TECHNICAL REGULATIONS No. 1210-5

WAR DEPARTMENT,
WASHINGTON, *May 20, 1929.*

AIRPLANE RADIO SET, TYPE SCR-134, AND RECEIVING EQUIPMENT USED IN CONJUNCTION THEREWITH

Prepared under direction of the
Chief Signal Officer

This pamphlet supersedes "Radio Communication Pamphlet No. 42"

SECTION I

DESCRIPTION OF TRANSMITTING EQUIPMENT

1. General.—The SCR-134 set is an aircraft radio set intended for use on observation airplanes. The set is designed for radiotelephone communication with radio stations on the ground up to a distance of 30 miles. Tone-modulated telegraph and C. W. telegraph can also be used, providing a greater distance range. The wave-frequency range is 400 to 850 kilocycles (350 to 750 meters). The set includes a receiver to be installed in the plane for the purpose of receiving signals from other airplanes or ground stations. (See par. 17.)

2. Parts.—A dynamotor unit, type BD-41, is connected to the 12-volt storage battery forming part of the central power plant of the airplane. The 750-volt power generated by the dynamotor supplies the plate circuit of radio transmitter, BC-114, the filament circuit being supplied from the 12-volt line. The radio transmitter, BC-114, contains all of the radio circuits except the antenna tuning inductance and ammeter, which are located in the radio control box, BC–119. The control box is the only part of the transmitting equipment which is installed in the airplane rear cockpit, and therefore is the only part accessible to the observer who operates the set. All multiconductor cables are connected by means of specially designed plugs, as indicated in Figure 1.

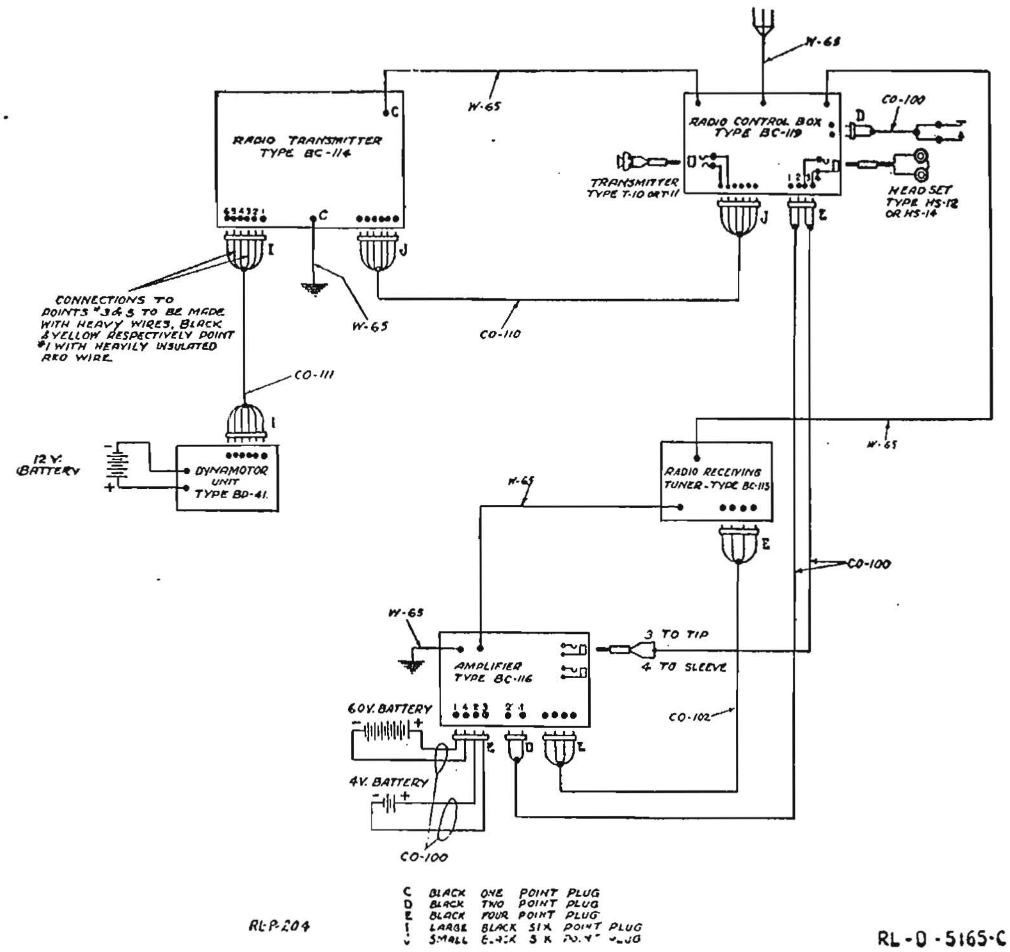

FIGURE 1.—Cording diagram for type SCR–134

3. **Dynamotor unit, BD–41.**—This unit consists of dynamotor, DM–13–B, and attached auxiliary parts as explained below. Dynamotor, type DM–13–B, includes a motor operating from 12 volts and a generator developing 750 volts under load. A panel is mounted above the dynamotor, carrying a relay for controlling the 12-volt supply to the dynamotor and the radio transmitter filament circuit. A large 6-point plug and socket provide for connection of 6-conductor cord connecting to the radio transmitter, BC–114. A view of the dynamotor unit is shown in Figure 2. The dynamotor unit, not including plug, measures 11⅛ inches high, 9 inches long, and 7¾ inches wide, and weighs 27 pounds.

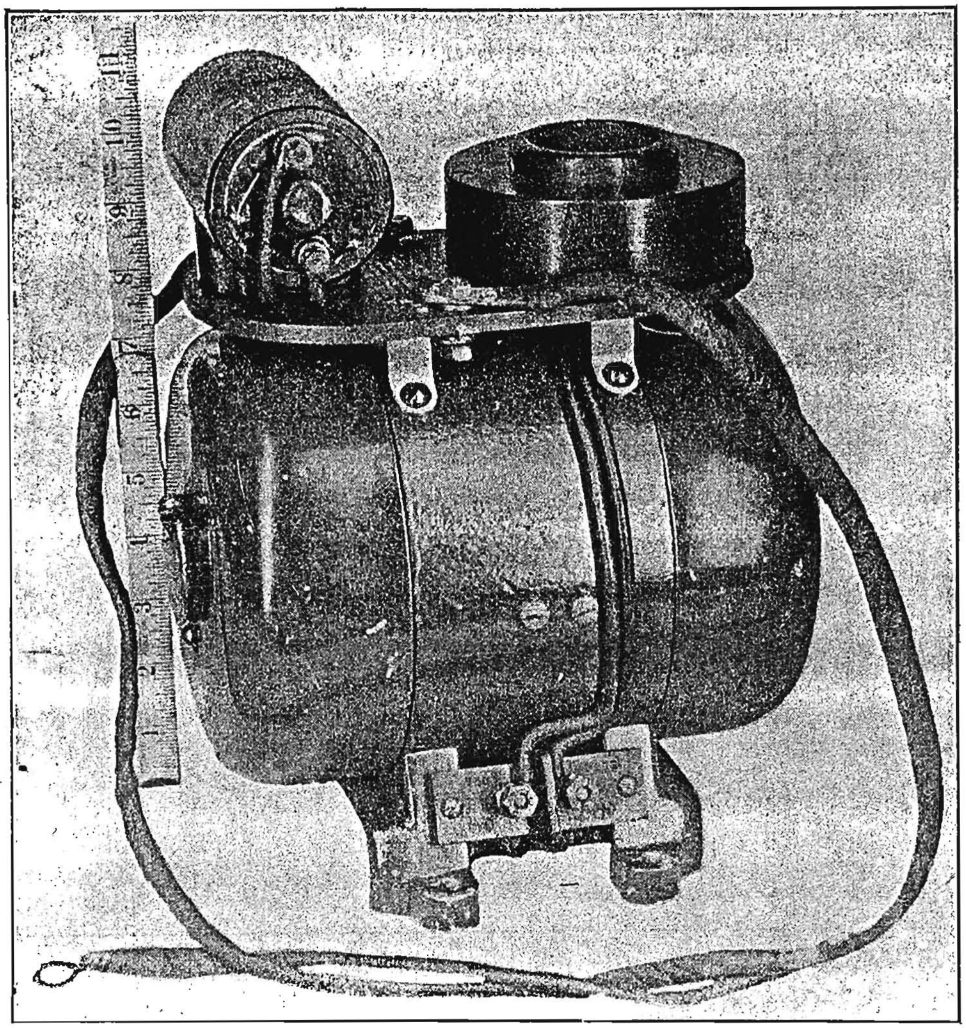

FIGURE 2.—Dynamotor unit, type BD–41

4. **Radio transmitter, BC–114.**—*a.* The radio apparatus in radio transmitter, BC–114, is mounted either on the bakelite panel or supported by a metal frame attached to the back of the panel. The panel with attached frame and apparatus is removed from the wood box by turning the handles of the panel locks upward, pulling the panel forward by means of the handles of the panel locks, and then lifting the panel off the pivots attached to the wood box. The tube shelf is attached rigidly to the supports as the rubber shock-absorber cord, used to suspend the radio transmitter within the airplane, provides sufficiently against vibration and jars. Three VT–4 tubes and one VT–2 tube are placed in the sockets mounted on the tube shelf. Sockets are mounted on the panel to receive the plugs of cords connecting to other parts of the radio set. The radio transmitter, not including plugs, measures 18 inches wide, including eyes, 14⅞ inches high, and 8¾ inches deep, and weighs 25½ pounds without tubes or plugs.

b. Views of the radio transmitter are shown in Figures 3 and 4. The apparatus legend is the same as used in the circuit diagrams shown later in this pamphlet.

