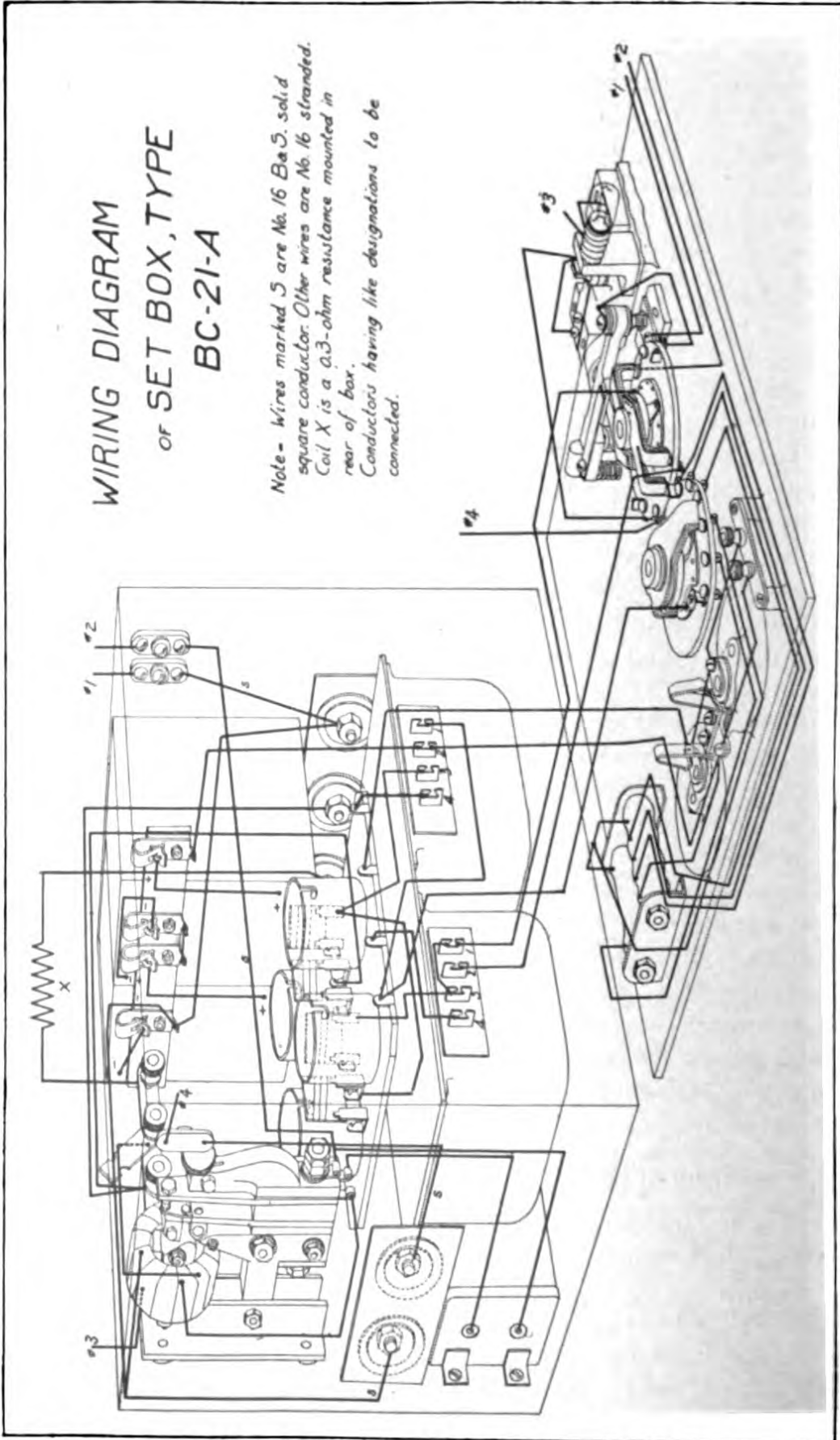
#### **Comparison of SCR-76-A with SCR-71 and SCR-72 Combination.**

The advantages of the SCR-76-A set over the former practice of utilizing the SCR-71 buzzer and SCR-72 amplifier are given as follows:

1. The set is more convenient to set up, as there is no switch to connect, thereby avoiding the numerous short interconnecting wires. Generally, all connections are easier to make.

# WIRING DIAGRAM OF SET BOX, TYPE BC-21-A

*Note - Wires marked 5 are No. 16 B&S. solid square conductor. Other wires are No. 16 stranded. Coil X is a 0.3-ohm resistance mounted in rear of box. Conductors having like designations to be connected.*



2. The radio apparatus is easier to transport, as it is contained in a single box which is not an excessive load for one man. The total weight of the two sets SCR-71 and SCR-72 is somewhat greater than that of the SCR-76-A.

