W. D. D. No. 1077

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SET, RADIO TELEGRAPH

TYPE SCR-105

Radio Communication Pamphlet No. 25

PREPARED IN THE OFFICE OF THE
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The following publication, entitled "Set, Radio Telegraph, Type SCR-105," Radio Communication Pamphlet No. 25, is published for the information and guidance of all concerned.

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BY ORDER OF THE SECRETARY OF WAR:

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

OFFICIAL:
P. C. HARRIS,
The Adjutant General.

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SET, RADIO TELEGRAPH, TYPE SCR-105.

GENERAL DESCRIPTION OF SET.

1. The SCR-105 is a transmitting and receiving quenched-spark radio set. It is designed to be used for communication between headquarters which are usually not more than 5 miles apart. It can maintain communication with a like set over a distance of 5 miles. If an amplifier is furnished with the receiving set, this distance is increased to 13 miles. The transmitting wave lengths are fixed at 150, 180, 210, 240, 270, and 300 meters. It can be tuned for the reception of damped waves and audio frequency modulated continuous waves at any wave length between 100 and 550 meters. The set is intended only for intermittent duty and should not be used for continuous sending. The equipment is so packed that the set may be carried by hand when necessary. There are three distinct equipments comprising the set; the power, the antenna, and the operating chest.

DESCRIPTION OF POWER EQUIPMENT.

2. Storage batteries Type BB-23 furnish the power. This battery is a 10-volt lead storage battery of a nonspill type of 20 ampere-hour capacity. There are five cells in individual celluloid jars, all being contained in a wood case with peepholes for showing when the battery acid is at the correct height. The battery complete weighs 26 pounds and is provided with a carrying strap. Its dimensions are 12½ by 5 by 10 inches high. The three batteries are assigned as follows: One in use with the set; one spare, fully charged, with the set; and one at the charging point. (At the present time, however, only two batteries are being issued; one for use with the set and the other on charge.) A card containing the manufacturer's instructions accompanies each battery. Signal Corps Training Pamphlet No. 8 describes the care and charging of batteries.

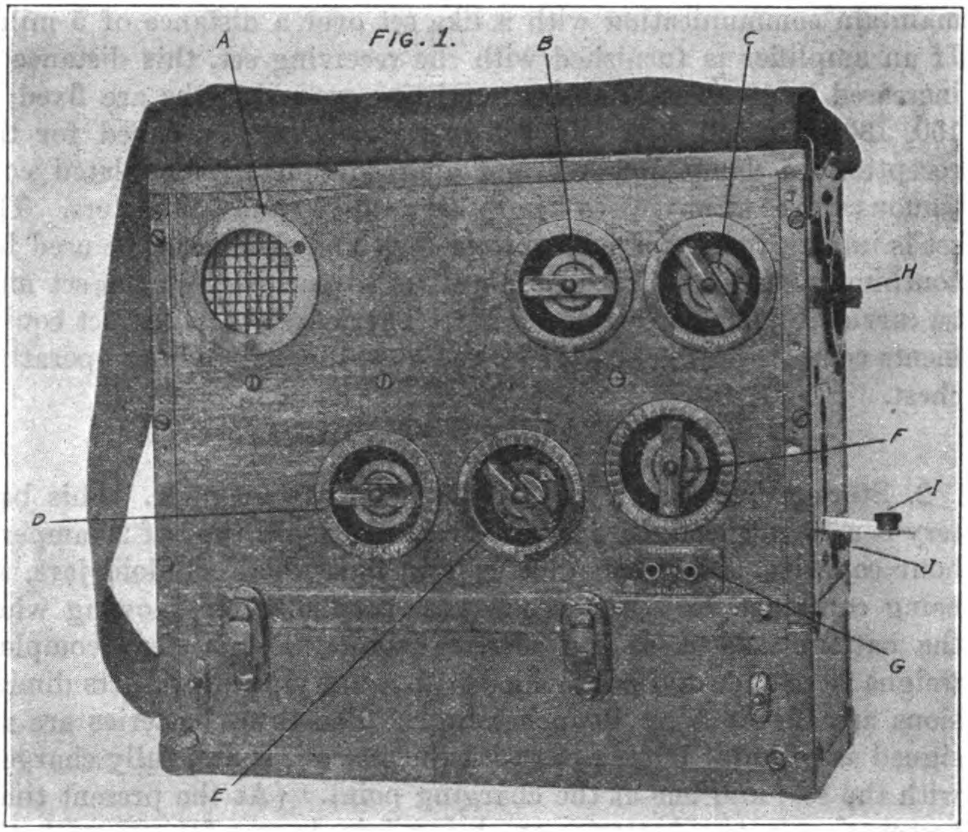
DESCRIPTION OF ANTENNA EQUIPMENT.

3. The antenna is a single wire inverted L 20 feet high, 75 feet long, and with a lead-in wire 25 feet long. It is supported by two bamboo masts, each with two guys. Each mast consists of two sections coupled together. The ground system is either a counterpoise or mats. There are two mats made of coarse copper-wire mesh, each being 9 by 1⅔ feet. The counterpoise consists of two heavily insu-

lated wires each 75 feet long. The essential electrical constants of the antenna are, approximately: Inductance, 0.037 millihenry; capacity, 0.000131 microfarad; fundamental wave length, 130 meters; resistance, 50 ohms.

DESCRIPTION OF OPERATING CHEST.

4. The radio equipment is contained in a chest which is shown in figures 1 and 2. Figure 1 shows the front and end view; figure 2 shows the top and other end. The chest weighs approximately 24



pounds, and has no projections when closed for transportation, and is furnished with a carrying strap. The dimensions are 15½ by 6 by 13 inches high. The chest is divided into two separate compartments. The lower compartment, hinged at the back and fastened at the front, contains the telephone receiver, cords, tools, and spare parts. The upper compartment, which is divided by a shelf, contains the necessary condensers, inductances, switches, etc., of the set. A canvas flap folds down over the front of the case in order to protect it. The top of the box is hinged so as to give ready access to the apparatus which is most liable to need adjustment. All transmitting and receiving adjustments can be made on the outside of the chest, except changing the transmitting wave length.

Transmitter.

5. The transmitter is a 50-watt quenched-spark set with an open type of gap energized from a 10-volt storage battery by a special buzzer transformer. The inductances of the primary and secondary of the oscillation transformer are conductively coupled and are vari-