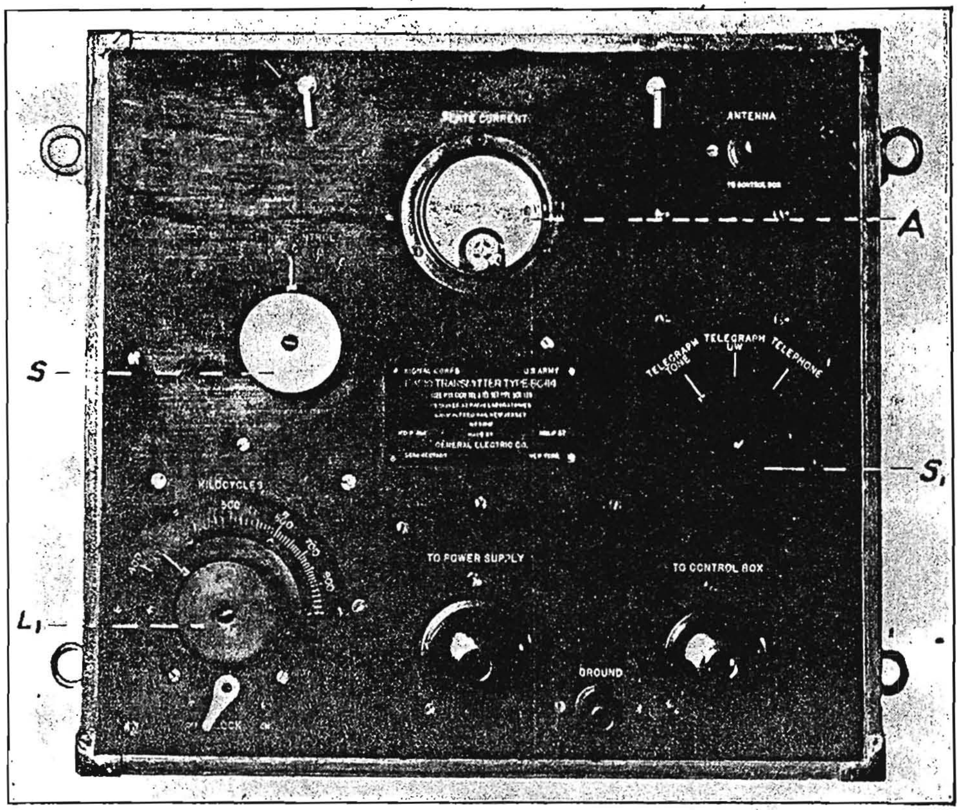

FIGURE 3.—Radio transmitter, BC–114. Front view, showing plugs inserted

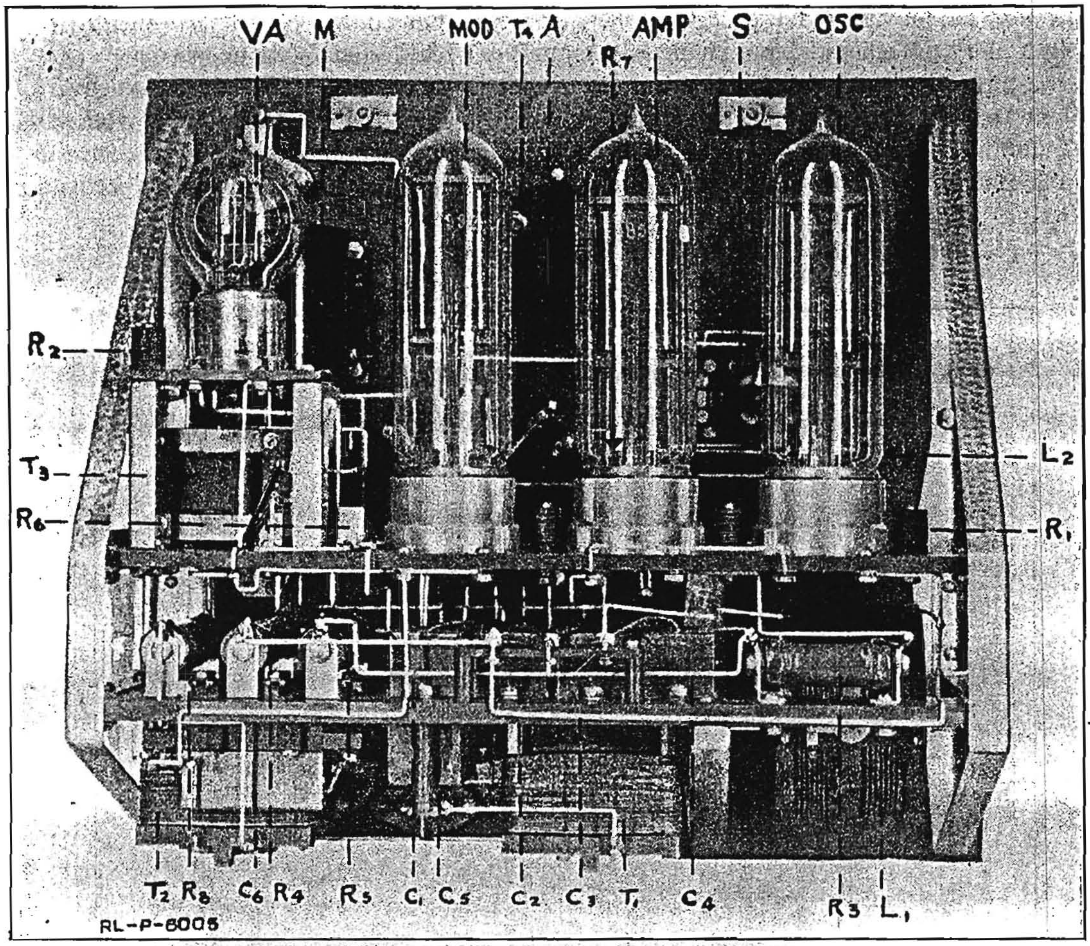

FIGURE 4.—Radio transmitter, type BC-114. Inside view

APPARATUS LEGEND

A = D. C. milliammeter, 0 to 500 milliamperes.
C_1=4,000 m. m. f. condenser.
C_2=2,500 m. m. f. condenser.
C_3=1,500 m. m. f. condenser.
C_4=500 m. m. f. condenser.
C_5=5,000 m. m. f. condenser.
C_6=500 m. m. f. condenser.
R_1=0.36-ohm resistance.
R_2=2.7-ohm resistance.
R_3=500-ohm resistance.
R_4=20,000-ohm resistance.
R_5=15,000-ohm resistance, tapped at 2,500 ohms.
R_6=0.5-megohm resistance.
R_7=5,000-ohm resistance.
R_8=10,000-ohm resistance.
T_1=Modulation transformer, type C-55.
T_2=Voice-amplifying transformer, type C-50.
T_3=Microphone transformer, type C-51.
T_4=Antenna transformer.
L_1=Oscillating variometer.
L_2=Choke coil, type C-58.
M = Motor alternator, type GN-33.
S = Field rheostat.
S_1 = Modulation control switch.

5. **Radio control box, BC–119.**—*a.* The antenna tuning circuit is contained in the radio control box which is mounted within reach of the observer. On the panel are mounted an antenna current thermoammeter, the inductance tap switch and variometer adjustment knob. The transmit-receive switch is mounted conveniently for the use of the operator. The control box, not including plugs, measures 6¼ inches wide, 7¼ inches high, including switch handle, and 6⅜ inches deep, including knobs on front, and weighs 5 pounds.

b. Views of the control box are shown in Figures 5 and 6.

