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U.W. Airplane Radio Telegraph Set Type SCR-80

Communication

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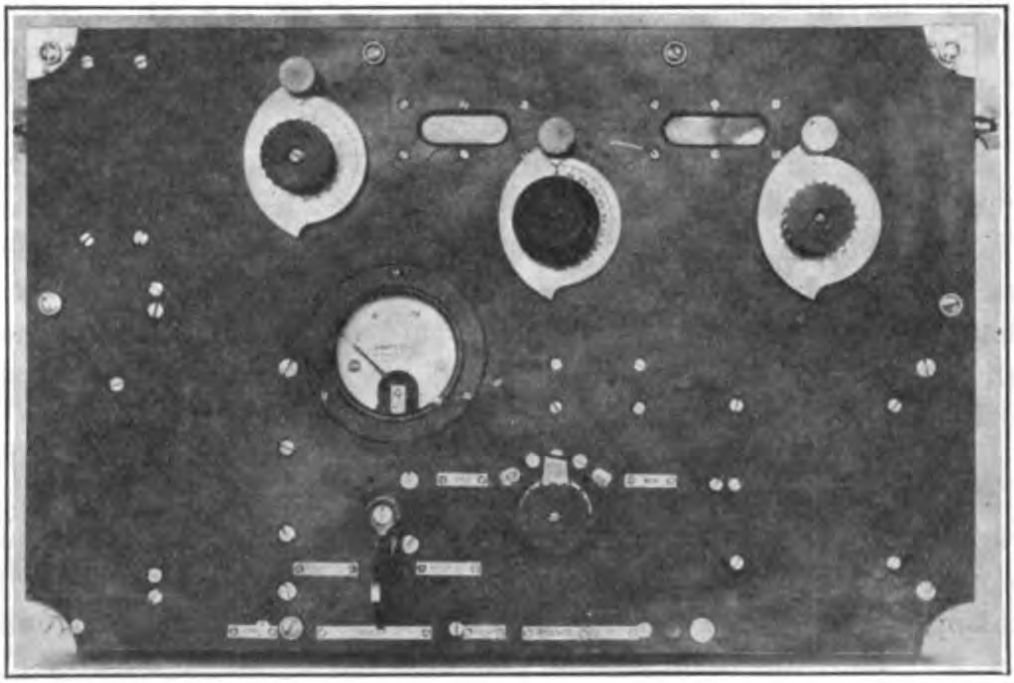
U.W. AIRPLANE RADIO TELEGRAPH SET

TYPE SCR–80

113918—19—1

THE TYPE SCR–80 SET is a transmitting and receiving undamped wave airplane radio telegraph set, having a wave length range of from 550 to 750 meters. It may be used with a single wire trailing antenna about 300 ft. long, or with a two-wire antenna, such as the type A–23, which gives the same range of wave lengths.

This set is primarily intended for long range fire control work in conjunction with the type SCR–79 ground set. However, it may



Operating Panel of Set Box Type BC–52 Used in Set Type SCR–80, as it Appears Set Vertically in Front of the Observer.

be used for intercommunication with other airplanes similarly equipped. When communicating with a type SCR–79 set, the type SCR–80 set has a range of about 20 miles. This distance will vary with the type of antenna used and may be as great as 40 miles. This is an exceptionally long range for an airplane set.

An advantage of this set is that it is practically interchangeable with the type SCR–68 set, as it uses the same double voltage, fan driven generator, the same filter box and interphone box. The set box itself may be mounted on a bracket differing but little from that

used for the set box of the type SCR–68 set. The principal difference in the installation is that one or more telegraph sending keys are used on the set box instead of telephone transmitters.

The set is rugged and compact and is very simple to operate, there being only one adjustment of the transmitting circuit and two adjustments of the receiving circuit.

General Description and Principle of Operation.

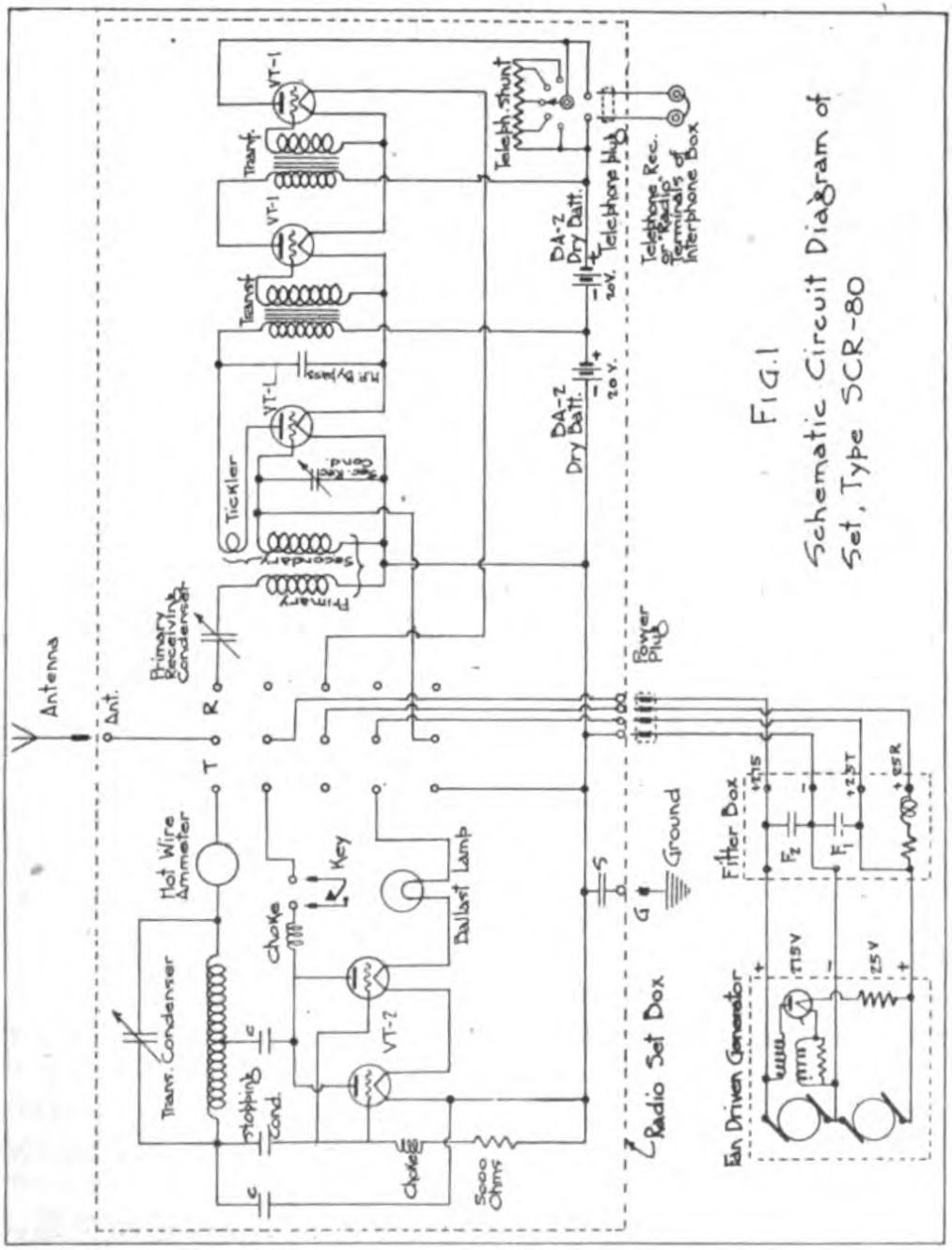
A complete schematic circuit diagram of the set is given in Fig. 1, which illustrates the principle of operation of the set. A five-pole, double-throw "Transmit-Receive" switch is provided on the set box, which effects all the necessary changes in the connections of the set box when transmitting or receiving.