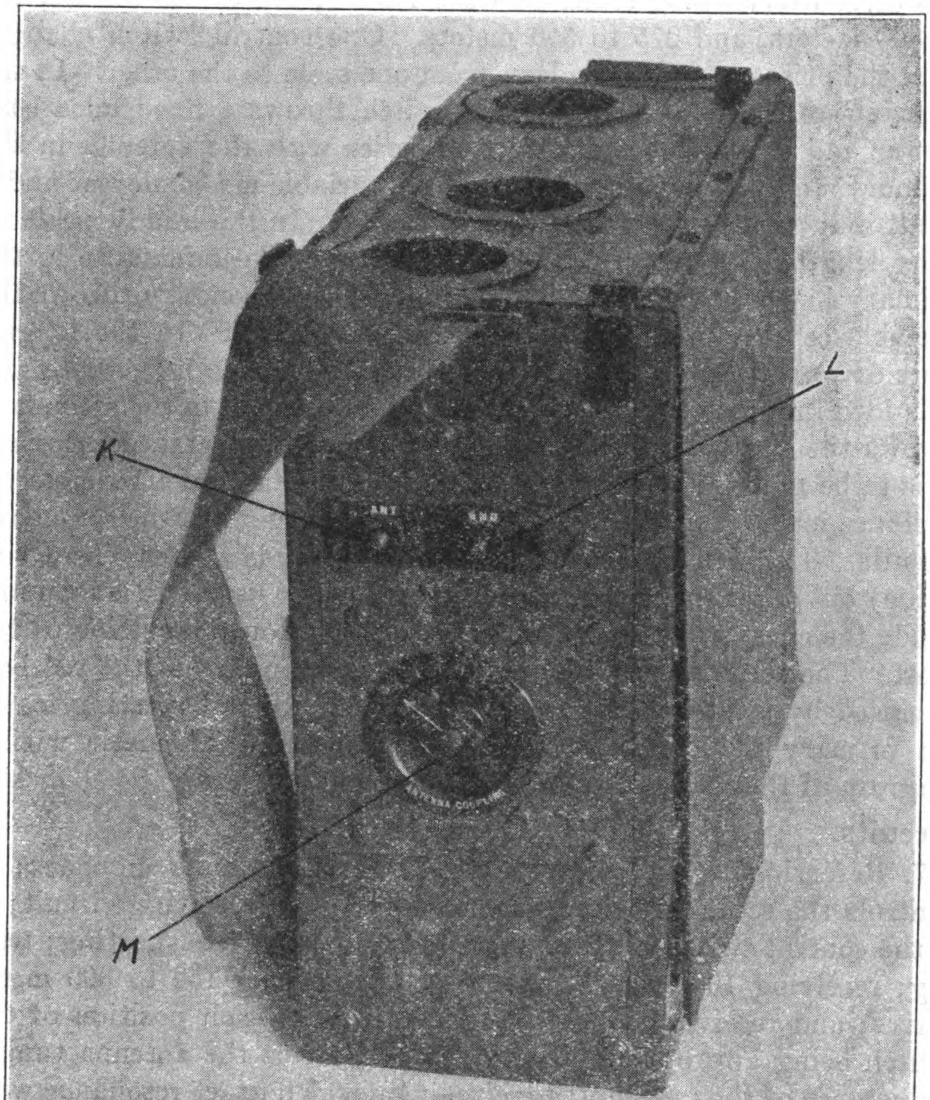


FIG. 2.

able in six steps controlled by one switch known as a "wave-change" switch. There is also a variable antenna tuning inductance of about 11½ turns in the secondary so that it can be exactly adjusted to resonance with the primary. A coupling switch controls the amount of inductance common to both the primary and secondary, and thus allows the coupling to be varied. The minimum coupling is at "1" and the maximum coupling is at "6" on the coupling handle scale. A Weston thermoammeter is in the antenna to ground circuit and indicates the antenna current.

Receiver.

6. The receiver is inductively coupled with variable coupling. It has three overlapping scales of wave length; 100 to 200 meters, 150 to 300 meters, and 275 to 550 meters. One control switch changes both the primary and secondary from one scale to the other. In the shortest scale of wave lengths the switch throws a fixed mica condenser and a variable inductance in series with the antenna in the primary, and at the same time throws a variable air condenser and a small inductance in series in the secondary. In the middle scale of wave lengths the switch throws only the variable inductance in the primary in series with the antenna, and in the secondary throws the variable condenser and more inductance in series. In the longest scale of wave lengths the switch throws the variable inductance and an added inductance in series with the antenna, and in the secondary throws the variable condenser and still more inductance in series. It is to be noted that exact tuning is accomplished by a variable inductance in the primary and by a variable condenser in the secondary circuits. The detector furnished with the set is galena (lead sulphide) but other similar crystal detectors can be used. It is mounted inside the chest, with a control for adjustment on the outside of the chest. The coupling between primary and secondary of the receiver is varied by means of the secondary inductance coil rotating inside the primary inductance coil. Figure 3 shows a schematic wiring diagram of the set.

Circuits.

7. Referring to figures 1 and 2, A is the antenna ammeter; B controls the secondary tuning condenser of the receiving circuit; C is the control switch with contacts providing for transmitting; testing; receiving 100 to 200 meter waves; receiving 150 to 300 meter waves; and receiving 275 to 550 meter waves; each position of the switch being appropriately marked; D controls the antenna tuning inductance of the transmitting circuit by which exact resonance with the primary is obtained; E controls the coupling between the primary and secondary of the receiver circuits; F controls the primary tuning inductance of the receiver; G is the jack for telephone or amplifier plug; H is the crystal detector control; I is the key; J is the jack to receive the plug leading to the battery; K and L are the terminals for the antenna and ground wires respectively; and M controls the coupling between the primary and secondary of the transmitter. Figures 5 and 6 are labeled similarly to figures 1 and 2. Figures 1 and 2 show the control handles; figures 5 and 6 show the actual apparatus.

