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Tank Radio Telegraph Set

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U. W. Radio Telegraph Set Type, SCR–78–A.

For Use in the 6-Ton Signal Tanks.

THE TYPE SCR–78 SET is designed primarily for use on the special 6-ton signal tanks. It may, however, be used on the 30-ton fighting tanks by making a few alterations. It is an undamped wave telegraph set employing four transmitting tubes, type VT–2, and three receiving tubes, type VT–1. Its wave length range both in transmitting and receiving is nominally 600 to 1000 meters, but due to generous design it is actually about 500 to 1100 meters. Its power is about 15 watts.

The tactical use will probably include three lines of communication as follows:

(*a*) Between tank and division headquarters or an intermediate field station.

(*b*) Between tank and infantry contact airplanes.

(*c*) Between tank and tank.

The radio set employed at division headquarters or the intermediate field station for communication with signal tanks will be the type SCR–79 which is very similar to the type SCR–78 and has the same wave length range, 500 to 1100 meters. The radio set employed by the infantry contact airplanes is an undamped wave set, type SCR–80, having a wave length range of 550 to 750 meters.

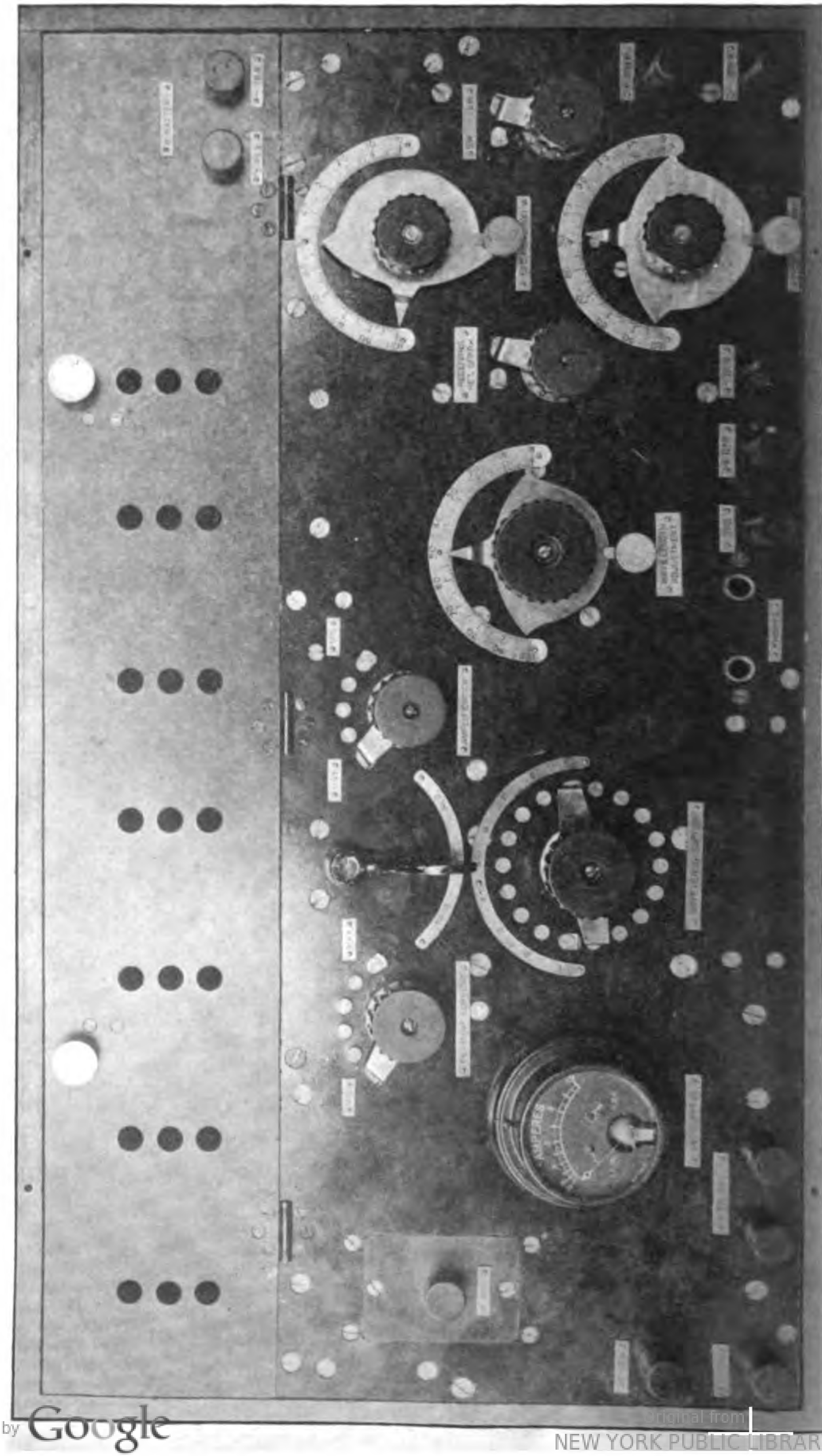
The maximum distances through which two-way communication can be expected over the above mentioned lines when the tank is in motion are listed below.

(*a*) Between tank and D. H. Q. or a field station, 6 miles.

(*b*) Between tank and infantry contact airplanes, 2 to 4 miles.

(*c*) Between tank and tank, 3 miles.

The limiting factor in communication with signal tanks is the reception within the tank. The noise encountered when the tank is in motion is very great, and this condition necessitates a rather strong signal. A much greater range of communication is possible if the tank is not in motion, and with the engine either idling very slowly or entirely stopped.



Operating panel of set box type BC-99 used in set type SCR-79-A.

Two types of tank antennae are furnished with the set, either one of which may be used as desired.

Theory of Operation.

A complete circuit diagram of the set is given in Fig. 1. A multipole 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 the simplified diagram, Fig. 2. The four type VT-2 three-electrode vacuum tubes used for the generation of oscillations are connected in parallel—that is, the plate, grid, and filament terminals are connected respectively together, as shown in Fig. 1. This is equivalent to using one single large tube, as shown in Fig. 2. The filaments are heated by the current from a 12-volt storage battery, made up of three type BB-17 4-volt units in series, described in a separate paragraph below. In series with this battery is a 6-point rheostat by means of which the filament current, and therefore the filament temperature, may be adjusted.

