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LOOP RADIO TELEGRAPH SET TYPE SCR-77-A

Radio Communication Pamphlet No. 6

PREPARED IN THE OFFICE OF THE
CHIEF SIGNAL OFFICER

January, 1923

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WAR DEPARTMENT,
WASHINGTON, *January 30, 1923.*

The following publication, entitled "Loop Radio Telegraph Set, Type SCR–77–A," Radio Communication Pamphlet No. 6, is published for the information and guidance of all concerned.

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BY ORDER OF THE SECRETARY OF WAR:

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

OFFICIAL:

ROBERT C. DAVIS,
The Adjutant General.

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LOOP RADIO TELEGRAPH SET, TYPE SCR–77–A.

Section I.

PURPOSE OF SET—RANGES.

1. *Purpose of set—Ranges.*—The Loop Radio Telegraph Set, Type SCR–77–A, is a light portable vacuum tube transmitting and receiving set, designed to furnish radio telegraph communication between units whose headquarters are usually from 3 to 5 miles apart. It will furnish reliable communication up to 3 miles. Under favorable conditions, such as open terrain, etc., this distance is increased to 5 miles. The range of wave length is from 74 to 76 meters and the set is so arranged that there are nine different wave-length settings in this range. Thus, nine stations in a communication net can work together without interference.

Section II.

GENERAL DESCRIPTION OF SET.

2. *Special features of the set.*—In addition to the arrangement which enables tuning so sharp that nine stations can work with a wave-length range of 2 meters, the set has a loop antenna and a "break-in" feature. The use of the loop antenna enables the set to be so designed that it is very portable and quickly set up. A moving unit furnished with this set can keep in constant communication within its transmitting range with other units furnished with a like set. The loop antenna is small and of low visibility, as its height when set up is only 4 feet. The break-in feature enables the receiving station, which must also be an SCR–77–A set, to interrupt the transmitting station at any time. This greatly facilitates communication. There is no change in the adjustment needed to reverse the direction of communication. Another feature of the set lies in the fact that, because of its method of reception, it is practically im-

possible to have a set receiving signals interferred with by a radio station transmitting damped waves.

3. *Carrying units of set—Weight and bulk.*—The whole set is assembled in five carrying units, each provided with a carrying strap. The loop antenna folds up and is carried in a bag, which is 28½ inches long, 4½ inches in diameter, and weighs 6 pounds with the loop in it. The transmitting and receiving apparatus is in an operating chest measuring 14⅝ inches by 9½ inches by 12⅜ inches high and weighs 20½ pounds complete. The four-volt storage batteries are carried in a case measuring 5⅞ by 10 9/16 inches by 8 13/16 inches high and weighing 27 pounds with the batteries in it. The equipment box has two distinct compartments, one of which carries the dry batteries and the other the spare vacuum tubes and the telephone head set. Its dimensions are 13 by 4⅝ inches by 15 5/16 inches high, and when filled it weighs 17½ pounds. The spare transmitting dry batteries, which like those in use are contained in a wooden case, are carried in a carrying bag which measures 10 by 3½ inches by 8 inches, and weighs 7½ pounds with the case in it. The case containing the transmitting dry batteries in use is contained in the equipment box. There is room for two extra BA–2 dry batteries in the carrying bag in addition to the case. It is a wise precaution to carry these two extra batteries, though they are not provided in the parts list. They weigh only 15 ounces each.

Section III.

DETAILED DESCRIPTION OF THE SET.

4. *The radio transmitter and receiver (type BC–9.)*—The transmitting and receiving apparatus is assembled in one operating chest. There are three VT–1 vacuum tubes used in the set. One of these is used as an oscillator. At the same time this oscillating tube acts as a detector. The other two tubes are used as audio-frequency amplifiers. Associated with these tubes are the various capacities, inductances, resistances, transformers, etc., necessary for their operation. The equipment, except for the head set, the loop and the plate batteries, is self-contained in the chest. The back of the operating chest is provided with sockets for connecting the loop antenna. The operating chest, when the set is in use, is placed on the equip-

ment box and is provided with hooks to which clamps on the battery box can be fastened. All the controls necessary for sending and receiving are mounted on a panel, a view of which is shown in Figure 1. The legend used is as follows:

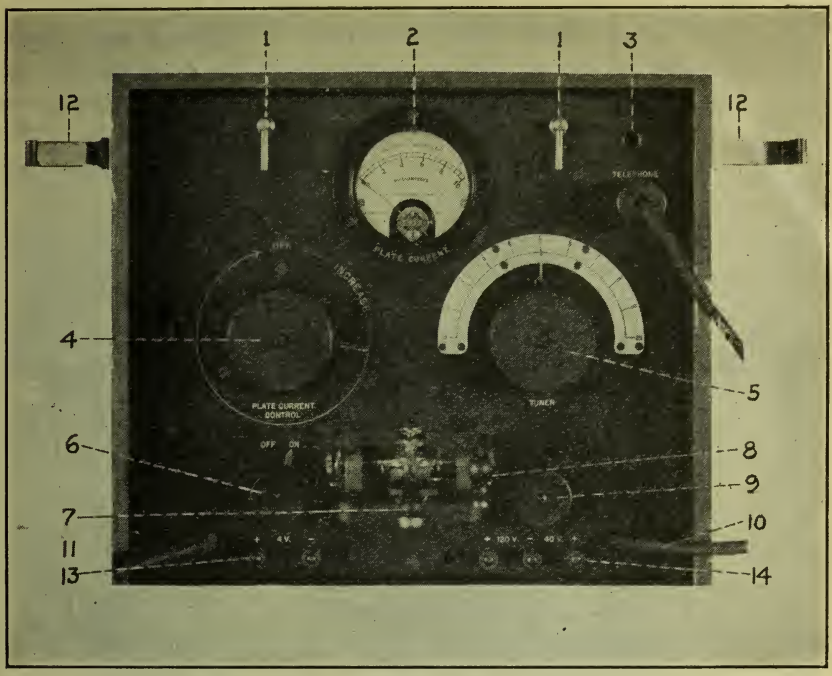


FIG. 1.

