138

INSTRUCTION BOOK FOR

RADIO SET SCR-AK-183

MANUFACTURED BY

AIRCRAFT RADIO CORPORATION

PRO PATRIA VIGILANS

~~RESTRICTED~~

PUBLISHED BY AUTHORITY
OF
THE CHIEF SIGNAL OFFICER

Order No. 17875-NY-39 Date Jan. 10, 1939

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TABLE OF CONTENTS

INDEX TO ILLUSTRATIONS

A. PHOTOGRAPHS

B. DIAGRAMS

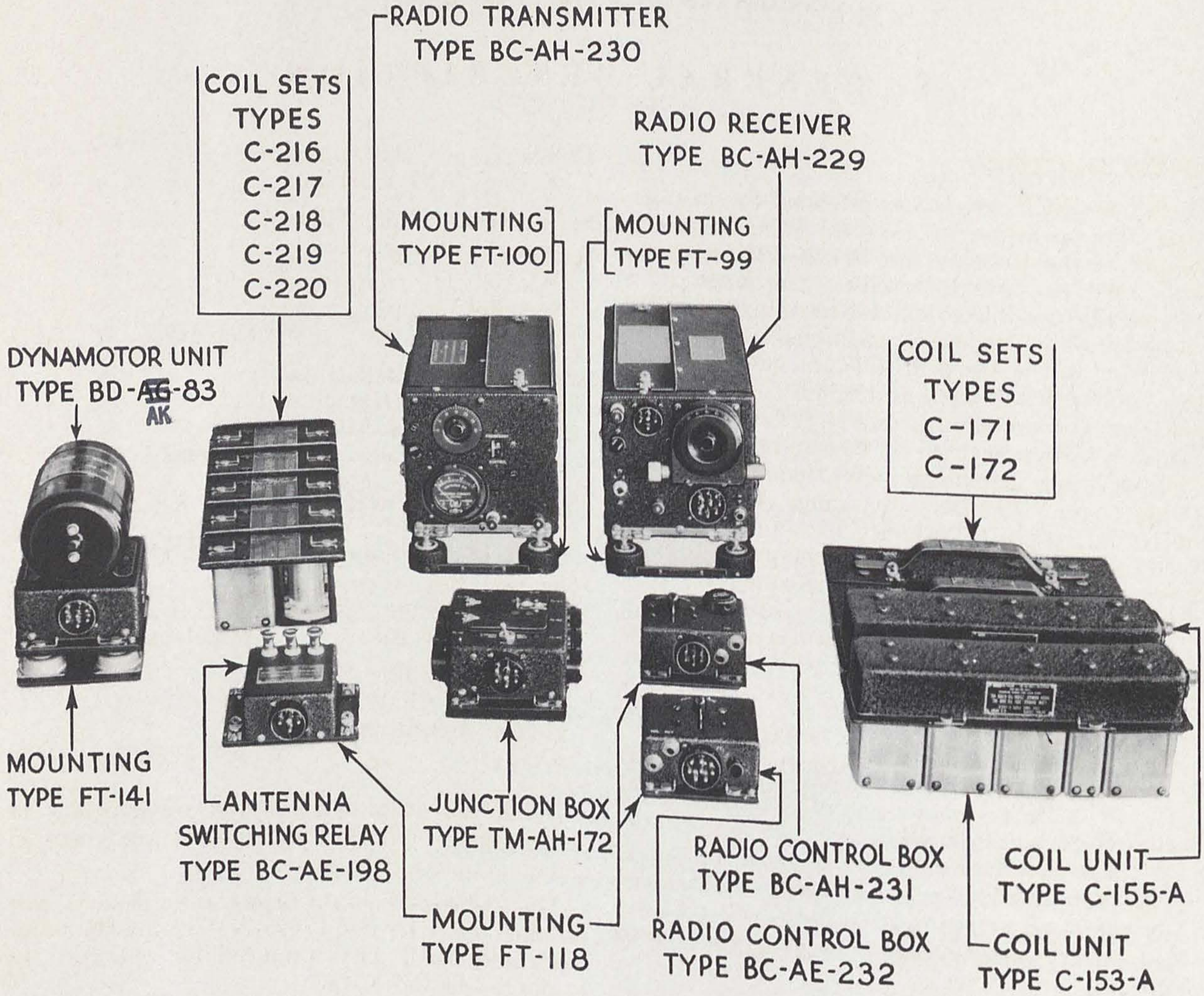

Fig. 1—Principal Components of Radio Set SCR-AK-183

SAFETY NOTICE

OPERATION OF THIS EQUIPMENT INVOLVES THE USE OF HIGH VOLTAGES WHICH ARE DANGEROUS TO LIFE. OPERATING PERSONNEL MUST AT ALL TIMES OBSERVE ALL SAFETY REGULATIONS. DO NOT CHANGE TUBES OR MAKE ADJUSTMENTS INSIDE EQUIPMENT WITH HIGH VOLTAGE SUPPLY ON. UNDER CERTAIN CONDITIONS DANGEROUS POTENTIALS MAY EXIST IN CIRCUITS WITH POWER CONTROLS IN THE OFF POSITION DUE TO CHARGES RETAINED BY CAPACITORS, ETC. TO AVOID CASUALTIES ALWAYS DISCHARGE AND GROUND CIRCUITS PRIOR TO TOUCHING THEM.

Radio Set SCR-AK-183

I. GENERAL DESCRIPTION

INTRODUCTORY

Radio Set SCR-AK-183 is intended for installation and operation in aircraft. The frequency ranges of the Receiver are 201 to 398 kilocycles and 2500 to 7700 kilocycles. (Although it is technically possible to extend the ranges beyond these bands by the use of additional coil sets, the extension of the frequencies is not authorized for this radio set and such additional coil sets have not been procured and cannot be furnished.) The Radio Set may be used to receive modulated or damped-wave signals at any frequency within these ranges. The frequency range of the Transmitter is 2500 to 7700 kilocycles, and it may be used to transmit unmodulated, tone-modulated, or voice-modulated signals at any frequency within this range.

The following component parts were supplied on Order No. 17875-NY-39 as part of the SCR-AK-183:

Item	Outside Dimensions (Inches)	Weight (Pounds)
Radio Receiver, type BC-AH-229(includes Mounting, type FT-99)	$15\frac{11}{16}$x$8\frac{1}{4}$x$7\frac{5}{8}$	12.0
Coil Set, type C-171 (receiving) (2500-4700 kc).	$11\frac{1}{8}$x$4\frac{1}{16}$x$3\frac{1}{2}$	1.75
Coil Unit, type C-155-A (receiving) (Dual, 201-398 kc and 4150-7700 kc)	$11\frac{1}{8}$x$4\frac{3}{4}$x$3\frac{1}{2}$	2.9
Chart, type MC-146-A....		0.1
Dial, type MC-145-A (201-398 kc and 4150-7700 kc)		0.7
Set of Receiving Tubes...		0.5
Radio Transmitter, type BC-AH-230 (includes Mounting, type FT-100)	$13\frac{1}{4}$x$6\frac{5}{8}$x$7\frac{5}{8}$	10.2
Coil Set, type C-216 (transmitting) (2500-3200 kc).		0.9
Coil Set, type C-217 (transmitting) (3200-4000 kc).		0.9
Coil Set, type C-218 (transmitting) (4000-5000 kc).		0.9
Coil Set, type C-219 (transmitting) (5000-6200 kc).		0.9
Coil Set, type C-220 (transmitting) (6200-7700 kc).		0.9
Set of Transmitting Tubes		0.5
Radio Control Box, type BC-AH-231 (receiving) (includes Mounting, type FT-118)	4x$4\frac{5}{8}$x$2\frac{7}{16}$	0.9
Radio Control Box, type BC-AE-232 (transmitting) (includes Mounting, type FT-118)	4x$4\frac{5}{8}$x$2\frac{7}{16}$	0.9
Dynamotor Unit, type BD-AK-83 (includes Mounting, type FT-141)	$7\frac{3}{8}$x$4\frac{3}{8}$x$7\frac{1}{16}$	9.9
*Junction Box, type TM-AH-172(includes Mounting, type FT-101)	$7\frac{3}{8}$x$4\frac{3}{8}$x$2\frac{11}{16}$	2.2
Antenna Switching Relay, type BC-AE-198 (includes Mounting, type FT-118)	4x$4\frac{5}{8}$x$2\frac{3}{4}$	1.1

All of the units listed above are irregular in shape; their significant dimensions are given in the diagrams of Fig. 19.