Switch in "Transmit" Position.—With the switch in the "Transmit" position, the circuits in use are equivalent to those shown in Fig. 2. The two type VT–2 three-electrode vacuum tubes used for the generation of the oscillations are connected with their filaments in series, and the filament heating circuit, which comprises also a ballast lamp, is connected across the 25-volt terminals of the fan driven generator.

The ballast lamp has a filament the resistance of which varies with the current flowing through it, and it functions to minimize the variations of the filament current resulting from the slight variations of generator potential. These potential variations are due to slight changes in the speed of the generator and to the action of commutation. They are reduced and smoothed out by the condenser F_1, which is located in the filter box, and acts jointly with the ballast lamp to deliver a constant current to the transmitting tube filaments.

The grids and plates of the two tubes are connected in parallel, so that the arrangement is equivalent to one single tube of larger size. A continuous positive potential of 275 volts, generated by the 275-volt armature of the fan driven generator, is applied to the plates when the telegraph key is closed. This location of the key in the plate circuit insures a very positive action of the tubes, since there is thus no plate current when the key is open, which prevents any accumulation of negative charge on the grid, and hence any lag in the starting of the oscillations when the key is closed is avoided. In order to smooth out small variations of plate potential, such as

those resulting from commutation, a condenser F_2 is connected across the 275-volt terminals of the generator. This condenser, like the condenser F_1, is located in the filter box.



A continuous negative potential is impressed upon the grid, which is derived from the potential drop resulting from the grid current flowing through a 5000-ohm grid resistance connected

between the grid and the filament. A choke coil is inserted in each of these d.c. grid and plate potential circuits in order to prevent the high frequency oscillations generated by the tubes from entering these circuits.

The plate and grid circuits just described are coupled electrostatically through the medium of two fixed mica condensers marked C, Fig. 2. The oscillatory circuit in which undamped oscillations are generated comprises the inductance coil L, the radiating antenna-ground condenser and the variable "Transmitting Condenser" in parallel with it. A hot wire ammeter in series with

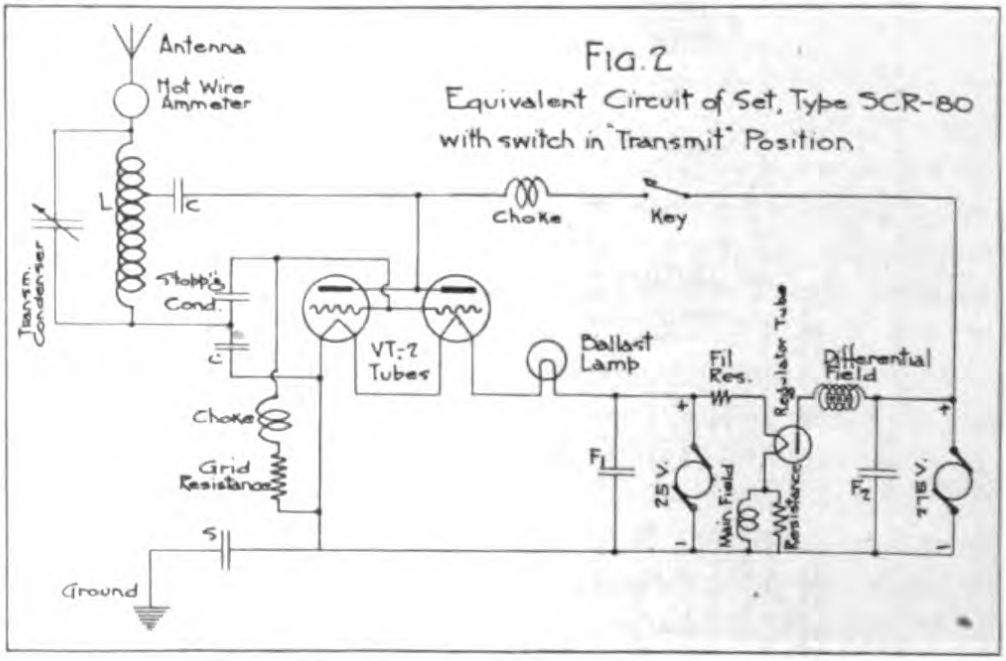


FIG. 2
Equivalent Circuit of Set, Type SCR-80 with switch in "Transmit" Position

the antenna indicates the radiation, and provides a method of checking that the vacuum tubes are in an oscillating condition. It should be noted that the condenser S in the ground wire prevents any possible outside short circuit of the generator. As may be seen from the above, the only adjustment provided in the circuit is that of the transmitting condenser. This is sufficient to cover the entire wave length range of the set.