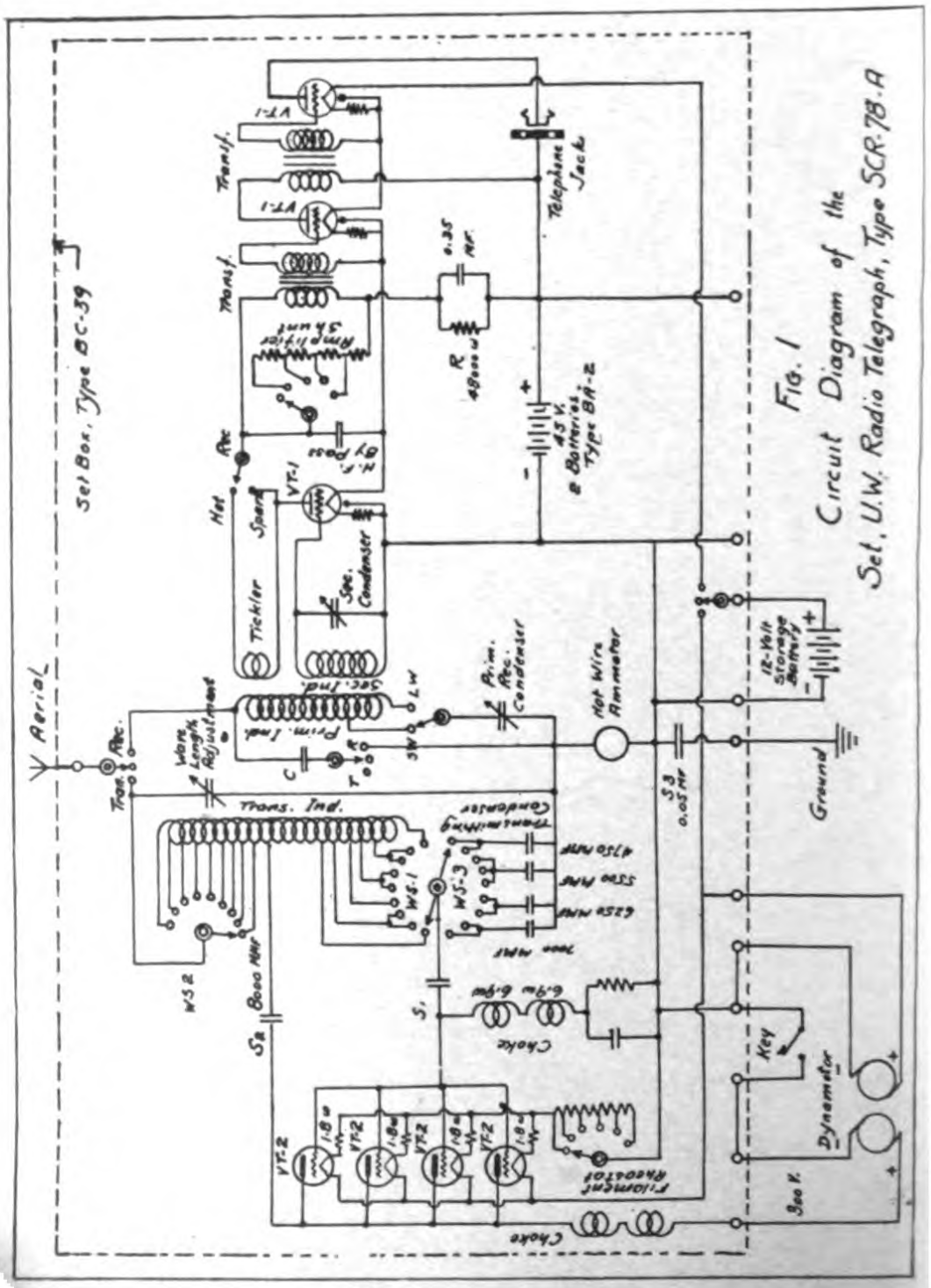
A continuous potential of about 350 volts is applied between the plate and the negative side of the filaments by a type DM-1 dynamotor, the low voltage side (motor side) of which is energized by the same 12-volt battery as used for heating the filaments. In series with the plate circuit is a choke coil which prevents the high frequency oscillations from damaging the dynamotor armature, and also prevents the antenna from being short circuited by the dynamotor. A telegraph sending key is also in series with the circuit, and it may thus be seen that the plate current, and therefore the oscillations generated by the tube, are entirely stopped when the key is open. The dynamotor does not run when the "Transmit-Receive" switch is thrown to "Receive."

A 2500-ohm resistance is connected between the grid and the filament of the transmitting tubes, in order to establish a negative potential on the grid when the tubes are oscillating. A choke coil in series with this resistance stops all high frequency oscillations in that circuit.

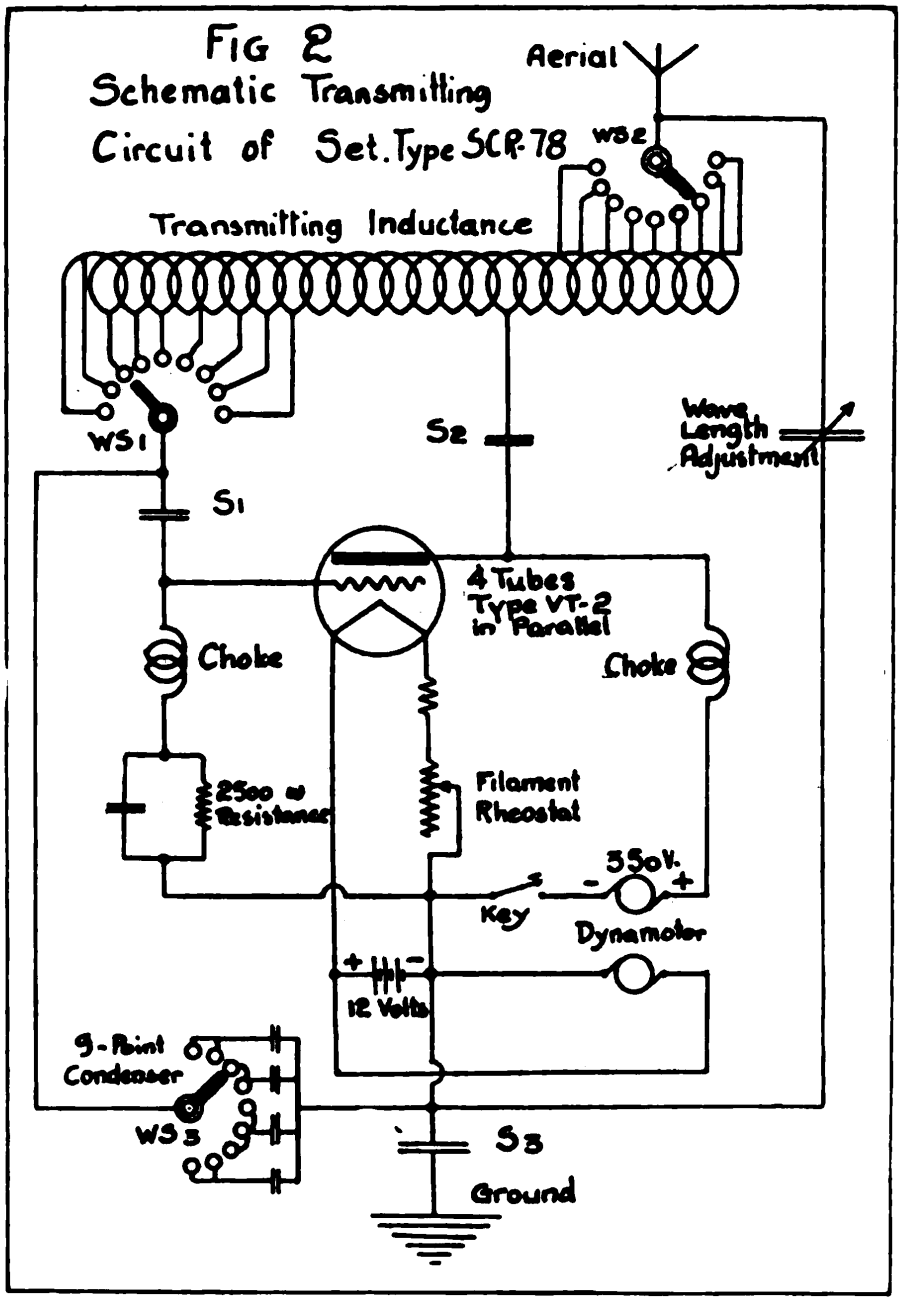
The d. c. grid and plate circuits just described are electrostatically and electromagnetically coupled for oscillation generation by means of the antenna, a 9-point condenser, and the transmitting inductance.

