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SETS UNDAMPED WAVE RADIO TELEGRAPH

TYPES SCR-79-A AND SCR-99

Radio Communication Pamphlet No. 17

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THE CHIEF SIGNAL OFFICER

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WAR DEPARTMENT,
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The following publication, entitled "Sets, Undamped Wave Radio Telegraph, Types SCR-79-A and SCR-99," Radio Communication Pamphlet No. 17, is published for the information and guidance of all concerned.

[062.1, A. G. O.]

BY ORDER OF THE SECRETARY OF WAR:

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

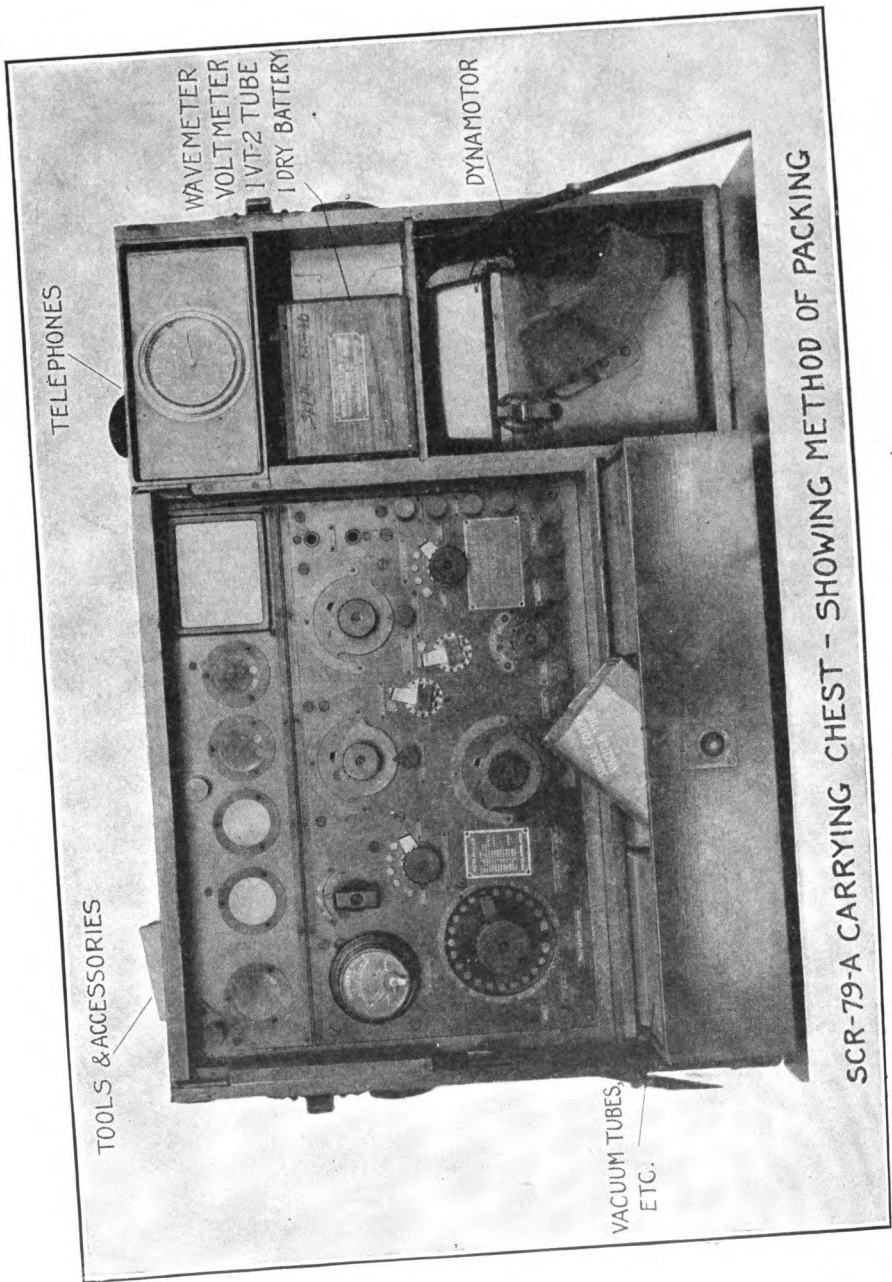
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TELEPHONES

WAVEMETER
VOLTMETER
1V1T-2 TUBE
1 DRY BATTERY

DYNAMOTOR

TOOLS & ACCESSORIES

VACUUM TUBES,
ETC.

SCR-79-A CARRYING CHEST - SHOWING METHOD OF PACKING

SETS UNDAMPED WAVE RADIO TELEGRAPH, TYPES SCR-79-A and SCR-99.

SECTION I.

PURPOSE OF SETS.

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Purpose of sets—Ranges.....	1

1. Purpose of sets—Ranges.—The radio telegraph sets, Types SCR-79-A and SCR-99, are vacuum-tube sets designed for transmitting undamped wave signals and for receiving either damped or undamped signals. Both sets use in the transmitter two tubes in parallel whose circuits are inductively coupled to the oscillating circuit of the antenna, and in the receiver inductively coupled circuits with a vacuum-tube detector and a 2-stage audio-frequency amplifier. When used with the prescribed antenna, the SCR-79-A set has a continuous range of wave lengths for transmitting and receiving of from 500 to 1,100 meters. Its transmitter delivers about 10 watts to the antenna, and with this power two similar sets can communicate over a distance of about 20 miles. The SCR-99 set is very similar to the 79-A except that it is somewhat more powerful, has a range of wave lengths of from 900 to 1,900 meters, and two similar sets can communicate over a distance of about 60 miles. Both sets are intended for use at command posts or at headquarters that are equipped with ample motor or wagon transport. Frontispiece shows a 79-A set in its carrying chest.

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DESCRIPTION OF SETS.

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2. **Equipments comprising the sets.**—Each set is comprised of three equipments as follows: Antenna, radio, and power. These equipments are alike in both sets except where noted below.

3. **Antenna equipment, Type A-9-A.**—The same antenna equipment is used with the SCR-79-A and SCR-99 sets. The essential component parts are the antenna, masts, counterpoise, ground mats, guys, and stakes. The antenna itself is a “V” with a 60-degree opening, 20 feet high, 100 feet long on each side, and with a 25-foot lead-in wire. Under some conditions, such as a limited space or for short-distance work, an inverted “L” may be used. This should be 20 feet high, 100 feet long, and with a 25-foot lead-in wire. The “V” antenna is supported on three masts, 20 feet high, each with two guys. The antenna wire is a bare stranded wire, and the lead-in is a lightly insulated wire or lamp cord. One end of both legs of the antenna wire forms the point of the “V” and to this is joined the lead-in wire. The two outer ends of the antenna and the point of the “V” are provided with strain insulators which have a snap or harness hook for fastening them to the tops of the masts. These insulators are made of an insulating material known as phenol fiber which has been thoroughly varnished and baked so as to secure high insulation. The antenna, lead-in, etc., are wound on two hand reels for convenience in storing away in transportation. The masts are of spruce and in three sections, each about $6\frac{3}{4}$ feet long, all sections being interchangeable. Each section is fitted at one end with a spike and at the other end with a steel tube that is tapered slightly to take the spike of the next section, and is pierced with three holes to take the snap hooks of the antenna insulators and guy ropes. The mast sections are carried in a carrying roll which has both a handle and a shoulder strap of nonelastic webbing. The guys are of No. 5 sash cord, 40 feet long, provided at one end with a snap or harness hook, for fastening in the holes in the steel tube of the topmast section and at the other end with a tent slide for adjusting the tension on the guy after it has been passed around the ground stake. In storing away they are wound on the same type of hand reels as the antenna. The ground stakes are of galvanized pipe, 18 inches long, and are provided with a binding post that makes it possible to use them as a ground rod if desired.