1. Fasteners to lock panel in place. 2. Direct-current milliammeter (0–10). 3. Telephone jacks. 4. Plate current control; controls grid circuit potentiometer. 5. Tuner graduated from 0–10; controls a variable air condenser. 6. Battery switch; turns off and on the filament battery and also the potentiometer battery. 7. Telegraph key. 8. Switch for short-circuiting telegraph key. 9. Fine adjustment control for tuner. 10. Cord to plate batteries. 11. Cord to filament battery. 12. Fastener to lock up front of box. 13. Auxiliary binding posts for filament battery. 14. Auxiliary binding posts for plate batteries.

The panel is protected by a cover which is hinged at the lower end. When lowered it rests upon the projecting end of the equipment box, thus forming a shelf for the operator. The telegraph key is hinged and is to be pushed up against the panel when the front of the chest is closed. Electrical connections to the key are provided by knife contacts, all flexible leads being eliminated in this way. The panel is locked in position when the handles of its fasteners are pointing downward. Turning the handles in either direction to the horizontal position unlocks the panel, which may be swung forward, as it is hinged at the bottom.

The back of the box is a wooden panel which has been specially treated so that it will not absorb moisture. Various pieces of apparatus are mounted on the inside of this panel. A small single-leaf

condenser used in calibrating the set is so mounted. The adjustment of this condenser is made by means of a machine screw projecting through the wood panel, thus being made accessible on the outside of the chest.

The bakelite panel can be entirely removed from the box by swinging it forward and then lifting it from its bearings and disconnecting the three flexible leads connected to the floor of the box. Figure 2 shows the view when the panel is swung forward as for putting in vacuum tubes or dry batteries. Figure 3 shows a view of the apparatus entirely removed from the box. The legend used in these two figures is as follows:

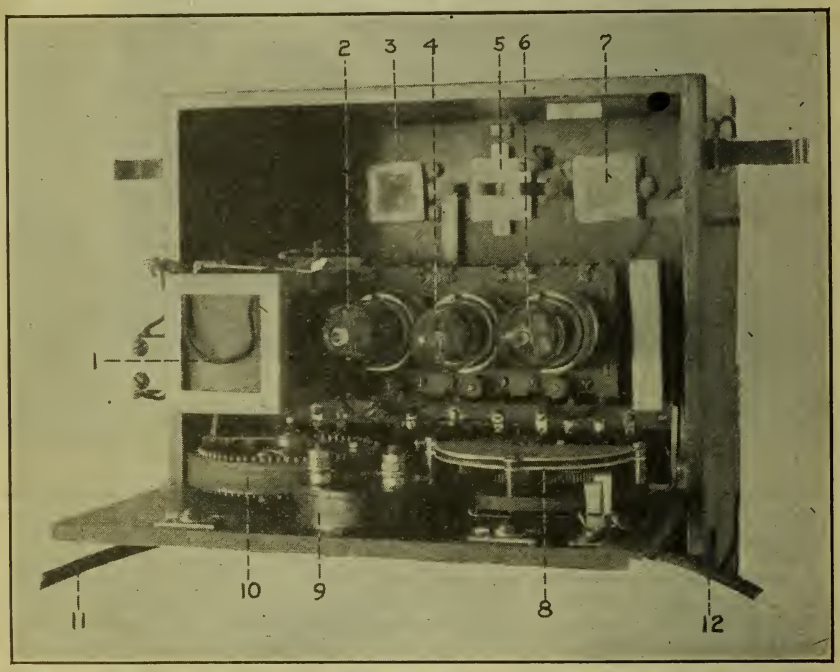


FIG. 2.

1. BA–2 battery for potentiometer. 2. VT–1 oscillator tube. 3. Grid oscillatory circuit condenser (1745 m. m. f.). 4. First audio-frequency amplifier tube. 5. Single-leaf variable condenser used in calibrating set. 6. Second audio-frequency amplifier tube. 7. Plate oscillating circuit condenser (720 m. m. f.). 8. Variable air condenser (tuner). 9. 0–10 d. c. milliammeter in plate circuit of oscillator tube. 10. Potentiometer for varying grid-filament biasing potentiometer of oscillator tube. 11. Filament circuit cord to storage battery. 12. Plate circuit cord to dry batteries (3-conductor). 13. One-to-one ratio transformer coupling plate circuit of second audio-frequency amplifier tube to telephone head set. 14. Two 5,000 resistances, forming part of potentiometer circuit. 15. Filter-circuit inductances. 16. Filter-circuit condensers. 17. Switch-controlling filament and potentiometer circuits. 18. Transformer (C–21) coupling oscillator tube plate circuit to first audio-frequency amplifier tube. 19. Stopping condenser (0.02 m. f.), prevents direct-current potential on oscillator tube plate from reaching the grid. 20. Transformer (C–21) coupling first audio-frequency amplifier to second audio-frequency amplifier.

It is to be noted that much of the apparatus is mounted on the tube shelf which rests on sponge rubber in order to minimize noise

in the receiver due to shocks and vibration. If it ever becomes necessary to remove the rear panel, the three copper strip connections going to the floor of the box should be disconnected by removing the screw at the upper end of each one.