Simultaneous changes of wave length and coupling are effected by means of the three switches marked WS_1, WS_2, and WS_3 in Fig. 2, which are all operated by a single "Wave Length Switch" handle.

Condensers S_1 and S_2 are stopping condensers. They prevent the 350-volt d.c. plate potential from reaching the grid through the transmitting inductance.



In order to make the variation of wave length continuous between two successive positions of the wave length switch, a wave length adjusting air condenser is shunted across the antenna.



A hot wire ammeter is inserted in series with the ground wire, and indicates antenna current. The stopping condenser S_3 prevents short circuits of the dynamotor high voltage armature.

Switch in "Receive" Position.—With the switch in the "Receive" position, the circuit in use is equivalent to that shown in Fig. 3. This circuit comprises a primary (antenna) circuit, a secondary

tuned detector circuit, and a two-stage vacuum tube cascade amplifier. The filaments of the three tubes are in series with the 12-volt storage battery. A 1-ohm resistance is in series with each filament, to maintain the grid at the proper potential.

The primary circuit comprises the aerial in series with the primary inductance, primary variable condenser, a stopping condenser S_3, and the ground. The primary condenser and coil are shunted by a fixed condenser C, which simplifies the construction of the set by permitting the use of a smaller primary inductance coil. A tap is connected to the primary inductance coil, which permits a rough adjustment of the set to long or short waves. The final primary adjustment is made by means of the variable primary condenser. The stopping condenser S_3 is large, and does not interfere with the high frequency oscillations of the system.

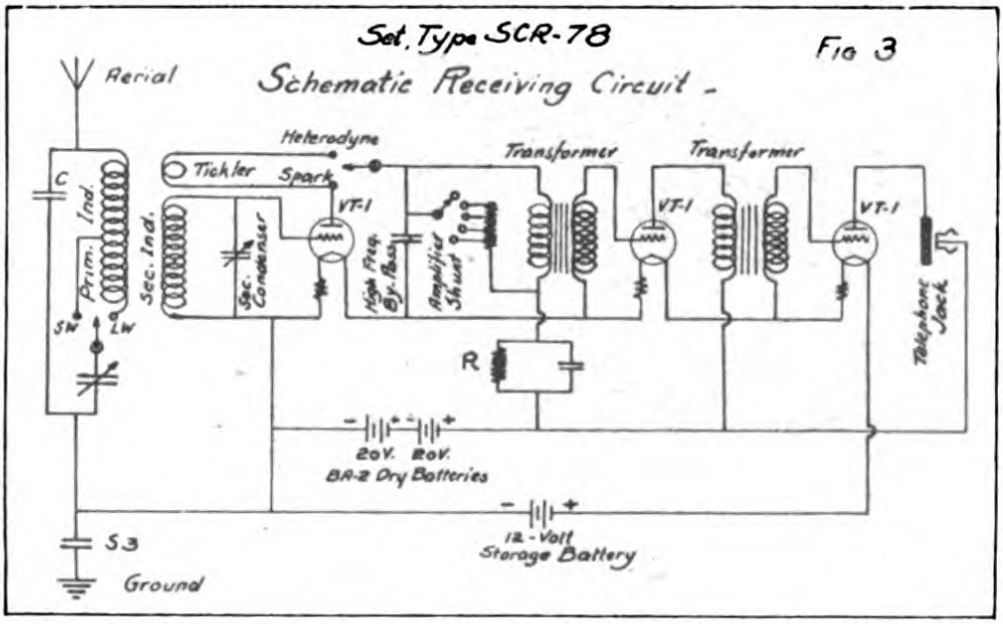
The primary and secondary circuits are coupled inductively, and the coupling is fixed. The secondary inductance coil, which is shunted by a variable air condenser, is connected on one side to the grid, and on the other to the filament of a type VT-1 three-electrode vacuum tube used as a detector. The plate circuit of this tube comprises a 40-volt dry battery, made up of two type BA 2 batteries in series, a high non-inductive resistance and the primary winding of an iron core transformer which couples the detector circuit to the first amplifier tube. A switch in the plate circuit of the detector tube permits of inserting a tickler coil in this circuit, for the reception of undamped waves by the self-heterodyne (autodyne) method. This tickler coil is permanently coupled to the secondary inductance coil, and the tube will oscillate without any further adjustment. When receiving damped waves, the tickler coil is cut out of the plate circuit by means of the switch. The purpose of the high resistance R is to reduce the plate potential to 20 volts on the detector tube. This resistance is shunted by a condenser which by-passes the audio frequency currents, while another condenser shunts the entire plate circuit to by-pass the locally generated high frequency oscillations.

The other type VT-1 vacuum tubes are connected for untuned cascade amplification, using iron core transformers. The full 40 volts of the dry battery are impressed on the plates of these tubes. Telephone jacks are provided in the plate circuit of the last tube. The degree of amplification may be varied by means of a variable resistance shunting the primary winding of the transformer of the first amplifier tube. The use of reduced amplification will frequently eliminate weak interfering signals.

Description of Parts.

Set Box.—The set box, type BC–39, contains all the controls and radio circuits for both transmitting and receiving. The box is made of wood with a removable cover, its overall dimensions including cover being: length, 23 in.; height, 13 in.; depth, 10¼ in. The panel is a sheet of micarta, upon which are mounted all the parts, the control handles projecting above the face of the panel. The vacuum tubes are all mounted on flexible sponge rubber supports to minimize jarring. They may be replaced by opening the door which extends completely across the top of the panel.

Set Box Mountings.—The set box mountings consist of four cylindrical sponge rubber pads and two spring anchor bands, the latter being essentially spiral steel springs with a hook at each end.