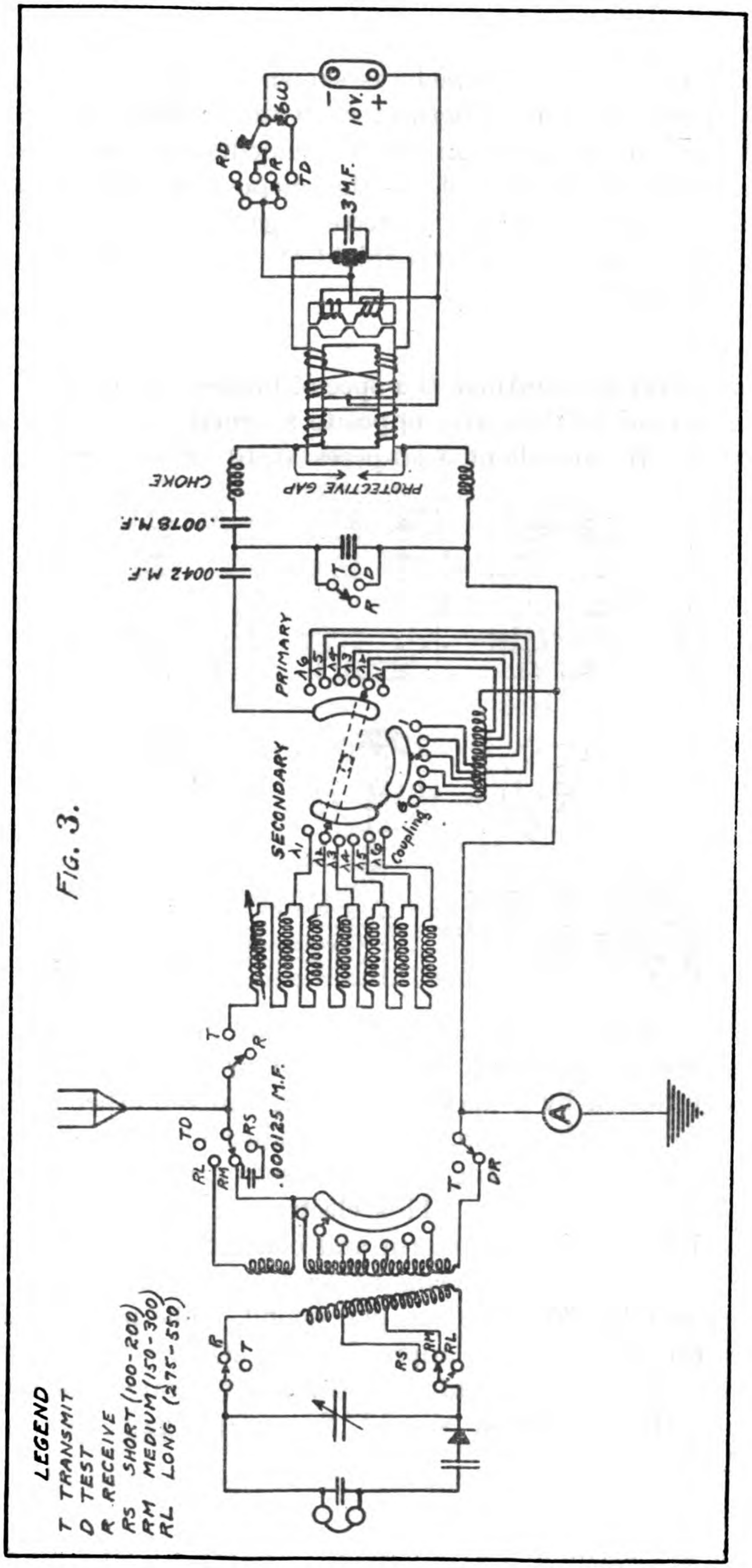

LEGEND
T TRANSMIT
D TEST
R RECEIVE
RS SHORT (100-200)
RM MEDIUM (150-300)
RL LONG (275-550)
PRIMARY
SECONDARY
Coupling
.000125 M.F.
.0042 M.F.
.0078 M.F.
CHOKE
PROTECTIVE GAP
3 M.F.
10 V.

FIG. 3.

Control Switch.

8. The control switch is a multicontact switch which makes connections between silver contacts as shown in figure 4. The arrows in the upper part of the diagram show the connections made when the switch is in the position shown immediately below each part. The legend on the diagram shows the purpose of each contact. The contacts and connections are protected against short-circuit by dirt or occasional drops of rain by a shield of xylonite, a noncombustible material resembling celluloid.

Buzzer.

9. The buzzer transformer is a special buzzer having two primary windings wound so as to give opposite magnetic effects when carrying current. It uses about 5 amperes at 10 volts. By means of a

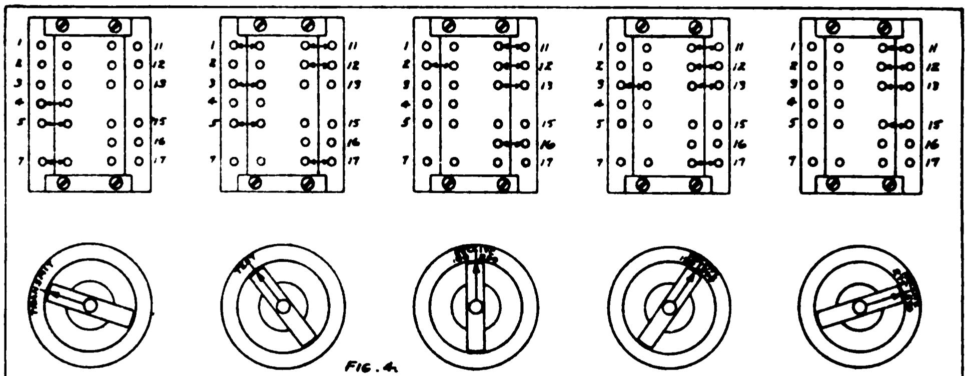


FIG. 4.

No.	FUNCTION	No.	FUNCTION
1	SHORT CIRCUITS QUENCHED GAP TO PROTECT OPERATOR	11	CONNECTS GROUND TO RECEIVER PRIMARY (GROUND SIDE)
2	CONNECTS SHORT WAVE SECONDARY TAP TO RECEIVING CONDENSER	12	CONNECTS BEGINNING OF SECONDARY COIL TO RECEIVING CONDENSER
3	CONNECTS MEDIUM WAVE SECONDARY TAP TO RECEIVING CONDENSER	13	CONNECTS LONG WAVE SECONDARY TAP TO RECEIVING CONDENSER
4	CONNECTS BATTERY TO BUZZER THROUGH KEY	15	CONNECTS ANTENNA TO LONG WAVE PRIMARY RECEIVING TAP
5	CONNECTS BATTERY TO BUZZER THROUGH RESISTANCE	16	CONNECTS ANTENNA TO SHORT WAVE PRIMARY RECEIVING TAP
7	CONNECTS ANTENNA TO TRANSMITTING LOADING COILS	17	CONNECTS ANTENNA TO MEDIUM WAVE PRIMARY RECEIVING TAP

vibrator which makes contact first with one primary and then with the other, there is produced in the secondary a maximum voltage in one sense followed by a maximum voltage in the other sense. The vibrator is actuated by the magnetism produced by the primary windings attracting and repelling a double electromagnet having opposite ends of the same polarity. This electromagnet is supported on a spring and has the vibrator arm and contacts attached to it. The vibrator is adjustable by means of set screws and has a frequency of approximately 360 vibrations per second. The peak voltage produced in the secondary is approximately 2,000 volts. There is a safety gap (P, fig. 6) mounted on the buzzer transformer to avoid puncturing the insulation should the spark gap be improperly adjusted.

Key.

10. The key is shunted by a 6-ohm resistance which allows enough current to pass so that the vibrator of the buzzer transformer is

kept in motion in the intervals between dots and dashes. The key contacts are of silver, which has excellent spark-quenching properties. Because of the shunt resistance and the silver contacts, the key breaks the current practically without sparking. The tension of the key spring is adjustable within certain limits. It can be increased by turning the screw just below the bottom of the key in a clockwise direction. It can be decreased by turning the screw in the opposite direction.

Spark Gap.

11. The spark gap has three silver plates separated by mica gaskets or separators 5 mils (0.005 inch) thick and the sparking occurs uniformly around the edges of the plates. The open type of gap is used, as it permits the operator to view the gap in operation and detect any irregularity in the spark or failure of the gaskets, and has the additional advantage that a punctured gasket can be easily replaced in the field. The gap is protected against being accidentally short-circuited by particles of dirt or occasional drops of rain by a shield of xylonite. The plates and separators can be removed after unscrewing the thumb nut. A view of the operating chest with front panel removed is shown in figure 5. A part of the front panel appears at the right.

SETTING UP THE SCR-105.

Antenna and Ground Installation.

12. The 75-foot antenna wire should be stretched out on the ground with the 25-foot lead-in wire in either of two positions, depending upon the use to which the set is to be put: (1) For general use the antenna may lie in any direction and the lead-in may be at either end of the antenna, but (2) for directional work the antenna must be in line with the direction of the distant station with the lead-in nearest that station. The mast sections should be coupled together, using two couplers on each mast, so as to give two masts each with a length over all of 20 feet. Lay one mast at each end of the antenna, along the antenna wire, and with the tops of the masts at the ends of the wire. Screw the mast cap insulators into the masts and attach the antenna insulators and guys to the caps. Drive two ground stakes near each mast, one on each side of the line of the antenna wire, about 10 feet beyond the ends of the antenna and 40 feet apart; and attach the guys to the stakes. Next raise one mast into position, placing the foot of the mast so that the strain from its guys and the rest of the antenna on the ground will keep it nearly upright. Then raise the other mast in a similar way, placing it so that there is sufficient tension on the antenna wire to keep it nearly horizontal. If necessary, straighten up both masts, tighten

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the guys, etc. If there is sufficient personnel, both masts can be raised at the same time and the guys tightened immediately after. In raising the antenna, handle the mast in such a way that the stress will be along the mast and not a bending one. For details in raising this antenna and for general information on antennas, see Radio Communication Pamphlet No. 2.