Switch in "Receive" Position.—Since the signals to be received by the set are undamped wave signals, the heterodyne method is used for their reception. With the switch in the "Receive" position, the circuits in use are equivalent to those of Fig. 3. The incoming signals first energize the primary circuit, which comprises

the antenna, primary tuning condenser, primary inductance, stopping condenser S, and ground (counterpoise). Inductively coupled to the primary inductance is the secondary oscillatory circuit, comprising a secondary inductance coil and a variable secondary condenser. No provision is made to vary the coupling of the primary and secondary coils since this is not necessary for satisfactory operation, and reduces the number of adjustments. A peculiar feature of the secondary condenser is the micrometer adjustment which makes possible a fine adjustment of the secondary

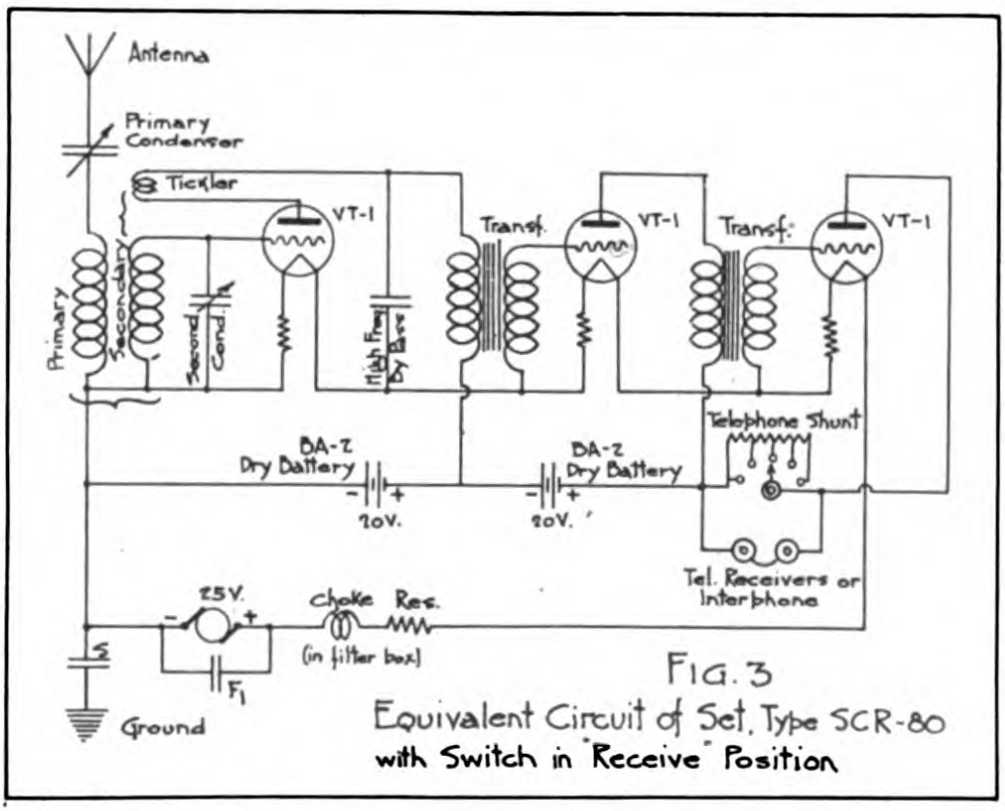


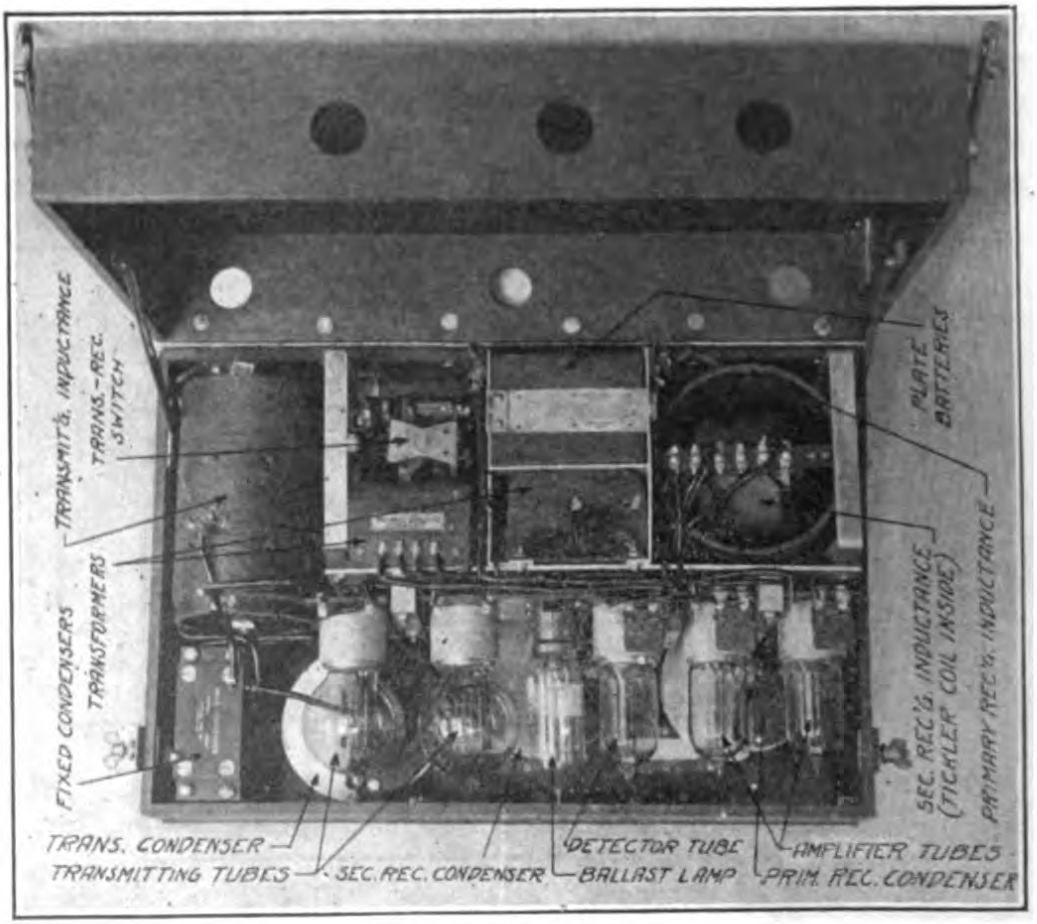
FIG. 3

Equivalent Circuit of Set, Type SCR-80 with Switch in "Receive" Position

circuit. This is made necessary by the use of the heterodyne method of reception. The secondary condenser is operated by means of an insulating handle which rotates all the movable plates but one. This one plate is operated separately by means of a smaller handle mounted on the same shaft.