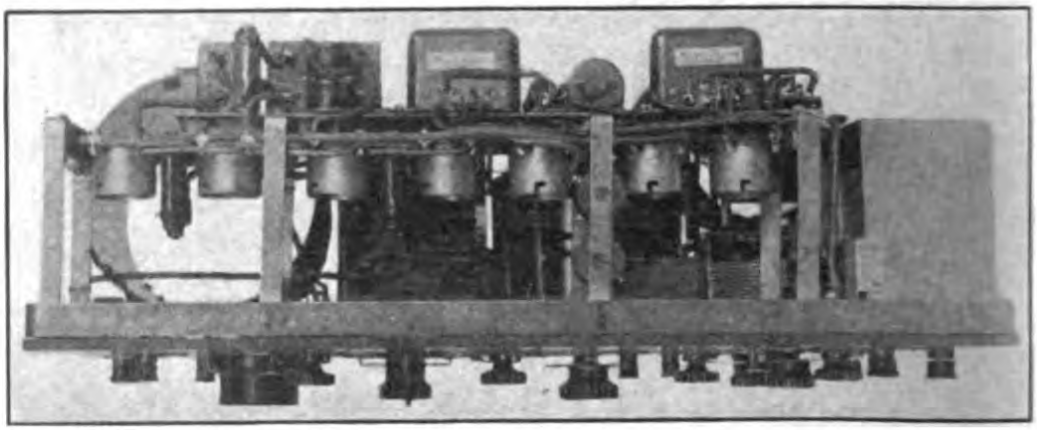
The pads protect the set box from any undue jarring and are screwed to the wooden shelf which supports the set box. The set box rests upon these pads and is held down by the two spring anchor bands which hook into the carrying strap handles and into the screw eyes fastened to the supporting shelf at each end of the set box.

Head Sets.—The telephone head sets are the standard Signal Corps telephone head sets, type P–11.

Keys.—The key is very similar to the standard Western Union key. It is not equipped with a short-circuiting switch and the contacts are ¼ in. diameter coil silver. Two keys are furnished,

one mounted in the cover of the set box, the other to be carried in the accessory box.

Storage Batteries.—The type BB–17 storage batteries are of the lead-acid type, 4-volt, 160-amp-hr. capacity at a discharge rate of 12 amp. The cell containers are of hard rubber while the battery boxes are of wood. The overall dimensions of each battery are: length, $12\frac{3}{8}$ in.; width, $8\frac{1}{4}$ in.; height, $10\frac{5}{8}$ in. The cover is hinged and has recesses in two corners for two external binding posts, so that connections may be made without opening the cover. The cover is flat topped to allow stacking of batteries. A remov-



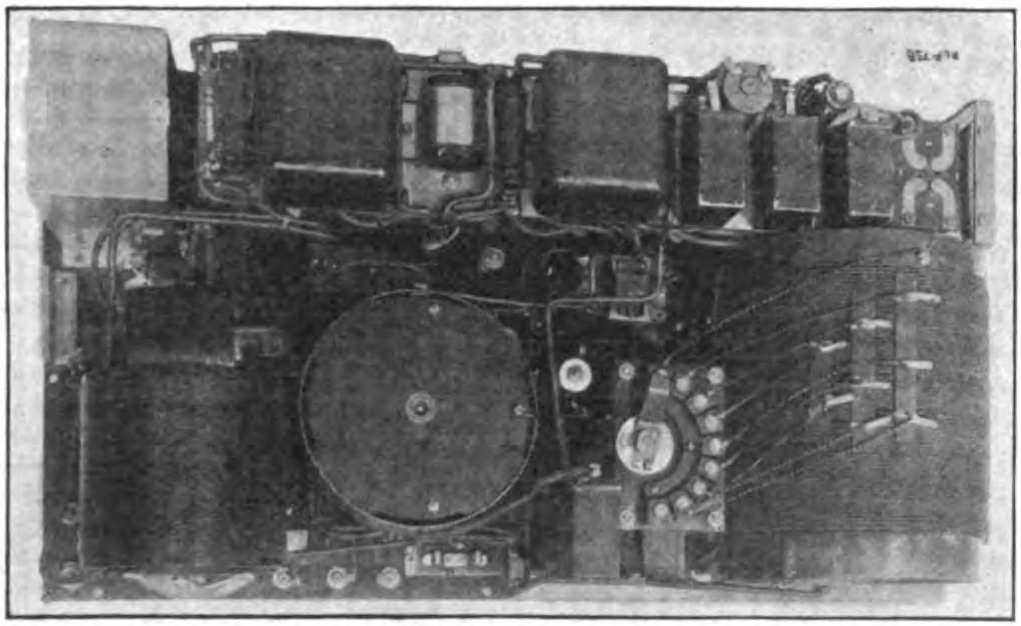
Top view of the panel of set box type BC–39 when removed from the box.

able carrying strap is provided which snaps into the handles at either end of the battery.

Dynamotor.—The dynamotor, type DM–1, is rated as a 50-watt, 10 to 300-volt machine. It is run, however, from the 12-volt storage battery and delivers about 160 milliamp. to the plate circuits of the four transmitting tubes at a potential of 350 volts. It is mounted in an aluminum carrying case which has a hinged cover and carrying strap. Binding posts are mounted on a micarta panel for attaching the connecting cords to the 12-volt and the 350-volt sides of the dynamotor. The panel also carries a two-pole, single throw switch which closes the 12-volt circuit, and a fuse block which is arranged for a small piece of 20-amp. fuse wire in the 12-volt circuit to protect the machine in case of a short circuit on the 350-volt line. A spool containing 10 ft. of fuse wire is mounted in the cover of the aluminum box.

Wavemeter.—The type SCR–95 wavemeter used with the set is similar to the French type T–1 wavemeter and has a wave length range of 500 to 1100 meters. The condenser in the oscillating cir-

cuit is a fixed mica condenser, the tuning of the meter being accomplished by means of a variable inductance. The position of the fixed coil of this inductance is indicated upon the panel of the meter. The wave length is indicated by the graduation on the movable circular dial which is raised slightly above the surface of the panel. The resonance point when transmitting is indicated by a miniature lamp which projects above the panel and which is in series with the condenser and variable inductance. A buzzer is provided for exciting the wavemeter when it is desired to tune the receiving circuit to a particular wave length. The wavemeter box is of wood



Rear view of panel of set box type BC-39 showing mounting of apparatus.

and its overall dimensions are: length, 5⅜ in.; width, 4⅞ in.; depth, 4½ in. This wavemeter is fully described in Radio Pamphlet No. 21, second edition.

Mast Antenna.—This type A–8 antenna is for use with signal tanks only. It is a tapered steel rod in five sections, the total length being 16 ft. The first or lower section is a piece of straight steel tubing having an outside diameter of 1 in and a length of 4 ft. The remaining sections are each 3 ft. long and vary in diameter from ⅝ in. at the bottom of the first to ⅛ in. at the top of the fourth. The sections fit together like a fishing rod and make thorough electrical contact.

Umbrella Antenna.—This type A–7 antenna is of steel and is in two sections, each 3 ft. long and 1 in. in diameter. When erected it has four light steel arms projecting from the top at right angles to

each other, and parallel to the earth. The four steel arms can be collapsed within the top section.