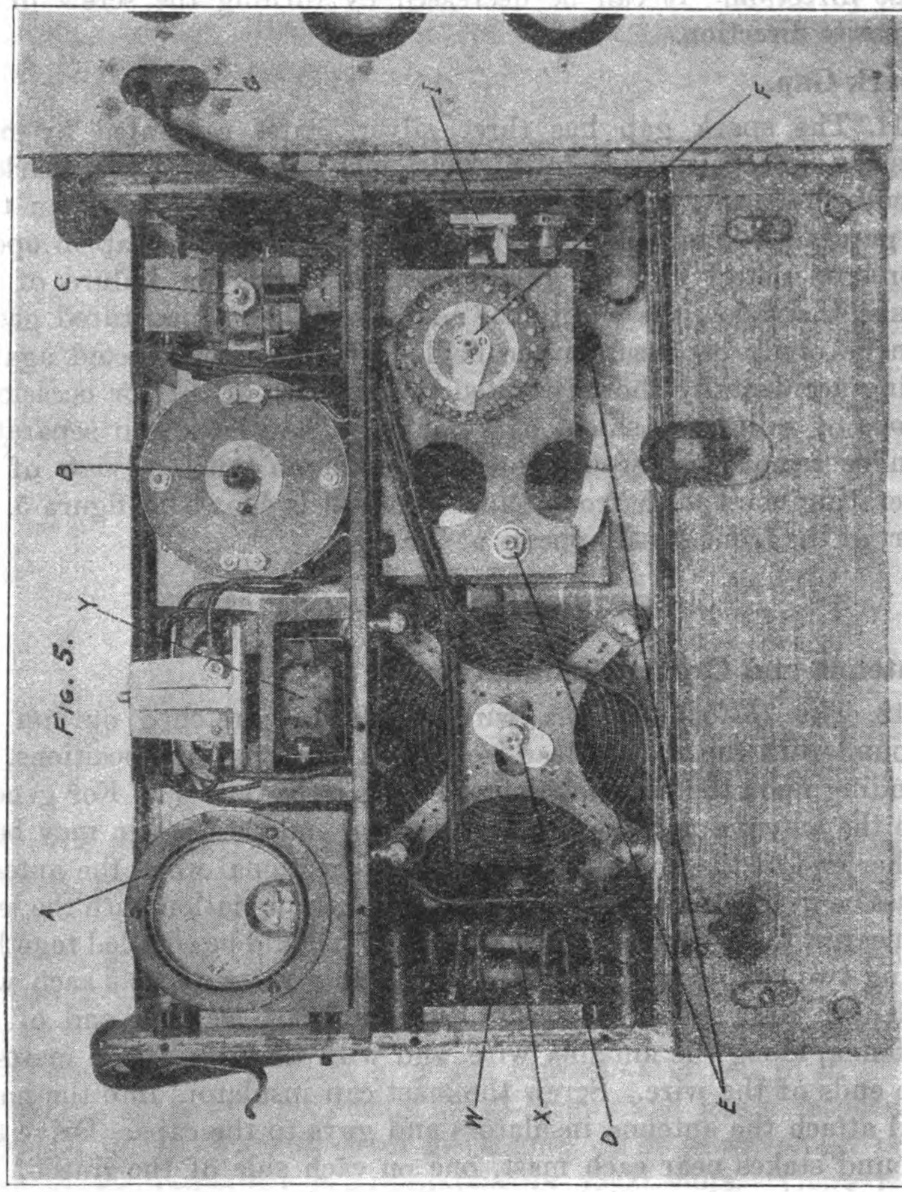

Fig. 5.

13. Whether the ground mats or the counterpoise is to be used depends upon the character of the ground, and the time available for installation. If it is possible to get a good ground, it is preferable to use the mats. The two mats should be connected in series and buried a few inches below the surface of the ground and the covering earth well tramped upon them. If the ground is dry or rocky or if the time available for installation does not permit of making

a good ground with the mats, the counterpoise should be used. When using the counterpoise, the two wires should be spread out at an angle of about 60° in such a manner that the antenna wire, if laid on the ground, would bisect the angle. The two counterpoise wires are connected electrically at the angle made by them.

14. Having decided which ground system to use, for general work (nondirectional) place the operating chest on a dry place underneath the antenna wire and if the ground mats are to be used put them also under the antenna and extend them away from the chest. If the counterpoise is used the angle of the wire should terminate near the operating chest, the wires being extended under the antenna and in the same general direction. For directional work the operating chest is placed outside the masts as far away as the lead-in wire will permit in the direction of the other station. Be sure that the lead-in wire does not touch the mast, as otherwise the antenna may be grounded thereby. The counterpoise is laid as described above, except that the wires should be extended away from the antenna. The mats should be buried beyond the operating chest. If additional counterpoise wires are available, they should be connected in parallel with the others. Similarly if other ground wires or plates are available they should be connected in parallel with the mats and in some cases the ground stakes may be used as additional ground connections. The better the ground connections or the greater the number of the counterpoise wires in general the sharper will be the tuning of both transmitter and receiver.

Necessary Connections.

15. Open the bottom compartment and remove the telephones and battery cords. Connect the antenna lead-in wire to the antenna binding post (K, fig. 2) and connect the mats or counterpoise to the ground binding post (L, fig. 2). Connect the battery cords to the proper terminals of the 10-volt battery and plug it in the battery jack (J, fig. 1), being sure to observe the proper polarity as marked on the jack and plug. Plug the telephone in the telephone jack (G, fig. 1). Pull down the key lever (I, fig. 1) until it snaps into place at right angles to the box. If no amplifier is to be used and the set has been properly adjusted, it is now ready to operate. If an amplifier is to be used, instructions for its use are contained in Radio Communication Pamphlet No. 9.

OPERATION OF THE SET.

To Transmit.

16. Raise the cover of the chest and move the wave-length lever (N, fig. 6) to the wave length desired. The upper edge of the slide *must be just below the white line* which is under the wave-length figure. This position must be exact, as otherwise the movable con-

tact will short-circuit turns on the primary coils (shown at W in fig. 5) and will not give the wave length desired. Set the control switch (C, fig. 1) in the "transmit" position. The buzzer should start vibrating although the key is not depressed, but there will be no spark at the spark gap (O, fig. 6). If the buzzer does not start vibrating, the set is not in adjustment. (See paragraphs 23 to 27, inclusive, on care and adjustment of the set.) Now set the antenna-coupling handle (M, fig. 2) to the maximum coupling for all wave lengths except 150, when it should be set one step lower than the maximum coupling. The coupling control is marked from "1" to "6"; the position at 1 gives the minimum coupling; that at 6 gives the maximum coupling. In setting the coupling be sure that the two index marks form a straight line. The coupling coil is shown at X in figure 5. Press the key and tune with antenna-tuning inductance (D, fig. 1) until the antenna ammeter shows the highest reading. Lower the antenna coupling one step and retune. Do this progressively until you are using the lowest possible antenna coupling that gives sufficient antenna current. The set is now ready for transmission. Under average field conditions the antenna current will be from 0.4 to 0.5 ampere and larger for the shorter wave lengths than for the longer ones.