The counterpoise consists of two lengths of 150 feet of heavily insulated wire which is laid out on the ground in a “V” shape with a 60-degree opening under the antenna. In storing away they are wound on two hand reels. As an alternative for the counterpoise, three ground mats, which are of a fine copper gauze, each 13 feet long and 3 feet wide, are furnished. These have wood strips at both

ends to keep the mats flat and are provided with binding posts at both ends for convenience in making quick connections. The mats are generally rolled up for transportation and carried in the roll with the mast sections. The antenna and counterpoise wires, guys, stakes, hammer, etc., are carried in a carrying bag. The essential electrical constants of the "V" antenna are approximately: Inductance, 0.04 millihenry; capacity, 0.0004 microfarad; fundamental wave length, 240 meters; and average resistance, 50 ohms. Additional information about antennas and their theory in general can be found in Signal Corps Radio Communication Pamphlet No. 2, entitled "Antenna Systems."

4. **Power equipment, Type PE-7.**—*a. Battery equipment.*—The same power equipment is used with the SCR-79-A and SCR-99 sets. The essential component parts are the batteries and the dynamotor with its case. The battery furnishes current for the filaments of the transmitting and receiving vacuum tubes and for the dynamotor. It is a lead storage battery of a nonspill type; of 12 volts and 90 ampere-hour capacity, consisting of 3 units, each unit being a BB-14 battery of 4 volts. These units are connected in series by two extension cords. The connections should be made as follows: The positive or red binding post terminal of the first battery should be left free to be connected later to the operating chest (set box) by an extension cord; the negative or black binding post terminal of this battery should be connected to the positive or red terminal of the second battery; the negative or black terminal of this battery should be connected to the positive or red terminal of the third battery; and the negative or black terminal of this battery should be left free to be connected later to the operating chest (set box). If for any reason the polarity or color of the terminals can not be told, they may be identified in the BB-14 battery as follows: If the battery box is so placed that the cover opens away from the operator, the right-hand terminal in the box is positive and the left-hand is negative. The battery boxes can also be connected in series with battery cords and plugs by means of the sockets on each unit box. Both ends of the cord are provided with plugs which can fit in the socket (receptacles) only in one way, and thus no mistake can be made in the series connections. The polarity of the two receptacle terminals can be identified by the same rule as the binding posts. If neither set of battery cords is available, the necessary connections can be made as described above by any heavy wire. The connection between the battery and the operating chest (set box) is made with an extension cord. At the battery end the cord is provided with heavy lugs stamped "Plus" and "Minus." The junction of the cord and its lug is covered with rubber tubing. At the chest end it has red and

black wires, respectively, for plus and minus, that are to be connected to the binding posts on the operating chest (set box) marked, respectively, "Plus 12 V" and "Minus 12 V."

Each battery unit holds two cells in series, in hard rubber or celluloid jars, contained in a wood carrying case. If the jar is of celluloid, the wood case has two peepholes for noting the height of the electrolyte. The over-all dimensions of the two kinds of batteries (rubber and celluloid jars) differ slightly, but as an average each unit is $7\frac{1}{2}$ by $8\frac{1}{2}$ inches by 14 inches high, weighs about 37 pounds, and is provided with a battery carrying strap. Three 12-volt batteries (9 BB-14 units) are provided with the set. These should be assigned as follows: One in use with the set; one spare, fully charged with set and ready for immediate use; and the other under charge at the charging plant. Brief instructions by the manufacturer for the care of the battery are contained on a card in the cover of the battery box. Additional instructions on the use and maintenance of storage batteries will be found in Signal Corps Training Pamphlet No. 8, entitled "Storage Batteries."

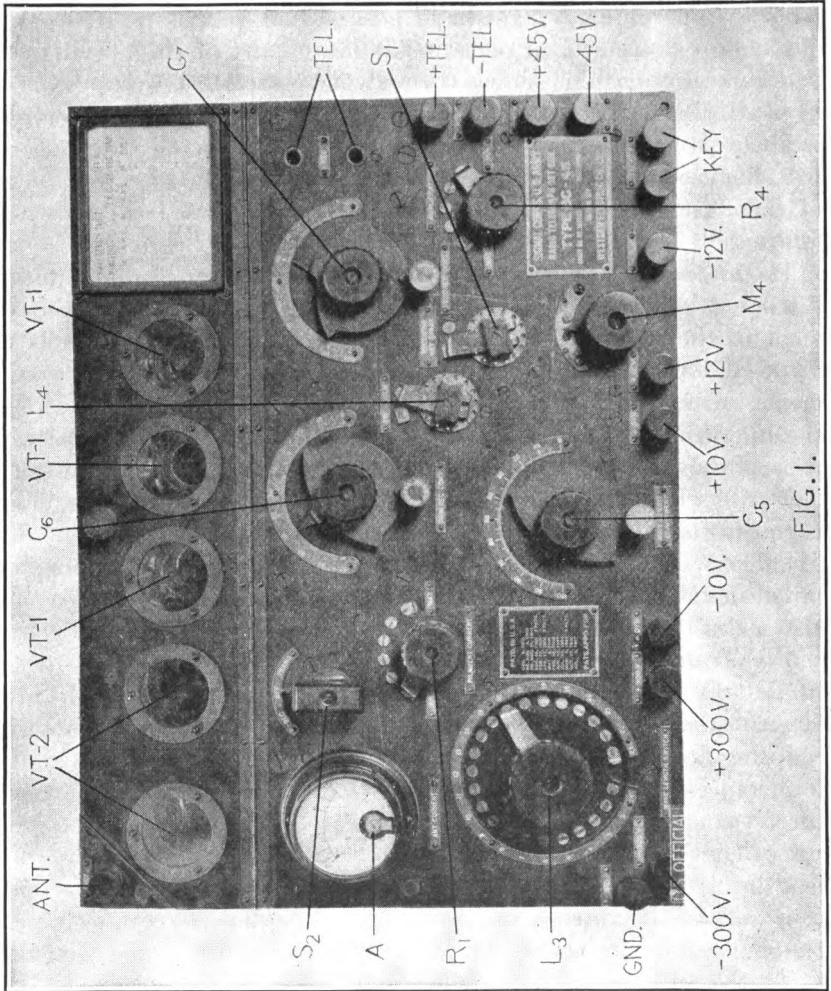
4 b. *The dynamotor, Type DM-1.*—The dynamotor, type DM-1, is a combined motor and generator that, together with certain accessories, is contained in a cast aluminum alloy case. With the motor running light—that is, with no generator load—it takes a current of about 4 amperes at 10 or 12 volts from the storage battery. At full load the motor takes about 10 amperes at 10 or 12 volts, and the generator delivers about one-sixth ampere (167 milliamperes) at 300 to 350 volts to the plate circuit of the vacuum tubes of the transmitter. The motor input is therefore about 120 watts, the generator output about 50 watts, and the over-all efficiency is between 40 and 50 per cent. The machine is a converter from a low to a high direct-current voltage. It has separate motor and generator armature windings and commutators mounted on the same shaft, revolving in a single common magnetic field. The speed of the machine is 2,550 R. P. M. (revolutions per minute). The motor end is marked but can still further be identified by the heavier wires at the brushes. Generator ends are marked on the end shield. The necessary wiring from the motor and generator is brought up onto a bakelite panel that carries a fuse block, with 15-ampere fuse wire, a switch in the motor leads, extension cords, oiling holes, etc. Spare fuse wire is wound on a small spool in the cover of the box. On the panel the motor terminals are marked "10 Volts," "Plus," and "Minus." An extension cord is provided to connect them to the binding posts on the operating chest (set box) marked, respectively, "Plus 10 V" and "Minus 10 V." The generator terminals are marked "300 Volts," "Plus," and "Minus." An extension cord is provided to

connect them to the binding posts on the operating chest (set box) marked, respectively, "Plus 300 V" and "Minus 300 V." In both cords the red wire is positive and the black is negative. Both cords are permanently fastened to the dynamotor terminals and are to be stored away on top of the panel. The polarity of the dynamotor terminals is marked on the panel, but in both cases they can be identified by noting that with the cover of the case opened away from the operator the right-hand post of each pair is positive. The dynamotor is secured in place in the lower part of its carrying case by two heavy machine screws through the bottom. The approximate over-all dimensions are 7 by 11 inches by 9 inches high, its weight is about 24 pounds, and it is provided with a carrying strap.