The following Signal Corps standard parts, not supplied on Order No. 17875-NY-39, are the minimum additional parts required for operation of Radio Set SCR-AK-183:

*Cord, type CD-110 (Junction Box to Battery),

*Cord, type CD-111 (Junction Box to Receiver),

*Cord, type CD-112 (Junction Box to Dynamotor Unit),

*Cord, type CD-113 (Junction Box to Transmitter Control Box),

*Cord, type CD-114 (Junction Box to Transmitter),

*Cord, type CD-137 (Junction Box to Antenna Switching Relay),

*Cord, type CD-304 (Junction Box to Receiver Control Box),

Microphone, type T-17 or Microphone, type T-20-A with Microphone Amplifying Equipment, type RC-19-A,

Headset, type HS-18 or P-20,

NOTES

* *In new aircraft a junction box with rigid conduit connected thereto, is normally built into the aircraft for use instead of Junction Box, type TM-AH-172 and Cords, types CD-110, CD-111, CD-112, CD-113, CD-114, CD-136, CD-137 and CD-304. Such built-in junction boxes are different in design from, but provide the circuits and operation of the TM-AH-172. The built-in conduit has flexible conduit extensions and plugs on the far ends, which are connected into the sockets of the radio receiver, radio transmitter, dynamotor, etc.*

Tuning Unit, type MC-127 (local, for receiver tuning),

Two Control Units, type MC-137 (local, for loop-antenna switch and dual Coil Unit band change switch),

Antenna Wire,

Insulators.

The following parts may be used, if desired, with the equipment listed above:

Case, type CS-44 (individual, for Receiver Coil Set),

Case, type CS-47 (individual, for Transmitter Coil Set),

Control Unit, type MC-135 (remote, for dual Coil Unit band change switch),

*Cord, type CD-136 (Junction Box to remote send-receive switch),

Control Unit, type MC-139 (remote, for loop-antenna switch,

Control Shaft, type MC-134 (for remote operation of dual Coil Unit band change switch),

Cord, type CD-307 (headset extension),

Cord, type CD-308 (for use with key),

Coupling, type MC-136 (for right-angled connection of tuning shaft to Receiver),

Dial, type MC-141 (graduated 0-100 divisions, clockwise),

Dial, type MC-143 (graduated 0-100 divisions, counter-clockwise),

Key, type J-5, J-5-A or J-37,

Plug Jackets, type M-143, M-144, and M-145,

Socket Caps, type M-163 and M-164,

Switchbox, type BC-326 (for night lamp on Tuning Unit, type MC-125-A),

Tuning Shaft, type MC-124 (for remote tuning),

Tuning Unit, type MC-125 or MC-125-A (for remote tuning).

* See footnote on page 5.

II. DETAILED FUNCTIONING OF PARTS

VACUUM TUBES

To assist in the explanation of the operation of Radio Receiver, type BC-AH-229 and Radio Transmitter, type BC-AH-230, the following brief description of the required vacuum tubes is presented.

Tube, type VT-49 is a pentode comprising an indirectly heated cathode, a control grid, a screen grid, a suppressor grid internally connected to the cathode, and a plate. The oxide-coated cathode is heated by a two-terminal "heater" filament. The tube is designed primarily as a radio-frequency amplifier. In operation the control grid is biased negatively by an amount depending upon the amplification desired and the screen grid is maintained at a positive potential of approximately one-half the plate voltage. The control grid terminal is brought out at the top of the glass envelope of the tube. The heater, screen grid, cathode and plate terminals are brought out through five prongs in the tube base. Functionally the tube is characterized by (a) high amplification factor; (b) small variation in plate current with control grid bias at high values of negative bias; (c) high internal plate resistance; (d) low power output.

Tube, type VT-37 is a triode comprising an indirectly heated cathode, a control grid, and a plate. The cathode and heater are the same as those used in Tube, type VT-49. The heater, cathode, control grid and plate terminals are brought out through five prongs in the tube base. In Radio Receiver type BC-AH-229, the grid and plate electrodes are connected externally to serve electrically as a single anode, and the tube is used as a two-electrode detector, without external direct-current voltages on any electrode except those voltages developed by the rectification of amplified radio signals. When used in this manner it presents a single internal resistance of the order of 300,000 ohms to the two terminals through which it is connected to the receiver circuit.

Tube, type VT-38 is a pentode comprising an indirectly heated cathode, a control grid, a screen grid, a suppressor grid, and a plate. The heater and cathode are the same as those used in Tube, type VT-49. It is designed primarily for use as a high-gain audio-frequency amplifier. In operation the control grid is given a permanent negative bias and the screen grid is maintained at a positive potential less than that of the plate. The suppressor grid, which is positioned between the screen grid and the plate, is permanently connected to the cathode inside the tube. The control grid is brought out at the top of the glass envelope. The heater, cathode, screen grid, and plate terminals are brought out through five prongs in the tube base. Functionally the tube presents a compromise between the high amplification with low power output which characterizes a screen grid tetrode, and the relatively low amplification with large power output which characterizes the ordinary triode.

The following table gives the significant constants of typical Tubes, types VT-49 and VT-38 within their operating range, in this Receiver.

	Type VT-49	*Type VT-38*
Heater Voltage	6 .3 v.	6 .3 v.
Heater Current	0 .3 a.	0 .3 a.
Control Grid Voltage	—3 v.	—12 v.
Screen Grid Voltage	90 v.	120 v.
Plate Voltage	180 v.	165 v.
Plate Current	.0045 a.	.01 a.
Amplification Factor	750	100
Plate Resistance	750,000 ohms.	80,000 ohms.

Tube, type VT-52 is a triode comprising a directly heated filament, a control grid, and a plate. It is designed primarily for use as an audio-frequency power amplifier, and is characterized by large filament emission, low amplification factor and low internal plate resistance.

Tube, type VT-25 is a triode comprising a directly heated filament, a control grid, and a plate. It is designed primarily as an oscillator and radio-frequency amplifier, and is characterized by somewhat higher amplification factor and internal plate resistance than Tube, type VT-52. The filament is the same as the filament of Tube, type VT-52 but the plate and grid are spaced differently. It also differs from Tube, type VT-52, which has a bakelite base, in that it is equipped with a ceramic base having low dielectric constant and low dielectric losses at radio frequencies.

The following table gives the significant constants of typical Tubes, types VT-25 and VT-52, within their operating range in this Transmitter.

	Type VT-25	*Type VT-52*
Filament Voltage	7 v.	7 v.
Filament Current	1.2 a.	1.2 a.
Grid Voltage	—20 v.	—40 v.
Plate Voltage	300 v.	300 v.
Plate Current	.025 a.	.035 a.
Amplification Factor	8	3.6
Plate Resistance	4,000 ohms.	1,600 ohms.

RADIO RECEIVER, type BC-AH-229 (Including Mounting, type FT-99) RECEIVER COIL SETS

Radio Receiver, type BC-AH-229 consists of a set-box including the supply and coupling circuits, tube sockets, power terminals, and plug-in coil terminals, required for the reception of radio signals. It is shown together with the Mounting and one Coil Set, in Fig. 2. Internal views of the Receiver with Tubes are shown in Fig. 3 and Fig. 4, and a view of one Coil Set is shown in Fig. 6. The Receiver Circuit is shown in Figs. 5 and 17 and a wiring diagram of the Receiver appears in Fig. 18.

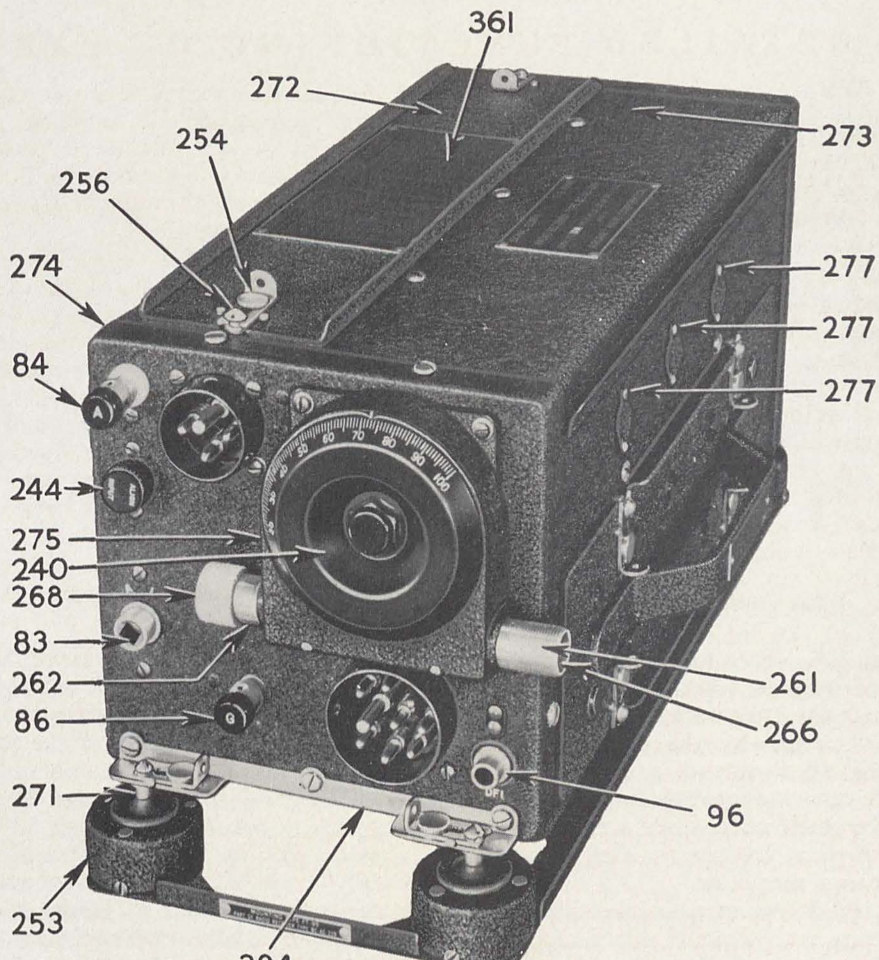

FIG. 2—RADIO RECEIVER, TYPE BC-AH-229 WITH COIL SET AND MOUNTING, TYPE FT-99 IN PLACE

The external dimensions and weight of the Receiver and Mounting are shown in Fig. 19.