Mast Clamp.—The type FT-12 mast clamp is made almost wholly of iron and steel and when installed in the turret of the small signal tank is located in the forward right hand corner of the observer's conning tower. It is supported from three insulators which are bolted to the roof of the turret. As its name indicates, it is used to hold the mast antenna or the umbrella antenna rigidly in a vertical position. The part of the clamp which makes contact with the mast, that is, the part below the insulators, is in two halves, one half fixed to the insulators and the other half hinged to the first. The movable half swings through an arc of about 100° and is locked in place by the motion of a single handle. Electrical contact with the mast antenna or the umbrella antenna is made through the clamp, a binding post being provided on the bottom of the stationary portion of the clamp, to which the antenna wire from the set box is connected.

Rain Shield.—The type M-10 rain shield is a funnel shaped piece of hard rubber which is slipped over the lower section of either tank antenna in such a position that when the antenna is erected it shields the opening in the roof of the turret, through which the antenna projects, from rain. Its maximum diameter is 4 in.

Voltmeter.—The type I-10 voltmeter is a direct current instrument with two ranges, 0 to 10 volts and 0 to 50 volts. The 10-volt range is used for storage battery testing and the 50-volt range is used for testing the type BA-2 dry batteries. The meter box is of wood covered with black leather. The negative contact is a pointed brass prong projecting from one end of the box, and the positive contact is a small pointed brass rod set in a red handle on the end of an 18-in. extension cord which is connected to a binding post at the end of the box opposite the negative terminal. In order to use the 10-volt range it is necessary to press a small push button at the back of the box.

Operator's Light.—The operator's light is a portable desk lamp which fastens to the set box shelf with a spring clamp. It has a cylindrical shade, the axis of which is parallel to the front edge of the shelf and about 6 in. from it. The shade is capable of rotation so that the light may be thrown either on the set box or on the operator's writing desk. The socket is equipped with a key switch. The lamp used is a 12-volt, 0.35-amp. lamp with a candelabra

base. The source of energy is the storage battery, a 3-ft. connecting cord being furnished, the spade terminals of which are connected to the battery binding posts on the set box.

Accessory Box.—The type BC–33 accessory box is built of fiberoid and shaped much like a suitcase, its external dimensions being: length, 18 in.; width, 12½ in.; thickness, 6 in. It is used to store and carry spare parts and small pieces of apparatus like vacuum tubes, dry batteries, the voltmeter and wavemeter. The cover is hinged and fastened shut with suitcase snaps. The box is equipped with a carrying strap.

Charging Set.—The 6-ton signal tanks are provided with a battery charging outfit, which consists of a 12-volt generator and its control apparatus. This outfit is fully described on page 18.

Installation of Set Type SCR-78-A in the 6-Ton Signal Tank.

All of the radio apparatus except the storage batteries is mounted on a shelf or platform which extends around the four sides of the turret, the operator standing in the opening with his outfit conveniently grouped about him. The set box is placed at the right hand side of the shelf which extends across the front of the turret, as shown in Fig. 4. The face of the panel should be about even with the edge of the shelf and the right hand end of the set box should be about 2½ in. from the corresponding wall of the turret. The four sponge rubber pads which support the set box at the corners are to be set in holes in the wooden shelf, diameter 2 in., depth ½ in., and screwed in place by the 1-in. No. 6 wood screws and washers furnished for this purpose. The holes in the wood shelf are not provided and must be bored therein at the time of installation. One of the No. 10 screw eyes is to be fastened to the shelf at each end of the set box and about 1½ in. therefrom, to catch the hooks of the spring anchor bands which hook into the carrying strap handles and hold the set box in place. The wooden shelf can be easily removed by taking out a few machine screws, so that the holes for the rubber pads can readily be bored and pads screwed in place. There is room behind the set box for the cover when the set is in use.

Either the key mounted in the set box cover or the one carried in the accessory box is fastened with screws to the small folding wooden shelf in front of the radio operator. Its location should be near the left or outer edge of the shelf, so that the operator may more easily use a message pad, which would then be placed to the right of the key.

The storage batteries are placed on the floor of the tank in approximately the position shown in Fig. 4. Since the battery extension cords are complete in one piece, it is quite essential that each battery face in the direction shown in this sketch.

The dynamotor is carried on the shelf at the operator's right. Fig. 4.

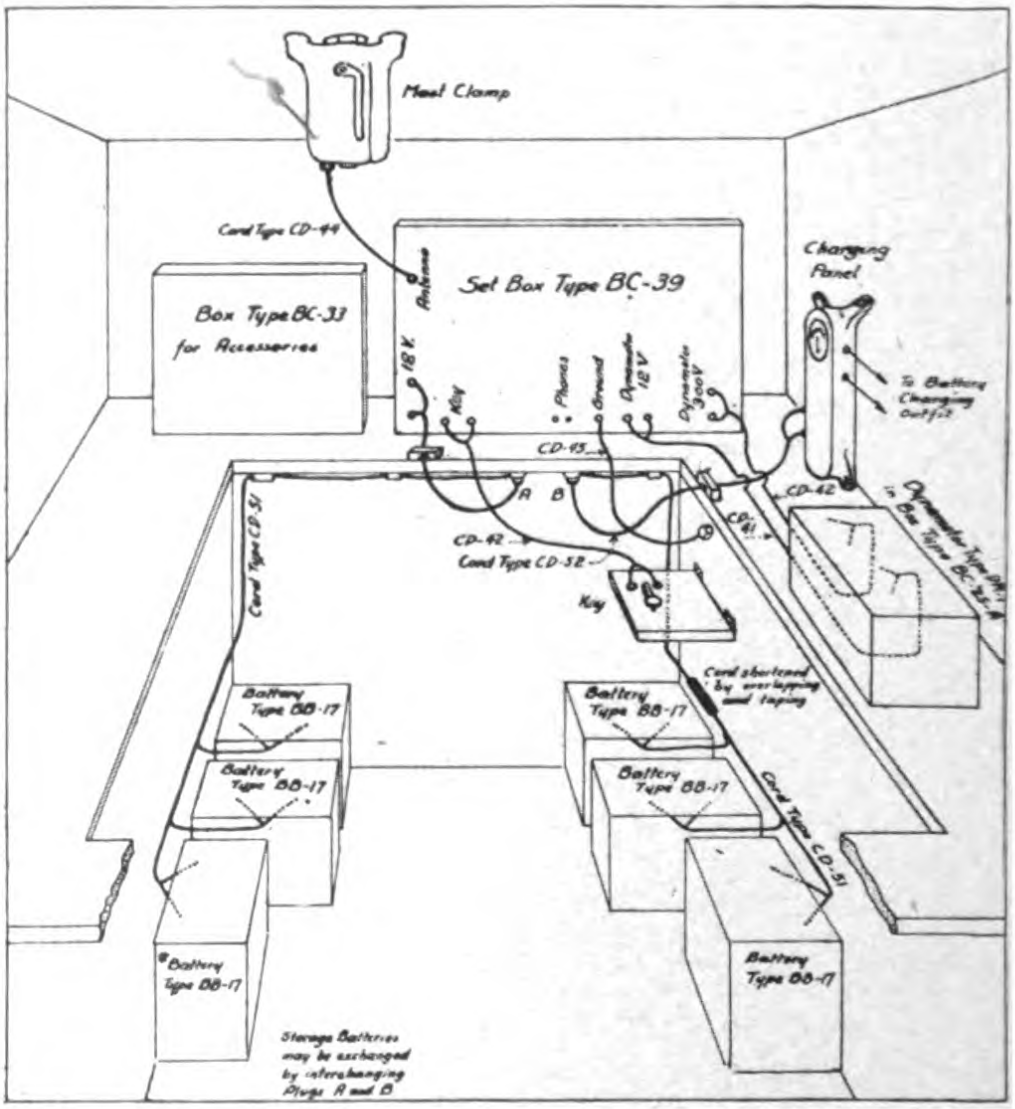


FIG. 4.—Cording diagram and general arrangement of the parts of set type SCR-78-A in the turret of a tank.