5. Radio equipment for SCR-79-A and SCR-99.—The radio equipment of these sets is mounted in an operating chest (set box) shown in figure 1.

The radio equipment of the SCR-79-A, RE-5-A, is mounted in the operating chest (set box), Type BC-32-A, and the radio equipment of the 99, RE-7, is mounted in the operating chest (set box), Type BC-45. These operating chests, together with auxiliary equipment, are all carried in a carrying chest, Type BC-43. Although the operating chests are removable from their carrying chests, in general they should be left inside. The auxiliary parts carried in the operating chest are the telephones, key, wavemeter, voltmeter, clock, various extension cords, tools, and spare parts, including tubes. The dynamotor is also carried in this chest. There follows a more detailed description of the principal parts of the radio apparatus and also a description of the panel clock carried in the chest.

5 a. Transmitter.—The transmitting set in the SCR-79-A and SCR-99 is practically the same except for the range of wave lengths. It consists of vacuum-tube oscillating circuits with fixed inductive coupling between the tube and the antenna circuits. The transmitter inductances have been so designated that with standard antenna the correct couplings are automatically secured over the entire range of wave length when the inductances corresponding to a given wave length are in use. The wave length is determined by the electrical constants of the antenna circuit, and *not* by those of the *tube circuit*, being adjustable by a variable inductance L_3 and a variable condenser C_5 in the antenna circuit. When the key is closed power at about 350 direct-current volts from the dynamotor is supplied to the plate circuits of the tubes and the antenna circuit immediately starts oscillating. Thus the energy is radiated only when the key is pressed and there is no "back wave" as in some arc transmitters. The current in the transmitting-tube filaments is adjustable by a rheostat.



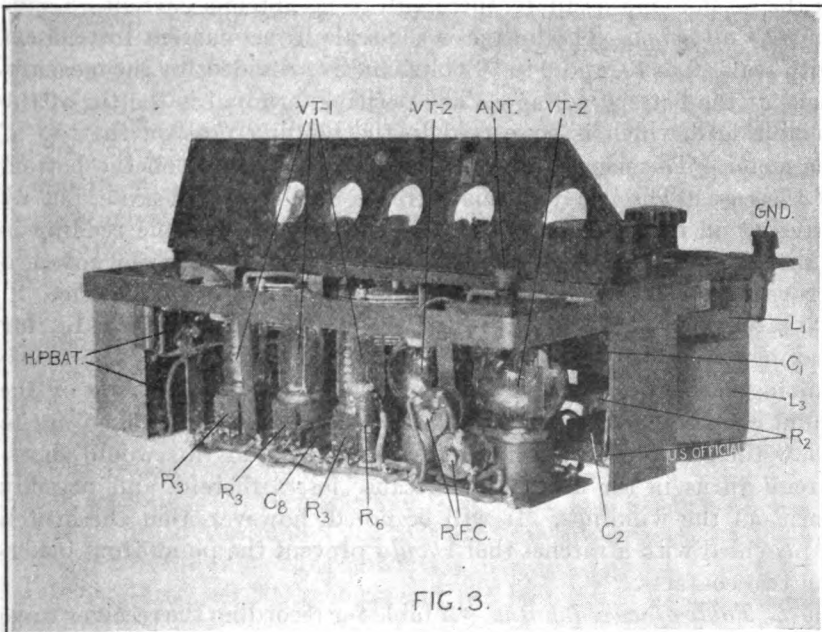
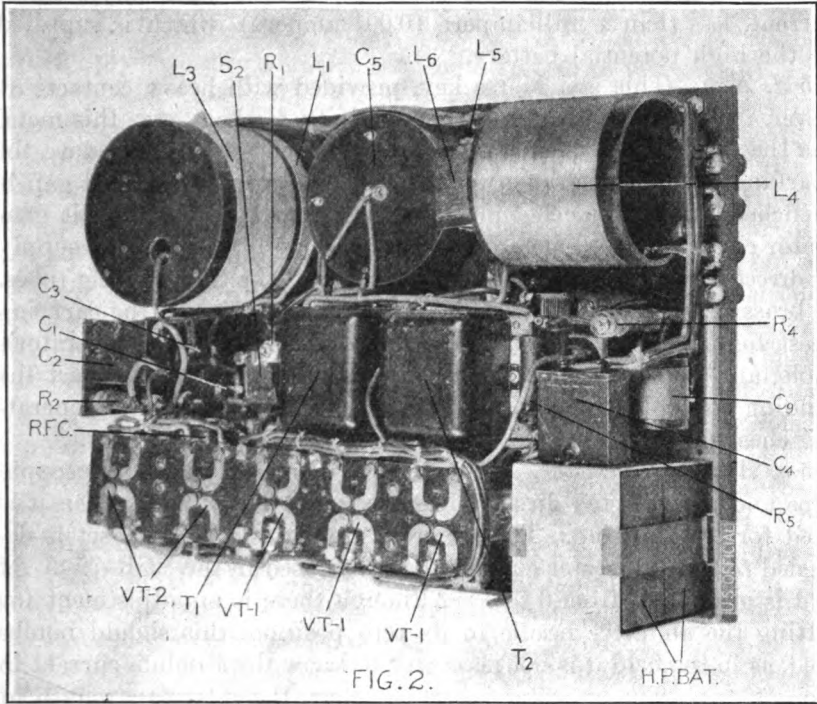
Each figure in this pamphlet has the identical parts marked the same.

In Figure 1 the controls bear the same legend as the actual parts. The legend is as follows:

A	Antenna ammeter.
ANT	Antenna binding post.
C₁	High-frequency by-pass condenser across dynamotor leads.
C₂	Grid leak condenser for VT-2 tubes.
C₃	Plate coil shunting condenser.
C₄	Ground circuit condenser.
C₅	Transmitter antenna tuning condenser.
C₆	Receiver antenna tuning condenser.
C₇	Receiver secondary tuning condenser.
C₈	High-frequency by-pass condenser across the primary of the first intervalve transformer.
C₉	Audio-frequency by-pass condenser across the resistance in the detector tube plate circuit.
Fl. Bat.	12-volt storage battery for heating filaments of VT-1 and VT-2 tubes.
GND	Ground binding post.
H. P. Bat.	45-volt high potential battery for plate circuits of VT-1 tubes.
L₁	Grid coil for VT-2 tubes.
L₂	Plate coil for VT-2 tubes.
L₃	Transmitter antenna tuning inductance.
L₄	Receiver antenna tuning inductance.
L₅	Reaction or " feed-back " coil.
L₆	Receiver secondary circuit coil.
M₁	Fixed coupling between VT-2 grid coil, L ₁ , and antenna coil, L ₃ .
M₂	Fixed coupling between VT-2 plate coil, L ₂ , and antenna coil, L ₃ .
M₃	Fixed coupling between reaction coil, L ₅ , and primary receiving coil, L ₄ .
M₄	Variable coupling between primary and secondary receiving circuits.
R₁	Variable filament resistance for VT-2 tubes.
R₂	Grid leak resistance for VT-2 tubes.
R₃	Series filament resistance for VT-1 tubes.
R₄	Shunt resistance across primary of first intervalve transformer for variations in amplification.
R₅	High resistance in detector tube plate circuit for adjustment to best detecting point on characteristic curve.
R₆	Series filament resistance for VT-2 tubes.
RFC	Radio frequency choke coils in dynamotor leads.
S₁	Switch to change from spark to tube reception, and vice versa.
S₂	Switch to change from transmitting to receiving, and vice versa.
T₁	Intervalve iron core transformer between detector tube and first amplifying tube.
T₂	Intervalve iron core transformer between first and second amplifying tubes.
TEL	High impedance telephone receivers.
VT-1	Receiving vacuum tubes for detector and audio-frequency amplifiers.
VT-2	Transmitting vacuum tubes for developing oscillations in transmitting antenna.