The Receiver case 273 is of riveted aluminum having one end blank and the other end open. It has an opening in one side for the Coil Set and a second opening in the top closed by tube cover 272 which allows access to the tubes. The open end of the set-box is closed by a metal panel 274 on which are mounted the antenna binding post 84, loop receptacle 175, ground binding post 86, the input alignment condenser 80, and its adjusting knob 244, the antenna-loop switch 83, and a current jack 96 for use, if desired, with other equipment not a part of this Radio Set, together with the tuning gear unit 275, carrying dial 240, and the power plug receptacle 163. The internal frame or chassis of the Receiver is permanently attached to the front panel 274. The case is attached to the front panel and various other points of the Receiver and forms, together with the front panel, a complete shield closure for the Receiver. Tube cover 272 is secured to the set box by two snap-slides 254. The tube compartment is divided into cells by the tube shields 276 which serve to reduce the capacity coupling between the tuned stages of the radio-frequency amplifier.

Electrically, the Receiver comprises four stages of radio-frequency amplification which amplify at the incoming frequency, a detector and one stage of audio-frequency amplification. The four radio-frequency amplifier stages use Tubes, type VT-49. The detector is a Tube, type VT-37, and the audio amplifier stage uses one Tube, type VT-38. Each of the Coil Sets includes the same essential parts of the radio-frequency amplifier circuit, and except where otherwise noted the following discussion applies to the Receiver when using any one of the Coil Sets.

The four radio-frequency stages are coupled by five coupling circuits, four of which consist of radio-frequency transformer coils 89, 90, tuned by equal sections 58, of the variable gang tuning condenser. The fifth consists of a fixed band-pass coupling circuit which is made up of a coil 93 and a resistor 66, coupled together by a fixed condenser 13. These three elements are included in the band-pass stage of all Coil Sets. The coil assembly (reference No. 92) which is used in Coil Unit, type C-155-A (low) also includes fixed condensers 82 which serve, in cooperation with condenser 13, as a radio voltage divider. The function of the fixed band-pass coupling between the first and second tubes of the radio-frequency amplifier is to equalize the amplification over any frequency band which is covered by rotation of the gang tuning condenser through 180 degrees. All tubes coupled by the tuned transformers 89, 90, amplify considerably more at small values of tuning capacity than at large values of tuning capacity. The band-pass coupling unit is designed for each Coil Set, so that the amplification of the vacuum tube nearest the antenna is greatest at the low-frequency end of each frequency band.

The capacities of the equal sections 58, of the gang condenser, which tune the coupling coils 90

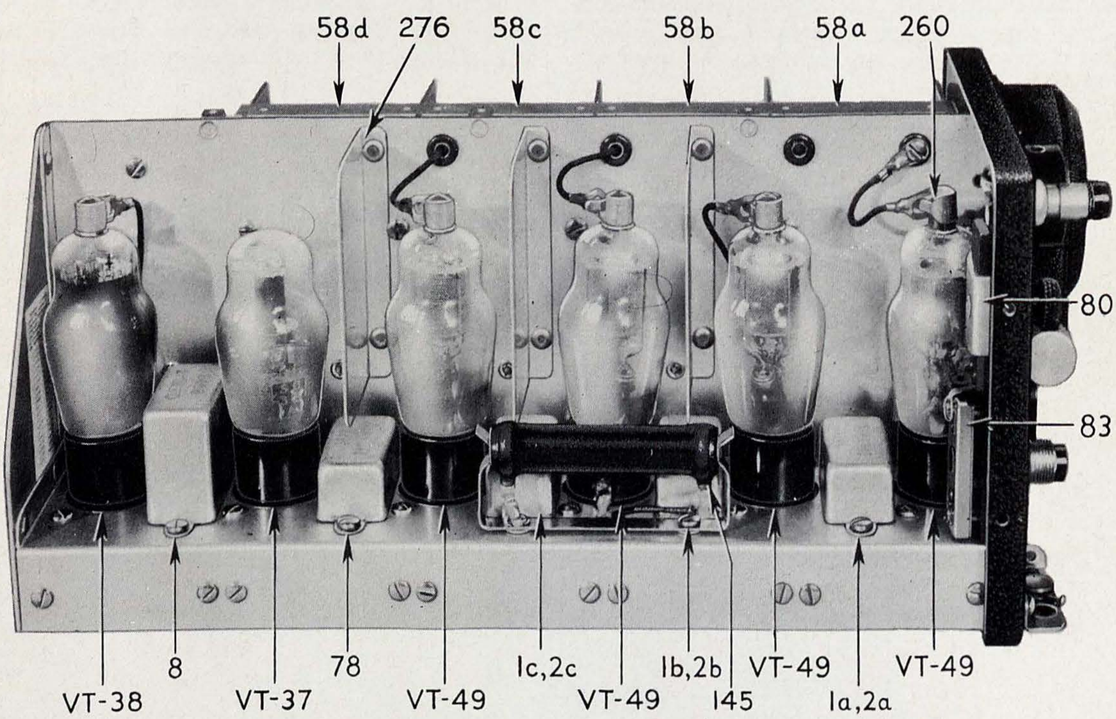

Fig. 3—Radio Receiver, Type BC-AH-229; Side View with Case Removed

to resonance with each other and with the incoming radio signal, are augmented by the aligning condensers 59. These aligning condensers are built into the respective sections of the gang condenser, and are separately adjustable, but not as a Receiver operating adjustment. The function of condensers 59 is two-fold; first to compensate in all frequency bands for slight inequalities in the residual capacity of each stage; second to provide a relatively high capacity in each tuned stage following the antenna stage. The first stage is coupled to the collecting structure through a two-position rotary switch 83. With switch 83 in the "A" position the antenna, connected to terminal 84, is coupled to the input coil through variable series condenser 80, adjustable by knob 244. Condenser 80 is adjustable, for any given receiving antenna, input circuit. The input coil assemblies 89, of Coil Sets, types C-166, C-167, C-168 and C-169, and Coil Units, types C-153-A (low) and C-155-A (low) are designed to operate in this fashion with a loop having an inductance of approximately 0.11 millihenries and a distributed capacity of approximately 100 micromicrofarads. With a loop having approximately these constants connected to terminals 63, 65 through Plug, type PL-77, and a switch in the "L" position, it is possible to find a setting of the input alignment condenser 80 which resonates the input circuit for any frequency within the band defined by the rotation of the gang tuning condenser. It should be borne in mind, when receiving from a loop, that the input section 58a of the gang tuning condenser is the main variable tuning element of the loop circuit, and con-