5. *The loop (type LP–2).*—The loop is a single-turn one made of brass tubing provided with hinges so that it can be folded up to fit in its carrying case. The joints are provided with wing nuts to enable the loop to be firmly fastened together. The threads at the ends of the bolts on which the wing nuts screw are scored so as to

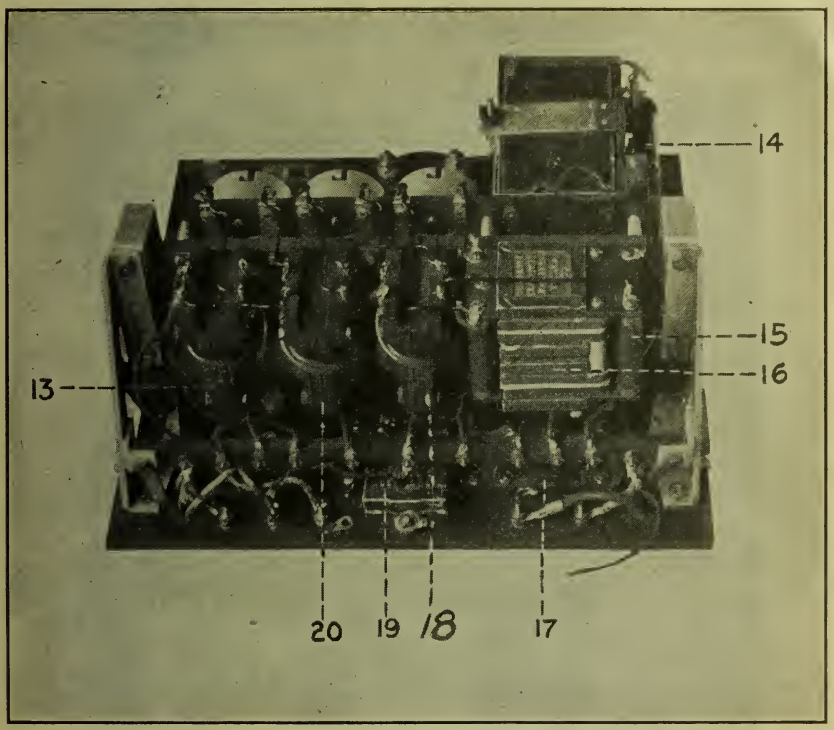


FIG. 3.

prevent the removal or loss of the nuts. Two slotted supports for the loop are provided on the back of the operating chest, and the ends of the loop are made to fit firmly into these supports. The length of the loop is 48 inches, and its height from the support is 36 inches. The whole loop is given an extra heavy black nickel finish.

6. *The equipment box, type BE–48.*—This box carries auxiliary equipment and serves as a base upon which is fastened the operating chest when the set is in use. There are two main compartments in the box, one of which contains the dry batteries furnishing the plate potentials for the tubes. A view of the box showing this compartment is shown in Figure 4. The other main compartment which

is also furnished with a cover on the opposite side to the one shown in the illustration carries three spare vacuum tubes and a telephone head set. The box is fitted with clamps for the covers, a carrying strap, and means of fastening the operating chest to it. The leads from the batteries carried in the box are brought to a jack having tip, ring, and sleeve connections. Into this is plugged the telephone plug on the cord leading to the operating chest. The jack is inside

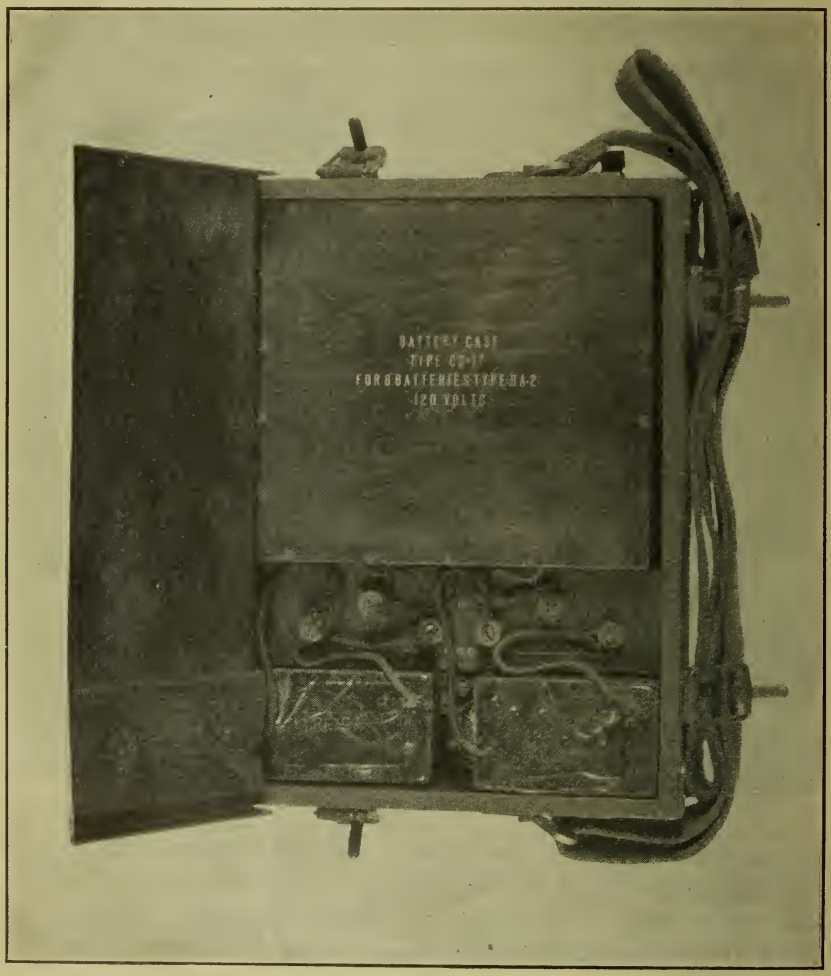


FIG. 4.

of the equipment box, but a small recess is provided to allow the cover to be clamped down over the cord.