5 *b. Receiver.*—The receiver set in the SCR-79-A and SCR-99 is practically the same except for the range of wave lengths. It is an inductively coupled set with a vacuum-tube detector and a 2-stage audio-frequency amplifier, arranged for both damped wave and undamped wave reception. In the antenna circuit an inductance, L_4 , with two taps, one for short waves, "SW," and the other for long waves, "LW," is connected in series with a variable condenser C_6 to change from short wave to long wave. In the secondary circuit a fixed inductance and a variable condenser (C_7) are connected in series to form a local resonant circuit with leads from its terminals to the detector. A "feed-back" or "reaction" coil can be put into circuit by the 2-point switch S_1 , depending on whether undamped or damped signals are to be received. The coupling between the primary and secondary circuits is controlled by a two-position switch (M_4). In some cases the full amplification given by the tubes is not desired and it may be reduced by the switch R_4 , which connects resistance shunts across the primary circuit of the first amplifier transformer. There is no adjustment for the filament current of the receiver tubes. Figures 2 and 3 show interior views of the set.

5 *c. Vacuum tubes.*—Two types of 3-electrode vacuum tubes are furnished with each set; one, Type VT-2, for the transmitter, and the other, Type VT-1, for the receiver. The transmitter type, VT-2, is spherical, and the receiver type, VT-1, cylindrical; and in some cases the type number is also marked on the base or on the glass. The bases and sockets for the two types are identical except for the position of a pin in the base and a slot in the socket, which are so arranged that only the right tube can be put in the right socket. The VT-2 filament uses about 1.35 amperes at about 7 volts, and as two tubes are connected in parallel, the total current is 2.7 amperes. If the 12 volts of the standard battery were applied directly to the filaments, too much current would flow and hence a small fixed resistance R_6 of about 1.8 ohms, is connected in series in one lead to each filament, and in addition, for fine adjustment and to compensate for a drop in the voltage as the battery runs down, there is inserted in series in one battery lead another small resistance that is variable by a 6-point dial switch, R_1 . In transmitting, the 12-volt battery furnishes the current for the filaments as well as that for running the dynamotor with its generator load of plate currents. The receiving tubes (VT-1) must be burned only at a dull reddish-yellow heat, as in the case of the VT-2 tubes, otherwise their normal life of 500 hours will be seriously shortened. The VT-1 filament uses about 1.1 amperes at about 3.6 volts, and in order to be able to use the 12-volt standard battery the filaments of the three tubes are connected in series and in addition there is a small fixed resistance R_3 of about 1.05 ohms, in the negative lead to each filament. There is no variable resistance in



circuit. The plate circuit of each receiving tube takes only a small current, less than a milliamperere (0.001 ampere), which is supplied by the high potential battery.

5 d. *Key*.—This is a Morse key, provided with heavy contacts of silver. On account of its high conductivity for heat, etc., this metal has the property of quenching an arc and hence tends to reduce the sparking in much the same way that the spark in a quenched gap is quenched. It is connected in series in one lead in the 300-volt generator circuit of the dynamotor and thus directly controls the supply of direct-current power to the plate circuit of the transmitting tubes. A brass plate is provided on the inside of the cover of the carrying chest for mounting the key when the cover is used as an operator's table, and the 1½-foot extension cord should be used to connect the binding posts of the key to the "KEY" binding posts on the operating chest (set box).

5 e. *Antenna ammeter*.—The ammeter used is of the thermocouple type and is connected directly in series with the antenna when it is used for transmitting. The ammeter used in the SCR-99 set is designed to read a greater current than that used in the SCR-79-A set and is graduated from 0 to 1. Although there is an adjustment for setting the ammeter needle to its zero position, this should not be used, as in the field it is not necessary to know the absolute current in the antenna. The ammeter is used to show the relative strength of current in the antenna and to show that the set is oscillating properly. If the set does not oscillate, there will be no antenna current.

5 f. *Voltmeter*.—This meter is a 2-scale direct-current instrument with scales 0 to 10, and 0 to 50 volts, and is provided for the measurement of the battery voltage. The positive terminal is the tip of the flexible lead which is connected to the binding post on the top of the meter. The negative terminal is the brass point on the bottom of the case. The meter normally reads on the 50-volt scale, but by pressing on the push button on the back of the base the reading is transferred to the 10-volt scale. There is no adjustment for any zero error of the needle, as such accuracy is not needed in field service.

5 g. *Wave-length switch*.—This is a 23-point dial switch, L_3 , for making large step adjustments in antenna inductances of the transmitting circuits. Exact adjustment of wave lengths is made by the shunt condenser, C_5 . In using the switch, care must be taken *not* to allow the switch point to rest on two contacts, as this would short-circuit turns in the antenna coil, cause losses therein, and possibly burn out the windings. It will be noted, however, that the switch is provided with a ratchet that *should* prevent the point from bridging two contacts.

5 h. *Table of wave lengths*.—A table for recording the receiver wave lengths in meters and the position of the secondary circuit condenser in degrees is provided in the upper right corner of the panel of the

operating chest (set box). The method of obtaining this data is given under "Wavemeter," paragraph 5 *k*, and by its use it is possible to pick up very easily a station sending on a known wave length.

5 *i*. *Amplification switch*.—This is a 5-point switch for the control of the amplification of the receiver signals, from the full amplification of two stages at "Max." to slightly more than one stage at "Min." The variation in amplification is obtained by shunting the primary or input winding of the first intervalve audio-frequency transformer by a variable resistance, R_4 . At "Max." the resistance is cut out of circuit so that all the audio-frequency current from the plate circuit of the detector tube is allowed to pass through the windings; at "Min." a low resistance is shunted across the windings so that most of the current is diverted from them and the resulting amplification is much reduced; and at intermediate steps the amplification is somewhere between these stages.

5 *j*. *Receiver-transmitter switch*.—This switch, S_2 , is a 3-throw, 2-pole switch with positions marked "Rec.," "Off," and "Trans." In the "Trans." position the circuits are connected as shown in figures 4 and 5, whereby the VT-2 filaments are lighted, and if the switch on the dynamotor panel is closed, the dynamotor is started and the circuits are ready for adjustment. It is to be noted that there is no motor starting resistance or box in circuit, but this is not necessary, as the motor is only a fraction of a horsepower in size and the starting current is not large. Whenever the dynamotor is to be stopped, it should be done by throwing the switch to the "Off" position rather than to open the switch on the dynamotor panel. The VT-2 filament current is adjusted to its correct value when the dynamotor is running; if its switch is now opened and the load of the dynamotor taken off the battery, the voltage across the battery will rise. This rise in voltage may so increase the filament current as to burn out the filament or seriously injure its life by the rush of excessive current. In the "Rec." position the circuits are connected as shown in figures 4 and 6. The VT-1 filaments are lighted, and the circuits are ready for adjustment. In the "Off" position the antenna and ground wires are simply disconnected from the rest of the circuits but the antenna is *not* grounded direct to the ground, as is sometimes the case in such a switch. For this reason when the set is not in use the antenna and ground wires should be disconnected from the set and the antenna put to ground. The complete circuits of the sets are shown in figure 4.