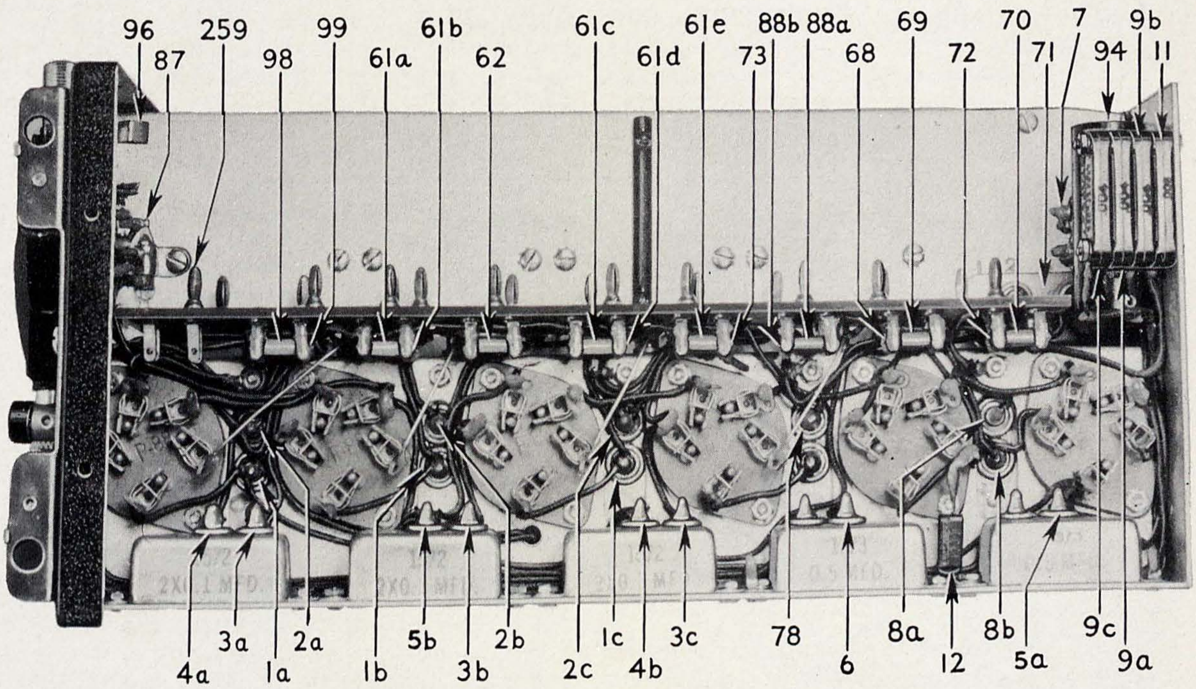

FIG. 4—RADIO RECEIVER, TYPE BC-AH-229; BOTTOM VIEW WITH CASE REMOVED

until the series combination of its capacity with the antenna capacity is equal to the residual or minimum capacity introduced into the remaining tuned stages by condensers 59. When this is done, the four tuned circuits are in resonance at all settings of the gang tuning condenser. Switch 83 is set at the "L" position when it is desired to use an inductive loop or coil aerial as a collecting structure, connected between the two terminals 63, 65. In this position the antenna binding post is grounded by the upper contacts (Fig. 5) of switch 83 and the input alignment condenser 80 is connected in parallel with the first tuned radio coil assembly 89. The loop terminals 63, 65 are connected in parallel with the ungrounded primary of coil assembly 89, which serves to couple the loop into the tuned denser 80 is merely a supplementary control. Resonance in the input circuit is not critical when a loop is used, but it will be found that slight readjustments of condenser 80, as the receiver is tuned throughout a frequency band, may produce slightly stronger received signals. But when using antenna reception, with switch 83 in its "A" position, *no readjustments of condenser 80 is necessary or desirable if it is properly set on installation.* The shaft of the gang condenser is brought out through the front of the Receiver and terminates in dial 240. It is rotated, for tuning to resonance with the incoming signal, by a worm-gear drive, to which coupling is made through outlets 261 and 262.

After successive amplification through the four Tubes, type VT-49, the incoming radio signal is

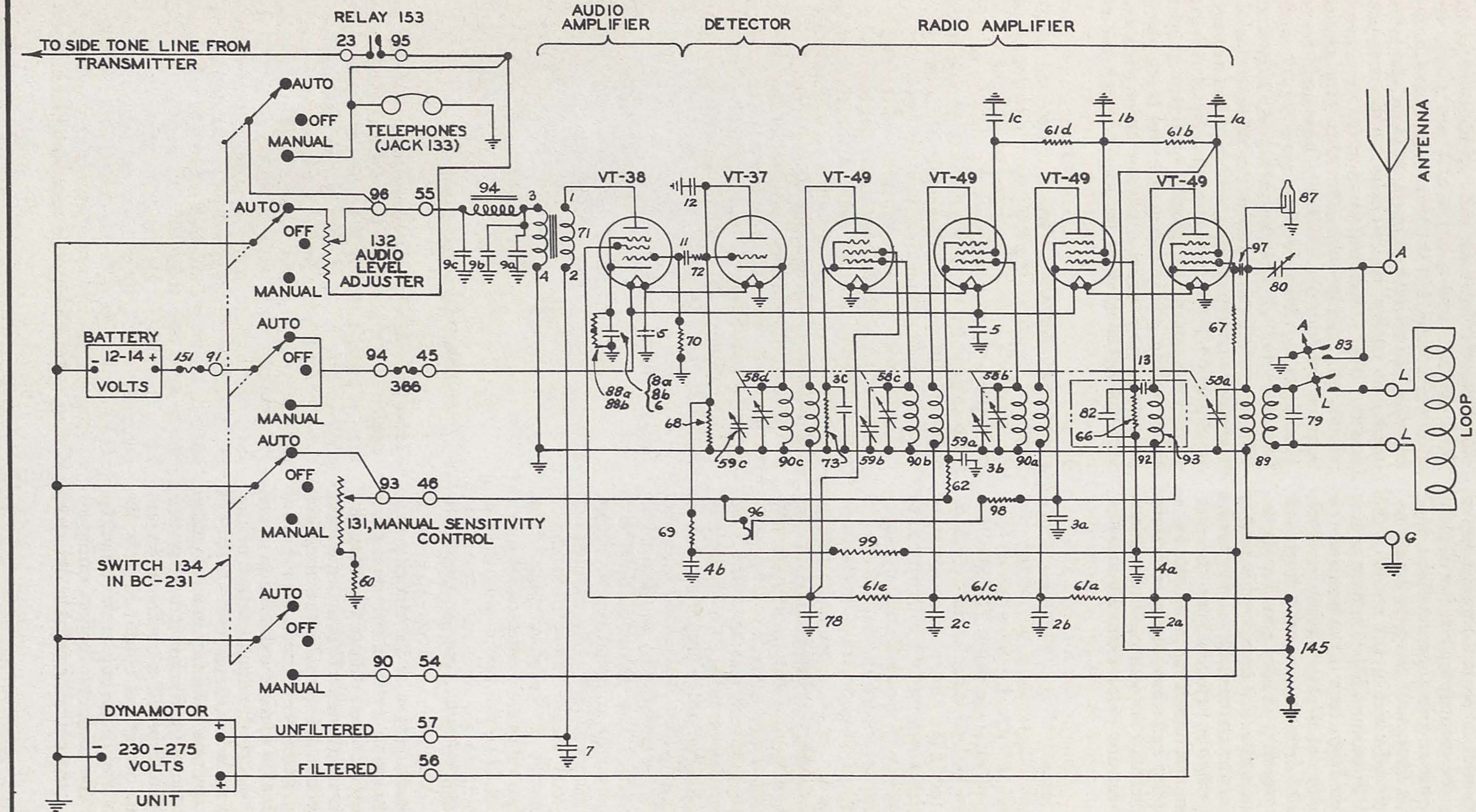

FIG. 5 RADIO RECEIVER TYPE BC-AH-229
FUNCTIONAL CIRCUIT DIAGRAM

impressed through resistor 68 and the last tuned coil 90c, between the cathode and the grid-plate anode of the detector. This tube acts as a two-electrode valve detector and develops across resistor 68 a d-c voltage which is the result of the rectification of the incoming carrier, and an audio-frequency signal voltage which is the result of the rectification of the incoming side (modulation) frequencies. The audio-frequency signal voltages are impressed on the grid of the audio amplifier Tube, type VT-38, through resistor 72 and condenser 11. This tube amplifies the radio signal, which passes from its plate through the primary of transformer 71. A low-pass filter section, comprising choke coil 94 and condensers 9 is connected to the secondary side of transformer 71. The low-pass filter attenuates all audio frequencies above about 3,000 cycles per second; it is included in the circuit to reduce audio "noise" occurring at the higher audio frequencies. Transformer 71 is a stepdown transformer, and the output terminal 55, of the Receiver is connected through the filter to the low-impedance side of this transformer. The Receiver is adapted for use with Headset, type HS-18 or type P-20. Resistor 72 is a filter resistor operating in conjunction with condenser 12 to keep radio-frequency currents out of the audio output stage; resistor 70 is a grid return for the output tube.

A closed-circuit jack 96 is provided on the front panel of the Receiver for connecting a suitable milliammeter into the circuit of two radio amplifier tubes for the measurement of the cathode current.