3. A great advantage is that there is only one storage battery required for the set, the 4-volt filament battery of the former set being entirely eliminated.

4. Space for spare vacuum tubes and dry batteries is provided within the set, while they had to be carried in separate boxes with the old sets.

The following disadvantages may be pointed out:

1. If the set is used at stations where one-way communication only is required, the SCR-76-A set provides superfluous material and equipment.

2. The amplifier of the SCR-76-A set cannot be used for radio frequency amplification purposes. If it is desired to use it in connection with radio signals, it must be connected in the audio frequency circuits of the receiving set.

### PARTS LIST.

In ordering this set or parts of this set, specification must be made by names and type numbers as listed below, exactly. The designation printed in bold face type *only* will be used in requisitioning, making property returns, etc.

In ordering *complete* sets it is not necessary to itemize the parts; simply specify, "1 Set, Two-Way T.P.S., Type SCR-76-A." If *all* the parts listed under a group heading are desired, it is not necessary to itemize the parts; simply specify, for example, "1 Equipment Type RE-3-A."

The type SCR-76-A set is not complete unless it includes all of the items listed below.

#### **Set, Two-Way T.P.S Type SCR-76-A.**

**Equipment Type PE-11: power:**

**3 Batteries, Type BB-23; storage; lead; 10-volt, 20 amp-hr.; acid for electrolyte to be supplied separately in carboys; 1 in use, 2 spare.**

(Or, as an alternative, not for overseas use, **Equipment Type PE-13; power, comprising 2 Batteries, Type BB-3; storage; Edison; 10-volt, 8-cell, 25-amp-hr.; with electrolyte in separate containers; 1 in use, 1 spare.**)



<b>Equipment Type GD-3-A; ground:</b>	★
<b>1 Bag Type BG-8; carrying</b> .....	(1)
<b>12 Stakes Type GP-6; ground</b> .....	(2)
<b>2 Drums Type DR-3; for breast reel</b> .....	(3)
<b>1 Reel Type BL-6; breast</b> .....	(4)
<b>1000 ft. Wire Type W-4; two 500-ft. lengths, each wound         on drum</b> .....	(5)
<b>60 ft. Wire Type W-5; two 30-ft. lengths, each wound in         3-in. coil</b> .....	(6)
<b>1 Hammer Type HM-1</b> .....	(7)
<b>Equipment Type RE-3-A; t.p.s.</b>	
<b>1 Set Box Type BC-21-A; two-way t.p.s.</b> .....	(8)
<b>1 Cord Type CD-61; extension; set box to battery</b> .....	(9)
<b>1 Tool Roll Type BG-20</b> .....	(Not shown.)
<b>1 Weight Type WT-2; large; for vibrator</b> .....	(10)
<b>2 Weights Type WT-3; small; for vibrator</b> .....	(11)
<b>2 Contacts Type CN-1; upper; for vibrator; spare</b> .....	(12)
<b>2 Contacts Type CN-2; lower; for vibrator; spare</b> .....	(13)
<b>1 Wrench Type TL-6; for changing vibrator weights</b> ....	(14)
<b>1 Gage Type TL-7; air gap; for vibrator</b> .....	(15)
<b>1 File Type TL-5; for vibrator contacts</b> .....	(16)
<b>2 Head Sets Type P-11; telephone</b> .....	(17)
<b>4 Batteries Type BA-2; dry; 2 in use, 2 spare</b> .....	(18)
<b>4 Tubes Type VT-1; vacuum; receiving; 2 in use, 2 spare</b> .	(19)
<b>3 Lamps Type LM-6; current indicating; 1 in use, 2 spare</b> (20)	
<b>1 Bag Type BG-13; carrying</b> .....	(21)
<b>1 Switch Type SW-16; selector</b> .....	(Not shown.)
<b>1 Compass Type I-1; "cebynite" or equivalent</b> .....	(22)
<b>¼ lb. Tape friction; ¼ in.</b> .....	(23)
<b>1 Pliers Type TL-19; pair combination</b> .....	(24)
<b>1 Voltmeter Type I-10; 0-10/0-50 volts; with lead</b> (Not shown.)	
<b>1 Screwdriver Type TL-2</b> .....	(25)
<b>1 Sheet Emery Cloth, No. 4-0; approx. 11 in. x 8 in.</b> .....	(26)

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\* Figures in parenthesis in the right hand column refer to the corresponding parts in the illustration on the opposite page.