The three mast clamp insulators should first be bolted to the roof plate of the observer's conning tower, at the forward right hand corner, using the nine $\frac{3}{8}$ in. by $1\frac{1}{4}$ in. hexagonal head bolts provided for the purpose. The nuts should be placed on the under side of the roof plate. The main part of the clamp may then be

fastened to the three bolts which protrude from the insulators. Great care should be taken to properly tighten all of the nuts, so that the clamp will be held perfectly rigid.

To erect the mast antenna, first swing the mast clamp open, get all five sections in a vertical position under the clamp and resting on the floor of tank. Then push the top or smallest section through the hole in the roof above the clamp. Push the lower end of this smallest section into the top end of the next largest section and raise this upward. Repeat the process until all sections are together. Push the mast up until the lower end is about even with the bottom of the clamp, then close and lock the clamp. Care should be taken to see that all joints are free from grease, mud and dirt and that the bottom 1 ft. of the mast and the surfaces of the clamp which grip it are clean and bright. Emery cloth is provided for removing rust from the clamp and the lower end of the mast. These precautions must be taken to insure good electrical contact all the way from the tip of the mast down to the antenna binding post on the set box.

The umbrella antenna is erected in much the same manner as the other. The top section is held in a vertical position beneath the mast clamp and the four arms are pulled out in a bunch and the brass plug, to which they are pivoted, locked in place by a 20° turn. The top section is raised partly through the hole and the lower section attached and the whole shoved up until the lower end is about even with the bottom of the mast clamp, when the mast clamp is locked. The same precautions regarding electrical contact are to be observed as in the case of the mast antenna. The operator should note whether all the arms fall into their proper position, as it is possible for them to fall the wrong way.

The rubber rain shield is slipped over the bottom section of either tank antenna and located at such a distance from the lower end that when the antenna is erected, the rain shield will not be closer than ½ in. nor farther than 1 in. from the steel ring around the mast hole. The minimum distance is so specified because of the high voltage between the mast and the tank. The maximum distance is put at 1 in., so that rain will not drive in beneath the shield.

The operator's light fixture is not equipped with leads, the connecting cord being furnished separately. The connecting cord, type CD–46, is 2 ft. 6 in. long, and is connected to the socket in the same manner as a regular lamp socket. The spade clips are

attached to the same binding posts on the set box as the battery cords marked "—12 V" and "+12 V." The spring clamp is attached to the front shelf, which supports the set box, so that the fixture projects straight out from the edge of this shelf. The shade may then be rotated, so that the light may be thrown either on the key shelf or on the set box panel.

The accessory box is to be carried on the front shelf to the left of the set box.

The installation of the charging set is included in the assembly of the tank proper, and will therefore not be taken up here.

Connecting up the Set.—All of the two-conductor extension cords are made up with one red cord and one black cord, the red being plus and the black minus. The spade clips are also stamped + and —. No cord should be connected up without throwing the transmit-receive switch to "Off." The installation of connecting cords is a rather important matter and care should be taken to see that all contacts are clean and tight and that all cords are placed out of the way of driver, operator, and observer, and that any excess length of cord is properly taken up by doubling it back and taping up the overlapped part. Fig. 4 gives approximately the proper position of the various cords, except that the binding posts are not shown exactly as they are on the actual set box. It will be noted that each set of batteries has attached to it an extension cord type CD–51 which has on the opposite end a Hubbel wall receptacle. These receptacles should be screwed to the lower side of the set box shelf about centrally located with respect to the set box and perhaps 2 in. or 3 in. apart. The cords should be fastened to the lower side of the shelf by means of the cleats provided. The connections from the batteries to the set box and charging panel are completed by cords, type CD–52, which have a polarity plug on one end and spade clips on the other, and which should be fastened down by means of the cleats as shown in Fig. 4. It is intended that these cords, type CD–51 and CD–52, shall be left in the tank even though the set is removed. The ground connection is made to the bolt directly beneath the right hand edge of the front shelf.

Method of Operating the Set.

Having connected up the set as explained above, and erected the antenna it is desired to use, the set may be operated according to the following rules.

Transmitting Signals.—1. Turn the "Filament Current" switch to "Minimum," and then close the "Transmit-Receive" switch to "Transmit." The four VT–2 tubes (at the left hand side of the box) should glow a dull red, and the dynamotor should start running.

2. Lock the telegraph sending key so that it will be permanently closed, and turn the filament current switch toward the "Maximum" position until the ammeter reading reaches a maximum value. Then, turn the filament current switch back a little, so that the ammeter reading will fall off slightly.

3. To adjust the set for a given wave length, set the wavemeter switch to "C," and adjust the resistance so that the wavemeter indicator lamp will glow a dull red. Set the wavemeter to the desired wave length, and hold the wavemeter box directly beneath the left hand end of the radio set box, with the face of the panel in a vertical position.

4. Adjust the "Wave Length" switch and "Wave Length Adjustment" to the point where the wavemeter lamp will glow brightest.

5. Unlock the telegraph key, and start sending. When not using the set, place the transmit-receive switch in the "Off" position.

Receiving Signals.—1. Close the transmit-receive switch in the "Receive" position, and turn the "Amplification" switch to "Maximum." The three receiving tube filaments (at the right hand side of the box) should now glow a dull red.

2. Set the receiving switch to "Heterodyne" or "Spark" according to whether undamped or damped wave signals are to be received. Signals sent out by a type SCR–78, SCR–79, or SCR–80 set are undamped wave signals, and should be received on "Heterodyne."

3. If the wave length to be received is below 800 meters, set the switch marked "S.W.—L.W." to "S.W." If it is above 800 meters, set it to "L.W."

4. Set the primary condenser in various positions successively, varying the secondary condenser over its entire range for each one of these positions, until the signals are heard with the greatest intensity.