The sensitivity of the Receiver is controlled by varying the control-grid bias, and hence the radio frequency amplification of either two or three of the type VT-49 radio-frequency amplifying tubes. This is done externally, by a manually operated variable resistor, or internally, by an Automatic Gain Control circuit. The grounded lines and points in Fig. 5 form the common return circuit of all supply and bias voltages. The cathodes of the first three radio tubes are connected for direct current to terminal 46 of the power plug. The grids of the first two tubes are connected for direct current to terminal 54 of the power plug, as well as to a line running to the detector circuit. If terminal 54 is grounded externally at Switch 134 (MAN), thus completing all grid circuits to ground, the external resistance 131 between the cathodes (terminal 46) and ground will limit or control the amplificaton of the first three tubes by making the grids more negative with respect to the cathodes. If terminal 46 is grounded externally at Switch 134 (AUTO) bringing all cathodes to ground, a d-c voltage between terminal 54 and ground will determine the grid bias and hence the amplification of the first two tubes. Such a voltage is developed automatically, when terminal 46 is grounded externally, by rectification of the incoming carrier wave at the detector Tube, type VT-37. This d-c voltage, which appears across the output resistor 68, of the detector, is approximately proportional to the amplitude of the incoming carrier, owing to the characteristics of the two-electrode detector. This voltage is led back through resistors 69 and 99 to the grid circuits of the first two tubes. Resistors 69 and 99 and the two condensers 4 form a low-pass filter which suppresses from this automatic gain control line all of the audio-frequency signal voltage developed by the detector across resistor 68, leaving only a direct-current voltage between the grids of the VT-49 Tubes and ground. This direct-current voltage biases the grids of the first two VT-49 Tubes more and more negatively with respect to their respective cathodes as the incoming signal increases. The radio-frequency amplification is decreased as the radio-frequency signal increases, and the signal output of the Receiver is thus held substantially constant over a wide range of incoming signal strengths. The connections of the control circuits to Switch 134 external to the power plug are such that terminals 46 and 54 cannot be grounded simultaneously; either 54 is grounded, permitting external adjustment of the radio-frequency amplification, or 46 is grounded, permitting internal control of the radio-frequency amplification by the d-c voltages from the detector. The grid bias on the fourth radio amplifier tube, adjacent to the detector, is fixed, being determined by resistor 73.

Terminal 45 of the power plug and receptacle is a positive 12-14.25 volt terminal, and is connected within the Receiver to each of the three series-connected pairs of heaters of the six vacuum tubes. The cathode of the output Tube, type VT-38 is connected through bias resistors 88, bypassed by condensers 8 and 6, to provide for the control grid of this tube a 25-30 volt negative bias with respect to this cathode. A residual negative bias is im-

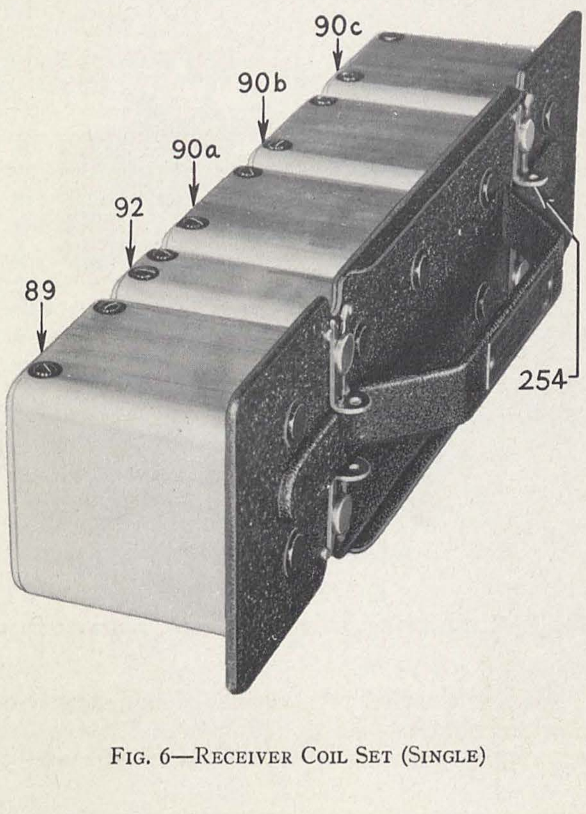

FIG. 6—RECEIVER COIL SET (SINGLE)

parted to the grids of the VT-49 Tubes by including between ground and their cathodes two resistors, 62 and 98. Terminal 47 of the receptacle is left blank in this Receiver. Resistors 61 b, d and condensers 1 a, b, c, are "decoupling" filter elements used to reduce radio-frequency interaction between the several stages. Terminal 56 is a high-voltage terminal supplying the plate circuits of the VT-49 Tubes and the screen of the VT-38 Tube. Resistors 61 a, c, e and condensers 2 a, b, c, 78 are decoupling filter elements. Terminal 57 is a second high-voltage terminal feeding the plate of the VT-38 Tube. Terminal 55 is connected externally to the telephone receivers. The screen grids of the first three VT-49 Tubes are supplied with voltage from a center tap on the voltage-divider resistor 145. The screen grid of the fourth VT-49 Tube is operated at the same voltage as the plate of this Tube.

A two-element gaseous (neon) tube, 87, is permanently connected in parallel with the secondary winding of the first radio-frequency transformer 89 in the antenna stage. This tube is a voltage limiting device designed to protect the amplifier from damage if it is accidently tuned to the frequency of a nearby transmitter. The tube 87 ionizes at a voltage of about 75 volts and a gaseous discharge occurs which effectively short-circuits the input stage of the amplifier, but only so long as the high incoming voltage is present.

Condenser 79 is a small fixed condenser permanently connected across the primary terminals of the first tuned radio-frequency transformer to compensate, in tuning alignment, for the interelectrode tube capacities present across the primaries of all other radio-frequency transformers.

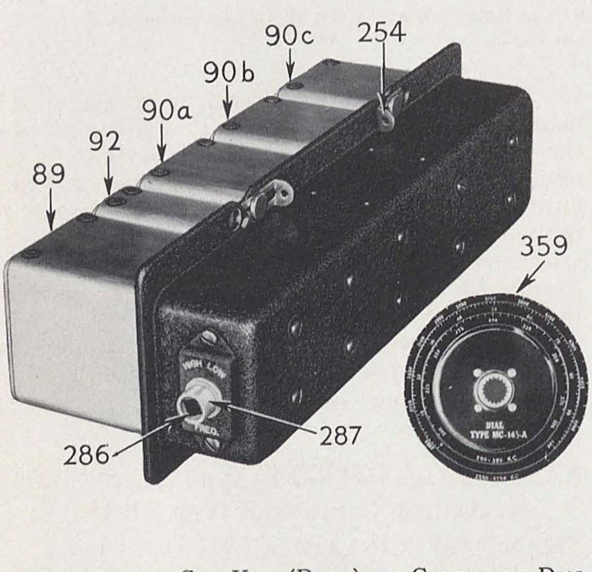

FIG. 7—RECEIVER COIL UNIT (DUAL) AND CALIBRATED DIAL

Each of the Coil Sets consists of an assembly of shielded plug-in radio-frequency transformers (one transformer 89, three transformers 90) and a shielded band-pass coil assembly 92. Each Coil Set is identified by a certain frequency range, which is the range throughout which the Receiver can be continuously tuned, when that Coil Set is mounted in the Receiver. Tuning is accomplished by rotating the tuning condenser between its maximum and minimum positions indicated respectively by the end-points 0 and 100 on the tuning dial 240.

The Receiver dial 240 is graduated in equal divisions from 0 to 100, increasing numbers corresponding to increasing frequency on any Coil Set. Increments in frequency in any band are proportional to increments in dial setting. Coil Sets of all types are plugged into the Receiver at the side, as indicated in Fig. 2, and secured by snap slides 254 at four points.

The Coil Unit C-155-A (Dual) is a combination of two Coil Sets with the necessary built-in switches to shift from one set to the other. The C-155-A Dual Coil Unit is shown in Fig. 7. The high-frequency band of this Coil Unit is 4150-7700 kc and the low-frequency band is 201-398 kc. Each set of coils comprises four tunable radio-frequency transformers, 89, 90, and one band-pass coupling unit, 92. When a Dual Coil Unit is plugged into the Receiver the circuit connections between all coil terminals and the corresponding terminals of the Receiver are, *for both positions of the band-change switch*, exactly the same as shown in Figs. 5 and 17 for a single Coil Set. In Fig. 7 the shaft which controls the band-change switch is shown at 286. In order to operate this switch, and throw it between the "HIGH" and "LOW" bands it is necessary to attach to the outlet 287 either a Control Unit, type MC-137, or Control Shaft, type MC-134 and Control Unit, type MC-135.

Mounting, type FT-99 consists of a metal frame with a shock-proof cup assembly 253 at each corner. Four snapslides on mounting brackets 284 on the Receiver engage the four studs 271 which are molded in the soft rubber of the shock-proof cup assemblies.

Two Charts, type MC-146-A are furnished with each Receiver. One is mounted on the tube cover panel, 272, and the other is left unmounted. These Charts cannot be used to tune the Receiver to an exact predetermined frequency, but are intended merely as a general guide in locating stations on the Receiver Dial.

Similar approximate calibrations are shown on Dial, type MC-145-A. Dial, type MC-145-A is designed to be mounted on Tuning Unit, type MC-125 (remote) for use when Coil Unit, type C-155-A is plugged into the Receiver.