5 *k*. *Wavemeter*.—Wavemeter, Type SCR-95, is furnished for use with the SCR-79-A set and Type SCR-111 for use with the SCR-99 set. Each has the same range of wave lengths as its set, i. e., 500-1,100 meters, or 900-1,900 meters, and can be used to measure both transmitter and receiver signals. They are of the type that uses for the essential elements of its resonant circuit a fixed (mica) condenser as the capacity, in series with a variometer as the inductance,

COMPLETE CIRCUIT

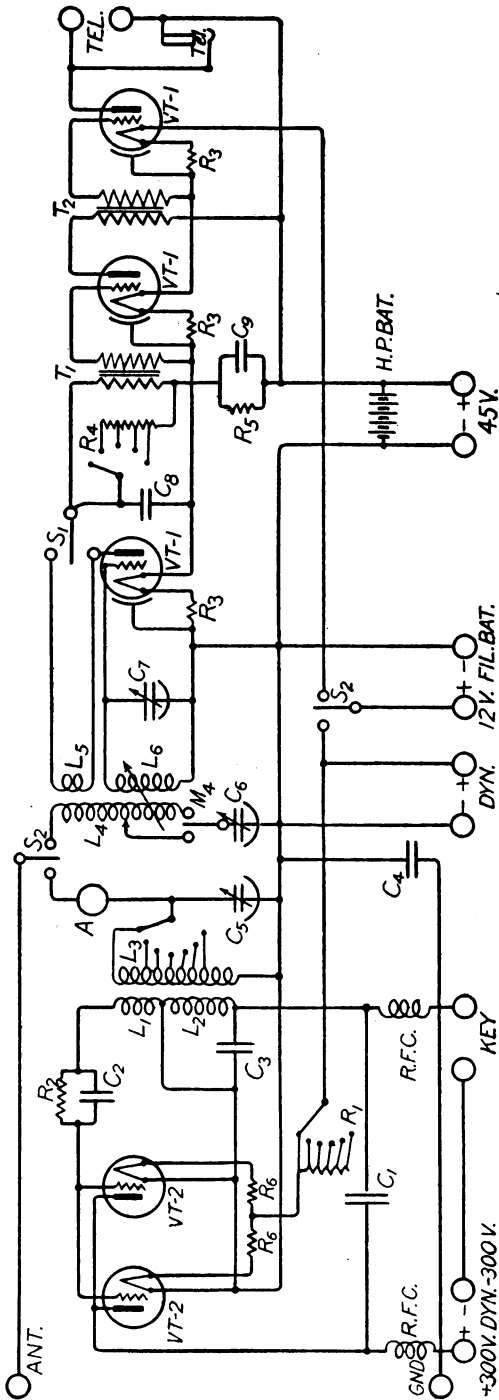


FIG. 4.

and a miniature (flashlight) lamp, Type LM-4, as the means of indicating resonance. One dry cell, Type BA-4, of 1.5 volts, about 3 inches long and $1\frac{1}{4}$ inches in diameter, is provided for lighting the filament of the lamp, also for operating a buzzer. The wavemeter has one scale for direct reading of wave length and another one of degrees. There is a 3-point switch which, when on contact C, puts the lamp into circuit; on B puts the buzzer into circuit for receiver signals; and on A disconnects the battery. Although the battery is disconnected when the switch is on the A contact, yet the meter is operative for strong transmitter signals, as its circuit is still complete. A small, adjustable carbon rheostat is placed in the lamp circuit to keep the filament burning at a dull red where it is most sensitive in showing small changes in current caused by the reception of signals. The front of the box is hinged so as to provide access to the inside of the meter for replacing the battery, adjusting the buzzer, etc. When the meter is held with the scale horizontal, the plane of the fixed variometer coil is vertical and parallel with the rear of the box. It is often necessary to take note of the position of this coil in obtaining coupling with the circuit under measurement. Brief instructions for the use of the meter are contained on a card inside the front cover of the box, as follows: "To measure wave length, set switch on 'C' and adjust carbon resistance until lamp glows a dull red. Couple wavemeter by holding near inductance coil of sending set. Rotate dial slowly until lamp lights to maximum brilliancy, when wave length is indicated on wavemeter dial. To set receiver for given wave length, set switch on 'B,' adjust buzzer to give a clear note, and turn dial to desired wave length. Couple as above and tune receiver until buzzer is heard loudest in phones. CAUTION: Replace battery when it fails to operate buzzer or lamp. When meter is not in use, leave switch on 'A' only." For further information concerning wavemeter, see Radio Communication Pamphlet No. 21 or 28. See also paragraph 11, this pamphlet.

5 l. Clock.—The clock is an 8-day Waltham automobile clock that is mounted flush with its panel. To wind or set the clock, press in on the knurled metal frame carrying the plate-glass front and turn it counterclockwise until the clock springs out from its panel. This will generally occur when the "1" or "2" hour mark is at the top. It is then held by a universal joint that permits access to the key that lies in a slot on the top of the clock. To wind, raise the key and turn it clockwise. To set the clock, pull up on the key until a sharp click is heard, in which case the key is engaged with the gears that will now turn the hands. After setting, be sure to push the key down until the sharp click is again heard. After winding or setting the hands, put the key back flat in its slot and return the

clock to its panel by inserting it with the "1" or "2" hour mark at the top and turning clockwise until the "12" hour mark is at the top. There is no adjustment provided for "faster" or "slower" regulation. Under ordinary circumstances the clock should never be removed from the panel, but when necessary this can be done by unscrewing the narrow ring at the back of the clock, which is prevented from working loose by a heavy spring washer.

SECTION III.

SETTING UP AND OPERATION OF SETS.

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Installing the ground mat.....	8
Installing the operating chest (set box).....	9
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How to transmit.....	11

6. Setting up the antenna.—The antenna can be installed for either of two purposes: (1) general use and (2) directional use. For the former the orientation of the wire is not important, but for the latter the point of the "V" should be directed toward the other station.

Stretch out the antenna wires on the ground with an opening of about 60 degrees. Couple three mast sections together for each mast and lay them on the ground alongside the wire and in the same straight line with it. Attach the antenna insulators to the tops of the three masts by means of the snap hooks and also attach two guys to each mast. Drive two ground stakes near each mast about 20 feet beyond the end of the wire so that the guys will lie at an angle of about 45 degrees with the line of the wire. Having raised the mast at the point of the V, raise the other mast tops gradually by using a light strain on the guys and, keeping the bottom ends of the masts on the ground, move them toward the points where they are to be when the mast is in the vertical position. Pass the guys around the ground stakes and take up the slack with the tent slides. If necessary, straighten up the masts and tighten the guys so that the antenna wires are nearly horizontal. Care should be taken in raising the masts to keep them in the prolongation of the antenna wires, as then there will be little or no stress tending to bend the masts.

7. Installing the counterpoise.—For general use the two counterpoise wires should be laid out on the ground under the antenna with the point of the "V" at the "GND" binding post of the operating chest (set box). If four counterpoise wires are available they should be laid out as two "Vs" with the points together, one under the antenna and the other with its free ends opening out toward the other station.

For directional use the two wires should be laid out as a "V" with the point at the "GND" post as before and with the free ends opening out toward the other station.

8. Installing the ground mat.—As an alternative for the counterpoise, three ground mats are furnished that should be connected to the "GND" post of the operating chest. These mats should be buried under a few inches of earth, which should be well packed down so as to get good contact with all the wires. Under some circumstances the spare ground stakes should be used as an additional ground, and the other ground wires or plates connected to the chest. The ground connection should preferably be made where it is wet, but in each case use whichever apparatus will give the largest reading on the antenna ammeter.

9. Installing the operating chest.—Set up the operating chest on a dry place under the point of the "V" of the antenna. Before making any connection to the chest be sure that the switch, S_2 , is in the "Off" position, and that the high potential battery, 2 units Type BA-2, in series, is in its compartment. If there is no battery, an external battery of 45 volts may be connected to the binding posts marked "Plus 45 V" and "Minus 45 V," being sure that the positive or red-wire terminal is connected to the upper and positive post and the negative or black wire terminal to the lower and negative post. These connections must be correctly made, as otherwise the receiver will be inoperative. If the standard high potential battery is available, it is preferable to install it in place as follows: Take out the right-hand VT-1 tube so as to give free access to the battery compartment. Put one BA-2 battery in place with the line of its terminals vertical and to the left, connecting them to the Fahnestock clips on the small panel by passing the lead wires behind the panel; put the other battery similarly in place except for passing the leads in front of the panel; the positive or red-wire terminal of each battery must be connected to the clips on the red part of the panel and the negative or black-wire terminals to the clips on the black part of the panel; if these connections are correctly made the two batteries will be in series, with the positive terminal connected to the plate circuit of the last tube through the telephone receivers and with the negative terminal to the ground.