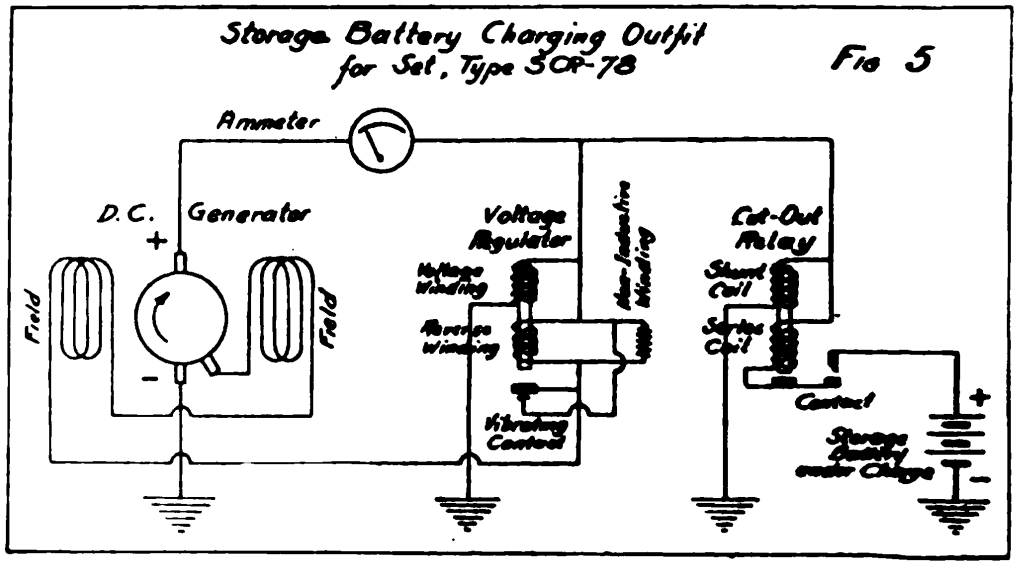
5. If required, reduce the amplification by means of the "Amplification" switch.

6. If the wave length to be received is known in advance, set the wavemeter to that wave length, and excite it by means of the buzzer by placing the wavemeter switch on "B." Set the "Receiving" switch of the radio set box on "Spark," and tune the set as explained

in paragraph 4 above. After tuning, stop the buzzer, and set the switch to "Heterodyne."

Battery Charging Outfit.

Two 12-volt storage batteries are furnished with the set and installed in the tank, as shown in Fig. 4, one being used to energize the radio set, the other being a spare, and usually under charge while the first is in use. A battery charging outfit is therefore provided in the tank for this purpose. This comprises a 12-volt, d.c. generator and its control apparatus, which are furnished by the Tank Corps and not included in the parts list for the type SCR-78-A set.



Generator.—The generator is mounted on the tank motor and is driven by a chain belt from the magneto shaft. It is a 12-volt, two-pole generator, with the negative terminal grounded. The armature is carried on ball and roller bearings, a ball bearing being provided on the drive end and a roller bearing on the commutator end of the armature shaft.

Regulation of the generator voltage at different engine speeds and varying battery conditions is obtained by the use of a third brush used in connection with a vibrating type voltage regulator, described below with the control apparatus. The third brush method of regulation permits of a rather high charging rate at slow operating speeds when the storage battery is partially discharged, but prevents an excessive charging rate on nearly discharged batteries when the

engine is running at high speed. The output of the generator may may be varied by changing the position of the third brush on the commutator. Shifting it in the direction of rotation of the armature produces an increase in the charging rate. A decrease of the charging rate is then obtained by shifting the brush in the reverse direction. The maximum safe charging rate is about 14 amp.

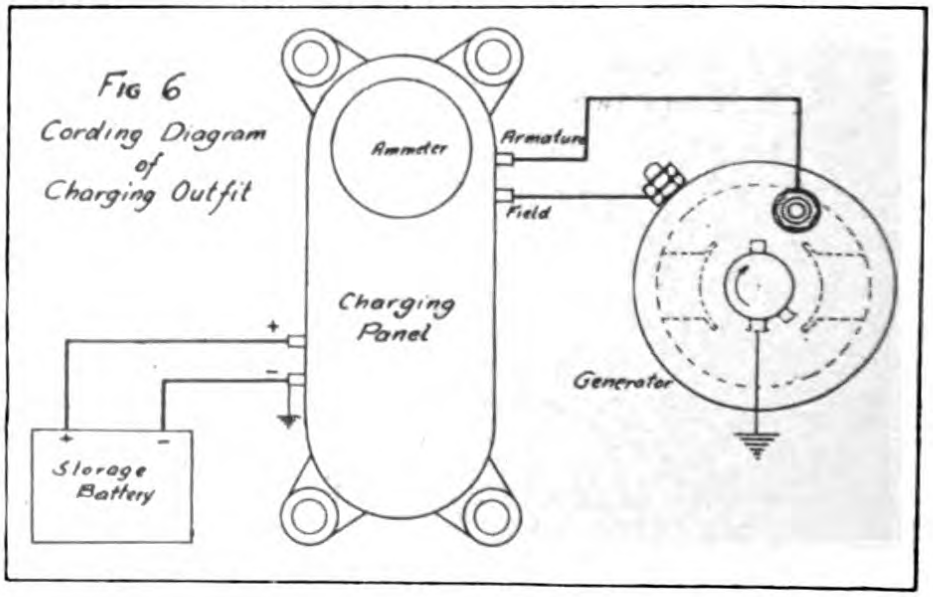
After changing the position of the brush, it should be noted that it is seating properly on the commutator, since improper seating will affect the generator output materially. As the negative terminal of the generator is grounded to the frame, only one armature terminal is provided, the other being connected to the grounded main brush. One of the field leads is connected to the third brush, while the other is brought out to a terminal on top of the generator and connected to the voltage regulator through the field terminal on the side of the control box. The generator is provided with two oilers, and should be oiled about every two weeks.

Control Apparatus.—The control apparatus comprises an automatic voltage regulator, an automatic cut-out relay, and an ammeter, Fig. 5. These are mounted in a waterproof iron box, with only the ammeter face exposed to view. The box is bolted to the right side of the turret. Connection from the generator to this box is made by running a wire from the field terminal of the generator to the "Field" binding post of the box, and another wire from the main brush terminal of the generator to the "Armature" binding post of the box.

Voltage Regulator.—The function of the voltage regulator is to keep the generator voltage at a constant value. The regulator consists of a coil having three windings wound around a common soft iron core. These windings consist of a voltage winding, a reverse winding, and a non-inductive winding. The voltage winding is made up of a large number of turns of fine copper wire, and is connected across the main generator brushes. The reverse winding is connected in series with the generator field, and the current in this winding flows in the reverse direction to that of the voltage winding. The non-inductive winding has no magnetic effect on the core, and simply acts as a resistance. It is connected in parallel with the reverse winding.

The entire coil is mounted on a frame, which also supports a movable armature, which is attracted toward the iron core of the coil, when the latter is magnetized. Upon being attracted, two contact points are separated by the motion of the armature. These contacts

are connected in parallel with the reverse winding and non-inductive winding. The operation of the regulator is then as follows. When the generator is in operation, a certain current flows in the voltage winding, proportional to the generator voltage. This current will set up a magnetic field in the iron core, and tend to attract the movable armature. If the generator voltage rises beyond a certain limit, the current in the voltage coil will be great enough to overcome the tension of the armature spring, and the armature will be attracted toward the core, opening the contacts, which while closed, shunted the reverse winding and carried the greater part of the generator field current. As they break contact, however, a large part of the field current flows through the reverse winding. This has two effects. By introducing the resistance of the reverse winding in the field cir-



cuit, it reduces the generator field current, and therefore the generator voltage. Also, it decreases the magnetic field in the regulator, since the field due to the voltage winding is counteracted by that of the reverse winding. The decrease in generator voltage resulting from this decrease in the generator field current produces a decrease in the current through the voltage winding of the regulator and thus further reduces the attraction on the vibrator contact armature. The armature will therefore fall back in place and again close the contacts. The generator voltage then rises again, and the operation repeats itself. The contacts vibrate at a very high speed, and the currents do not build up to their final value. The strength of the current and therefore the generator voltage depending on the speed

of vibration, it will be possible to regulate the voltage by adjusting the tension spring of the vibrator. It is thus possible to hold the voltage anywhere between 13.5 and 15 volts.