RADIO CONTROL BOX, type BC-AH-231
(Including Mounting, type FT-118)

Radio Control Box, type BC-AH-231 (hereinafter referred to as BC-231) is a small unit carrying a switch, control resistors, and telephone receiver jacks. It is designed for remote control of the electrical power and amplification circuits of the Receiver. It is shown in the photograph, Fig. 1, and a rear view with cover removed is shown in Fig. 8. The circuits of the Control Box are shown schematically in Figs. 5 and 17, a wiring diagram is shown in Fig. 18, and a diagram giving its dimensions and weight appears in Fig. 19. This Control Box carries two manually operated controls: the switch 134 operated by handle 263 and the volume control 131, 132, operated by knob 265. The switch has a center position, "OFF," a side position "MANUAL"; and a second side position, "AUTO." Both the side positions are operating positions. Terminal 95 of receptacle 167 is wired to the tip contacts of the two telephone jacks adapted to

Receiver output, from 96, which is impressed upon the telephone jacks 133. The contact portions of switch 134 consist of a group of spring contacts arranged in pairs, associated with a group of short-circuiting studs. The various pairs of spring contacts are mounted about the circumference of a circle and are fixed with respect to the frame of the BC-231 Control Box. The studs are mounted in a similar circle upon the rotatable member of the switch, and short-circuit the respective pairs of spring contacts as they rest between them. The switch member upon which the studs are mounted is rotated by means of the handle 263. In the schematic circuit diagram, Fig. 17, the rotatable member of the switch is shown as a circle and pointer. The studs, indicated by black circles,

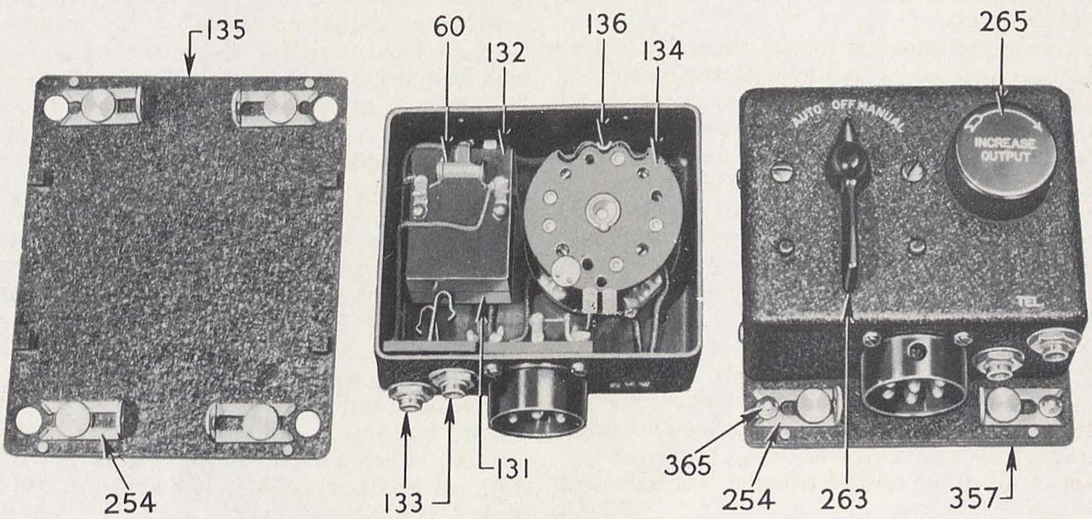

FIG. 8—RADIO CONTROL BOX, TYPE BC-AH-231 WITH BASE REMOVED AND WITH BASE AND MOUNTING, TYPE FT-118 IN PLACE

receive a telephone Plug, type PL-47, PL-55, or equivalent, and also to one fixed terminal of variable resistor 132. Terminal 93 is connected to the switch and to the manual gain-control resistor 131. Terminals 90, 91 and 94 are connected to the switch. Terminal 92 is grounded to the case. Terminal 96 is connected to the sliding contact of resistor 132 and also to the switch. Variable resistor 132 is an audio-frequency level adjuster which is connected between 95 and a section of the switch which grounds the low end of 132 in the "AUTO" position, only. Resistor 60 is connected in series with variable resistor 131 to give a fixed residual bias to the control grids of the first three tubes. Resistors 131 and 132 are varied simultaneously by a single shaft which is rotated by knob 265. This knob is, in both operating positions, a volume control knob controlling the Receiver output. In the "MANUAL" position of the switch it controls the volume by varying the gain of the first three Tubes, type VT-49, of the radio-frequency amplifier. In the AUTO position it controls the volume by varying the fraction of the

are to be considered as rotating with the switch member between each of the three positions, and the contact springs are fixed with respect to the remainder of the diagrams. In the functional diagram, Fig. 5, the connections which are made by the studs and spring contacts are indicated by the arrows marked "Switch 134", which are to be considered as all moving simultaneously between the three switch positions.

Mounting, type FT-118, 357 in Fig. 8, is a base plate having studs 256, to which the Control Box is attached by means of snapslides 254.

RADIO TRANSMITTER, type BC-AH-230 (Including Mounting, type FT-100)

TRANSMITTER COIL SETS

Radio Transmitter, type BC-AH-230 consists of a set-box including the circuits and tuning elements required for the generation, amplification and modulation of radio-frequency currents. It is shown, together with its Mounting in Figs. 1 and

9. Internal views are shown in Figs. 10 and 11. The circuit is shown in Figs. 12 and 17 and the wiring in Fig. 18. The external dimensions and weight are shown in Fig. 19.

The Transmitter case 278 is a riveted aluminum case having an opening in one end for the power plug and the other end entirely open. It has an opening in one side for the Coil Set and a second opening in the top, closed by tube cover 280. The open end of the case is closed by metal panel 279 on which are mounted the antenna and ground binding posts 84, 86, frequency control knob 241, dial 242, antenna condenser knob 243, locking knobs 250, 251, and antenna current ammeter 129. The internal frame or chassis of the Transmitter is permanently attached to panel 279. The case is attached to this panel and various other points of the chassis and forms, together with the panel, a complete shielding closure for the Transmitter. The tube cover 280 is attached to the case by two snap-slides 254.

Electrically the Transmitter comprises a radio-frequency oscillator, a radio-frequency amplifier, a coupling circuit for transferring radio-frequency power from the amplifier to the antenna, and a modulator stage for amplifying either internal or external modulation currents and modulating the radio frequency amplifier therewith. The radio oscillator and radio amplifier are Tubes, type VT-25. The modulators are Tubes, type VT-52. (See Fig. 12.)

The radio oscillator circuit comprises a shielded coil assembly 122 having three windings, a, b and c, variably tuned by condenser 116, which is operated by the frequency control knob 241 and carries dial 242. This control knob drives the condenser shaft through a worm gear. The dial is graduated

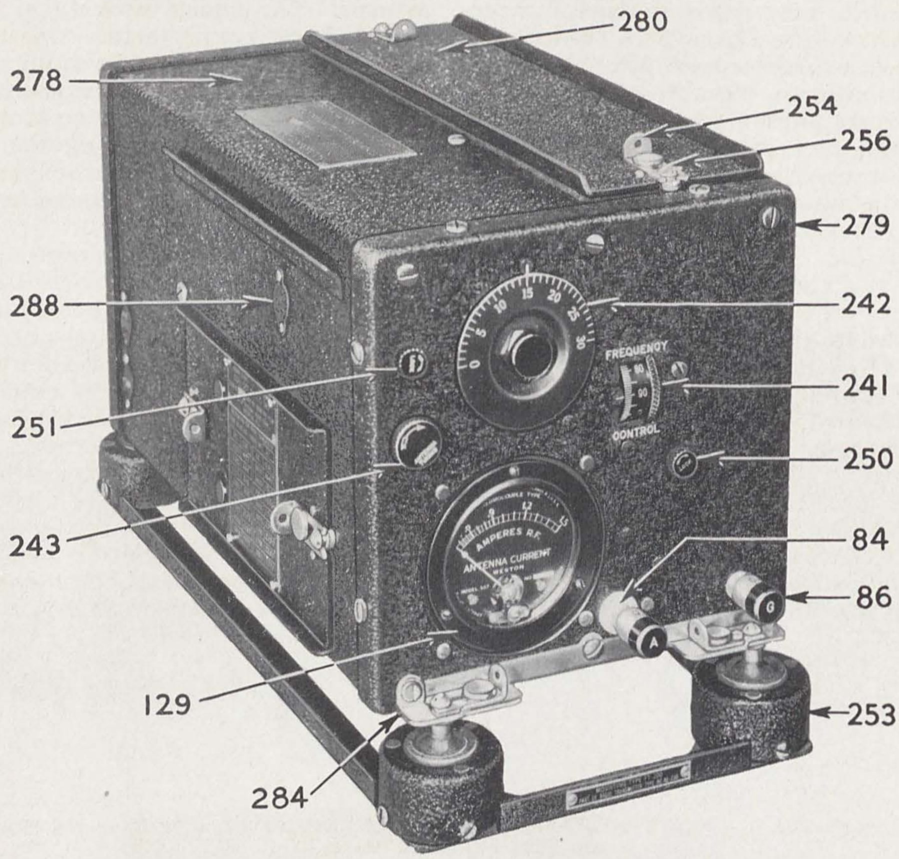

Fig. 9—Radio Transmitter, Type BC-AH-230 with Coil Set and Mounting, Type FT-100 in Place