7. *Dry batteries used with the set.*—There are nine type BA–2 dry batteries used with the set. Six in series furnish plate potential for the oscillator tube; two in series furnish plate potential for the amplifier tube; and one is used in the potentiometer circuit. The po-

tentiometer battery is mounted within the operating chest; the two amplifier tube batteries are carried in the equipment box as are also the six oscillator tube batteries. The latter, however, are all assembled in a battery case (type CS–17) which therefore may be considered as a 120-volt battery. Figure 4 shows a view of this case, as well as the two amplifier tube batteries, both being mounted in the equipment box. The six type BA–2 batteries in the battery case have their terminals firmly soldered together and taped. The end leads project from the case. It is intended that when the 120-volt battery becomes exhausted in field service the complete CS–17 battery case will be replaced by one containing fresh batteries. Fresh BA–2 batteries are installed in the case at the supply base or other designated point. An extra 120-volt unit in its case is carried with the set. The bag in which the case is carried has room enough to also carry two BA–2 dry batteries. These should be carried when obtainable so as to provide spare batteries for the potentiometer and for the amplifiers.

8. *Storage batteries used with the set.*—The filament current is furnished by a BB–41 lead storage battery. This is a small battery having a rating of 16 amp. hour. The cell containers are made of hard rubber and are fitted with a nonspill plug. The battery case is made of steel and it is fitted with a cover which is removable. Slots alongside of this cover are provided so that the cover may be placed on the battery while it is in use. The batteries are $4\frac{5}{8}$ by $5\frac{5}{32}$ inches by $8\frac{11}{16}$ inches high and weigh approximately 11 pounds. The normal charging rate is $1\frac{2}{3}$ amperes. The normal discharge rate is 3.2 amperes for 5 hours, the final voltage being 3.5 volts. There are three BB–41 storage batteries furnished with the set. It is intended that two of these, fully charged, be carried in the field in the case provided with the set and one be at the charging plant. Of the two carried with the set in the field, one is in use and one is a spare. For further information about storage batteries, see Training Pamphlet No. 8.

Section IV.

INSTALLING THE SCR–77–A.

9. *Preparing the equipment box.*—Place the battery case (CS–17) containing the 120-volt unit in its compartment in the equipment box. Connect the terminals to the binding posts marked "—120 volts+," being sure to observe the correct polarity and to make firm connections.

Place two BA–2 batteries in the smaller compartment on the same side of the equipment box. Connect the terminals of one to the left-hand pair of binding posts, marked "—20 V+," and of the other to the right-hand pair marked in the same way. Observe the proper polarity and make clean, tight connections. Close and fasten the cover of this side of the equipment box.

Open the other side of the equipment box, remove the telephone head set and also the vacuum tubes, if some are not already in the operating chest. Plug in the plate battery cord (the one attached to the lower right side of the operating chest). Having run the cord through the slot provided in the cover of the equipment box, close and fasten it. Place the box on a level spot of ground with its fasteners up.

10. *Preparing the operating chest.*—Place the operating chest on the top of the equipment box and fasten it in place by the catches provided. Open the cover of the operating chest, allowing it to rest upon the projecting end of the equipment box. Turn the "Off—On" switch to the "Off" position. Turn the handles of the two fasteners at the top of the box to a horizontal position and pull the panel forward. Place a BA–2 battery in its holder alongside of the vacuum tube. Connect its terminal to the binding posts alongside the holder. Observe correct polarity and make tight connections. Secure the battery in place by means of the clamp. Place a VT–1 vacuum tube in each of the three sockets. Close the front panel and lock it in place by turning the handles of the fastener downward. Pull the top of the telegraph key downward to its operating position. Plug in the telephone head set.

Place the storage battery carrying case near the operating chest and connect to *one* of the storage batteries the terminals of the cord extending from the left-hand side of the operating chest. Observe the correct polarity as marked. The cover of the battery should then be closed.

11. *Preparing the loop.*—Remove the loop from its case and unfold it. Jam the ends of the loop firmly into the sockets on the back of the operating chest. Tighten up all wing nuts on the loop. The set is now ready for operation, if the tube in the left-hand socket (oscillatory circuit) will oscillate.

12. *Selection of oscillator tube.*—Because of minute differences that arise in the process of manufacture, some VT–1 vacuum tubes work better in the oscillatory circuit than others. The tubes received with the set should be tested and the best one used in the oscillator tube socket. The test can be made very easily. When the left-hand side of the loop is touched with the bare hand the plate current, as shown by the milliammeter, will decrease in value when the tube is oscillating. Of course the set must be transmitting

when this test is made. Thus each tube in turn is placed in the oscillator tube socket and tested. The best two oscillators are marked and one of these is used in the set and the other is held as a spare.

SECTION V.

CALIBRATION OF SET.

13. *Necessity for calibration.*—The feature by which break-in communication is obtained in the SCR–77–A sets necessitates that reception be accomplished by the heterodyne method. One oscillation used in the heterodyne method is produced by the transmitting set, the other oscillation is produced by the receiving set. Thus both the transmitting and the receiving set are oscillating and, in order to produce beats of good audibility, their oscillation frequency must not vary by more than 1,000 per second. As the frequency at a wave length of 75 meters is 4,000,000 per second, this allows of a variation of only 1 part in 4,000. Sets can not be manufactured with such precision, so means are provided to adjust the frequency of the sets so that one set can be made to have a frequency very nearly that of another set when the tuners of the two sets are in the same position.