To Receive.

17. Turn the control switch (C, fig. 1) to the "test" position. In this position a small current keeps the buzzer in vibration so as to serve as a testing buzzer for the detector. Adjust the detector by moving the detector adjustment (H, fig. 1) until a sensitive point has been found and the note of the buzzer is clearly heard in the telephone. In passing from transmitting to receiving, this test should also be made, as any previous adjustment is liable to have become disarranged. If the wave length to be received is known, the approximate setting of the tuning elements in the receiving circuits is shown in the following table:

CONTROL SWITCH SET AT "RECEIVE 150-300."

Wave length.	Ground mat.			Counterpoise.		
	Primary tuning inductance.	Secondary tuning condenser.	Receiver coupling.	Primary tuning inductance.	Secondary tuning condenser.	Receiver coupling.
150	13	2	40	13	1	60
180	17	5	80	13	4	35
210	19	5	30	13	6	25
240	16	6	30	19	8	25

CONTROL SWITCH SET AT "RECEIVE 275-550."

300	14	5	40	12	1	25

18. The above table is only approximate and will vary somewhat for each set. A table extending the wave lengths throughout their whole range should be made for each set. The table should be printed on a card and fastened to the inside cover of the operating chest. It saves much time in operating. It must be remembered that the table is only strictly accurate for the exact antenna used in compiling the table.

19. As soon as the signals are picked up, make slight adjustments of the tuning, coupling, detector, etc., until the loudest possible signals are obtained with the loosest possible coupling, that is, with the "receiver coupling" (E, fig. 1) as near the "minimum" as possible. Under these conditions any interference from other wave lengths will be reduced as much as possible with this set. The most important receiver adjustments are the sensitivity of the detector and the tuning of the secondary condenser. In a few cases the same wave length can be received with the "control switch" in two successive positions, near the end of the scale in the first position, and near the beginning of the scale in the second position. This is due to the overlapping of the scales and in many cases one adjustment is much better than the other.

20. If the wave length is unknown, signals may be found by trial somewhat as follows: Set the "control switch" (C, fig. 1) on the "275–550" meter range; the "receiver coupling" (E, fig. 1) at "maximum"; and the "secondary tuning condenser" (B, fig. 1) near the zero end of its scale. Tune with the "primary tuning inductance" (F, fig. 1) over its scale. If signals are not picked up, set the "control switch" on the "150–300" meter range and repeat. If necessary, repeat with the "control switch" on "100–200." When hunting for signals, make sure that the detector is kept in a sensitive condition by occasionally turning the "control switch" handle to the "test" position and then turning it back to its former scale position. As soon as the signals are heard, loosen the coupling, retune both circuits, etc., as stated in the previous paragraph.

Wave Length Measurements.

21. The transmitting and receiving wave lengths can be measured by a wave meter. Reference, Radio Communication No. 28. In measuring the wave lengths of the primary of the transmitter, that is without an antenna and ground connected to the set, the plane of the wave-meter coil should be parallel to the lower left end of the box near the antenna-coupling adjustment in order to couple with the primary coil. In measuring the wave lengths radiated by the set, the wave-meter coil may be brought near the antenna or if necessary parallel to the back of the box immediately behind the antenna-tuning-inductance adjustment in order to couple with the antenna

coils. The receiver wave lengths are measured by the usual methods. In every case, however, the usual precautions of loosely coupling the meter to the set must be observed so as to avoid any appreciable reaction between the two circuits.

Amplifier.

22. When an amplifier is used with the set in receiving, it is connected by a cord to the telephone jacks. The set itself contains a detector and should the amplifier also contain a detector, the latter one should not be used. The BC–101 amplifier, which will be most commonly used with the SCR–105, consists of a vacuum tube detector and a two-stage amplifier. A switch is provided on this amplifier which permits the detector being cut out of the circuit. It should be so cut out when used with the SCR–105 set. Radio Communication Pamphlet No. 9 will contain operating instructions for the BC–101 amplifier.

CARE AND ADJUSTMENT OF THE SET.

23. The operating chest should be kept dry and clean. Do not store it in a damp place, as it is impossible to make a set of this type waterproof. If it has been exposed to the rain it should be carefully wiped off and dried, but not exposed to direct heat. The battery cord is waterproof but the telephone cord is not. If the latter gets wet and short-circuits the telephones use another cord if available and in the meantime carefully dry out the wet cord, which will become operative again. If no other cord is available cut away very carefully the *outer* braid on the cord, making certain that the conductors are not injured and then separate them, thus removing the short-circuit. Do not subject the chest to unnecessary jars or rough treatment. The interior of the chest contains a great many parts packed in a small space and these are subject to derangement. The connection between the parts may also become loose if the chest is roughly handled. The detector crystal is mounted in a small casting of a low melting point alloy, known as Wood's metal. This is held by a screw in a post that is removable for convenience in renewing the crystals. Care must be taken to keep the sensitive surface dry and clean and not to scratch it in any way. The surface is sensitive only when it has been obtained from a *natural* fracture. Crystals should be separately wrapped in a paper wrapping and kept in the small box in the lower compartment. When not in use the key should always be folded into the end of the chest and the detector adjustment knob should always be pushed in flush with its plate.

Telephones.

24. The telephone receivers must be carefully handled, special care being taken never to drop them and never to injure the diaphragm. If the latter is bent or dented the diaphragm 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 is "dead" although otherwise in perfect condition. In order to obtain the correct clearance under the diaphragm the poles of the magnet are ground *after assembly*, this being necessary as the standard parts can not otherwise be assembled with sufficient accuracy. For this reason the telephone should never be taken apart as it is certain that these adjustments will be disturbed. In putting away the telephones into the bottom compartment the following standard practice should be followed in order to protect the diaphragms and terminals: Place the two receivers with the faces of the caps parallel and together so that all access to the diaphragms through the openings in the caps is closed and then bind them in this position by winding the telephone cord around the outside of the headband, beginning close to the caps.

Buzzer Adjustments.

25. The adjustment of the buzzer requires patience and experience. Theoretically it is possible to adjust it so that there is no sparking at the contacts. Actually this is seldom attained, but it can be adjusted so that nearly sparkless operation obtains. In adjusting the buzzer it is well to do it under working conditions, i. e., in the field with the proper antenna and with the battery assigned to the set, but care must be taken not to cause interference to other stations. This interference can be avoided by using the loosest possible coupling between the antenna and primary circuits; that is, by setting the antenna coupling at 1. After the buzzer adjustment has been completed, be sure to return the antenna coupling to its correct position. In adjusting the vibrator, be sure that the control switch is in the "transmit" position, and then if it does not work when the key is pressed, *release the key instantly*, as otherwise the primary winding will be burnt out. With the vibrator working properly, it is the reactance of the primary winding that keeps the current down to its proper value, but with the vibrator stopped there is only a low resistance in circuit that will allow a very heavy direct current to flow. In transmitting, also, if the vibrator sticks, release the key instantly for the same reason.