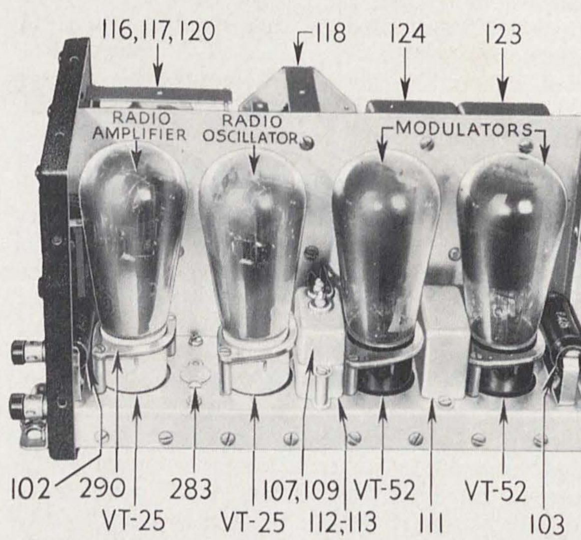

Fig. 10—Radio Transmitter, Type BC-AH-230: Side View with Case Removed

in equal divisions from 0 to 30, each division corresponding to one rotation of the knob 241, which is itself graduated 0 to 100. Condenser 117 is a fixed air condenser connected in shunt with 116 and mounted in the same frame. The oscillator has a grid resistor 105 and a grid condenser 114. Condenser 120 is a small variable air "trimmer" condenser also mounted in the same frame and adjustable with a screw-driver through an aperture under the condenser cover 288. The function of this condenser is to compensate, by small changes in the fixed capacity of the oscillator circuit, for frequency changes introduced when the oscillator or amplifier tubes are changed. The oscillator is coupled to the grid of the amplifier tube through a third coil, c, of assembly 122. Resistor 126 is a small cartridge resistor mounted *inside the shield of coil assembly 122.* Its function is to equalize the amplitude of oscillation throughout the frequency band identified with a particular Coil Set. Grid bias is generated for the VT-25 amplifier Tube and the two VT-52 modulator Tubes by the flow of rectified grid current through resistor 104 bypassed by condenser 113. Condenser 119 is a leaf-type mica condenser used for balancing out the grid-plate capacity of the VT-25 amplifier Tube. The amplifier plate feeds coil b, of shielded coil assembly 121, which is the second element of the Transmitter Coil Set (see Fig. 12). Coil c of assembly 121 is a coupling winding for the balancing condenser 119. In parallel with a portion of the antenna winding, a, is the variable condenser 118, which may be adjusted by knob 243. The capacity of this condenser decreases in the direction of the arrow on the knob. The antenna binding post is connected to the coil through ammeter 129 by the adjustable tap 130. 110 is a bypass condenser, comprising two series sections, 110a and 110b. The plate of the radio amplifier tube may be supplied with d-c voltage through the winding 3-4 of modulation transformer 124 by external connection between terminal 20 and terminal 22. This connection is made when control switch 141 is set on "VOICE" or "TONE". It may be supplied with d-c voltage direct from the high-voltage terminal 21, without including in its plate circuit a winding of the modulation transformer, by external connection of 20 to 21. This connection is appropriate for the transmission of CW signals and is made when control switch 141 is set on CW. Resistor 103 is merely a load resistor for the secondary windings 3-4 of the modulation transformer 124. When 20 is externally connected to 21 for the transmission of unmodulated CW signals, resistor 103 is by this connection shunted across the modulation transformer, and the power and side-tone levels in the Transmitter are thereby maintained undisturbed. The radio oscillator is supplied with d-c plate voltage by permanent connection of its plate circuit through the drop resistor 102 to terminal 21. 112 is a bypass condenser. The two modulator tubes, type VT-52 are