14. *Selection of the master set.*—When a number of sets are to work together in a communication net all sets must be calibrated alike. In order to do this one set is selected as the master set. At first this selection of the master set must be made arbitrarily, but after several days of operation the peculiarities of each set in the net become known. The master set should then be selected from the group. It must be a good transmitter and receiver. It should be the set whose frequency of oscillation is most constant and not easily changed by accidental factors and whose range of frequency of oscillation is so limited that all the other sets to be in the net can be calibrated with it.

NOTE.—The adjusting screw (on the rear of the operating chest) of the master set should usually need no adjustment, for the sets as delivered by the manufacturer have all been calibrated, and so it should be possible to calibrate all sets in the net with the master set. However, if it is found impossible to calibrate all sets in the net, it may be necessary to change the adjusting screw of the master set. It should be turned to that position which permits the other sets to be calibrated with it. The head of the adjusting screw is quite large, but the screw itself is small. Do not force the screw too far either way. To do so will either strip the threads or break the upsetting on the end of the screw, thus permitting the screw to become detached from the movable part of the condenser.

15. *Method of calibration.*—Having selected the master set, the calibration is done as described below. It must be remembered that each set in the net must be calibrated in turn, always using the same master set. The calibration must be done with the sets outdoors and resting on the ground. The set to be calibrated is placed at a distance of at least 200 feet from the master set and turned so that its loop is at right angles to that of the master set. Turn the "Tuner" condenser of the master set exactly to the No. 5 position. The master set transmits while the set being calibrated is adjusted. The latter set is acting as a receiver. With the head set on, the "Tuner" of this set is turned to the No. 5 position and then its adjusting screw is turned backward or forward until low-pitched signals from the master set are received. No further adjustments are made with the adjusting screw. The tuner of the master set is then turned successively to positions 4, 6, 3, 7, etc. In each position the master set transmits. The tuner of the set being calibrated is turned to the corresponding position on its scale and then, if the signal is not picked up, is slowly turned back and forth until low-pitched signals are heard. The position at which signals are heard is then marked with a lead-pencil line on the scale. This is done for each different position of the master set tuner.

It may happen when the master set tuner is in position No. 5 that the variation in frequencies produced by turning the adjusting machine screw on the back of the set being calibrated is not sufficient to enable signals to be heard when its tuner is exactly on the No. 5 position. In this case turn the adjusting screw either to the right or to the left as far as it will go (see footnote on page 9), using that position of the adjusting screw which will place the pointer of the tuner nearer the No. 5 mark when the low-pitched signals are heard. The position of the pointer of the tuner should then be marked with a lead-pencil line. The other positions are found and marked in the usual way.

After all sets that are to work together in a net have been calibrated, it is well to try out intercommunication between the different sets while the sets are all in the same vicinity. Any faulty calibration can then be checked up and corrected without the confusion that would result if the sets were taken into the field before the faulty calibration were discovered.

16. *Permanency and limits of calibration.*—The calibration of the set as described above is quite permanent and reliable. However, any heavy jar or shaking up of the set is liable to disarrange the adjustment. If the set is operated at a station where the surroundings or earth conditions are different from those under which the set was calibrated, the frequency of the set will probably be slightly changed. This is most apt to occur when the loop of the set is near some object.

The position of the set should be changed if practicable. In some cases it will be necessary to recalibrate the set in the position at which it is to be used. This should be done under the direction of the officer in charge of the net. In extended operations the calibration of the sets should be checked up at least every day by comparison with the master set. This may be done by the operator transmitting for a definite length of time with his tuner upon each position. The other stations within the net should then, one at a time, make any correction to the markings on their scale that may be necessary.

17. *Number of sets in a net.*—The number of sets in a net when each set has assigned to it an exclusive wave length is limited by the number of different settings on the tuner. The permanent markings on the tuner scale are set as closely together as is practicable. They are numbered from 0 to 10, thus indicating 11 different wave length settings. However, only the wave length range of each set that overlaps the wave length range of all other sets in the net can be used. This limitation makes it practical to use only nine different wave length settings in a net.

Section VI.

OPERATION AND CARE OF SET.

18. *Break in communication.*—As has been stated, the SCR–77–A set is so designed that the operator receiving the message can interrupt the transmitting operator at any time. When receiving, the key switch is closed; when transmitting, the key switch is open. Thus because the switch is closed the receiving set is generating oscillations continuously. The transmitting set, however, is generating oscillations only when the key is operated to make the dots and dashes. The transmitting set is also acting as a receiver. Hence, when the sending operator works his key he hears his own signals because the oscillations produced by the receiving set heterodyne his own signals, thus making them audible. Now if the receiving operator opens his key switch, he stops his set from producing oscillations and the sending operator can not hear his own signals because of the lack of the heterodyne effect which was produced by the oscillation of the receiver. This failure to hear his own signals informs

him that the receiving operator desires to send. The sending operator closes his key switch and listens for the message from the other operator. In other words, the stoppage of the audible signals in the operator's own telephone when he is transmitting is a signal that the receiving operator desires to send. The closing of the key switch on the set enables the message in the reverse direction to be received.

19. *Adjustments for transmission.*—The only regular adjustments for transmission are the tuner and the plate current control. The tuner should be turned to the wave length of the station with which it is desired to communicate, using the calibration mark. With the key pressed down the control handle of the plate current should be turned until the milliammeter shows a reading of 5. If, after this adjustment is made, no beat note is heard in the receivers of the transmitting set, the tuner may be moved slowly back and forth until the beat note is heard. The failure to hear the beat note when the tuner is first set means that either one or the other, or both, of the sets are incorrectly calibrated.