Connect the antenna and ground wires respectively to the two binding posts marked "ANT" and "GND." Make the other connections to the binding posts as shown by their name plates on the chest, taking care that the polarity is correct in the case of both sets of dynamotor terminals and of the storage battery. (See par. 4.) It is specially necessary that the high potential side of the dynamotor be correctly connected, as otherwise the transmitter will be inoperative. Be sure to connect the battery leads first to the chest and then to the battery, as otherwise the battery may be short-cir-

cuted by the other terminals of the cord being in contact. If the telephone is not provided with the standard plug, connections can be made by the telephone cord to the posts marked "TEL," making sure that the green tracer wire is connected to the "Plus" post and the red tracer wire to the "Negative" post. If for any reason the two wires can not be identified, the correct polarity of the connections must be found by trial, using faint signals which may be generated by the wavemeter with the set. *Close the switch* on the dynamotor panel and then turn the switch S_2 to "REC." or "TRANS." as desired. The set is now ready for tuning either the receiver or transmitter.

10. How to receive.—Turn the switch " S_2 " to the "Rec." position and the three VT-1 filaments should light; if they do not, there is either a bad battery contact or one or more broken or burnt-out filaments. Examine the battery connections and the filaments and correct the difficulty. In a few cases the filament pins in the base of the tube may not make good contact with the springs of the socket, but generally this can be remedied simply by taking the tubes out and putting them back in the sockets. It must be remembered that the three filaments are in series in the battery circuit and that one break in the circuit will prevent all filaments from lighting. If signals are to be received from another SCR-79-A or 99 set or from any undamped wave source, set the switch " S_1 " on the "Het." position and the switch " R_4 " on the "Min." position. If the wave length is known, set the secondary receiver condenser handle, " C_7 ," at the reading corresponding to this wave length as shown in the "Wave-length table" in the upper right-hand corner of the panel of the operating chest (set box). Set the switch " L_4 " on the short-wave position, "SW," or on the long-wave position, "LW," depending upon whether the signal is at the short-wave or long-wave end of the scale of wave lengths for the given set. Set the switch " M_4 " on the "Min." position. This adjusts the coupling between the primary and secondary circuit to the best average value for the reception of undamped signals. Vary the primary receiving condenser, " C_6 ," slowly over its scale until the signals are heard. As the tuning with undamped signals is much sharper than with damped signals, the tuning must be accurately done in order to pick up signals—in many cases a change of 1 or 2 degrees on a condenser scale will completely cut out the signals. After the signals are picked up, adjust the primary and secondary condensers, " C_6 " and " C_7 ," until the loudest signals are heard at the best note for the operator. If necessary, increase the amplification by moving the switch " R_4 " toward the "Max." end of the scale.

If spark signals or damped wave signals are to be received, set the switch " S_1 " at the "Spark" position and the switch " M_4 " on the

"Max." position (sometimes "Min." position is preferable). If the wave length is known, set the secondary receiving condenser, " C_7 ," at the given wave length as shown on the table; set the switch " L_4 " in the short or long wave position, depending upon the wave length to be received; and vary the primary receiving condenser, " C_6 ," until the signals are heard. Adjust both condensers and the amplification if necessary.

If the wave length of the undamped or damped wave signals is unknown, then they can be picked up only by trial, somewhat as follows: First, set the switch " L_4 " at, say, the long-wave position; the primary condenser, " C_6 ," near the 100-degree end of its scale; and vary the secondary condenser, " C_7 ," slowly over its scale, until the signals are picked up. If no signals are heard, set the primary condenser near 80 degrees on its scale and vary the secondary condenser as before. Proceed in this way by repeated trials until the signals are found.

11. **How to transmit.**—Close the switch on the dynamotor panel. Set the switch " S_2 " in the "Trans." position. The filaments of the two VT-2 tubes should light and the dynamotor start. If only one filament lights it is certain that either there is a bad contact in the socket of the other or that its filament is burnt out. Under these conditions the set is operative, but it is working only at half power and consequently its range of operation and signal strength will be reduced. Close the sending key, which should immediately set the antenna circuit into oscillation and give a reading on the antenna ammeter "A." The wave length of the transmitter is determined by the constants of the antenna and can be adjusted to any given values within its range by means of the variable inductance " L_3 " and variable condenser " C_5 ." In order to measure the wave length in use, the wavemeter must be used as follows: Set the button switch on contact "C" and with a screw driver adjust the screw at the "Lamp resistance" until the indicator lamp shows a dull red glow. Close the telegraph key and bring the meter near the lower left corner of the panel of the operating chest (set box) with the back of the wavemeter box parallel with the panel, thereby coupling the wavemeter coil with the variable inductance " L_3 " in the antenna circuit. Vary the wavemeter handle slowly over its scale until the lamp shows its brightest glow. The wave length in meters can then be read directly from the wavemeter scale. In order to radiate a predetermined wave length, set the wavemeter at that wave length, close the telegraph key, bring the wavemeter near the lower left corner of the panel as before, and vary switch " L_3 " of the transmitting set until contact is made which gives the brightest glow in the lamp. Then adjust condenser " C_5 " until a still brighter glow is attained, and clamp in this position. The inductance adjustment is

in large steps and the condenser gives a continuous, fine adjustment for exact tuning of wave length to that of the wavemeter. The radiated wave length is then the same as that of the wavemeter setting and the set is ready for transmitting. Set the button switch of the wavemeter back on contact "A" so as to cut the battery out of circuit.

Under some conditions the antenna ammeter may not show a reading when the key is pressed. This generally indicates that the filaments of the VT-2 tubes are not hot enough and that there are no oscillations being developed. The current through them should be slightly increased by turning the switch "R₁" from the minimum position toward the maximum position until the ammeter indicates that there are oscillations, and that these are always developed with the closing of the key.

Under average field conditions the SCR-79-A set should give an antenna current of about 0.4 of an ampere and the SCR-99 set more than 0.5.

SECTION IV.

CARE OF SETS.

	Paragraph.
Handling and storage-----	12
The telephones-----	13
Don'ts-----	14

12. Handling and storage.—A careful handling is due any radio set, as the apparatus is very compact and there are a large number of connections inside the operating chest (set box). Careless, rough handling may dislodge the apparatus and will surely weaken or entirely break some connections. The set should not be permitted to become wet if it is possible to prevent it. If, for any reason, the set does become wet, either from exposure to rain or a long spell of damp weather, it should be carefully dried out but not exposed to any direct heat, as from a stove or radiator. The sets should be stored in a dry place that is free from dust.

13. The telephones.—The telephone receivers, Type P-11, must be carefully handled, special care being taken not to injure the diaphragm. If the diaphragm is bent or dented it may touch the pole pieces of the magnet and the magnetic attraction may be so strong that it will be held there with the result that the telephone becomes "dead." In order to obtain the correct clearance between the diaphragm and the poles it has been found necessary to grind the latter *after the assembly* of the telephone, as otherwise the standard parts can not be assembled with sufficient accuracy. For this reason the telephones should never be taken apart, as it is certain that the adjustments will be disturbed. If it becomes necessary to replace the cords the connections to the plug and to the receivers should be made so that the steady current from the plate battery will cause the mag-

netic flux in the receivers to be in the same direction as the flux of the permanent magnet; otherwise the magnet will be partially demagnetized and the efficiency of the telephones reduced. The following facts will enable one to make the correct connections: The spring of the telephone jack in the operating chest is positive with respect to its sleeve, and hence when the telephone is plugged in its tip will be positive and its sleeve negative. The telephone magnets are so wound that when the diaphragm is uppermost and the terminals are toward the operator, the right-hand terminal is positive. The cords have a colored thread or tracer running through them so as to give a color scheme to identify the various wires—as green, white, and red; the green tracer cord should always be connected to the tip. It then becomes the positive wire and should be connected to the right-hand terminal of one of the receivers; the white cord should be connected to the left terminal of the same receiver and to the right-hand terminal of the other receiver; and the red cord should be connected to the left terminal of this receiver and to the sleeve of the plug. In putting the telephones away into their compartment, the following standard practice should be followed in order to protect the diaphragm and the terminals: Place the two receivers with the faces of the caps parallel and together so that all access to the diaphragm is closed; and then bind them in this position by winding the telephone cord around the outside of the headband, beginning close to the cap.