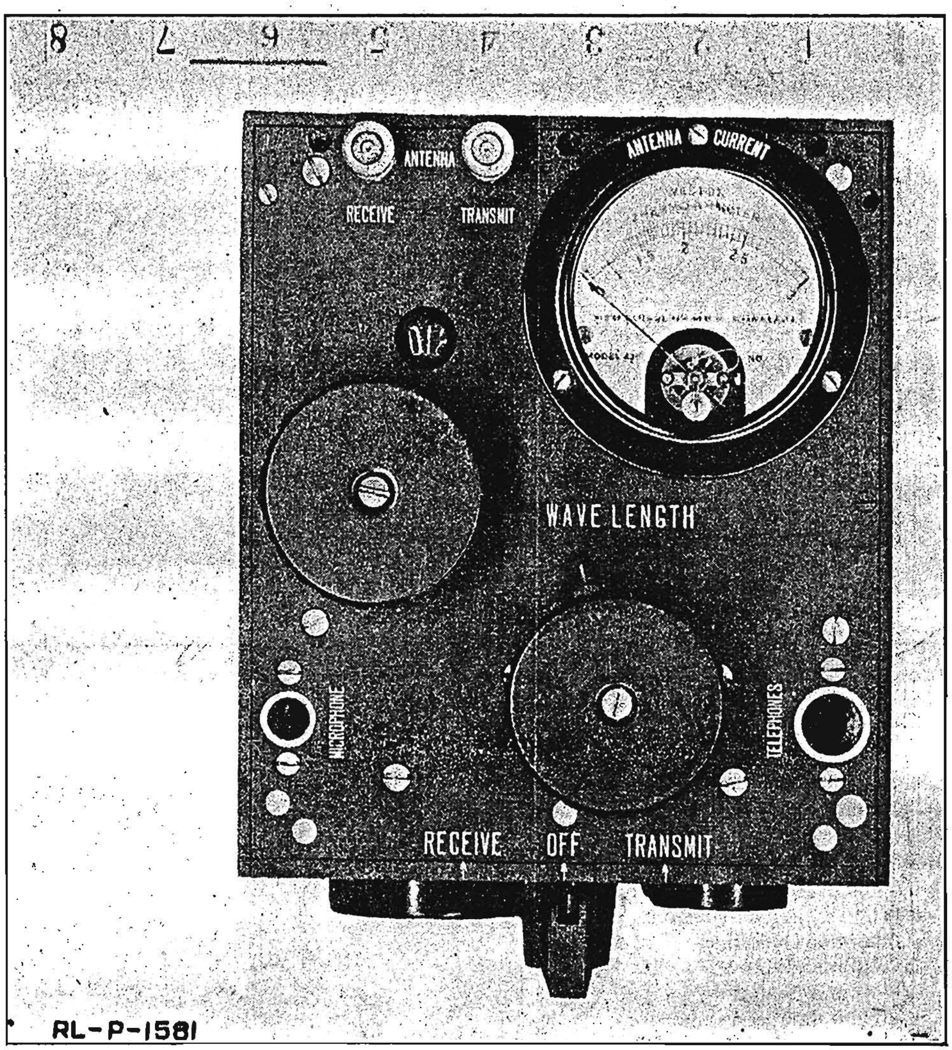

FIGURE 5.—Control box, type BC–119. Front view

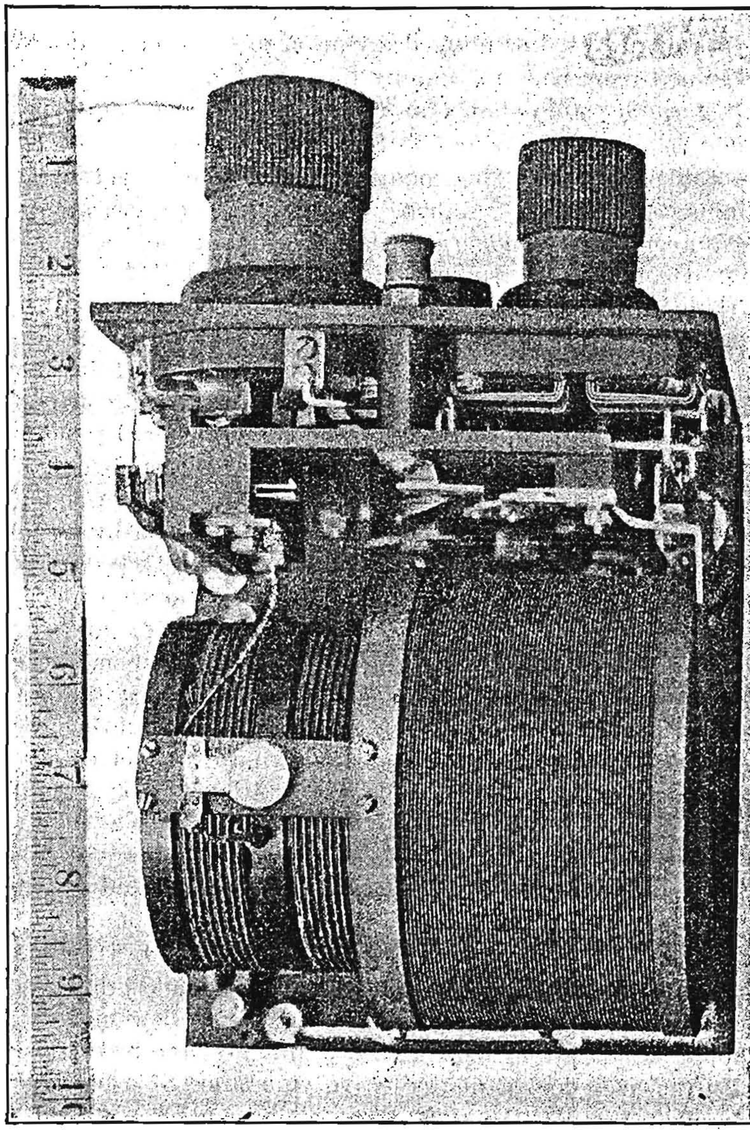

FIGURE 6.—Control box, type BC-119. Inside view

SECTION II

INSTALLATION, OPERATION, AND CARE OF TRANSMITTING EQUIPMENT

6. Installation.—Detailed instructions for the installation of the radio set in various types of planes, including description of trailing wire antenna to be used, will be issued from time to time by the Air Corps. The cording diagram of the SCR–134 radio set is shown in Figure 1. The various types of multiconductor cable required in wiring the SCR–134 set according to Figure 1 are called for in the parts list. The conductors are to be carefully soldered to copper terminals, Belden code "Nabob." The ends of the terminals are to be firmly pressed around the rubber insulation so that no bending can occur where the bared conductor is soldered to the terminal. If the terminals are found to work loose under the fastening screw of the plug contact stud, the terminals may be sweated to the plug contact studs or small lock washers may be provided. The various conductors must be carefully identified at the two ends of the cable, using a buzzer, head set, or other convenient means, in order that a conductor may connect to the same numbered plug contact stud at each end. The single-conductor wire W–65 is to be provided with the Delco terminals No. 20953. The end of the terminal is to be formed around the rubber insulation and then securely bound to the insulation by means of heavy thread, afterwards varnished to prevent slipping.

7. Operation and care.—*a.* The only parts of the radio set which are accessible to the operator during flight are the radio control box and the receiving tuner. All power to the radio set is cut off when the transmit-receive switch is on "Off." Throwing the switch to "Transmit" causes the relay on the dynamotor unit to close, starting up the dynamotor and lighting the transmitting tube filaments. When the switch is thrown to "Receive" the receiving tubes are lighted. As the BC–114 radio transmitter is not accessible to the operator during flight, all adjustments thereon must be made before leaving the ground. The pointer on the shaft of the master oscillator variometer should be turned to the wave frequency desired and the setting fixed by means of the locking device. The switch on the transmitter panel should be turned to C. W. telegraph, tone telegraph, or telephone, as desired. If tone telegraph is to be used, the switch marked "Tone control" should be turned to the desired tone. Tone "E" has the highest pitch. Before leaving the ground the radio set should be tested by connecting a dummy antenna consisting of a capacity of 250 m. m. f. and a noninductive resistance of 4 ohms between the "Antenna" binding post on the underside of the control box and the ground connection to the plane. The transmit-receive switch should be thrown to "Transmit" and the inductance switch on the control box turned to the proper wave-frequency range. Then, if using telephone, the antenna variometer adjustment can be turned slowly until maximum reading of the antenna current ammeter is obtained. When a loud note is sung into the microphone the antenna current should increase slightly, indicating that the set is modulating properly. If tone telegraph or C. W. telegraph is used, it is necessary to hold down the key during the tuning of the antenna circuit. With the set properly tuned and the key held down, the antenna current should increase slightly when the switch on the radio transmitter is turned from C. W. telegraph to tone telegraph, indicating that proper modulation is being obtained. The test thus made determines whether the radio transmitting equipment is operating properly. The antenna tuning adjustment used is not suitable when using the airplane trailing wire antenna, and therefore the antenna circuit must be carefully tuned again when the airplane is in the air.

b. When the airplane has attained sufficient altitude, the trailing wire antenna is let out by means of the antenna reel. With the airplane flying a straight course at normal speed, the transmit-receive switch should be thrown to "Transmit," which will start the dynamotor unit, BD–41, and light the filaments in the radio transmitter, BC–114. Then, if using telephone, turn the inductance switch on the control box to the proper wave-frequency range and carefully adjust the antenna variometer until maximum reading of the antenna current ammeter is obtained. If tone or C. W. telegraph is being used, it is necessary to hold the telegraph sending key closed during this tuning process. The operator throws the transmit-receive switch to "Receive" to connect the antenna to the receiving equipment and light the receiver tube filaments.

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Section III

PRINCIPLES EMBODIED IN TRANSMITTING EQUIPMENT

8. **Dynamotor unit, BD–41.**—Circuit diagram of the dynamotor unit is shown in Figure 7. The motor of the dynamotor and the filament circuit of the radio set are supplied from the 12-volt storage battery forming part of the central

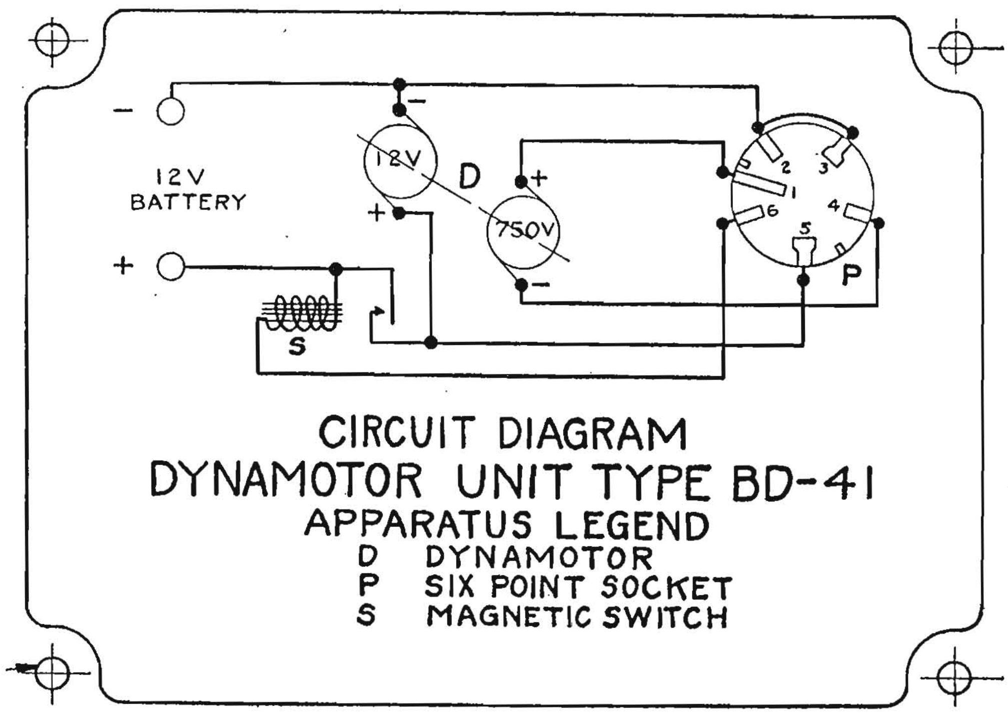
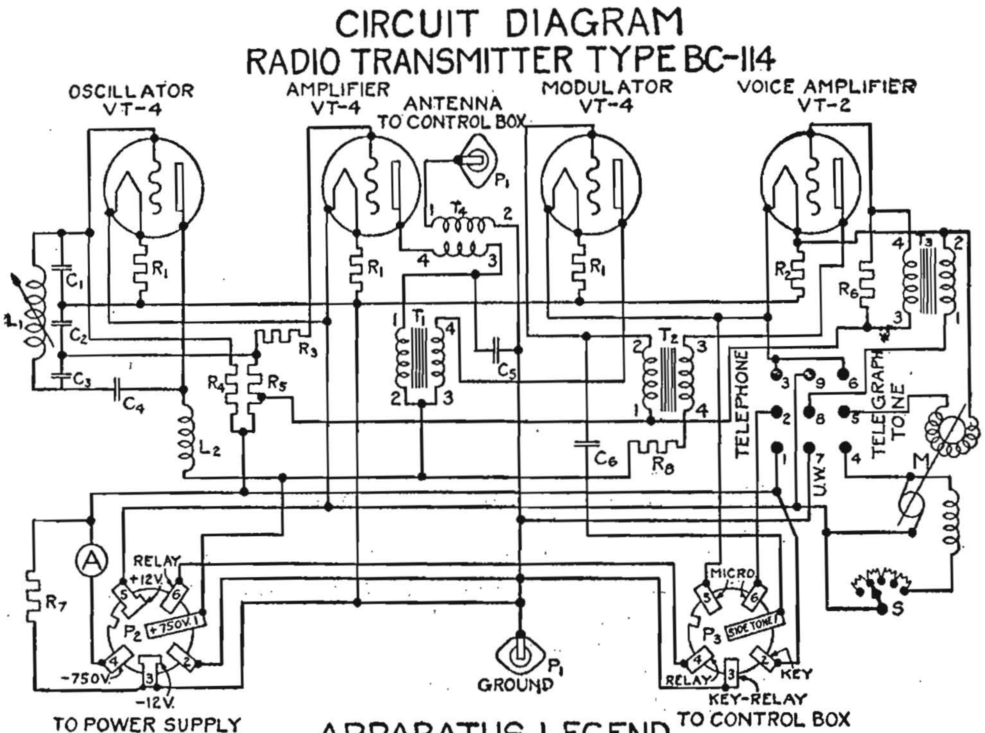


Figure 7

power plant on the airplane. The motor is started by the closing of the relay mounted on the panel above the dynamotor. The relay contacts also close the filament current supply circuit. The relay winding is controlled by the transmit-receive switch in the radio control box. The field winding of the motor also supplies the excitation for the high-voltage generator. A 2 m. f. condenser is connected across the high-voltage armature for the purpose of smoothing out variations in output due to commutation, and to protect the armature from high-voltage surges obtained due to modulation of the radio transmitter. The high-voltage generator supplies the plate current for all the tubes.

9. **Radio transmitter, BC–114.**—Circuit diagram of the radio transmitter is shown in Figure 8. A complete schematic diagram of the transmitting equipment is shown in Figure 9. The apparatus legend is the same as used for the other diagrams and photographs in this pamphlet.