20. *Adjustments for reception.*—The set is put into condition to receive by closing the key switch and placing the tuner pointer on the calibration mark that represents the wave length of the station. If the plate control current has not already been adjusted so that the milliammeter shows the proper reading, this should be done. If it is desired to break in on the transmitting operator, it is only necessary to open the key switch for a few seconds and then transmit.

By reducing the plate current below 5 milliamperes it is possible to reduce the interference that may occur in a congested area. This reduction of plate current reduces the power of the set, thus effecting a reduction in interference. Reducing the power of the set also makes it a more sensitive receiver, as it brings the amplitude of the local and the received oscillations into a more effective ratio. However, in reducing the power it is necessary that care be taken not to reduce it so much that the oscillations fail to produce the heterodyne effect in the distant transmitting set; otherwise the sending operator will stop transmitting, as he will expect a break-in message.

21. *Limitation in distance of break-in communication.*—The fact that reducing the strength of the oscillations of the receiving set increases its efficiency as a receiver makes it possible to communicate over a much greater distance with these sets if the break-in feature is not used. Thus, if break-in communication is not desired, the transmitting set may have its power increased, by adjustment of the potentiometer, to the limits of the set, as the decrease in the receiving ability of the set is no longer a factor to be considered. Also the receiving set may have the strength of its oscillations reduced to that point which gives the maximum reception, as these oscillations

are not used by the transmitting station. These two factors make for a greater possible distance of communication. It is often possible, therefore, to obtain ordinary radio communication between two SCR–77–A sets when break-in communication can not be established.

22. *Troubles and remedies.*—If the set is inoperative after being installed, go over carefully all connections made in installing the set. Especially examine the loop joints to see that they are clear and bright and make good electrical contact. If the set is still inoperative, pull forward the operating chest panel and see if all their filaments are lighted. If not, trace out the circuit for poor or broken connections. The tube socket contact springs sometimes make poor contact with the contact pins of the tube, due to dirty contacts or weak-spring tension. Of course a run-down storage battery may be the cause of the failure of the tubes to light up.

If the instrument still fails to operate properly, as indicated by failure of meter to read as much as 5 milliamperes and by failure to obtain a marked drop in plate current when the left-hand side of the loop is touched with the bare hand, note whether the telephone click produced in this manner is louder while operating the key when the meter is shunted. If so, the meter is burned out. If the clicking is the same and quite weak, the trouble probably lies in faulty or run-down BA–2 batteries or faulty connections between the batteries or otherwhere in this circuit.

If the milliammeter is burned out or otherwise becomes open-circuited, it can be shunted until replaced or repaired. To shunt the meter, connect its two terminal posts together by a piece of wire. To test whether or not the set is oscillating when there is no meter, touch the left-hand side of the loop with the bare hand. A distinctive click in the telephone receiver is heard if the set is oscillating.

If it is impossible to cause the meter to read as low as 5 milliamperes by adjustment of the plate control current knob, it is due either to reverse polarity of storage-battery connections or a run-down or wrongly connected grid potentiometer battery. It may happen, however, that an exceptionally good oscillator tube will cause a plate current that can not be reduced to the proper value.

23. *General care of the set.*—The sets are made as rugged as possible with this type of apparatus. However, they should not be subject to any heavy jars or severe shaking, as this will break connection or injure the apparatus. The set should not be unnecessarily exposed to rain or dampness. If it becomes wet it should be thoroughly dried out but not exposed to intense direct heat. Care should be taken to keep all terminals bright and clean, including the

joints of the loop. If the sets are stored they must be kept in a dry place. Instructions for the care of the head set are given in Figure 5.

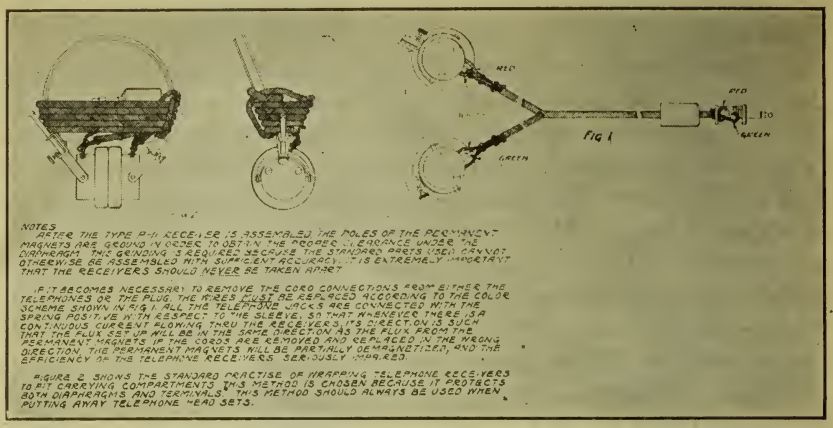


FIG. 5.

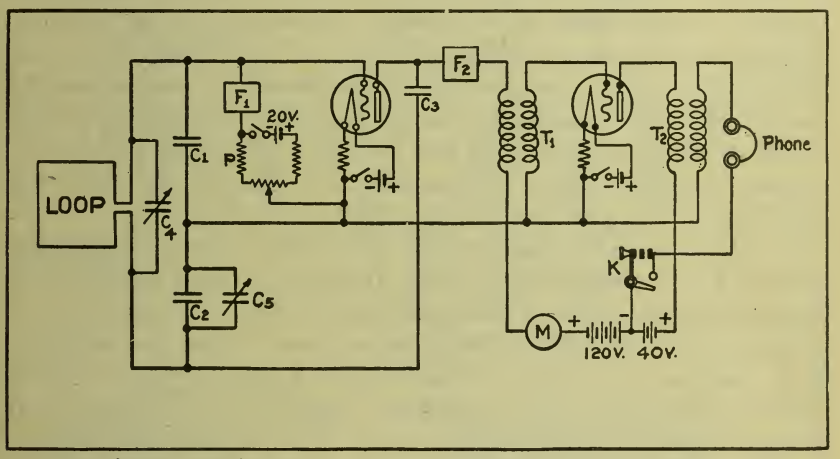
SECTION VII.