The secondary oscillatory circuit is connected between the grid and the negative side of the filament of a type VT–1 vacuum tube used as a detector. The plate current for this tube is furnished by a 20-volt, type BA–2 dry battery. The plate circuit comprises a tickler coil, permanently coupled to the secondary inductance, and

the primary winding of an iron core transformer which couples the detector tube circuit to the first amplifier tube. Shunting this transformer winding and dry battery is a fixed mica condenser which



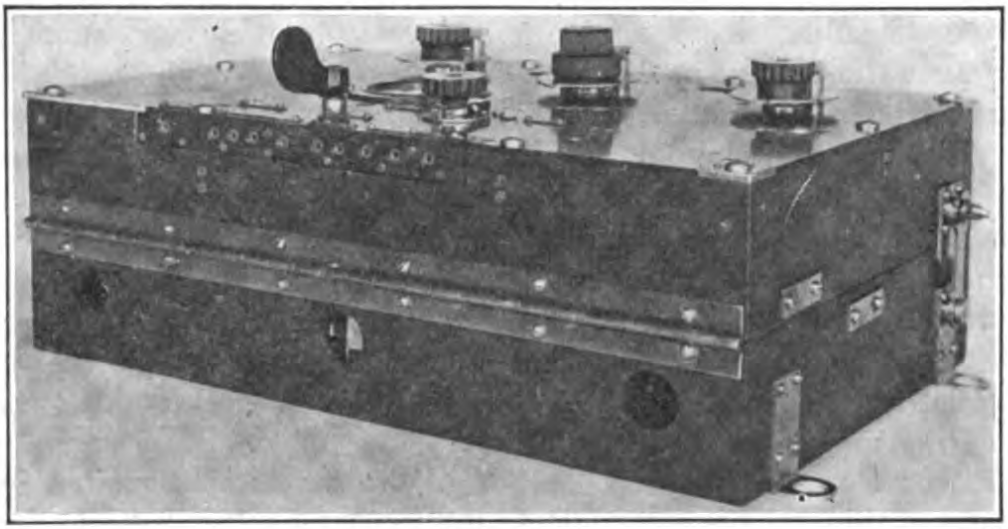
View of Set Box Type BC-52 Interior, as it Opens Before the Observer When the Set Box is Mounted in the Airplane Cockpit.

serves as a by-pass for the locally generated high frequency oscillations.

The remainder of the receiving circuit is a two-stage cascade amplifier using type VT-1 vacuum tubes, with a plate potential of 40 volts on each one of these tubes, and iron core transformers coupling them. Telephone receivers are inserted in the plate circuit of the last tube. These are shunted by a resistance variable in five steps, which is used to vary the proportion of the signal current flowing through the receivers and thus permits the elimination of weak interfering sounds.

All three filaments are connected in series, the heating current being furnished by the 25-volt side of the fan driven generator. In series with the latter is a choke coil and resistance, which are located in the filter box and which serve to reduce the commutation pulses which were not by-passed by the condenser F_1. This condenser shunts the generator terminals and smooths out the commutation pulses of the generator. In series with each filament is a 1-ohm resistance the voltage drop across which supplies to the grid of each tube the proper negative potential.

It will be noted, Fig. 1, that the secondary receiving condenser is short circuited when the switch is in the "Transmit" position.



Bottom View of Set Box Type BC–52 Showing Connecting Jacks and Elevation of Operating Handles.

This arrangement is made in order to prevent excessive currents from being induced in the secondary receiving inductance coil by the oscillations taking place in the transmitting inductance while sending.

Description of Generator.—The fan driven generator, type GN–1–A or GN–2–A, used with this set is the same as that used with the type SCR–68–A airplane radio telephone set. It has two armature windings, giving 25 and 275 volts, respectively, when the generator is run at rated speed. Since it is very important for the satisfactory operation of the set that the terminal voltage of the generator remain constant, a regulating fan, type FA–7, is used. This fan has a variable pitch which adjusts itself automatically for vary-

ing wind velocities, so that it will rotate at a constant speed within wide limits of wind (or airplane) velocities. When no regulating fan is available, a type FA–3 wooden airfan may be used, which, however, is likely to give less satisfactory operation under conditions of varying wind velocity. In addition to the regulating action of the variable pitch airfan, the voltage output of the generator is also controlled through the use of a main and a differential field winding, the fluxes of which are opposed in effect. There is also a special two-electrode regulating tube inserted in series with the differential field. The complete connections are illustrated in Fig. 1. The action of this device may be explained as follows:

When the generator is driven at a higher speed than normal, the generated voltage has a tendency to increase, which consequently increases the current in the main field winding and in the regulator tube filament in series with it. It also increases the plate voltage on this tube, and therefore the plate current. The latter current, flowing through the differential field winding, increases the flux in the latter, which counteracts that of the main field, and thus prevents any further rise of the generator voltage. In case the generator is driven at a speed below normal, the phenomena occur in exactly the opposite manner. By means of this arrangement, the output voltages of the generator are maintained fairly constant under the conditions encountered in practice.

Filter Box.—With the operation of the generator regulated by means of the variable pitch airfan, the regulator tube, and differential field, there remains the pulsating terminal voltage of the generator resulting from commutation to be eliminated. The result of such a pulsating current is a steady hum in the telephone receivers. This noise is minimized by the use of a filter box, which is of the same type as that used with the type SCR–68–A set. It consists of two condensers, shunting the 25-volt and 275-volt terminals of the generator, and a reactance coil and resistance connected in series in the filament circuit of the receiving tubes.

Interphone.—While the type SCR–80 set is essentially a radio telegraph set, it is of great importance in connection with its use that the pilot and observer should be able to talk to each other during the flight. Also, while the observer is the only one to use the sending key, it is of advantage that both the pilot and observer receive the incoming signals, so that the pilot will not talk to the observer while the latter is receiving a message. This double function is accomplished by the interphone which is connected to the radio

set box in place of the telephone receiver, as shown in Figs. 1 and 4. The set used is the Set, Airplane Interphone, Type SCR–57–A, for which a circuit diagram is shown in Fig. 5. This set is also used on airplane radio telephone sets, such as the type SCR–68–A. It has two radio telephone transmitter terminals, which are not used when the interphone set is used with the telegraph set type SCR–80.