26. The buzzer should vibrate when the "control switch" is in the "test" and also when it is in the "transmit" position, even when the key is not closed, but there should not be any spark at the spark gap under these conditions. When the key is pressed down the buzzer

should vibrate, and there should be a good spark at the spark gap. If it does not vibrate, do not under any circumstances add higher battery voltage. As shipped from the factory after inspection by the Signal Corps, the buzzer has been adjusted to give this operation. In general it will require very little adjustment when received.

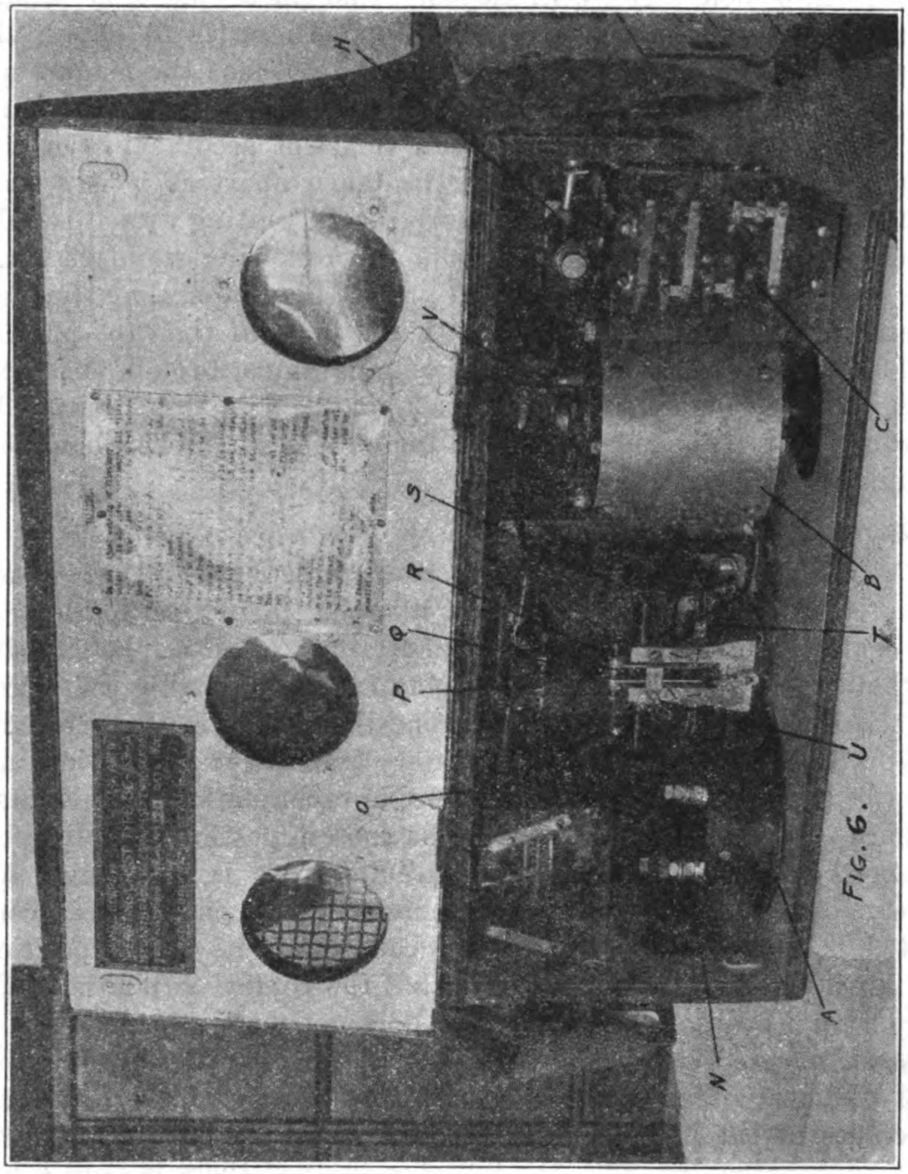

FIG. 6.

27. Figure 6 is a view looking down into the set, showing the buzzer. The end of the vibrator with its double contacts is shown at Q. This vibrator is between two other fixed contacts symmetrically placed, one of which is labeled "R." The four contact tips are of platinum-iridium, which because of its hardness and the high temperature of its melting point makes the sparking much less than between other metals. The tips should have plane surfaces and be

parallel when contact is made. The play of the moving contacts should be about one one-hundredth of an inch. (The thickness of three sheets of this pamphlet is very nearly one one-hundredth of an inch.) After having been in service for some time, the contacts become roughened and should be cleaned. This is done with a fine file, which is a part of the equipment of the set carried in the lower compartment. The contacts should not be removed, but the locknuts loosened and the contacts unscrewed until the file can be introduced between them. It is seldom necessary to move these locknuts for any other purpose than cleaning. The two screws marked U in Figure 6 are for clamping the two adjustment screws with the black knobs marked S. The latter should never be turned without first loosening U, as otherwise their threads may be stripped. The black knobs are used in adjusting the opening between the fixed contacts, which must be such that the movable contact rests against one of the fixed contacts when no current is flowing, and so that the poles of the movable magnet, which is shown at T, Figure 6, do not hit the poles of the fixed magnet. If they do, the poles are liable to stick together. This condition will also prevent good contact at the vibrator points and will cause considerable sparking there. If a strip of paper can be passed between the poles when the buzzer is operating, the adjustment in this respect is good. If one of the poles hits, this can be remedied by *screwing* in the adjustment knob on the *opposite* side of the buzzer and *unscrewing* the knob on the *same* side until both pole tips are free.

Spark Gap.

28. The spark gap can be taken apart by unscrewing the thumb nut. When the sparking becomes localized at one or two points on the plate, unloosen the thumb nut and rotate each plate slightly on the mounting until the sparking is uniform again. If it is found impossible to get uniform sparking by this method, then the plates must be polished. This should be done by placing them face down on a sheet of fine emery or sand paper on a flat surface and rubbing them over the paper lightly, using a rotating motion. Great care must be taken not to polish only one part of the sparking surface, as this will decrease the thickness of the plate at this point, and hence may so increase the width of the gap that no sparks can pass. The thickness of each plate between its sparking surfaces is uniform to within less than half a thousandth of an inch. After polishing be sure that the particles of emery and metal dust are carefully cleaned off the plates, otherwise the emery may cut and puncture the mica gaskets. Care should be exercised in handling the gaskets in order to avoid cracking them. If a gasket fails replace it with a new one.

Cautions.

29. In handling and adjusting the set:

Don't subject it to rough usage. To do so will damage the instruments therein.

Don't try to adjust the ammeter. It is used to show comparative values of the antenna current and not exact values.

Don't use a closer coupling in transmitting than is absolutely necessary. The radiated wave will be very broad with a close coupling.

Don't connect more than 10 volts to the buzzer. A higher voltage will burn it out.

Don't expect the set to operate if the storage batteries are near discharge. It takes just 10 volts for the buzzer; less than 10 volts will not operate it.

Don't tinker with the buzzer adjustments when once properly adjusted. The buzzer is very easily thrown out of adjustment.

Don't hold the key down continuously for more than 10 seconds, and

Don't transmit continuously with the set, and

Don't fail to release the key instantly if the vibrator sticks. The buzzer will burn out if these three precautions are not observed.

Don't use a gasket in the spark gap thicker than the one provided. The voltage necessary to jump a longer gap will puncture the insulation and the transmitter note will be made rough or irregular.

Don't carry any parts in the upper compartment; use the bottom compartment.