PRINCIPLES EMBODIED IN THE SET AND ITS CIRCUIT DIAGRAM

24. *Principles of operation.*—The SCR–77–A set uses three VT–1 vacuum tubes. One of these is connected as an oscillator, using a capacity coupling between the plate and the grid. The other two tubes are used as audio frequency amplifiers to amplify the heterodyne note produced, as explained below. The oscillating circuit is so designed that at the same time it is oscillating this tube will also act as a detector. It is performing both of these functions simultaneously, so that the set is always being used as a transmitter and as a receiver. The set receiving the message has its key short-circuited by a switch, and hence is generating undamped waves continuously, i. e., not broken up into dots and dashes. The set transmitting the message generates undamped waves, which are interrupted to form dots and dashes. As the two sets in communication have been so adjusted that their difference in frequencies of oscillation is equal to an audible frequency, the heterodyne effect produced by the two oscillations gives rise to an audio frequency note when detected. As

both sets are detecting as well as generating, the signals sent out are heard in both sets. If either set should stop oscillating, the signals would disappear, for there would be no heterodyning wave. Thus, when the operator sending the message ceases to hear his own message, he knows that the receiving operator has stopped his set from oscillating. This is a signal that the receiving operator desires to break in. The operation of the sets may be thought of as follows: The set receiving the message is acting as an autodyne (self heterodyne) for itself and also as separate heterodyne for the set transmitting the message. Both sets are able to receive the heterodyne note. The circuits of the set are so designed that the scheme outlined above will be effective with a loop antenna.

25. *Simplified diagram of set and explanation.*—A simplified diagram of the circuit is shown in Figure 6. The loop gives an induc-



(For legend, see Fig. 7.)

FIG. 6.

tance large enough to permit stable oscillations at the frequencies used by the set to be established. Across this loop is the grid condenser C_1, and the plate condenser C_2, which supply the coupling between the plate and the grid necessary to build up and maintain oscillations. The plate voltage of the oscillator tube is supplied by a 120-volt battery, which is also connected to the filament through a key. The closing of this key suddenly throws a high negative potential on the filament, thus upsetting its stable nonoscillating condition and starting oscillations. A milliammeter in the plate circuit enables the operator to determine the amount of power being used by the tube. A condenser of large capacity C_3 in the lead from the plate to the oscillating circuit prevents the 120-volt direct current potential from passing through the loop to the grid. Because of its large capacity, it offers little impedance to the radio frequency oscillations.

A very small single-leaf variable condenser, C_4, is shunted across the loop to permit an adjustment of the frequency of the oscillating circuit. This is the condenser used in calibrating the set. A variable air condenser C_5 is shunted across the plate-coupling condenser. This also provides an adjustment of the oscillation frequency of the set. It is controlled by the tuner knob on the front panel.

26. *The potentiometer and filter circuit.*—The grid and filament of the oscillating tube are connected by a filter, which replaces the radio frequency choke coil commonly used, and a potentiometer. The potentiometer consists of a 20-volt battery (BA–2) and three resistances, one of which is provided with a sliding contact. The biasing potential between the grid and filament is controlled by the potentiometer. A change in this biasing potential will produce a change in the power output of the tube. The adjustment is needed so that the strength of the oscillation produced by the tube may be limited to such values as will enable the tube to act as an efficient detector at the same time that it is producing oscillations. The filter in this circuit prevents any radio frequency oscillations from passing directly from the grid to the filament. The oscillations produced by the tube, therefore, are forced to follow the circuit to the filament through the grid condenser, C, thus giving the proper coupling between the circuits of the tube.

27. *Detection and amplification.*—The radio frequency oscillations produced by the tube and the radio frequency arising from the radio wave produced by the set with which the first set is working are both present in the oscillating circuits of each set. These two oscillations give rise to a composite radio frequency wave whose amplitude varies periodically with a frequency equal to the difference in frequency of the two original oscillations. This difference of frequency has been adjusted, by the process of calibration, to be equal to an audio frequency. The composite wave is detected by the oscillating tube and because of its periodically varying amplitude gives rise to an audio frequency pulsation in the plate circuit of this tube. These audio frequency pulsations, because of the high impedance of the condensers, C_3, C_2, and C_5, to them can not follow this path to the filament and are forced to follow the circuit through the filter, F_2, the primary of the first audio frequency transformer, the 120-volt battery, and the key to the filament. The functioning of the amplifier tubes is very similar to that of an ordinary amplifier.

It is to be noted that the plate circuits of the amplifier tubes are fed by a 40-volt battery (two BA–2) and that the telephone receivers are in a separate circuit from the tube, being coupled to the plate circuit of the last tube by a special one to one transformer. The

circuit in which the telephone receivers are placed is closed and opened by the operating of the telegraph sending key, which has two contacts. The complete circuit of the set is shown in Fig. 7.