APPARATUS LEGEND

A D.C. MILLIAMETER O TO 500 MILLIAMPERES
C_1 4,000 M.M.F. CONDENSER
C_2 2,500 M.M.F. CONDENSER
C_3 1,500 M.M.F. CONDENSER
C_4 500 M.M.F. CONDENSER
C_5 5,000 M.M.F. CONDENSER
C_6 500 M.M.F. CONDENSER
R_1 0.36Ω RESISTANCE
R_2 2.7Ω RESISTANCE
R_3 500Ω RESISTANCE
R_4 20,000Ω RESISTANCE
R_5 15,000Ω RESISTANCE TAPPED AT 2500Ω
R_6 0.5 MEG. RESISTANCE TYPE RS-1
R_7 5,000Ω RESISTANCE
R_8 10,000Ω RESISTANCE
1,2,3,4,5,6,7,8 & 9 MODULATION SWITCH
T_1 MODULATION TRANSFORMER TYPE C-55
T_2 VOICE AMPLIFYING TRANSFORMER TYPE C-50
T_3 MICROPHONE TRANSFORMER TYPE C-51
T_4 ANTENNA TRANSFORMER
L_1 OSCILLATING VARIOMETER
L_2 CHOKE COIL TYPE C-58
P_1 ONE POINT PLUG SOCKET
P_2 LARGE SIX POINT PLUG SOCKET
P_3 SMALL SIX POINT PLUG SOCKET
M MOTOR ALTERNATOR TYPE GN-33
S FIELD RHEOSTAT

FIGURE 8

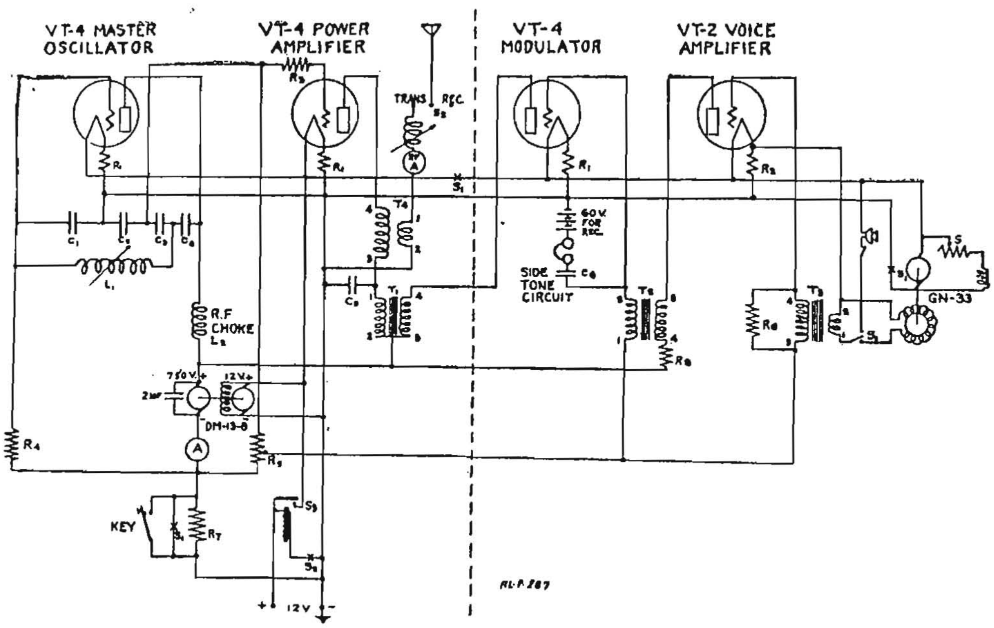


FIGURE 9.—Schematic circuit diagram, BC–114

10. Master oscillator.—*a.* The master oscillator power-amplifier circuit is used. The master oscillator is a Colpitt's type circuit formed by condensers C_1, C_2, C_3, and variometer inductance L_1. The condenser C_4 is a blocking condenser to keep the direct plate current from the tube grid. The radio-frequency choke coil L_2 prevents the short circuit of the radio-frequency voltage through the plate voltage generator to the filament. The large grid leak resistance R_4 operates with the grid condenser C_1 to provide a negative grid biasing voltage by accumulative rectification of the radio-frequency energy since the grid takes current during only the positive half of the cycle. The plate ratio capacity C_2, C_3, is divided in order that the smaller voltage across C_3 may be used for the excitation of the grid circuit of the power-amplifier tube.

b. The power-amplifier tube has the grid circuit excited by the radio-frequency voltage supplied by the master oscillator. The radio-frequency voltage is amplified by the tube so that the plate current has a large radio-frequency component. This radio-frequency energy is transferred to the antenna circuit by means of the antenna or output transformer T_4. The primary (plate) winding consists of a large inductance so designed as to offer large reactance to the radio-frequency current over the wave-frequency band covered by the radio transmitter. This prevents the power amplifier obtaining excessive plate current when the antenna circuit is detuned. The secondary (antenna) winding consists of a small number of turns, so that the small radio-frequency current and large voltage operating through the tube plate to filament impedance are stepped down to a large radio-frequency current and small voltage which are more suitable for supplying current to the low-resistance antenna. The antenna circuit is tuned to resonance by means of the tapped inductance and variometer in the radio-control box in order to obtain maximum antenna current as indicated by radio-frequency ammeter on the radio-control box.

c. The resistance R_3 in the grid circuit of the power-amplifier tube is for the purpose of reducing the grid current flowing in the power-amplifier tube during the positive half cycle. Otherwise this grid current is particularly large during the interval due to the plate audio modulation when the effective plate voltage is low. This varying load on the master oscillator circuit changes the wave frequency slightly, which is objectionable. The grid of the power-amplifier tube is kept at a negative bias potential by means of the accumulative rectification in the grid circuit of the radio-frequency excitation provided by the master oscillator. Condenser C_2 acts as the grid condenser and resistance R_6 acts as the grid leak in this case. The resistance R_6 is tapped so that part of the negative potential built up across it may be used for negative biasing the grids of the voice amplifier and modulator tubes. The plate current for the power-amplifier tube is supplied through the modulation transformer T_1. The condenser C_6 provides a low reactance by-pass so that the radio-frequency component of plate current need not pass through the modulation transformer.

11. **Keying.**—The resistance R_7 is connected between the negative side of the 750-volt generator and the filament circuit, so all plate current drawn passes through this resistance when connected for telegraph operation with key open. The plate current causes a large negative voltage to be set up across this resistance which is impressed upon all the grid circuits, reducing the total plate current to a very small value. When the key is closed to send a dot or dash, the resistance is short-circuited and the plate current quickly reaches normal value. By this means the oscillations reach large amplitude with key closed and drop to zero with key open. This method of keying is used for both C. W. telegraph and tone-modulated telegraph. For telephone operation, the resistance is short-circuited by the three-position switch S_1 on the radio-transmitter panel.

12. **Sources of modulation.**—*a.* The high-ratio transformer T_3 has an alternating-current voltage impressed on the primary which is stepped up by the transformer and then impressed on the grid of the speech-amplifier tube. For tone-modulated telegraph the alternating-current voltage is generated by a motor alternator GN–33, the motor of which is connected across the 12-volt circuit. A variable resistance is contained in the motor field circuit in order that the speed may be varied, controlling the frequency generated in the alternating-current windings. By this means various pitch tones can be obtained. This is useful when a number of the sets operating on nearly the same wave frequency are within receiving range. It will be noted that the tone modulation is supplied steadily and that keying is effected by controlling the plate current, the same as for C. W. telegraph. For telephone operation the motor alternator is replaced as a source of alternating current by a microphone. Power is obtained for the microphone circuit by utilizing the drop across the VT–2 voice-amplifier tube. The microphone T–11 is equipped with the open circuiting switch mounted on the stem. The secondary of the step-up transformer T_3 has connected across it a leak type resistance R_0, which serves to improve the modulation and prevent grid blocking, especially if the grid is caused to go positive by excessive modulation. A steady negative biasing potential is supplied the voice-amplifier tube grid by utilizing part of the voltage developed across the resistance R_5, as explained previously.

b. The audio-frequency voltage on the voice-amplifier grid is repeated in the plate circuit in amplified form. This plate current is supplied from the 750-volt dynamotor armature and is therefore passed through the resistance R_3 in order to reduce the effective voltage to a suitable value for the VT–2 tube. The plate circuit also contains the primary of the one-to-one ratio transformer T_2, which transfers the audio-frequency voltage to the grid circuit of the VT-4 modulator tube. A steady negative biasing potential is supplied the modulator tube grid by utilizing part of the voltage developed across the resistance R_5, as previously explained.

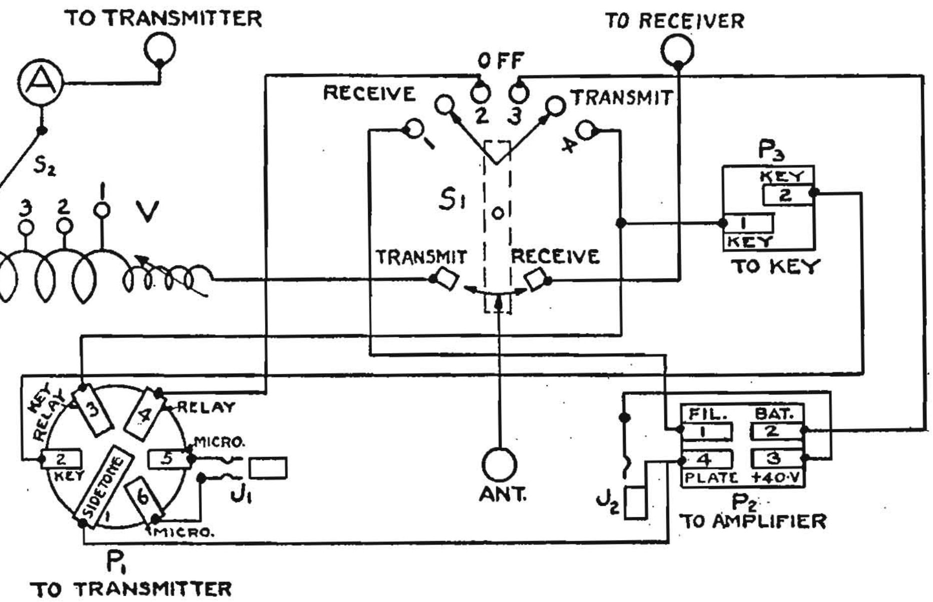
13. **Side-tone circuit.**—The quality and presence of modulation so far in the circuit are assured the operator by hearing his own signal by means of the side-tone circuit provided. This connects the modulator grid through the telephone head set plugged into the radio control box, completing the circuit through the 60-volt receiver-plate battery to the receiver ground connection. The side-tone circuit contains the condenser C_6 in order to block any direct-current flow, and also to moderate the volume of side tone so as to be suitable for the head set.

14. **Modulation of radio-frequency output.**—*a*. The audio-frequency voltage on the modulator grid is repeated in the plate circuit in amplified form. This plate circuit is supplied from the 750-volt dynamotor armature, the plate current passing through one winding of transformer T_1. This is a special low-reluctance core transformer, having 1,375 turns between terminals 1 and 2 and 1,750 turns between terminals 3 and 4. The two windings are connected in opposition so that the magnetic flux set up by one winding approximately neutralizes the flux set up by the other winding. This design prevents magnetic saturation of the core, enabling a smaller size and lighter weight core to be used. When the audio-frequency component of plate current to the modulator tube increases, the transformer T_1 has a voltage induced in the power-amplifier plate winding so that the plate current to this tube also increases. The audio-frequency modulation therefore causes the power-amplifier and modulator plate currents to increase and descrease together, following the wave form of the original modulation. The radio transmitter is so designed that the radio-frequency output of the power amplifier is directly proportional to its effective plate voltage (or current). The audio variations in the plate current cause corresponding variations in the radio-frequency output, effecting the desired audio-frequency modulation of the radio-frequency wave.

b. The filament circuits of all the tubes are supplied in parallel from the 12-volt line. Individual resistances fix the filament current at the proper values for VT-4 and VT-2 tubes. The voltage supplied to the set is about 11 volts, 1 volt approximately being required for the potential drop in the power-supply leads.