The method of functioning of the interphone may readily be understood from the circuit diagram. When the four-pole double-throw switch is closed in the position "Interphone," the contacts marked "I" in the diagram are closed. The pilot and observer are

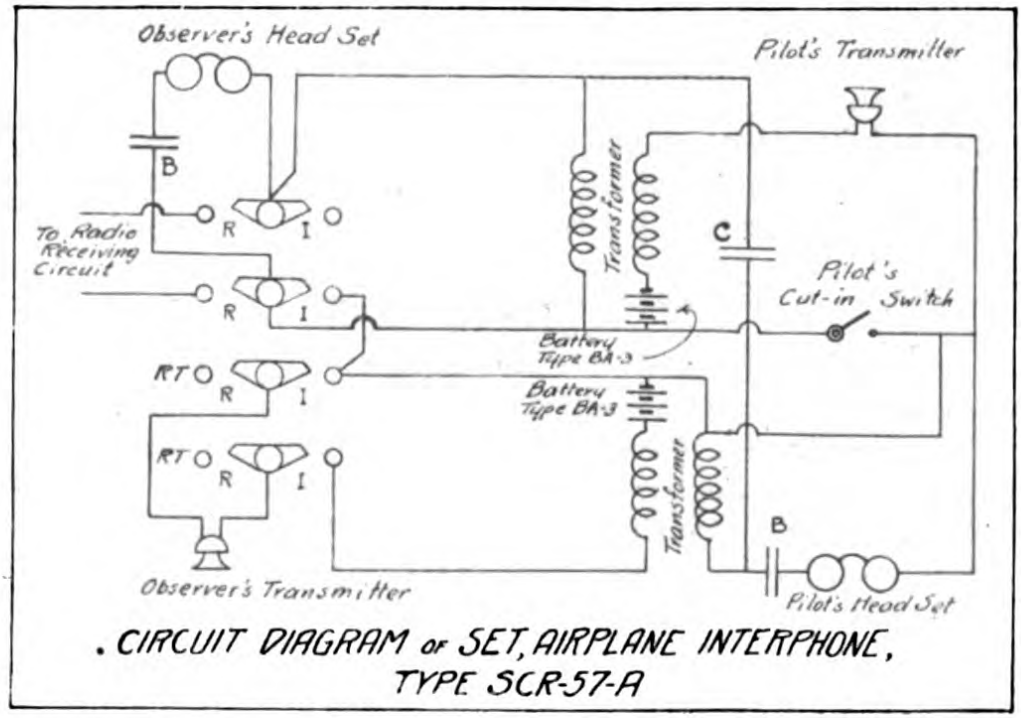


Fig. 5.—Circuit Diagram of the Interphone Set Used With Set Type SCR–80.

then entirely disconnected from the radio set, and are connected to each other by an ordinary telephone circuit. They may talk back and forth without any additional operation. A special feature of the set is the "side tone" circuit, which comprises the condenser C, and the purpose of which is to shunt some of the telephone current from the transmitter circuit back into the telephone receiver circuit of the person talking, so that he may hear his own voice and know how loud he is talking and whether or not the circuit is working.

When the switch on the interphone set box is closed to "Radio," the observer's telephone receivers are directly connected to the radio telegraph receiving circuit, and the observer receives incoming

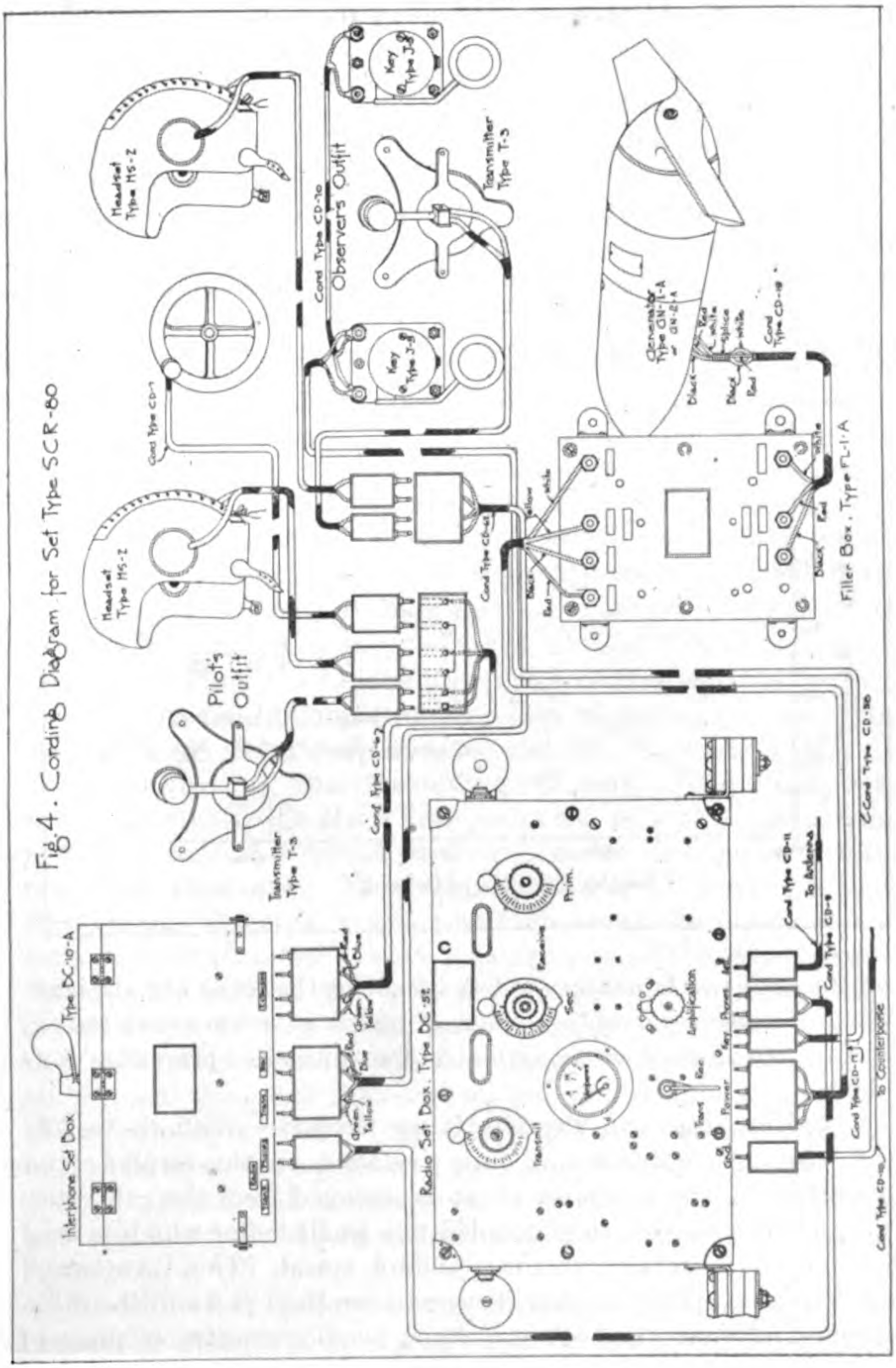
radio signals in the ordinary manner. The observer's telephone transmitter is entirely disconnected, so that he can not talk to the pilot. The pilot's circuits are disconnected, but by closing his cut-in switch he can receive the radio signals and talk to the observer. The operation is then as follows:

When the observer and pilot want to talk back and forth to each other, the observer closes the interphone-radio switch to "Interphone." When the observer desires to receive radio signals, this switch is closed to "Radio." If, now, the pilot desires to talk to the observer, he must first close his cut-in switch, and if he does not hear any radio signals, he may speak to the observer without interrupting him in the reception of a radio message. If he hears incoming radio signals, he should wait for the end of the message. If the observer desires to answer the pilot, he must close the interphone-radio switch to "Interphone." This, however, disconnects him from the radio set, so he should not leave the switch in this position longer than is necessary or he may miss some incoming radio signals.

Method of Installing the Set.

All of the apparatus described above is grouped in a number of units, as indicated schematically by the dotted lines, Fig. 1. These units comprise the fan driven generator, generally mounted on the right hand strut in the landing gear; the filter box, which may be installed on the floor inside the fuselage; the radio set box, preferably mounted as for the SCR-68 in front of the observer; and the interphone set box, which is conveniently mounted on the right hand side of the observer's cockpit. The antenna reel can then be mounted on his left hand side. When one telegraph key is used, it is mounted on the right hand side of the observer. When two keys are used, such as in the De Haviland DH-4 two-seated machine, one is mounted in front and the other in back of the observer. These suggestions for the installation of the set are, of course, of a general character, and the actual location of the apparatus will differ in the various types of airplanes. The usual precautions of good insulation, neat wiring, balancing of the load, etc., must be observed.

The interconnection of the various units should be made with the extension cords provided and in accord with the cording diagram given in Fig. 4. Care should be taken to see that all connections and plugs are tight, since a loose connection or broken cord will prevent satisfactory operation of the set.



Method of Calibrating the Set.

In general, an airplane will always use an antenna of the same length, so that it will be found of advantage to calibrate the transmitting circuit of the set for this antenna. This is done in order that the setting of the transmitting condenser will be known for any value of wave length it is desired to use. It is also well to calibrate the secondary receiving circuit of the set, so that it may be adjusted in advance to receive any predetermined wave length. The calibration of this latter circuit will not change, even if the set is used with an antenna having different characteristics. The calibration

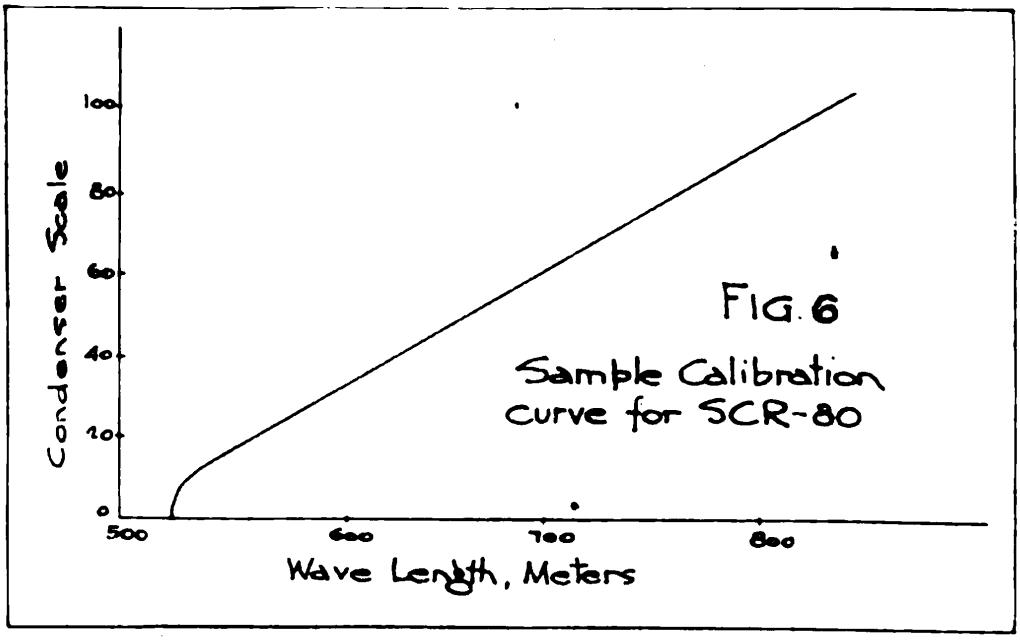


FIG. 6

Sample Calibration curve for SCR-80

may be made in a laboratory before installing the set on the airplane. This is of especial advantage when a number of sets are to be tested. For calibrating a set on an airplane, the method of procedure is as follows.

(a) **Calibrating the Transmitting Circuit.**—With the set in good working condition and fully installed on the airplane and connected up, the generator airfan is removed from the generator. The generator shaft is then coupled to a small motor which is used to drive the generator at the standard speed. The "Antenna" and "Ground" plugs are first removed from their jacks in the radio set box, and a phantom antenna, type A-50, connected in place of the real antenna. The phantom antenna is set to correspond to

the constants of the real antenna. If no phantom antenna is available, a condenser may be used having the same capacitance (about 300 micro-mfd.) as the real antenna. This is, however, not as good practice, since the calibration will not be quite so accurate. In all cases, whether the phantom antenna, type A–50, or an improvised phantom antenna is used, the connecting wires should be equipped with plugs, type PL–12, so they will fit the "Antenna" and "Ground" jacks of the radio set box.