Don't use a different antenna than the one prescribed. The variable inductance in the secondary of the transmitter is not great enough to permit any marked departure from the characteristics of the antenna prescribed.

Don't fail to study your set and to learn the causes of failure and their remedies. Learn also the appearance of the spark and the characteristic sound of the set when it is operating properly.

Don't fail to disconnect the battery when leaving the set for any purpose.

Don't fail to fasten both snap-catches on the bottom compartment when closing station.

THEORY.

Buzzer—Electric and Magnetic Circuits.

30. The buzzer transformer used in this set combines the principles of the induction coil and the resonance transformer. The moving part of the buzzer (the armature) is designed and adjusted to have a period of approximately 360 cycles per second. In order to insure sufficient pressure when contact is made, an electromagnet is used instead of a permanent magnet as it produces a stronger magnetic field.

This electromagnet is wound two ways upon its core from the center of the core, thus giving an electromagnet having both ends of the same polarity, with consequent poles in the middle of the core. This core is of steel and not laminated as the magnetic flux in it is nearly constant. There is a double primary in the transformer, one being wound so as to produce a magnetic flux opposite in direction to that of the other. The current passes through each primary successively as the armature successively makes one contact and then the other. The core of the transformer proper is built up of laminations of silicon steel with three projections, one near either end of the electromagnet and the third one near its consequent poles, which are along the axis of the vibrating system. When a current flows through a primary winding, a magnetic flux is established in the transformer core. Magnetic circuits resulting from the magnetic leakage from the projections pass through either end of the electromagnet and produce a torque on it. The electrical circuits are so connected and wound in the primary coils that the torque, produced by the magnetic flux established by the electric current passing through the circuit made by contact on one side, is such as to move the armature to the other contact. When the other contact is made, the resultant magnetic flux and therefore the resultant torque is changed in direction, thus pulling the armature back to make the first contact. There is only a single secondary winding which however is wound in sections, four on each leg of the core, thereby giving greater protection against high and sudden electromotive forces.

31. As a result of the action described in the previous paragraph, the magnetic flux made by the primary circuits and passing through the core of the transformer is periodically established in one direction, wiped out, and then established, with the same intensity, in the opposite direction. The electromotive force induced in the secondary therefore is symmetrical above and below the zero line. As a result of this symmetrical current induced in the secondary, and the precise and regular vibration of the armature giving regularly the corresponding changes in the induced current, the tone produced by the set in transmission is of good quality.

Vibrator.

32. In order to secure firm contact with a high rate of vibration, the armature was necessarily given a considerable mass, and a short distance of travel from contact to contact (about 0.01 inch). It is mounted on a tempered steel spring, silver plated, to prevent rusting, with an adjustable tension that is set at the time of assembly to give about 360 vibrations per second. The frequency of vibration of the armature is determined not only by the distribution of mass of the moving parts, its distance of travel between contact points, and its

method of suspension, but also by the constants of the electromagnetic circuits which actuate it. In this buzzer transformer, all parts are coordinated so as to give a frequency of approximately 360 vibrations per second.

Application of Resonance Transformer.

33. If no provision were made to diminish the arc resulting from self-induction, made at the breaking of the contacts, the arc would be considerable and would wear out the contact points in a short while, besides greatly reducing the efficiency of the apparatus.

34. To effect the reduction of this arc the primary and the secondary of the transformer are built so that their electrical constants are such as to give them the same natural (audio) frequency which is also the mechanical frequency of the vibrator. Thus the principle of the resonance transformer is used in the buzzer transformer. The design of the transformer involves the consideration of the electric and magnetic properties of each circuit separately, and the reflected value of one circuit as it appears in the other. Thus the capacity of the secondary condenser is reflected into the primary circuit in proportion to the inverse square of the ratio of transformation. With a ratio of primary to secondary of 1 to 175 the secondary series condensers of 0.0027-microfarad capacity appear in the primary increased 30,000 times or as 83 microfarads. The 3-microfarad condenser placed (shown at Y in fig. 5) across the contact points of the primary circuit is used to help establish the proper LC value of the primary. The leakage reactance of the magnetic circuit is an important factor in this consideration, as the magnetic leakage between the primary and secondary and from the projections of the core of the transformer is high.

35. Because of the resonance feature of the transformer the leads from the storage battery to the set box must not vary greatly in electrical length from those furnished with the set. Very long leads that are inclosed within an iron conduit should never be used on account of their high inductance. The leads from the battery are a part of the primary circuit of the transformer and any great change in their electrical length changes the LC value of this circuit and hence will throw it off the proper resonance point. Such conditions as described in this paragraph are, however, rarely met with in field service.

36. The action of the resonance transformer in reducing the arcing at the contact may be explained as follows: The time-voltage curve of electromotive force induced in the secondary lags behind the time-ampere curve of the inducing current in the primary. Thus when the primary current has reached its maximum value (i. e., sufficient to break the contact by its torque action) the electromotive

force in the secondary has not reached a value great enough to break down the quenched spark gap. At the instant the break is made in the primary there is released the energy of a large self-induction in the primary. The rising electromotive force of the secondary is not up to the final value that it attains because of its resonance and therefore keeps on mounting. The energy taken by this rising electromotive force is absorbed from the primary, thereby decreasing at the break the energy that would otherwise appear there and cause sparking. Also the electromotive force of the secondary rises higher because of this absorption of energy at the time of the break. It is the resonance feature of the transformer which causes the secondary electromotive force to rise higher at the primary break than it would do if it were an ordinary induction coil.

37. The condenser across the contacts also absorbs some of the energy of self-inductance. This condenser will then discharge with high frequency oscillation, thus dissipating the energy of the primary circuit and having the usual effect of quenching the arc.

38. The absorption of energy from the primary circuit and the quenching of the arc makes the arc a small one of short duration. When the electromotive force of the secondary reaches a value high enough to break down the quenched spark gap, the arc at the contacts of the buzzer has been extinguished and hence the circuit in the primary is not complete through the contacts and will not absorb appreciable energy from the current flowing in the secondary.

39. The constants of the circuits affecting resonance vary with the frequency of the alternations in the transformer. Thus the transformer works best on 360 cycles. If the current actuating the buzzer is entirely stopped, the buzzer comes to rest. The making of the circuit starts the buzzer which must pass from a zero frequency to the 360 frequency, and therefore the efficiency of the transformer during this time is very low. The transmission of dots and dashes involves many stoppings and startings of the current. Because of this fact, the key is shunted by a resistance of such a value that it

NOTE.—It may be possible that the 3-microfarad condenser across the contacts of this set is charged by the battery to a higher potential than the battery furnished. A circuit that will oscillate on discharge will also oscillate on charge. The equation for charging a condenser is:

$$e_1 = e\left\{1 - \epsilon^{-\frac{r}{2L}t}\left(\cos\frac{q}{2L}t + \frac{r}{q}\sin\frac{q}{2L}t\right)\right\}$$

when $q = \sqrt{\frac{4L}{C} - r^2}$ and the other symbols are those as commonly used. Thus if the damping factor $\left(\frac{r}{2L}\right)$ is not large, the e_1 value will rise to greater than unity in the quadrants in which $\cos\frac{q}{2L}t$ is negative. The oscillating electromotive force damps down to the electromotive force of the charging battery. Because of the brief time in which contact is made, the circuit may be broken before the oscillating condenser electromotive force has been damped down to its steady value.

allows the passage of a current just of sufficient strength to actuate the buzzer at its proper frequency, but not strong enough to build up an electromotive force in the secondary which will break down the spark gap.