15. **Radio control box, BC-119.**—Circuit diagram of the radio control box is shown in Figure 10. The transmit-receive switch connects the antenna either to the radio transmitter or receiver. The antenna transmitting circuit in the control box includes a large tapped inductance with a variometer in series, permitting fine adjustment of tuning between the taps of the large inductance. The antenna current thermoammeter is connected on the low-voltage side of the inductance. The transmit-receive switch when thrown to transmit closes the dynamotor unit relay winding circuit, causing the relay contacts to close, which in turn starts up the dynamotor and closes the transmitter filament circuit. The transmit-receive switch when thrown to receive closes the receiver filament circuit.

CIRCUIT DIAGRAM
RADIO CONTROL BOX TYPE BC-119



APPARATUS LEGEND

S_1-SEND-RECEIVE SWITCH
S_2-TAP SWITCH
A-THERMO AMMETER
V-VARIOMETER
J_1-MICROPHONE JACK
J_2-TELEPHONE JACK
P_1-6 POINT PLUG SOCKET
P_2-4 POINT PLUG SOCKET
P_3-2 POINT PLUG SOCKET

FIGURE 10

SECTION IV

PARTS LIST FOR AIRPLANE RADIOTELEPHONE AND TELEGRAPH SET, TYPE SCR-134

16. Parts list.

Quantity	Unit	Material
1	Each	Radio transmitter, type BC-114.
6	---do	Tubes, type VT-4B; 3 in use, 3 spare.
2	---do	Tubes, type VT-2; 1 in use, 1 spare.
1	---do	Radio control box, type BC-119.
1	---do	Headset, type HS-15.
1	---do	Transmitter, type T-11, microphone.
2	---do	Keys, type J-5-A.
1	---do	Radio-receiving tuner, type BC-115.
1	---do	Radio-audio-frequency amplifier, type BC-116-A.
1	---do	Plug, type PL-11.
2	---do	Terminals, type TM-50.
16	---do	Tubes, type VT-5; 8 in use, 8 spare.
9	---do	Batteries, type BA-2; 3 in use, 6 spare.
1	---do	Battery box, type BC-128.
[1] 40	Foot	Cord, type CO-100, 2-conductor No. 18.
[1] 45	---do	Cord, type CO-102, 4-conductor No. 18.
[1] 15	---do	Cord, type CO-110, 6-conductor No. 18, shielded.
[1] 30	---do	Cord, type CO-111, 2-conductor No. 10, 4-conductor No. 18, shielded.
[1] 60	---do	Wire, type W-65, single-conductor.
1	Each	Terminal, type TM-92 (positive terminal (lug).
1	---do	Terminal, type TM-93 (negative terminal (lug)).
2	Pieces	Tubing, rubber, grade A, ⅛-inch inside diameter, $\frac{1}{16}$-inch wall.
2	Each	Sleeves, tinned copper, receiver storage battery cord.
7	---do	Terminals, type TM-94 (Delco No. 20953 or approved equivalent).
50	---do	Terminals, type TM-95 (Belden "Nabob" or approved equivalent).
1	---do	Dynamotor unit, type BD-41.
3	---do	Batteries, type BB-4, 4-volt; 1 in use, 2 spare.
2	---do	Drums, type DR-2; 1 in use, 1 spare.
2	---do	Fair-leads, type F-5; 1 in use, 1 spare.
1	---do	Reel, type RL-2.
20	Foot	Twine, type RP-11.
10	Each	Weights, type WT-1; 1 in use, 9 spare.
3,000	Foot	Wire, type W-5.

[1] Cords will be issued in long lengths and cut for exact requirements at time of installation.

NOTE.—The 12-volt storage battery for operating the radio transmitter, and the 2-conductor No. 6 B. & S. twin-conductor cable connecting to the dynamotor unit will be provided by the Air Corps.

SECTION V

DESCRIPTION OF RECEIVING EQUIPMENT

17. General.—The wave-frequency range of the receiving equipment is 250 to 1,500 kilocycles (200 to 1,200 meters). The receiver is of the superheterodyne type and provides for telephone and I. C. W. telegraph reception, but not for C. W. telegraph.

18. Parts.—A 4-volt storage battery is provided for supplying the filament circuit. The plate battery is 3 BA-2 batteries in series (60-V), contained in a BC-128 battery box. The antenna lead connects to the receiving tuner, which contains an antenna tuning system and a separate heterodyne circuit. The combined wave frequencies of the signal and the heterodyne are carried to the amplifier unit, where proper rectification and radio and audio frequency amplification are obtained. The receiving tuner is the only part of the receiving equipment which is installed in the rear cockpit, and which is therefore accessible to the observer who operates the set. The filament rheostat controlling all the receiving-tube filaments is therefore located on the tuner panel. The headset connection to the amplifier is made through cord connection to the radio control box, which is also installed in the rear cockpit. The send-receive switch is part of this radio control box. All parts of the receiving equipment are connected with multiconductor cords terminated with specially designed plugs as indicated in Figure 1.

19. **Radio-receiving tuner, BC-115.**—*a.* Two sides of the receiving tuner are bakelite panels. The other four sides are covered by the wood box. The receiving tuner is 6½ inches wide, 7⅜ inches high (including tube shield), and 5½ inches deep (including binding posts). The tuner weighs 5 pounds without plug.

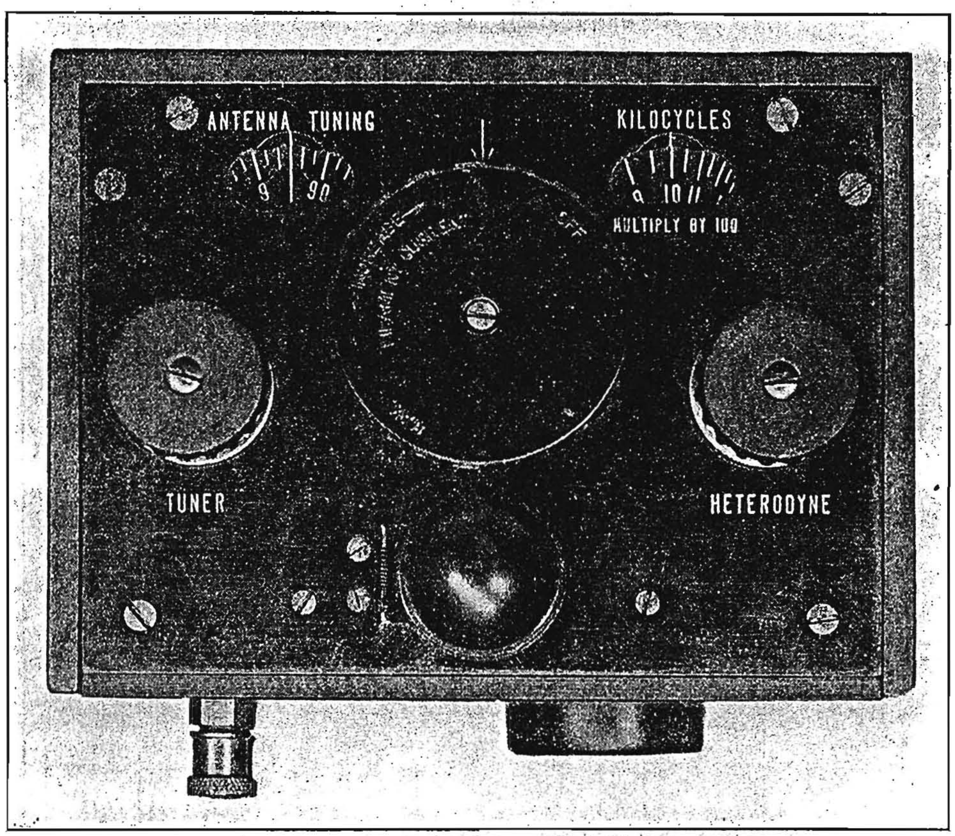


FIGURE 11.—Tuner, BC-115. Front view, showing tube shield

b. A front view of the tuner is shown in Figure 11. The knob to the left varies the condenser and variometer comprising the antenna tuned circuit. This knob operates through suitable gears to obtain slow motion of the dial on the condenser shaft. This scale is marked "Antenna tuning" and is divided into degrees of a circle. The knob to the right turns the separate heterodyne variable condenser through suitable gears to obtain slow motion of the dial on the condenser shaft. The scale reads directly in kilocycles by multiplying the reading by 100. On the lower part of the front panel is a hinged metal cap which is lifted to insert the VT-5 heterodyne oscillator tube in its socket. The filament rheostat is contained in the large knob, the edge of which is seen below the panel. Numbers are engraved along the edge of the rheostat knob to indicate the position of the rheostat. The series resistance decreases and the filament current increases as the number indicated on the knob increases.

c. A view of the under panel is shown in Figure 12. This view shows the 4-point socket providing for connection to the amplifier for filament and plate power supply, and two Delco binding posts to connect the signal voltage from the radio control box to the receiving tuner, and from the receiving tuner to the amplifier.