The "Transmit-Receive" switch is thrown to the "Transmit" position, and the set excited by running the generator at its rated speed. The telegraph sending key is closed and the wave length emitted by the set is measured by means of a type SCR–95 wavemeter for a number of positions of the transmitting condenser covering its entire range. A curve is then plotted, similar to that shown in Fig. 6, from which the transmitting condenser setting may be found for any value of wave length within the limits of the set. Maximum coupling between the type SCR–95 wavemeter and the type SCR–80 set radio circuits may be obtained, if required, by placing the side of the wavemeter box marked "Plane of Coil" in front of the lower left hand side of the operating panel of the type SCR–80 radio set. Complete instructions regarding the use of this wavemeter are given in Radio Pamphlet No. 21, second edition.

(b) **Calibrating the Receiving Circuit.**—To calibrate the receiving circuit, the set is first connected to a phantom antenna and the generator is driven by a small motor, as explained in the preceding paragraph. The "Transmit-Receive" switch is then closed to the "Receive" position, and the wavemeter is successively made to emit a number of wave lengths covering the entire range of the set. For each wave length, the secondary receiving condenser is adjusted to give maximum response in the telephone receivers. This calibration is made with the primary receiving condenser set on "0" and then with that condenser set at "100," and a curve is plotted similar to that of Fig. 6, giving the secondary condenser setting for receiving any desired wave length within the range of the set. The points will, in most cases, be on either side of the calibration curve, which should therefore be an average curve for the readings obtained.

The calibration of the receiving circuit, as explained above, will have to be made only once, as the set is put into use the first time.

The calibration of the transmitting circuit will have to be repeated every time a new antenna is used having different electrical constants.

Method of Operating the Set.

The following tests should be made on the ground prior to each flight, for the purpose of ascertaining that the set is in good working condition.

1. Remove the airfan from the generator shaft, and couple the generator to a motor, which will be used to run it at rated speed.

2. Remove the "Power" plug from the corresponding jack in the radio set box, and start the generator.

3. By means of a voltmeter, check the voltage between the "Power" plug terminals. The voltmeter readings should be 25 and 275 volts, respectively.

4. By means of a voltmeter, check the voltage of the type BA-2 dry batteries in the set box. This should not be less than 18 volts. Note that the batteries are connected with the correct polarity.

5. Connect a phantom antenna in place of the real antenna and ground, insert the "Power" plug into its jack in the radio set box, and close the "Transmit-Receive" switch in the "Transmit" position.

6. The two type VT-2 transmitting tube filaments should now glow a dull red, and the hot wire ammeter on the operating panel should read from about 0.9 to 0.6 amp. when the transmitting condenser is turned from the "0" to the "100" position.

7. Close the "Transmit-Receive" switch to "Receive," and the interphone switch to "Radio." The three type VT-1 tube filaments should now glow a dull red, and the characteristic commutation hum should be heard in the telephone receivers, for all positions of the primary and secondary receiving condensers.

8. Turn the telephone shunt switch over its entire range, and note that there occurs a gradual change in the intensity of the commutation hum.

9. Check the oscillating condition of the detector tube for various positions of the receiving condensers. This is done by opening the set box, and touching the grid terminal (upper terminal of the secondary condenser) with a wet finger, when a click should be heard in the telephone receivers.

10. The generator is now stopped, and the airfan replaced and locked tight to the shaft, so that it will not work loose or vibrate during the flight. The airfan blades should be twisted around once or twice, to see that they rotate properly. Oil the bearings slightly if required.

11. The set having been found in good working condition, the phantom antenna is removed, and the real antenna and ground are plugged in. The transmitting condenser is then set to the proper position, as given by the calibration curve of the transmitting circuit, for the wave length at which it is desired to transmit. The secondary receiving condenser is also set at the predetermined wave length to receive the signals from the ground set. This latter setting is only approximate and will have to be adjusted while in flight, as explained below.

12. The set is now ready for the flight. After the airplane has reached a sufficient height, the antenna is reeled out, if such a type be used, and the "Transmit-Receive" switch is closed in the "Transmit" position. Upon closing the telegraph sending key, the hot wire ammeter should read from 0.9 to 0.6 amp. It is well to check up that the waves emitted are of the desired length. This may be done by closing the key and using the type SCR–95 wavemeter, which can be readily taken up in the airplane on account of its small size. On account of the rather large current passing through the key, it is best to have a large opening of the key, in order to prevent possible arcing between the key contact points.

13. For receiving, the "Transmit-Receive" switch is closed in the "Receive" position, and the interphone switch placed in the "Radio" position. The secondary receiving condenser having been set on the ground at approximately the correct position for the signals to be received, it is not disturbed at first. The primary receiving condenser setting is varied over its range until a position is found at which the signals are heard. If the signals are not received after the entire range of the primary condenser has been tried, the setting of the secondary condenser should be altered slightly either way, and the operation repeated. It is well when flying within 5 to 10 miles of the sending station to set the telephone shunt switch on the middle tap. For finer adjustment of the set, the secondary condenser micrometer adjustment may be used, especially when receiving weak signals, such as when flying at a great distance.

Possible Sources of Trouble.

Among the possible sources of trouble with this set, the following may be mentioned:

Switch on "Receive."—Failure to receive signals with the set properly tuned may be due to a failure of the detector tube to oscillate. The test for oscillating condition is given in Par. 9 above.

If signals are not received and the commutation hum is not heard, the dry battery may be run down, or the filament of one of the three receiving tubes may be broken.

A crackling noise in the telephone receivers may be due to poor brushes on the generator, poor setting of the brushes, sparking at the commutator, or to poor dry batteries, or loose connections in the telephone cords or in the circuit. It may also be due to magneto interference. This last may be prevented effectively by shielding the magneto and magneto wires leading to the spark plugs of the airplane motor. A fairly satisfactory solution was found which involved the use of metallic covers for all the high tension wires and the magnetos. The most common practice made use of flexible copper clad cables for this purpose, but after considerable experimenting it was found that solid metallic tubing was preferable, it being possible to completely screen out the disturbances with this form of shielding.

Switch on "Transmit."—If the hot wire ammeter does not indicate any current, it may be due to a faulty transmitting condenser. This would usually be noticed in the preflight test on the ground. It may be the result of buckled and short circuited condenser plates.