14. Don'ts.—Don't fail to oil the dynamo after each two hours operation, with a few drops of oil.

Don't use too much oil on the dynamotor, as it will leak out on the commutator and cause sparking and other troubles.

Don't fail to keep the panel of the dynamotor clean, especially between the 300-volt leads.

Don't fail to have the control switch on the operating chest (set box) on the "Off" position before pulling the dynamotor switch.

Don't fail to see that the dynamotor switch is closed before placing the control switch on the operating chest (set box) in the "Transmit" position.

Don't use higher potentials than are supplied by the batteries furnished with the set.

Don't fail to check all the connections you have made before trying to operate the set, either for sending or receiving.

Don't fail to inspect connections of the high-volt battery occasionally and to renew it when they are defective.

Don't fail to store all spare parts so they can not shift in transportation.

SECTION V.

PRINCIPLES EMBODIED IN THE SETS.

Transmitter.....	Paragraph. 15
Receiver.....	16

15. **Transmitter.**—The transmitting circuit shown in simplified form in figure 5 is a modification of one of the fundamental oscillation circuits. The antenna circuit consisting of the antenna, the inductance L_3 shunted by small variable air condenser C_5 , the condenser C_4 , and the ground is the circuit which determines the frequency of oscillations of the set. In the valve circuits proper the inductance L_1 is the grid coil and serves as a reactance or feed-back coil, being coupled

TRANSMITTING CIRCUIT - SIMPLIFIED

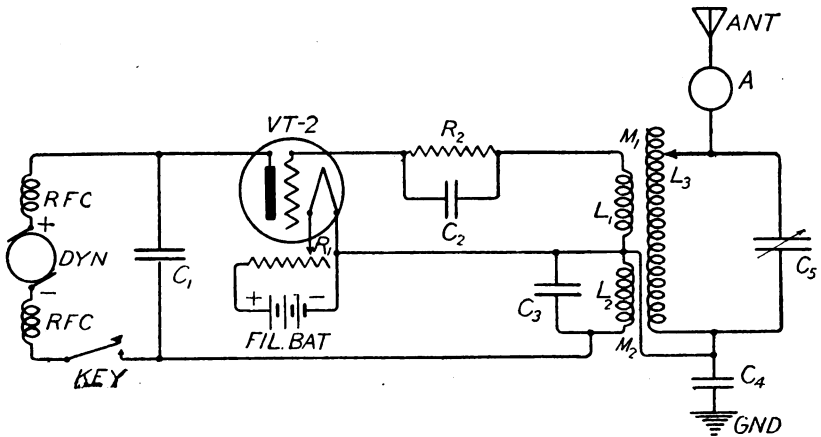


FIG. 5.

to the antenna coil L_3 . The plate coil L_2 is the driving coil and is also coupled with the antenna coil L_3 .

The high potential voltage, approximately 350 volts, is supplied by the dynamotor to the vacuum tubes. The key used in telegraphing is connected directly in series with the dynamotor. In order to protect the operator from possible shocks, the whole apparatus, including the generator side of the dynamotor, is carefully insulated from the ground. It is for this purpose that the large condenser C_4 is inserted in the antenna ground lead. The condenser C_3 , which shunts the plate coil, has a capacity of 450 microfarads and aids in giving steady and uniform oscillations at all wave lengths. The design of the coils L_1 , L_2 , and L_3 and their relation to one another is such that the required changes in coupling are automatically secured in approximately proper proportions that correspond with the wave-

length changes produced by manipulation of the wave-length switch, which changes the number of turns in series in the inductance L_3 . The design of these coils, together with the condenser C_3 , makes a separate coupling adjustment unnecessary, thus simplifying the operation of the set. The resistance R_2 and its by-pass condenser C_2 in the grid circuit are of such value to insure a negative voltage on the grid during oscillations and at the same time to put upon the grid, when there are no oscillations taking place in the tube, a potential which will permit oscillations to be readily started. The small variable air condenser C_5 shunted across the antenna inductance L_3 permits more exact changes in the wave length of the antenna to be made than is secured by the taps on the antenna inductance. It also, together with the connection from the tube circuit to the antenna circuit, insures the starting of oscillations when the key is closed. It is to be noted that the connection between the tube circuits and antenna circuits gives a direct coupling in addition to the inductive coupling between them.

The detail of operation is as follows: With the key open there are no oscillations occurring in the set, the plate being at a high positive potential and the grid having a negative potential with respect to the filament, being connected with the negative side of the filament battery. Closing the key disturbs the conditions as set forth above, as it throws a negative potential on the filament and because of the resistance R_2 a still higher negative potential on the grid. There is therefore a surge of current in the plate circuit which passes through the plate coil L_2 and starts oscillations in the antenna circuit. The antenna circuit induces oscillations in the grid coil L_1 , which affects the grid potential, and thus the oscillations are built up. The tube circuits are connected to the antenna circuit so that if a surge of current through L_2 should fail to start oscillations the sudden application of the high negative potential to the antenna circuit will upset its stabilized condition and start oscillations therein. This will cause the tube to oscillate as noted above.

The condenser C_1 furnishes a path for the oscillations so that they will not pass through the dynamotor. They are compelled to take this path because the dynamotor has in series with its leads radio frequency chokes which prevent the passage of high frequency oscillations. The radio frequency choke coils, RFC, together with the by-pass condenser C_1 , serve also to smooth out the commutator ripples that may be present in the dynamotor. The radio frequency choke coils have an inductance each of 3 millihenries and a resistance of 6.9 ohms. The inductance reactance of each coil then at frequency of 158,000 (corresponding to 1,900 meters) is nearly 3,000 ohms. Their reactance to the commutator ripples which at the usual

speed would occur at about a rate of 1,785 per second is 34 ohms, approximately.¹

16. Receiver.—The primary circuit of the receiver consists of the antenna, the inductance coil L_4 having two taps, a variable condenser C_6 , together with a fixed condenser C_4 and the ground, all in series. The coupling between the primary circuit described above and the secondary circuit is variable in two steps marked "Minimum" and "Maximum," on the control handle. The "Min." gives a 2 per cent coupling while the "Max." gives a 6 per cent coupling. The secondary consists of an inductance L_6 shunted by a variable air condenser C_7 , across which is placed the grid and filament of the detector tube. The two other VT-1 tubes are used as low-frequency amplifiers, they being connected by intervalve transformers. The simplified circuits are shown in figure 6. It is to be noted that the

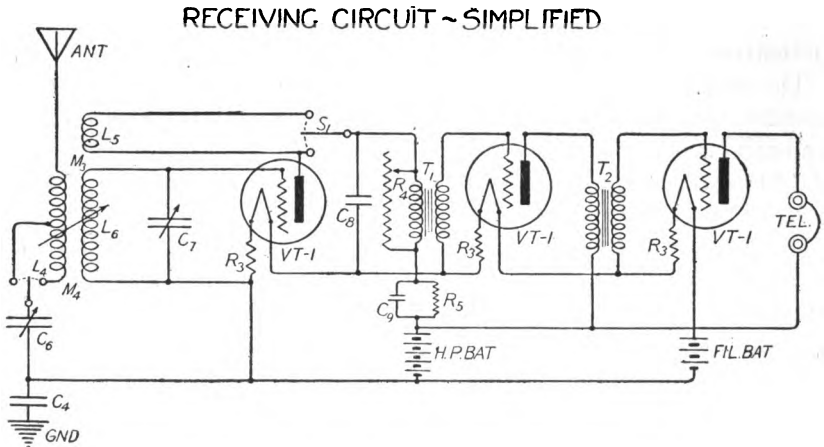


FIG. 6.

primary of the transformers between the detector and the first amplifying tube is shunted by a variable resistance. Variation of this resistance changes the amount of current passing through the primary of the transformer and hence is a control of the amount of amplification given by the set. This is found convenient especially in cutting down the amplification for the purpose of avoiding interference.