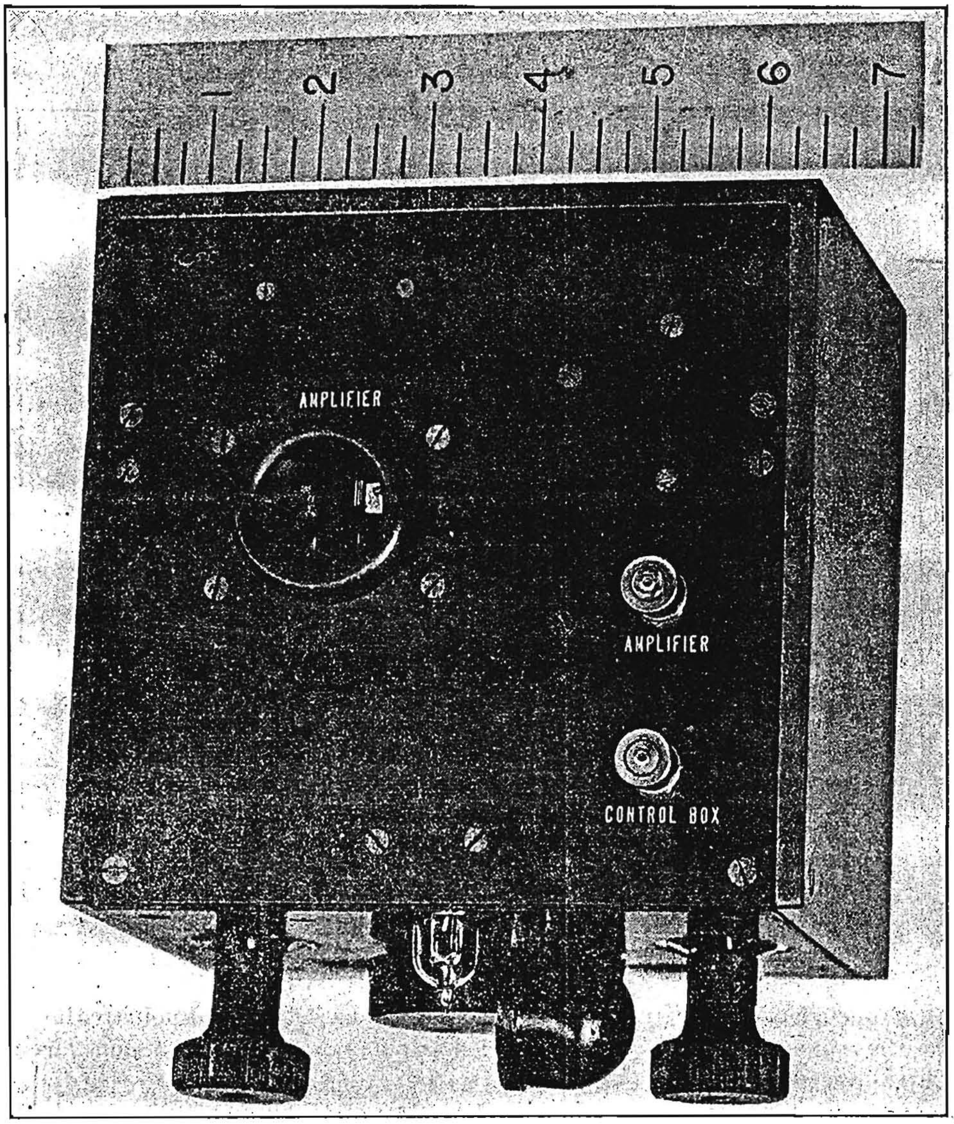


FIGURE 12.—Tuner, BC-115. Bottom view, showing tube

d. The apparatus installed inside the tuner is shown in Figure 13. The apparatus legend which follows uses the same symbols as the circuit diagram shown later in this pamphlet.

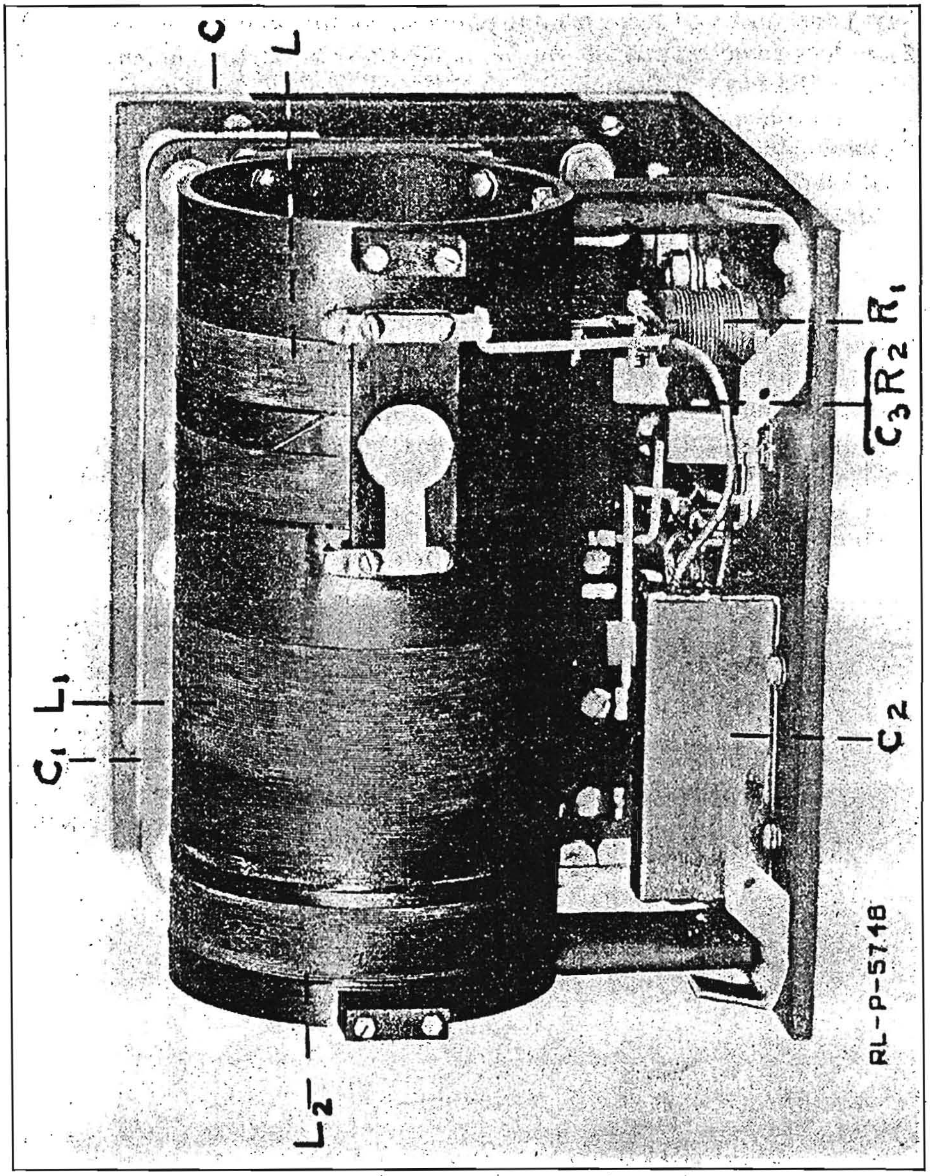


FIGURE 13.—Tuner, BC-115. Rear inside view

C =Tuner condenser, 600 m. m. f.
C_1=Heterodyne condenser, 600 m. m. f.
C_2=Fixed condenser, 10,000 m. m. f.
C_3=Fixed condenser, 150 m. m. f.
L =Tuner variometer.
L_1=Grid inductance.
L_2=Plate inductance.
R_1=Filament resistance, 6.5 ohms.
R_2=Resistance, 100,000 ohms.

20. Radio-audio-frequency amplifier, BC–116.—*a*. The amplifier consists of a bakelite panel with a bakelite shelf carrying the tubes, transformers, etc., supported on sponge rubber cushions on metal brackets fastened to the back of the panel. The panel and entire apparatus are removed from the box by turning the two panel locks to a horizontal position, pulling the panel forward by means of the lock handles, and lifting the panel upward off the supporting pins at the sides of the box. The amplifier is $15\frac{1}{8}$ inches wide, including eyes, $8\frac{13}{16}$ inches high, and 5 inches deep over all. The amplifier weighs 9 pounds without plugs or tubes.

b. A front view of the amplifier is shown in Figure 14. The two panel locks are along the upper edge of the panel. Delco binding posts at the left of the panel provide for connection of signal voltage from the receiving tuner to the amplifier and the ground connection to the amplifier. One 4-point socket marked "Receiving tuner" supplies filament and plate power to the tuner. The 4-volt storage battery for filament supply and 60-volt battery for plate supply connect to the amplifier 4-point socket marked "Plate and filament batteries." A 2-point socket on the amplifier provides for completion of the filament circuit through the send-receive switch on the radio control box, so that the receiver tubes are only lighted when the switch is thrown to "Receive." Telephone jacks are mounted on the panel, so that either one or two stages of audio-frequency amplification can be used as desired.

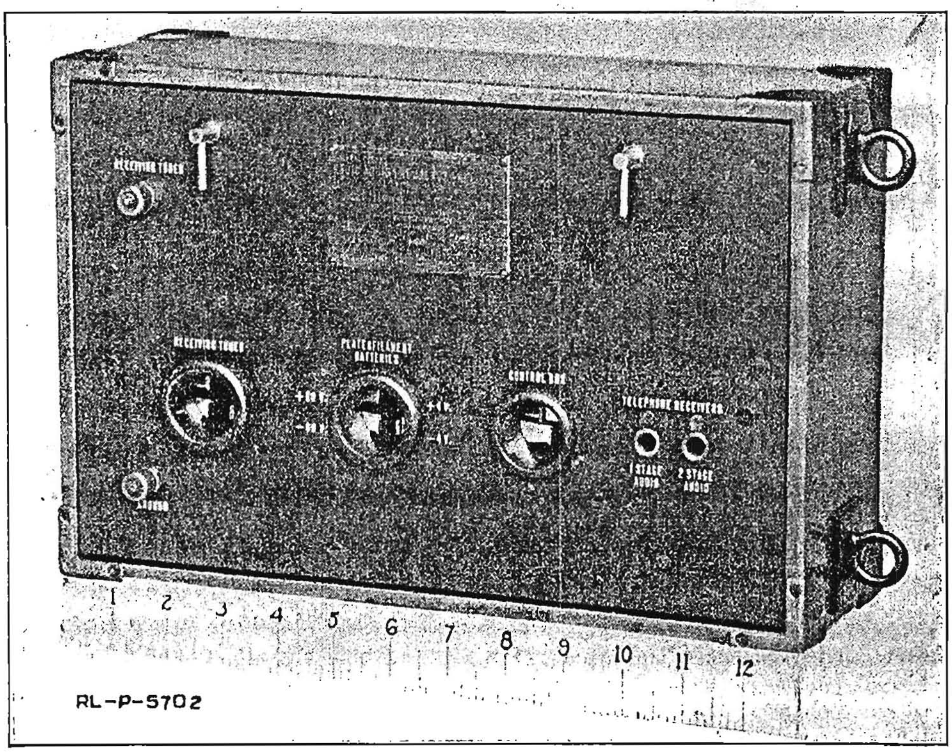


FIGURE 14.—Amplifier, BC–116. Front view

c. A view of the apparatus on the back of the panel is shown in Figure 15. The apparatus legend which follows uses the same symbols as the circuit diagram shown later in this pamphlet.