A broken filament of improper plate voltage such as might result from a faulty regulator tube in the generator, will prevent operation of the set.

Generator trouble will frequently be found to be in the wiring and mounting of the regulator tube, in the brushes or commutators, or in the differential field circuit. An open in the latter will generally cause the burning out of the regulator tube filament or the three-electrode tube filaments or even the highvoltage generator armature.

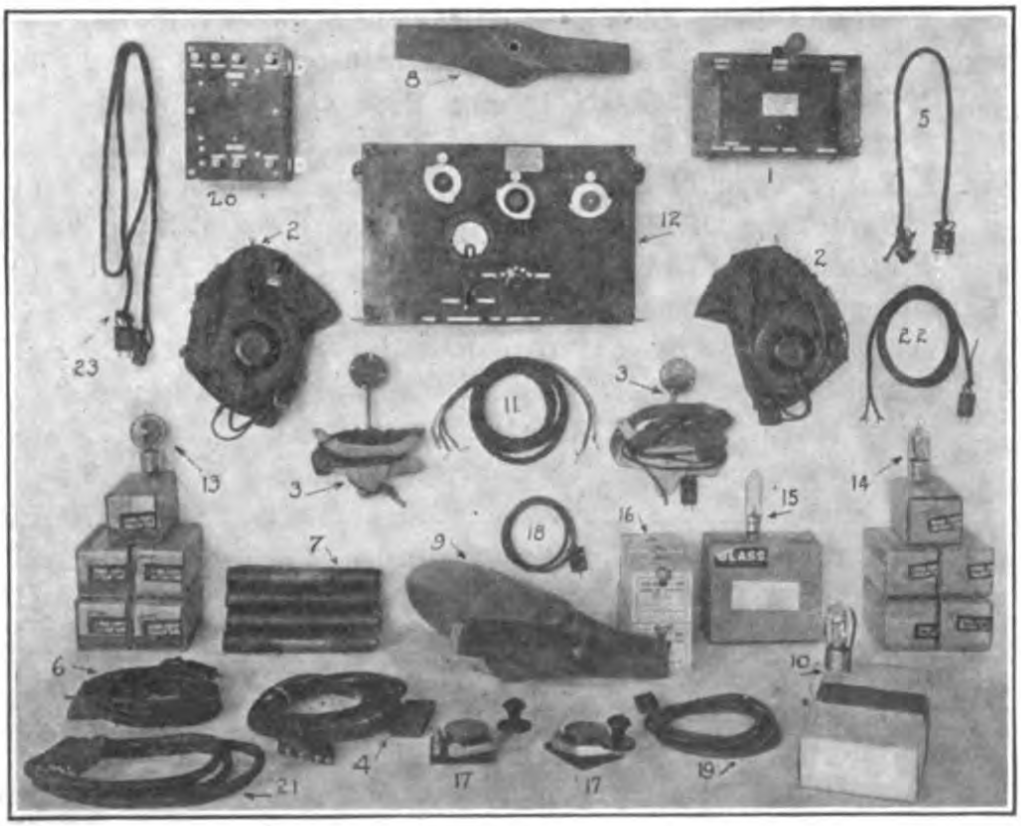
A frequent source of trouble will be due to loose connections at the filter box terminals. Breaking of the connection wires at those terminals usually results from the wires being run too tightly.

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 designations written 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, "2 Sets, U. W. Airplane Radio Telegraph, Type SCR-80." 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 PE-1-A."

The type SCR-80 set is not complete unless it includes all of the items listed below.



Set, U. W. Airplane Radio Telegraph, Type SCR–80.

1	**Set, Airplane Interphone, Type SCR–57–A:**	★
1	**Set Box Type BC–10–A**	(1)
2	**Head Sets Type HS–2**	(2)
2	**Transmitters Type T–3**	(3)
1	**Cord Type CD–6**; extension; 12 ft.; set box to pilot's jack	(4)
1	**Cord Type CD–7**; extension; push-button switch to pilot's jack	(5)
1	**Cord Type CD–62**; extension; 4 ft.; set box to observer's jack	(6)
20	**Batteries Type BA–3**; dry; 2 in use, 18 spare	(7)
1	**Equipment Type PE–1–A**; power:	
2	**Airfans Type FA–7**; regulating; or if not available, **Airfan Type FA–3**, wooden; 1 in use, 1 spare	(8†)
1	**Generator Type GN–1–A** or **Type GN–2–A**; wind-driven	(9)
5	**Tubes Type TB–1**; regulator; 1 in use, 4 spare	(10)
1	**Cord Type CD–19**; extension; generator to filter	(11)
1	**Filter Type FL–1–A**	(20)
1	**Equipment Type RE–9**; radio:	
1	**Set Box Type BC–52**; airplane radio telegraph	(12)
6	**Tubes Type VT–2**; vacuum; transmitting; 2 in use, 4 spare	(13)
6	**Tubes Type VT–1**; vacuum; receiving; 3 in use, 3 spare	(14)
3	**Lamps Type LM–1**; ballast; 1 in use, 2 spare	(15)
8	**Batteries Type BA–2**; dry; 2 in use, 6 spare	(16)
2	**Keys Type J–5**; flame proof	(17)
1	**Cord Type CD–10**; extension; BC–52 to ground	(18)
1	**Cord Type CD–11**; extension; BC–52 to antenna	(19)
1	**Cord Type CD–70**; extension; for connecting keys in parallel	(not shown)
1	**Cord Type CD–17**; extension; BC–52 to filter	(21)
1	**Cord Type CD–58**; extension; BC–52 to flame proof key	(22)
1	**Cord Type CD–9**; extension; set box type BC–52 to set box type BC–10–A	(23)

★The figures in parentheses in the right hand column refer to the corresponding part in the illustration on page 19.

†The airfan shown is the type FA 3, not regulating.

1 **Equipment Type A–23**; antenna:
- 1 **Antenna Type AN–6.**
- 780 ft. **Wire Type W–16**; in six lengths of 130 ft. each; wound on six spools; for use on AN–6; spare.
- 4 **Insulators Type IN–8**; phenol fiber rod; 4 in. long.
- ½ lb. **Tape Type TL–83.**
- 40 **ft. Cord Type RP–6**; impregnated linen; in two lengths of 20 ft. each.