28. *Filters.*—Filters may be made for different purposes. One type of filter allows low-frequency current to pass through it and prevents high-frequency oscillations from passing through. Another type permits the passage of high-frequency oscillations and prevents the passage of low frequency. Another type of filter prevents

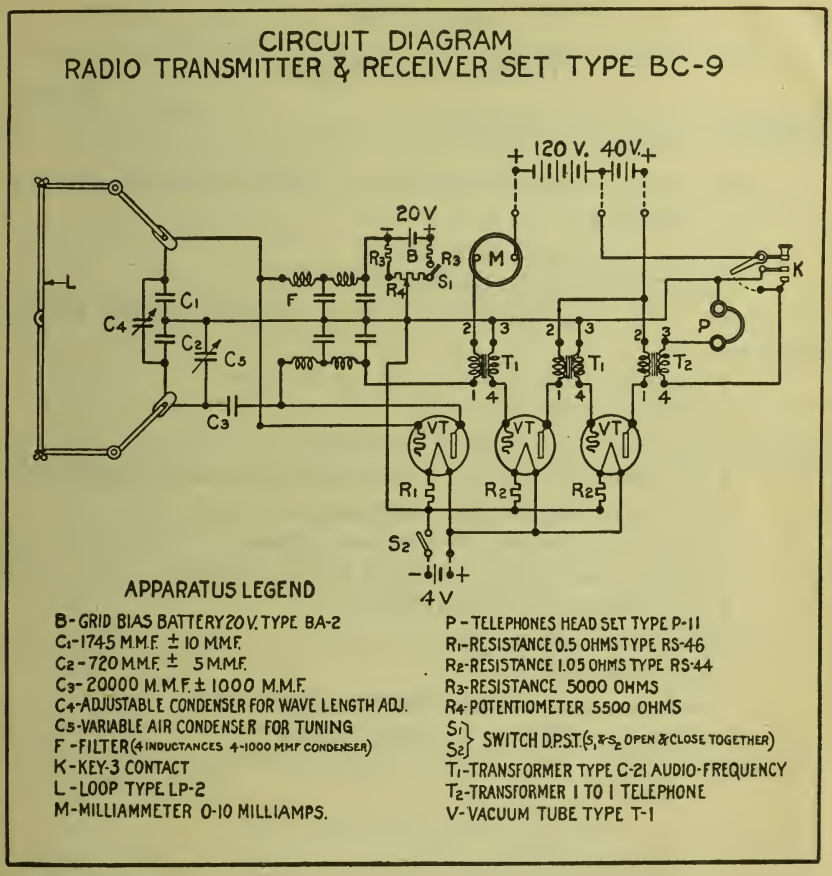


FIG. 7.

the passage of all frequencies except of a band which can be made as narrow or as broad as desired. Still another type of filter permits the passage of all frequencies except a band. Filters are made of combinations of inductances, capacities, and in some cases resistances. The filters used in the SCR–77–A set are both alike and permit the passage of low-frequency but not of high-frequency currents. In each filter there are two condensers having a capacity of 1,000

micro-microfarads each and two inductances having a value of 22.8 microhenries each. (Value measured at a frequency corresponding to a wave length of 85 meters.) Each inductance is made of 105 turns of No. 34 (0.0069 inch) "beldenamel" copper wire, 69 threads to an inch, wound on a bakelite spool 0.316 inch in diameter. For further information concerning filters, see Principles of Radio Communication, by Morecroft; Electric Oscillations and Electric Waves, by Pierce; United States Patent 1,227,113, "Electric Wave Filter."

SECTION VIII.

PARTS LISTS OF SET.

29. *Equipments in the SCR–77–A set.*—There are two equipments in the set, as follows:

Power equipment, type PE–37.
Radio equipment, type RE–23.

30. *Parts lists of equipments.*—Power equipment, type PE–37, comprises:

3 batteries, type BB–41; 1 in use, 2 spare.
1 case, type CS–19.

Radio equipment, type RE–23, comprises:

1 bag, type BG–13; for carrying battery case, type CS–17.
1 bag, type BG–18; for carrying loop.
15 batteries, type BA–2; 9 in use, 6 spare.
2 battery cases, type CS–17; 1 in use, 1 spare.
1 equipment box, type BE–48.
2 head sets, type P–11.
1 loop, type LP–2.
1 radio transmitter and receiver, type BC–9.
6 tubes, type VT–1; 3 in use, 3 spare.

SIGNAL CORPS PAMPHLETS.

(Corrected to February 1, 1923.)

Radio Communication Pamphlets.

(Formerly designated "Radio Pamphlets.")

No.

1. Elementary Principles of Radio Telegraph and Telephony (edition of 4–28–21.) (W. D. D. 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.
6. Loop Radio Telegraph Set, Type SCR–77–A (W. D. D. 1115).
9. Amplifiers and Heterodynes. (W. D. D. 1092.)
11. Radio Telegraph Transmitting Sets, Types SCR–74 and 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. (W. D. D. 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 and SCR–67–A. (W. D. D. 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. (W. D. D. 1077.)
26. Sets, U. W. Radio Telegraph, Types SCR–127 and SCR–130. (W. D. D. 1056.)
27. Sets, Radio Telephone and Telegraph, Types SCR–109–A and SCR–159. (W. D. D. 1111.)
28. Wavemeters and Decremeters. (W. D. D. 1094.)
30. The Radio Mechanic and the Airplane.
40. The Principles Underlying Radio Communication (edition of May, 1921). (W. D. D. 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. (W. D. D. 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. (W. D. D. 1020.) (2d edition.)
11. Elements of the Automatic Telephone System. (W. D. D. 1096.)

TRAINING PAMPHLETS.

1. Elementary Electricity (edition 1–1–21). (W. D. D. 1055.)
2. Instructions for Using the Cipher Device, Type M–94. (W. D. D. 1097.) For official use only.
4. Visual Signaling.
7. Primary Batteries (edition of 6–9–22). (W. D. D. 1112.)
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.

TRAINING REGULATIONS.

(Signal Corps subjects.)

165–5. Wire Axis Installation and Maintenance Within the Division.

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