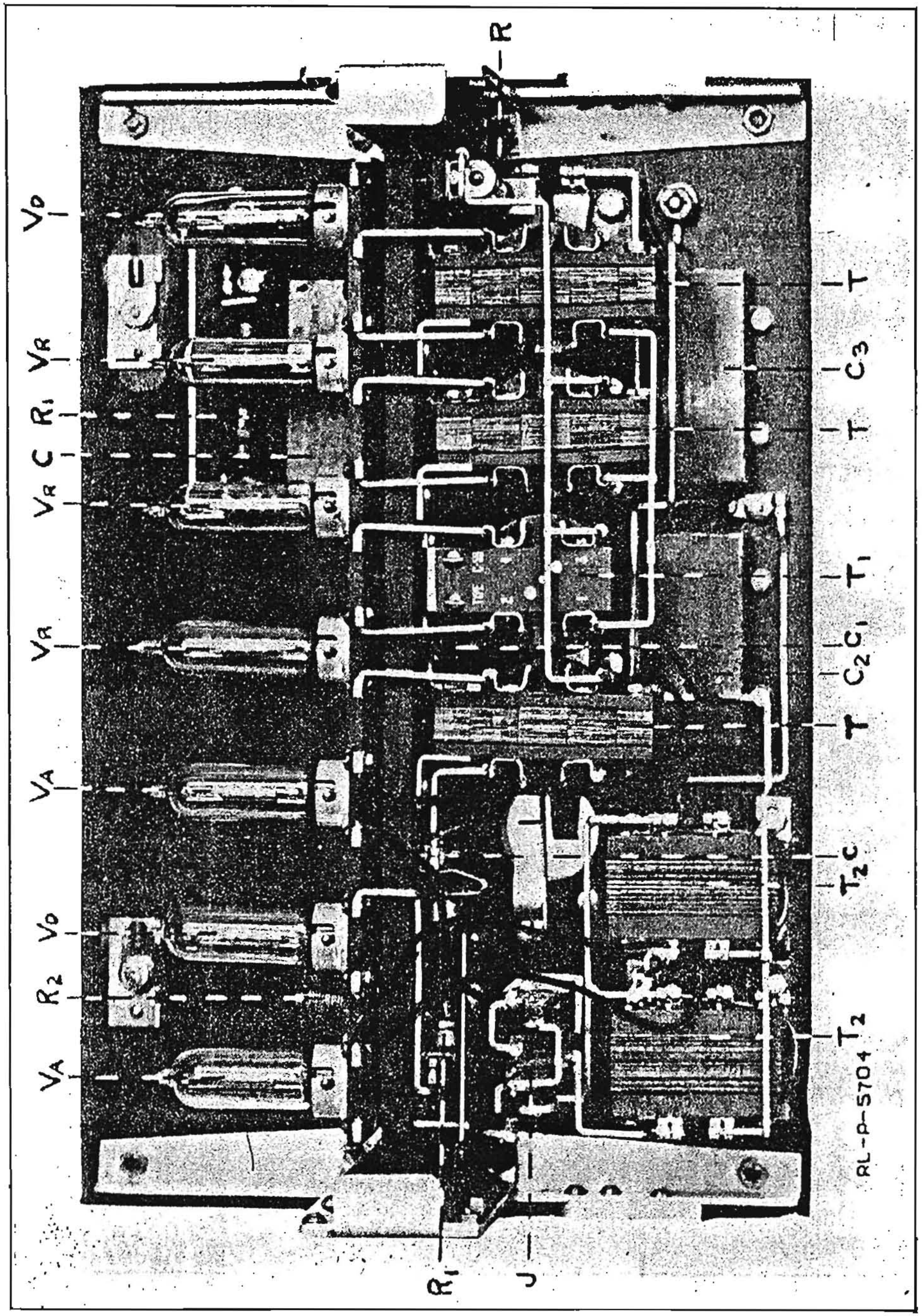


FIGURE 15.—Inside view of amplifier, BC-116

C =Condenser, 150 m. m. f.
C_1 =Condenser, 1,500 m. m. f.
C_2 =Condenser, 5,000 m. m. f.
C_3 =Condenser, 10,000 m. m. f.
J =Telephone jack.
R =0.5 megohm resistance, type RS–1.
R_1 =2.0 megohm resistance, type RS–3.
R_2 =7.0 ω resistance.
T =Transformer, type C–56.
T_1 =Transformer, type C–59.
T_2 =Transformer, type C–21–B (old model), type C–65 (new model).
V =Vacuum tube, type VT–5.
V_D =Detector.
V_R =Radio frequency, amplifier.
V_A =Audio frequency, amplifier.

21. Battery box, type BC–128.—This battery box is designed to contain the three BA–2 batteries supplying the plate current for the receiving equipment. The box is 7 9/64 inches long, 3 15/16 inches high (including binding posts), and 3 7/8 inches wide, and weighs 4 pounds with batteries. The box is shown in Figure 16.

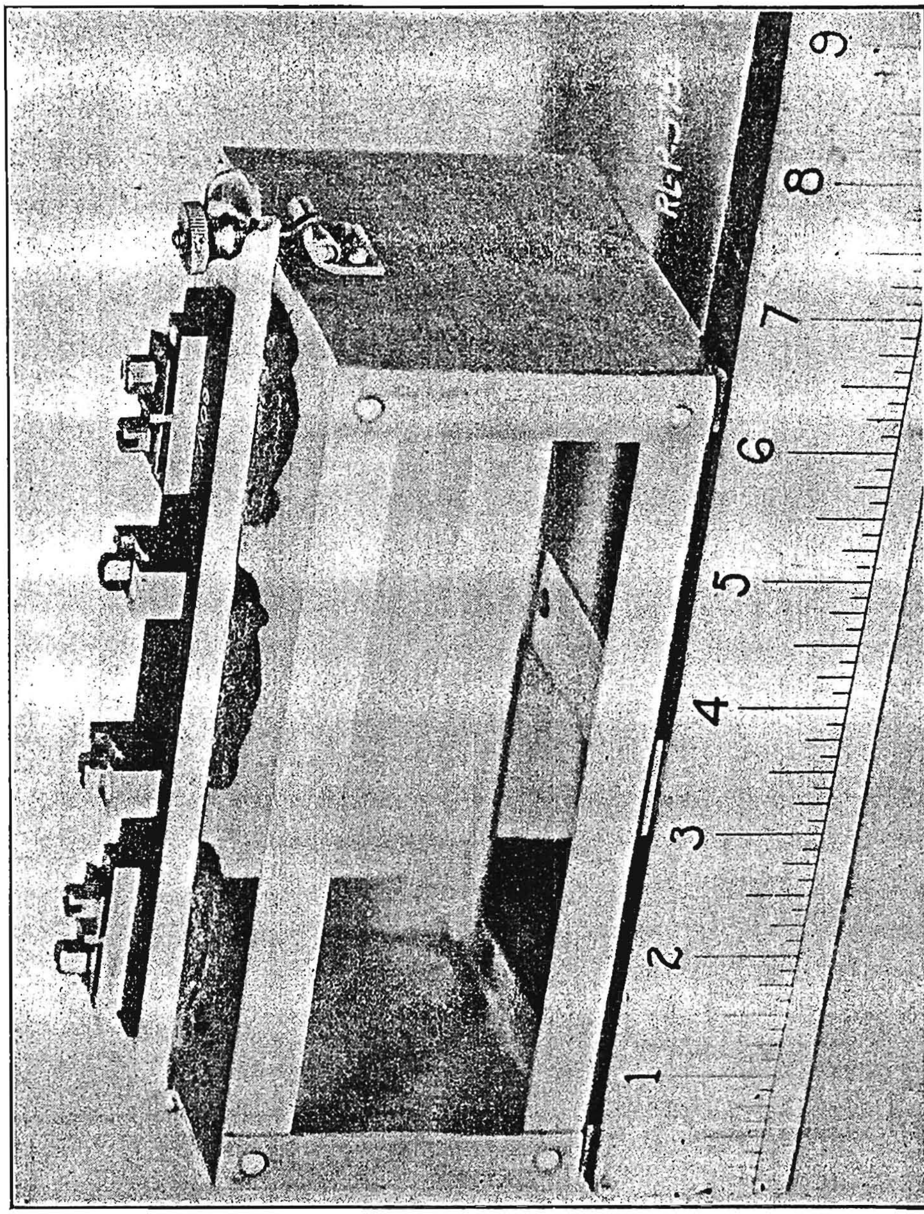


FIGURE 16.—Battery box, type BC–128

SECTION VI

INSTALLATION, OPERATION, AND CARE OF RECEIVING EQUIPMENT

22. **Installation.**—See paragraph 6.

23. **Filament adjustment.**—When the send-receive switch in the radio control box is turned to receive, the antenna is connected to the receiver, and also the receiver filament circuit is closed (if tuner rheostat is not on "Off"). The tuner rheostat is then turned to the proper position for obtaining normal filament current. The position of the rheostat, of course, depends upon the state of charge of the storage battery. An indication of the proper filament current is obtained by lifting the metal cap over the oscillator tube on the tuner and observing the brightness of the filament. The VT-5 tubes have a coated filament which should burn at a cherry-red color. If signals are being received, the rheostat should be turned to reduce filament current until the signal just begins to weaken. The life of the tubes is greatly shortened by burning them too bright. The amplifier tubes are connected so that the first three tubes are in series across the supply voltage, as are also the second three tubes. When one of these tubes burns out the other two will also fail to burn. The tubes can be tried in the second audio tube socket until the defective tube is located, as this second audio tube operates directly from the filament supply. The total filament current should be 1 ampere.

24. **Tuning.**—*a.* Tuning adjustments are made by means of the knobs on the receiving tuner marked "Tuner" and "Heterodyne." The heterodyne knob is turned until its scale reads the kilocycle wave frequency of the station to be received. The tuner knob is then turned until the signal is picked up. The knob must be turned slowly, as the tuning is very sharp. If the signal is not picked up by this operation, turn the heterodyne slightly first in one direction and then in the other direction, varying the tuner through the proper range each time. When the tuner is adjusted for best signal, go back to the heterodyne and slightly readjust that to see if any improvement can be obtained. It is well to record the "Tuner" settings for various "Heterodyne" settings, which will be of great value when using the same antenna for receiving.

b. When it is necessary to receive a station the wave frequency of which is not known, the finding of the station is a rather long and uncertain task. The heterodyne is progressively moved in short steps, each time turning the "tuner" through a range suitable for receiving the wave frequency indicated on the heterodyne. If this approximate calibration of the tuner is not known, it is necessary to turn the tuner adjustment through its whole range for each setting of the heterodyne. When the desired signal is picked up and the best tuner adjustment obtained, the heterodyne should also be readjusted slightly to obtain any possible improvement. It is usually possible to find two heterodyne settings for a certain tuner setting. The calibration on the heterodyne scale is in all cases for the adjustment using minimum setting of the heterodyne condenser, i. e., the adjustment having the higher kilocycle reading. The higher kilocycle reading is then the wave frequency of the received signal.

25. **Shielding of ignition system.**—The airplane ignition system must be carefully shielded to prevent the pick-up of disturbances which cause sounds similar to heavy static. The shielding is to be carried out and maintained in accordance with instructions to be issued by the Air Corps. If great interference is experienced while in the air, the shutting off momentarily of the ignition system by the pilot will determine whether the ignition shielding has become faulty.

26. **Preliminary test.**—The receiving equipment can be tested in the laboratory or after installation in the plane and before leaving the ground. An antenna consisting of a 15-foot length of wire is connected to the radio control box binding post marked "Antenna" or the receiving tuner binding post marked "Control box," in case the radio control box is not used. This small antenna is sufficient for picking up near-by stations and enables the receiving equipment to be tested before flight. If the same station is to be received in the air, the heterodyne scale reading will be very nearly the same as used in the ground test, but, of course, the "Tuner" scale reading will be different because the airplane antenna has much greater capacity than the short wire antenna suggested for the ground test.