Cut-out Relay.—The function of the cut-out relay is to provide a safeguard against discharging the storage battery through the generator when the engine is running at a very low speed, or is stopped entirely. The necessity of such a safeguard may be readily appreciated, since the storage battery is connected directly across the generator terminals. Should the generator be stopped, there being no longer any emf. to counterbalance that of the battery, the latter would discharge through the generator windings. This would also occur when the generator was driven at a speed low enough to make the generator emf. less than the battery emf. The cut-out relay therefore opens the circuit whenever the generator voltage becomes less than a certain predetermined value. Its operation is explained below.

The cut-out relay consists of a set of contacts which are held open by spring tension, and may be closed by an electromagnet when the magnetic field in the latter is strong enough. This electromagnet has a double winding, consisting of a voltage or shunt coil connected across the generator terminals, and a current or series coil, in series with the load. The armature contacts are also in series with the load, so that no current flows in the series coil and battery circuit as long as the contacts are open.

When the generator is started, the generator voltage builds up, and a current flows in the shunt coil of the cut-out relay, setting up a magnetic field in the core. When the generator voltage reaches a value of between 13 and 15 volts, this field is strong enough to overcome the tension of the spring, and attract the armature. This closes the contacts and completes the circuit between the generator and the battery. The current now flows through the series coil, which is so wound as to produce a magnetic field in the same direction as that due to the shunt coil. This strengthens the pull on the armature and holds the contacts closed. When the generator slows down and its voltage drops below that of the battery, the current flows from the battery to the generator in the reverse direction. This current flows also through the series coil of the relay, while the current in the shunt coil has not changed in direction. The magnetic fields of the two coils thus oppose each other, and the resultant field is no longer sufficient to hold the armature against the spring tension. The armature then falls back, opening the contacts, and

preventing any further discharge of the storage battery. The relay should cut out when the discharge current is between 0 and 1 amp.

In order to adjust the relay to cut out at the proper value of discharge current, two factors are to be considered—the air gap between the armature and the core, and the spring tension. The air gap has practically no effect on the cut-out point, which is almost entirely governed by the spring tension. The point of cutting in, however, is governed by both the air gap and spring tension.

Care should always be taken to keep the contacts clean and lined up properly. If required, they may be cleaned by means of some emery cloth.

Connecting up the Control Box.—The connection from the generator to the control box has been explained in the paragraph covering the generator. The storage battery terminals of the control box are connected to a type CD-52 extension cord, the polarity plug of which fits into the charging socket, as shown in Fig. 4. Care should be taken to connect up the cord with the proper polarity. The general scheme of connection of the generator, charging panel and storage battery are shown in Fig. 6.

PARTS LIST.

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

In ordering complete sets, it is not necessary to itemize the parts; simply specify "Set, U. W. Radio Telegraph, Type SCR-78-A." If all the parts listed under a group heading are desired, it is not necessary to itemize the parts; simply specify, for example, "1 Equipment Type PE 22."

The set is not complete unless it includes all of the items listed in the component parts table below.

Set, U. W. Radio Telegraph, Type SCR-78-A.

1 **Equipment Type PE–22**; power.
- 1 **Box Type BC–25**; or **Type BC–25–A**.
- 1 **Dynamotor Type DM–1**.
- 12 **Batteries Type BB–17**; 6 in use, 6 spare.

1 **Equipment Type RE–6–A**; radio.
- 1 **Set Box Type BC–39**; radio telegraph.
- 1 **Box Type BC–33**; accessories.
- 1 **Set Box Type BC–40**; wavemeter.
- 3 **Batteries Type BA–4**; for set box type BC–40; 1 in use, 2 spare.
- 4 **Batteries Type BA–2**; for set box type BC–39; 2 in use, 2 spare.
- 4 **Lamps Type LM–4**; for set box type BC–40; 1 in use, 3 spare.
- 4 **Lamps Type LM–5**; for operator's light; 1 in use, 3 spare.
- 2 **Head Sets Type P–11.**
- 2 **Keys Type J–12.**
- 1 **Screwdriver Type TL–21.**
- 1 **Pliers Type TL–19.**
- 1 **Voltmeter Type I–10.**
- 1 **Fixture Type FT–10.**
- 6 **Tubes Type VT–1**; 3 in use, 3 spare.
- 7 **Tubes Type VT–2**; 4 in use, 3 spare.
- 2 **Cords Type CD–41**; set box type BC–39 to 12-volt side of dynamotor; 1 in use, 1 spare.
- 3 **Cords Type CD–42**; set box type BC–39 to 300-volt side of dynamotor, and to transmitting key; 2 in use, 1 spare.
- 2 **Cords Type CD–44**; set box type BC–39 to antenna; 1 in use, 1 spare.
- 2 **Cords Type CD–45**; set box type BC–39 to ground; 1 in use, 1 spare.
- 2 **Cords Type CD–46**; for operator's light; 1 in use, 1 spare.
- 3 **Cords Type CD–51**; from storage batteries; 2 in use, 1 spare.
- 3 **Cords Type CD–52**; from charging panel to set box type BC–39; 1 in use, 2 spare.
- 4 **Bands Type FT–11**; 2 in use, 2 spare.
- 6 **Pads Type M–9**; 4 in use, 2 spare.
- 4 **Screweyes**; 2 in use, 2 spare.
- 2 lb. **Wire Type W–7.**
- 4 **Rain Shields Type M–10**; 1 in use, 3 spare.
- 6 **Screws and Washers**; 4 in use, 2 spare.
- 5 sheets **Emery Cloth.**
- ½ lb. **Tape Type TL–83.**

1 **Equipment Type A–7**; umbrella antenna.
- 3 **Mast Sections Type MS–6**; 1 in use, 2 spare.
- 3 **Mast Sections Type MS–7**; 1 in use, 2 spare.

1 **Equipment Type A–8**, mast antenna.
- 7 **Mast Sections Type MS–8**; 1 in use, 6 spare.
- 7 **Mast Sections Type MS–9**; 1 in use, 6 spare.
- 7 **Mast Sections Type MS–10**; 1 in use, 6 spare.
- 7 **Mast Sections Type MS–11**; 1 in use, 6 spare.
- 7 **Mast Sections Type MS–12**; 1 in use, 6 spare.
- 1 **Clamp Type FT–12.**
- 1 **Bag Type BG–16.**