The detector vacuum tube operates on the bend of its characteristic curve, the resistance R_5 , together with the resistance R_3 , insuring the proper relative potentials of the filament, grid, and plate for it to act as a detector. The resistance R_5 is shunted by the by-pass

¹ The transmitting circuits employed in the SCR-79-A and 99 sets are fully discussed in treatises on vacuum tubes as applied to radio telegraphy. For a full mathematical discussion, see chapter 8, particularly section 89, of "Thermionic Vacuum Tube" by Van Der Bijl.

condenser C_6 , to permit free passage of oscillations. A tickler coil L_5 , permanently coupled with the secondary inductance L_6 , causes the detector tube to oscillate when thrown in circuit, thus making the first tube an autodyne. These oscillations, whose frequency is determined by the characteristics of the secondary circuits, L_6 and C_7 , produce with the incoming oscillations a beat note which is used in receiving undamped waves.

The purity of the autodyne note so produced depends upon the constancy of the frequency in both the receiver and transmitter. As the frequency depends in part upon the capacity in the circuit, it is evident that the capacity must be allowed to vary only as desired for tuning of the circuits and adjusting the pitch of the note in the receiver. If no precautions are taken, the approach of the operator's hand, or even its contact on the insulating handle of the receiving detector, may so change its capacity as to cause the autodyne note to become inaudible. This trouble has been avoided in these sets by connecting the moving plate of the transmitting wave-length adjustment, the receiving primary and receiving secondary condenser plates and their metal parts together, so as to form a shield. The approach of the operator's hand, therefore, does not have any appreciable effect on the autodyne note.

SECTION VI.

PARTS LIST OF SETS.

	Paragraph.
Equipments in 79-A set.....	17
Equipments in 99 set.....	18
Parts comprising above equipments.....	19

17. Equipments in 79-A set.—The SCR-79-A comprises the following equipment:

- One equipment, Type PE-7.
- One equipment, Type RE-5-A.
- One equipment, Type A-9-A.

18. Equipments in 99 set.—The SCR-99 comprises the following equipment:

- One equipment, Type PE-7.
- One equipment, Type RE-7.
- One equipment, Type A-9-A.

19. Parts comprising above equipments.—These equipments are made up of parts as noted below:

- Equipment, Type PE-7:
- Battery, Type BB-14 (9).
- Box, type BC-25 or BC-25-A (1).
- Dynamotor, Type DM-1 (1).

Equipment, Type A-9-A :

- Antenna, Type AN-8 (2).
- Bag, Type BG-12 (2).
- Cord, sash, No. 5, olive drab (300 feet).
- Guy, Type GY-4 (8).
- Hammer, 2-face, 2-pound (1).
- Insulator, Type IN-10 (4).
- Mast section, Type MS-14 (12) 9 in use; 3 spare.
- Mat, Type MT-5 (3).
- Pliers, combination, 6-inch (1 pair).
- Reel, Type RL-3 (8).
- Roll, Type M-15 (1).
- Stake, Type GP-8 (12).
- Tape, friction (1 roll).
- Wire, Type W-4 (50 feet).
- Wire, Type W-6 (300 feet).
- Wire, Type W-24 (750 feet).

Equipment, Type RE-5-A :

- Battery, Type BA-2 (4) 2 in use; 2 spare.
- Battery, Type BA-4 (4) 1 in use; 3 spare.
- Chest, Type BC-43 (1).
- Clock, Type I-15 (1).
- Cord, Type CD-15 (3).
- Cord, Type CD-38 (5).
- Cord, Type CD-47 (2).
- Cord, Type CD-48 (2).
- Cord, Type CD-49 (2).
- Head set, Type P-11 (2).
- Key, Type J-12 (1).
- Lamp, Type LM-4 (4) (for wavemeter), 1 in use; 3 spare.
- Pliers, combination, 6-inch (1 pair).
- Screw driver, 2½-inch blade (1).
- Set box (operating chest), Type BC-32-A (1).
- Set box (wavemeter), Type BC-40 (1).
- Tape, friction (½ pound).
- Tube, Type VT-1 (6) 3 in use; 3 spare.
- Tube, Type VT-2 (4) 2 in use; 2 spare.
- Voltmeter, Type I-10 (1).
- Wire, Type W-7 (2 pounds).
- Radio Communication Pamphlet No. 17 (1).

Equipment, Type RE-7 :

- Battery, Type BA-2 (4) 2 in use; 2 spare.
- Battery, Type BA-4 (4) 1 in use; 3 spare.
- Chest, Type BC-43 (1).
- Clock, Type I-15 (1).

Equipment, Type RE-7—Continued.

- Cord, Type CD-15 (3).
- Cord, Type CD-38 (5).
- Cord, Type CD-47 (2).
- Cord, Type CD-48 (2).
- Cord, Type CD-49 (2).
- Head set, Type P-11 (2).
- Key, Type J-12 (1).
- Lamp, Type LM-4 (4) (for wavemeter), 1 in use; 3 spare.
- Pliers, combination, 6-inch (1 pair).
- Screw driver, 2½-inch blade (1).
- Set box (operating chest), Type BC-45 (1).
- Set box (wavemeter), Type BC-49 (1).
- Tape, friction ($\frac{1}{2}$ pound).
- Tube, Type VT-VT-1 (6) 3 in use; 3 spare.
- Tube, Type VT-2 (4) 2 in use; 2 spare.
- Voltmeter, Type I-10 (1).
- Wire, Type W-7 (2 pounds).

SIGNAL CORPS PAMPHLETS.

(Corrected to November 1, 1921.)

RADIO COMMUNICATION PAMPHLETS.

(Formerly designated Radio Pamphlets.)

No.

1. Elementary Principles of Radio Telegraphy and Telephony (edition of 4-28-21) (W. D. D. No. 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).
11. Radio Telegraph Transmitting Sets (SCR-74; SCR-74-A).
13. Airplane Radio Telegraph Transmitting Set (Type SCR-73).
14. Radio Telegraph Transmitting Set (Type SCR-69).
17. Sets, U. W. Radio Telegraph, Types SCR-79-A and SCR-99. (W. D. D. No. 1084.)
20. Airplane Radio Telephone Sets (Types SCR-68; SCR-68-A; SCR-114; SCR-116; SCR-59; SCR-59-A; SCR-75; SCR-115).
21. Theory and Use of Wavemeters (Types SCR-60; SCR-61).
22. Ground Radio Telephone Sets (Types SCR-67; SCR-67-A).
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. No. 1077).
26. Sets, U. W. Radio Telegraph, Types SCR-127 and SCR-130 (W. D. D. No. 1056).
30. The Radio Mechanic and the Airplane.
40. The Principles Underlying Radio Communication (edition of May, 1921) (W. D. D. No. 1069).

WIRE COMMUNICATION PAMPHLETS.

(Formerly designated Electrical Engineering Pamphlets.)

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

TRAINING PAMPHLETS.

1. Elementary Electricity (edition of 1-1-21) (W. D. D. No. 1055).
4. Visual Signaling.
5. The Homing Pigeon, Care and Training (W. D. D. No. 1000).
7. Primary Batteries (formerly designated Radio Pamphlet No. 7).
8. Storage Batteries (formerly designated Radio Pamphlet No. 8).

FIELD PAMPHLETS.

1. Directions for Using the 24-CM. Signal Lamp (Type EE-7).
2. Directions for Using the 14-CM. Signal Lamp (Type EE-6).
3. Directions for Using the Two-Way T. P. S. Set (Type SCR-76).