Section VII

PRINCIPLES EMBODIED IN RECEIVING EQUIPMENT

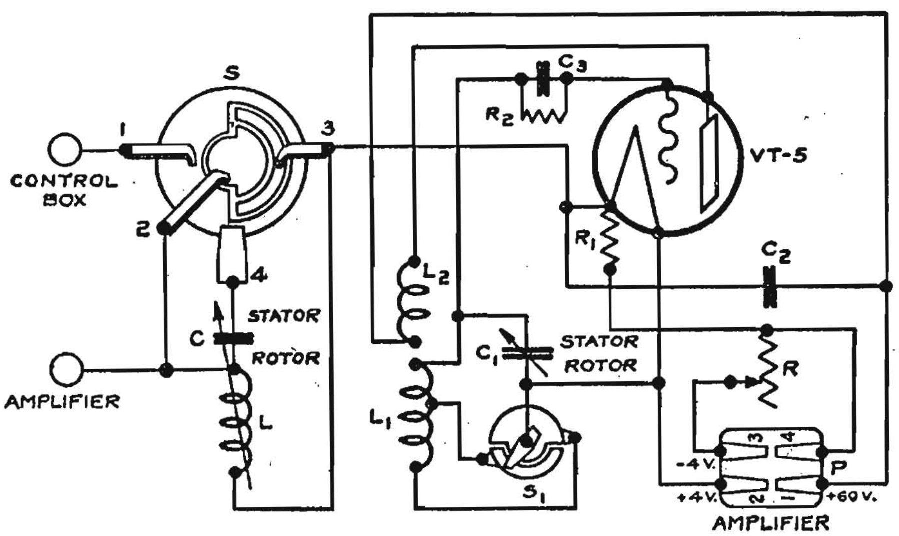
27. **General principles.**—*a.* The radio receiving equipment is of the superheterodyne type. The antenna circuit is tuned to the incoming signal. Loosely coupled with the antenna circuit is an oscillator or separate heterodyne circuit, the frequency of which is adjusted to obtain the desired frequency beat note with the signal frequency. This beat note is not an audio-frequency such as is obtained when a C. W. telegraph signal is heterodyned. Instead, a very high frequency of approximately 66.7 kilocycles (or 4,500 meters) is used. This frequency is selected as permitting the design of a very efficient radio-frequency amplifier. The amplifier operating on a fixed frequency of 66.7 kilocycles is far more efficient than any amplifier which could be designed to amplify directly the very high-signal wave frequencies and covering a wide wave-frequency band. The latter also would be more critical and would require a potentiometer or other means for controlling oscillations set up in the amplifier. The 66.7 kilocycle, or intermediate frequency amplifier is made very sharply resonant, which provides the great selectivity obtained. We have seen that the signal frequency and the heterodyne frequency are combined to provide a beat note corresponding to their difference in frequency, or 66.7 kilocycles. However, all we have done so far is to modulate the signal frequency at the rate of 66.7 kilocycles. This latter frequency is not available to the radio-frequency amplifier until the modulated wave is rectified, the same way ordinary audio-fre-

quency is not available in an ordinary radio receiver until the wave frequency has been passed through the detector tube. Accordingly, the voltage due to the combined frequencies set up across the antenna tuning inductance is impressed upon a detector tube, which is the first tube in the BC–116 amplifier. The 66.7 kilocycle frequency obtained by this rectifying operation is then connected to the input of a three-stage radio-frequency amplifier. Three iron core radio-frequency transformers, C–56, and one air core radio-frequency transformer, C–59, are used in the radio-frequency amplifier. The air core transformer, with the condenser across the secondary, is sharply tuned and determines the resonant frequency of the amplifier. The frequency carried through the amplifier consists of the 66.7 kilocycle radio-frequency and the audio-frequency modulation due to telephone or tone telegraph provided at the radio transmitter, which has persisted through all the transformations so far. In order to obtain the audio-frequency it is necessary to again rectify the signal, so the output of the radio-frequency amplifier connects to a second detector tube. This recovers the audio voice or I. C. W. modulation, which is then passed through either one or two stages of audio-frequency amplification as desired, in order to secure sufficient volume to enable the signal to be heard above the wind and engine noises in the airplane.

b. Quite loud signals are usually required in the air in order to be audible above the engine and wind noises not entirely excluded by the receiver helmet, and the static and other interference picked up by the very sensitive receiving equipment. The receiving equipment is very selective, which causes the elimination of most of the interference from radio sets operating on other wave frequencies. As the receiving equipment does not provide in any way for an audio-frequency beat note with the signal, it is impossible to receive C. W. telegraph signals. The heterodyne calibration does not show the frequency of the oscillator, but does indicate the proper heterodyne adjustment to receive a signal of the wave frequency indicated on the heterodyne scale. The actual heterodyne frequency is 66.7 kilocycles lower than the reading. In practice the heterodyne is adjusted until best signal is obtained through the radio-frequency amplifier. As the amplifier operates at 66.7 kilocycles, this adjustment indicates that a beat note of this frequency is being set up between the signal and the heterodyne.

28. Receiving tuner, BC–115.—The circuit diagram of the receiving tuner is shown in Figure 17. The antenna circuit consists of a variable air condenser and variometer connected on the same shaft so as to turn together. The tuner rotary switch automatically connects the variable inductance and capacity in series for high wave frequencies, and in parallel for lower wave frequencies. The heterodyne oscillator circuit includes a fixed inductance and variable air condenser in the grid circuit. The fixed inductance has a tap used for the higher frequency scale, connected automatically by the heterodyne rotary switch. Fixed coupling is provided with an inductance in the plate circuit. The grid circuit includes a grid leak and condenser so that the radio-frequency oscillations build up a steady negative grid bias to reduce the oscillator plate current. The filament current is limited by means of a fixed resistance of 6.5 ohms, in series with the rheostat which controls all the receiving tubes together. The plate and filament supply for the oscillator is obtained from the amplifier, BC–116, by means of the 4-point socket provided.

CIRCUIT DIAGRAM
RADIO RECEIVING TUNER TYPE BC-115



APPARATUS LEGEND

C - TUNER CONDENSER 600 M.M.F.
C_1 - HETERODYNE CONDENSER 600 M.M.F.
C_2 - FIXED CONDENSER 10000 M.M.F.
C_3 - FIXED CONDENSER 150 M.M.F.
L - TUNER VARIOMETER
L_1 - GRID INDUCTANCE
L_2 - PLATE INDUCTANCE
P - FOUR POINT PLUG SOCKET
R - RHEOSTAT 2ω MAX.
R_1 - FILAMENT RESISTANCE 6.5ω
R_2 - RESISTANCE 100000ω
S - TUNER ROTARY SWITCH
S_1 - HETERODYNE ROTARY SWITCH
VT-5 - VACUUM TUBE

P. - 0-5171

FIGURE 17

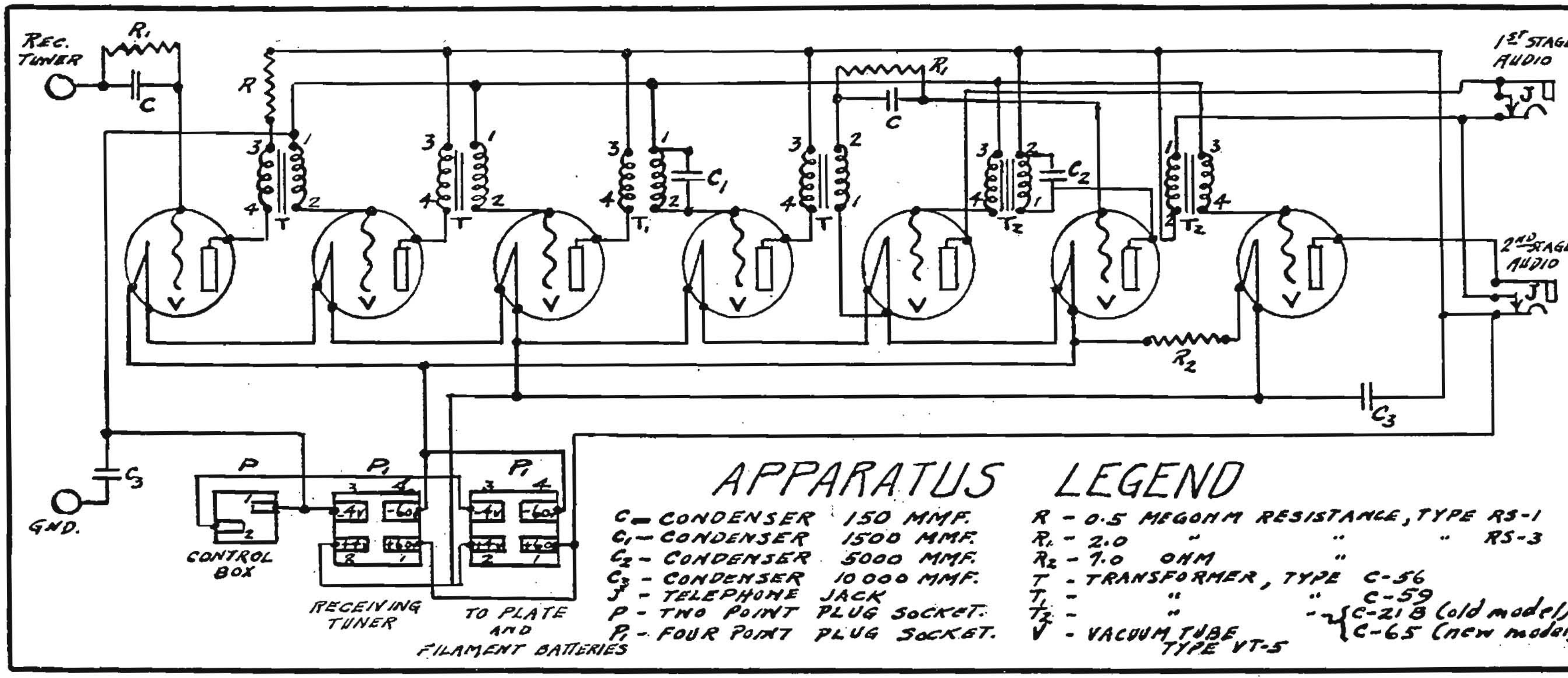


FIGURE 18.—Circuit diagram, radio-audio-frequency amplifier, BC–116

29. **Radio-audio-frequency amplifier, BC–116.**—The circuit diagram of the amplifier is shown in Figure 18. The first tube is a detector tube and has the usual grid leak and condenser in the grid circuit. The detector plate circuit is coupled to the first intermediate frequency amplifier tube by means of iron core radio-frequency transformer, C–56. The detector plate circuit also includes a 0.5 megohm resistance to reduce the plate current to the proper value for a detector tube. The coupling between the third and fourth tubes is by means of an air core radio-frequency transformer, C–59, which has a fixed condenser across the grid winding forming a highly selective tuned circuit. The fifth and sixth tubes (audio amplifier and detector, respectively) are interchanged on the tube shelf from the usual order, so as to make more convenient the filament wiring, which is arranged to provide the proper grid biasing potentials. The fourth tube then has its radio-frequency output connected to the sixth tube which is a detector tube. The detector tube plate circuit includes the primary of an audio-frequency amplifying transformer, with a condenser across the winding to prevent the audio amplifier from howling. The detector tube is connected by means of the transformer to the fifth tube which is used as an audio amplifier. The last tube on the tube shelf is an audio amplifier. Jacks are provided in the plate circuits of the two audio-amplifier tubes so that either one or two stages of audio can be used as desired. A 10,000 m. m. f. condenser provides a by-pass from the common plate circuit bus to the filament, reducing the undesired coupling arising from the use of a common plate battery, and leads. The filament circuits are arranged in a series grouping so as to utilize the voltage drop across successive tubes to provide suitable negative grid biasing voltage for the amplifier tubes.

[A. G. 062.12 (8–7–28).]

By order of the Secretary of War:

C. P. SUMMERALL,
General,
Chief of Staff.

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C. H. BRIDGES,
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The Adjutant General.

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