Choke Coils.

40. In order to protect the buzzer secondary windings from puncture by the radio frequency oscillations from the primary oscillating circuit, two heavily insulated choke coils of high inductance (0.35 henry) have been inserted in the leads of the buzzer secondary, one of which is shown at V in figure 6. The protection which such a coil can give by its inductance reactance (2 Π N L) is shown by the following: At a frequency of 1,000,000 cycles per second, corresponding to the 300-meter wave length, the reactance is 2,000,000 ohms. Thus each coil offers such a high impedance to the radio frequency oscillations as to reflect them back into the oscillating circuit and thus protect the buzzer windings. These same coils, however, offer only a slight impedance (800 ohms at 360 cycles) to the low-frequency current from the buzzer secondary that charges the oscillating circuit condenser.

Secondary Condensers.

41. In the schematic wiring diagram (fig. 3) it will be noticed that in the circuit of the buzzer secondary there are two condensers in series, one of 0.0078 microfarad, and the other of 0.0042 microfarad. The resultant capacity is 0.0027 microfarad, which had previously been found necessary for resonance at the buzzer frequency of 360 cycles per second, but too small for the capacity of the primary oscillating circuit. For this reason two larger capacities were used in series, one of 0.0042 microfarad as desired for the primary circuit and the other of 0.0078 microfarad, to give the correct resultant capacity as above. Both condensers are of mica, with sections in series to withstand the high potentials of the buzzer secondary circuit and the primary oscillating circuit, and they are sealed with a suitable wax to exclude the air and moisture.

Reception of Short Wave Lengths.

42. For the best reception of short wave lengths, that is with the control switch in the 100 to 200 position, it has been found necessary to short-circuit the turns needed for long waves. This is accomplished at contact 13 in figure 4 as noted in the legend giving the function of each contact. The purpose of the short circuit is to eliminate the so-called "dead-end" effect in which inactive turns absorb energy from the useful turns which would otherwise operate the detector.

Telephone Circuits.

43. In the schematic wiring diagram (fig. 3) it will be noticed that in the telephone circuit of the tuned secondary receiving circuit there is an extra condenser connected between the detector and telephones. This condenser is necessary however as will be seen from the following circumstances—if by mistake the 10-volt battery plug instead of the telephones is connected to the telephone jack, and if at the same time the detector arm or contact spring makes good connection with the detector post, then the 10-volt battery is applied directly to the windings of the secondary circuit. As a result either the windings will be burnt out or the battery will be run down. By the use however of a comparatively large condenser connected in series both the radio frequency currents and the audio frequency pulsating telephone currents will be permitted to flow freely, but the steady battery current will be completely stopped.

44. The telephones are wound with many turns of fine wire, and hence to a high resistance (2,500 ohms) as is necessary for use with crystal detectors. The windings are protected against high potentials by a small spark gap at their terminals. The *impedance* of the windings at the standard telephone testing frequency of 800 cycles per second, with the diaphragm clamped, is about 10,000 ohms. The *motional* impedance, however, will be different, particularly near the natural frequency of the diaphragm, which is between 700 and 1,000 cycles per second.

Efficiency.

45. The over-all efficiency of the set is about 20 per cent; that is, 20 per cent of the battery output is delivered to the antenna. Thus the battery output is 5 amperes at 10 volts or 50 watts; and the antenna input is 0.45 ampere in a 50-ohm circuit or 10 watts. The efficiency is therefore 20 per cent.

Parts List.

46. The SCR–105 set is complete only when it includes all of the items in the parts list given below. In ordering complete sets it is not necessary to itemize the parts but only to specify "1 set, radio telegraph, Type SCR–105." If all parts listed under a group heading, as "1 equipment, Type RE–12, radio," are desired, it is not necessary to itemize the parts but simply to specify the name of the equipment as given in the parts list. In ordering parts of the set use only the names and type numbers as given below. This list supersedes all others issued prior to the date of this pamphlet (November, 1921).

PARTS LIST OF SCR-105 SET.

[Arranged by equipment.]

1 Equipment, Type PE-11; power:
- 3 batteries Type BB-23—storage, lead; 10 volts, 20 ampere-hours; 1 in use, 2 spare.

1 Equipment, Type RE-12; radio:
- 2 contacts, Type CN-8—buzzer, movable contact; 1 in use, 1 spare.
- 4 contacts, Type CN-9—buzzer, fixed contacts; 2 in use, 2 spare.
- 2 contacts, Type CN-13—control switch, spring with silver contact; pairs with contact Type CN-14; 1 in use, 1 spare.
- 2 contacts, Type CN-14—control switch, bracket with silver contact; pairs with contact Type CN-13; 1 in use, 1 spare.
- 2 contacts, Type CN-15—key, screw with silver contact; pairs with contact Type CN-16; 1 in use, 1 spare.
- 2 contacts, Type CN-16—key, spring with silver contact; pairs with contact Type CN-15; 1 in use, 1 spare.
- 3 contacts, Type M-14—detector, spring contact; 1 in use, 2 spare.
- 1 cord, Type CD-95—10-volt leads, battery to operating chest.
- 1 cord, Type CD-96—amplifier leads from operating chest to amplifier.
- 4 crystals, type DC-1—detector, mounted galena; 1 in use, 3 spare.
- 1 file, 3½ inches, single cut, flat needle.
- 1 head set, Type P-11—used with amplifier.
- 1 head set, Type HS-11—used with operating chest.
- 1 operating chest, Type BC-53-A.
- 1 plier, pair, side cutting, 4-inch.
- 1 screw driver, 1½-inch blade, 1/8-inch tip.
- 6 separators, Type IN-9—mica, for quenched gap; 2 in use, 4 spare.
- 1 wrench, Type TL-100—buzzer contacts.

1 Equipment, Type A-16—antenna:
- 1 bag, Type BG-12—carrying counterpoise, stakes, etc.
- 250 feet cord, sash, 5/32-inch diameter—guy ropes.
- 2 counterpoise, Type CP-5—each 75 feet counterpoise wire.
- 6 couplers, Type FT-2—coupling mast sections; 4 in use, 2 spare.
- 6 fasteners, Type FT-9—for guy rope; 4 in use, 2 spare.
- 1 hammer, 2-pound, 2-face.
- 4 insulators, Type IN-5—for antenna; 2 in use, 2 spare.
- 3 insulators, Type IN-6 or IN-7—mast cap; 2 in use, 1 spare.
- 6 mast sections, Type MS-5—bamboo; 4 in use, 2 spare.
- 2 mats, Type MT-2—ground; connected in series.
- 3 pins, insulator, Type FT-3—for insulators IN-6 or IN-7; 2 in use, 1 spare.
- 1 pliers, pair, 6-inch combination.
- 7 reels, Type RL-3—2 for counterpoise; 1 for antenna; 2 for guys; 1 for spare wire; 1 spare.
- 1 roll, Type M-15—carrying mast sections, mats, etc.
- 6 stakes, Type GP-1 or GP-16—for guy ropes; 4 in use, 2 spare.
- 1 roll tape, friction.
- 250 feet wire, Type W-1—antenna, 75 feet; lead in, 25 feet; 150 feet spare.

1 Radio Communication Pamphlet, No. 25.

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