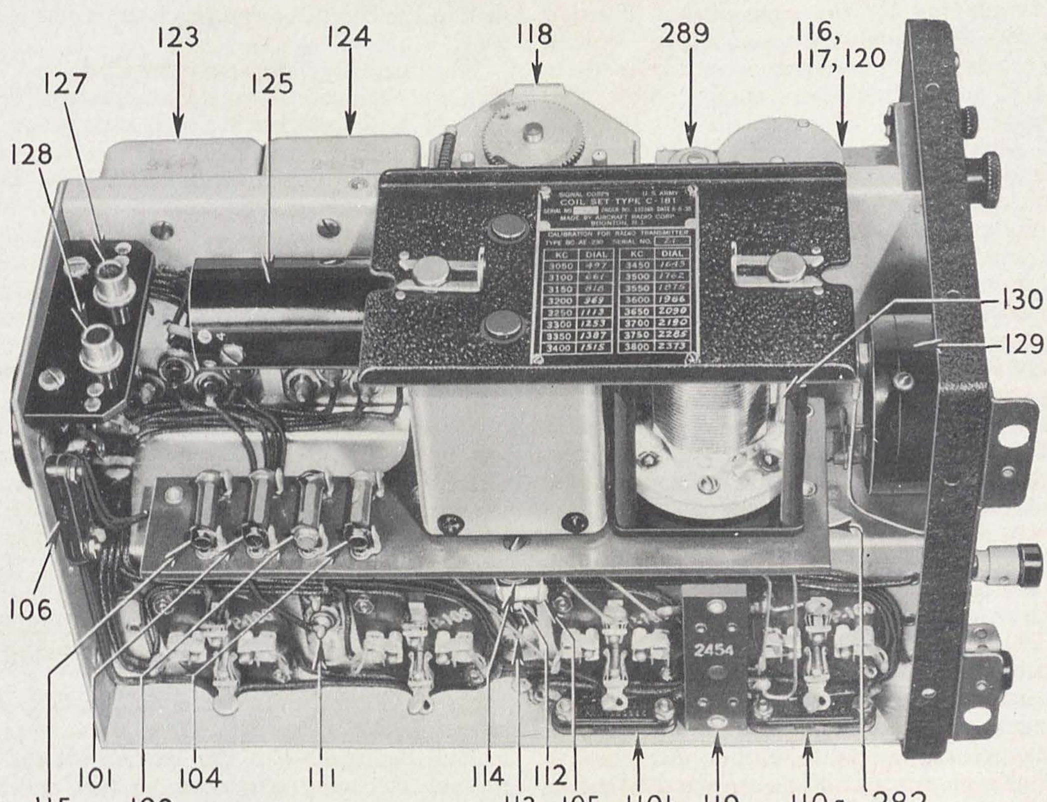

FIG. 11—RADIO TRANSMITTER, TYPE BC-AH-230; BOTTOM VIEW WITH CASE REMOVED AND COIL SET IN PLACE

connected in parallel to modulate by plate-voltage variation the single VT-25 radio amplifier tube. 125 is a tone oscillator coil assembly and 123 is the microphone or modulator-grid transformer. The modulators obtain plate voltage, through windings 3-4 of 125 and 1-2 of 124, from terminal 21. Grid bias is obtained for the modulators by the connection of their grid circuit through the filter resistor 100 to the d-c negative side of resistor 104. External modulating (microphone) currents are brought into the Transmitter from terminal 33 through winding 1-2 of transformer 123, the secondary, 3-4, of which feeds the modulator grid circuit. The function of the top section of control switch 141 shown in Fig. 12 is to short-circuit the microphone in the "CW" and "TONE" positions. 34 is a positive 12-14.25 volt terminal so that when the microphone is connected externally between 33 and ground it obtains a d-c polarizing potential of 12-14.25 volts through the small drop resistor 101. Any audio frequency currents in the modulator grid circuit are amplified and transmitted to the plate circuit of the radio amplifier tube through the modulation transformer 124. These modulating currents also flow through winding 3-4 of the tone oscillator coils 125. Terminal 32 is a short-circuiting terminal for the tone oscillator coil assembly, which is effectively removed from the circuit if terminal 32 is grounded externally. If terminal 33 is grounded externally no external modulation currents can reach the radio amplifier. When this external connection is made the Transmitter is adapted for the transmission of either tone-modulated signals or unmodulated signals. In this condition the modulators may be made to oscillate at a tone frequency (about 1,000 cycles) by *opening* terminal 32 externally ("CW" and "TONE" positions of switch 141). This tone oscillation is generated as follows: winding 3-4, of tone oscillator coil 125, is connected in the plate circuit of the modulators. Winding 1-2 is coupled in the correct sense to 3-4 to produce self oscillation if terminal 2 is connected to the modulator grids. This connection is effectively made by condenser 106. Transformer 123 has no function when the modulators are set for tone-oscillation, and it is effectively removed from the circuit by: (a) short-circuiting the primary 1-2 by grounding terminal 33 externally; (b) the provision of resistor 115 across the secondary 3-4 of 123. This resistor is small enough to allow the grids to be adequately excited for self oscillation through condenser 106, but sufficiently large so that it does not hinder the operation of 123 as a microphone transformer. The modulators are allowed to oscillate, as described, when switch 141 is set on either "CW" or "TONE". For tone transmission the secondary 3-4 of the modulation transformer is connected in the plate circuit of the radio amplifier tube through the external connection of terminal 20 to terminal 22. For CW transmission terminal 22 is left open and 20 is connected direct to the high-voltage terminal 21, thus cutting the modulation transformer out of this radio amplifier circuit. A low-impedance tertiary winding on transformer 124, connected between ground and terminal 23, supplies side-tone to the external circuits. It has a high tap 7 and a low tap 6, giving a choice between two levels of side-tone. If a telephone circuit is externally connected between 23 and ground it will receive audio voltage corresponding to any audio current flowing in the plate circuit of the modulators, regardless of whether this current is produced by external voice modulation or internal tone oscillation. In virtue of the fact that the modulators may be allowed to oscillate, when transmitting CW signals, as described above, a tone-frequency side-tone is supplied to terminal 23 during CW transmission. 109 is a bypass condenser and 111 is a filter condenser of high capacity. The function of 111, working in conjunction with drop resistor 101, is to filter from the microphone line (terminal 33) any ripple voltage which may be present in the 12-14.25 volt source connected to terminal 34. The filaments of all four tubes are so connected between 34 and ground that the parallel modulator tubes both operate at the same bias with respect to their filaments. A section of switch 134 (Receiver Control Box) is shown in Fig. 12 because this particular section makes and breaks the circuit between the Transmitter filament terminals 34 and the primary 12-14 volt source. All other switches shown in Fig. 12 are sections of switch 141 in the Transmitter Control Box. 127 is a closed-circuit jack in the common d-c plate circuits of the modulator and radio oscillator tubes. 128 is a closed-circuit jack in the d-c plate circuit of the radio amplifier tube.

The operating frequency band of the Transmitter is determined by the transmitter Coil Set. Each of these Coil Sets is a demountable unit similar in function to the Receiver Coil Sets, and attached in the Transmitter by snapslides. The Coil Set includes the oscillator coil assembly 122 and an antenna coil assembly 121. The antenna coil assembly is connected to the antenna through an adjustable slide tap 130. The frequency calibration for each Coil Set is shown on a plate mounted on the Coil Set. *The calibration for each Coil Set applies only to the Transmitter bearing the same serial number as that Coil Set.*

Mounting, type FT-100 is similar to the Mounting, type FT-99 for the Receiver, except that the dimensions of the frame are different. It is provided with shock-proof mounting cups 253 having snapslide studs to which the Transmitter is secured by four snapslides on mounting brackets 284.

RADIO CONTROL BOX, type BC-AE-232 (Including Mounting, type FT-118)

Radio Control Box, type BC-AE-232 (hereinafter referred to as BC-232) is a small unit primarily identified with the control of the Transmitter. It carries a selector switch, a telegraph key, and a jack for use in modulating the Transmitter from a microphone or other external source. It is shown in Figs. 1 and 13, the circuit is shown

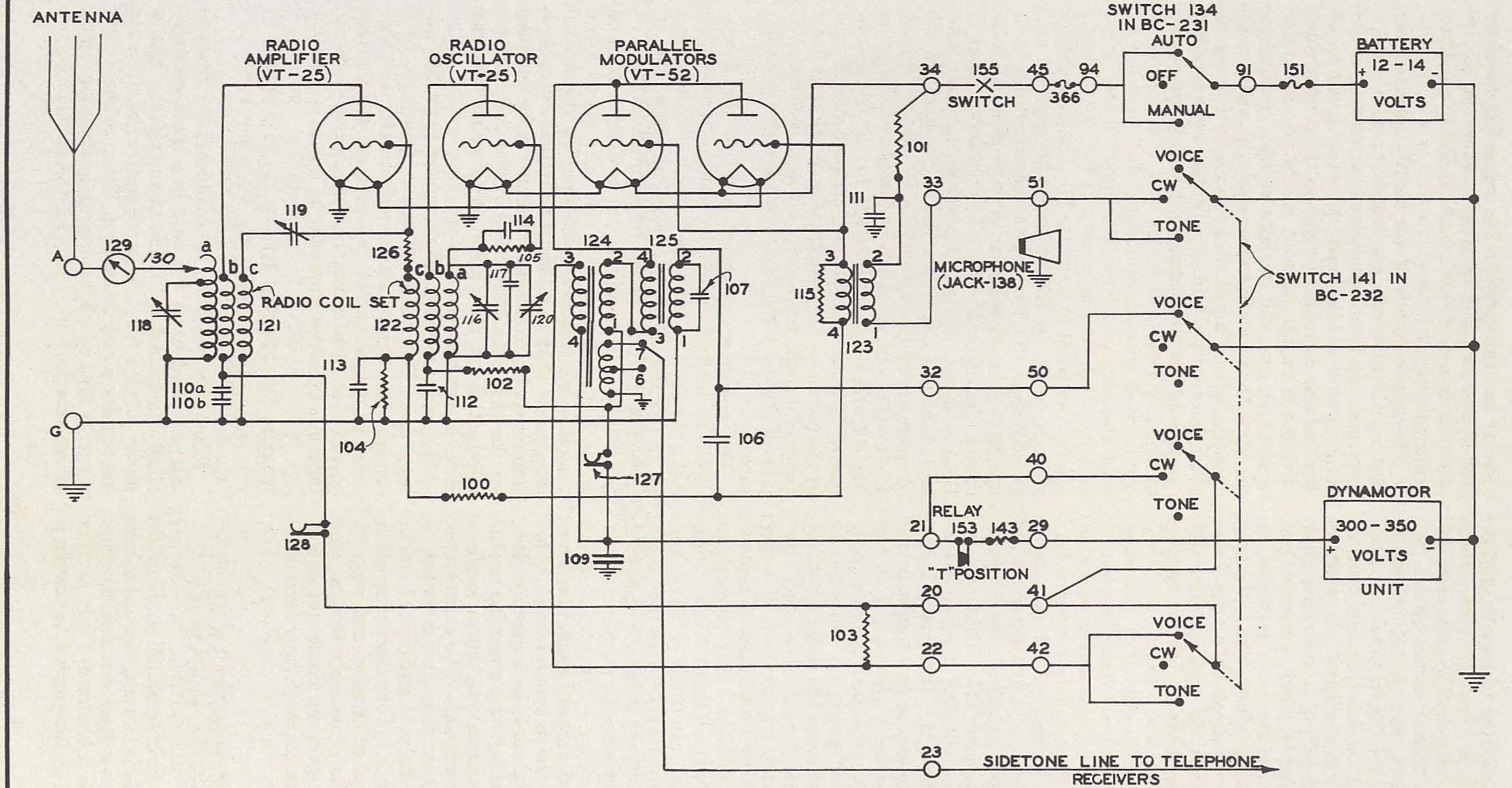

FIG. 12 RADIO TRANSMITTER TYPE BC-AH-230
FUNCTIONAL CIRCUIT DIAGRAM

in Figs. 12 and 17, the wiring in Fig. 18, and the dimensions and weight in Fig. 19. This Control Box carries besides the telegraph key one manually operated control, the three-position switch 141, operated by handle 263. Switch 141 selects the type of emission from the Transmitter. It has a center position "CW," a side position "TONE," and a second side position "VOICE." Terminal 51 of the plug receptacle is wired to the ring contact of the microphone jack 138, which accommodates a Plug, type PL-68 or equivalent. The sleeve contact of the jack 138 is grounded. The tip contact is connected through terminal 48 to the power relay 153 and the Antenna Switching Relay. The telegraph key 139 also closes the circuit between terminal 48 and ground. Adjusting screw 142 may be used to adjust the spacing between the key contacts. It may also be used to lock the key closed for test purposes. Terminal 52 is grounded and the remaining terminals are connected to various contact springs of the switch 141. The construction and operation of this switch is similar to that of switch 134 in the BC-231 Control Box, in which the short-circuiting studs are mounted on a member rotated by the switch handle, and stop between the various pairs of spring contacts. Jack 140 is an extra two-way outlet connected in parallel with key 139, for use with an external key if desired.

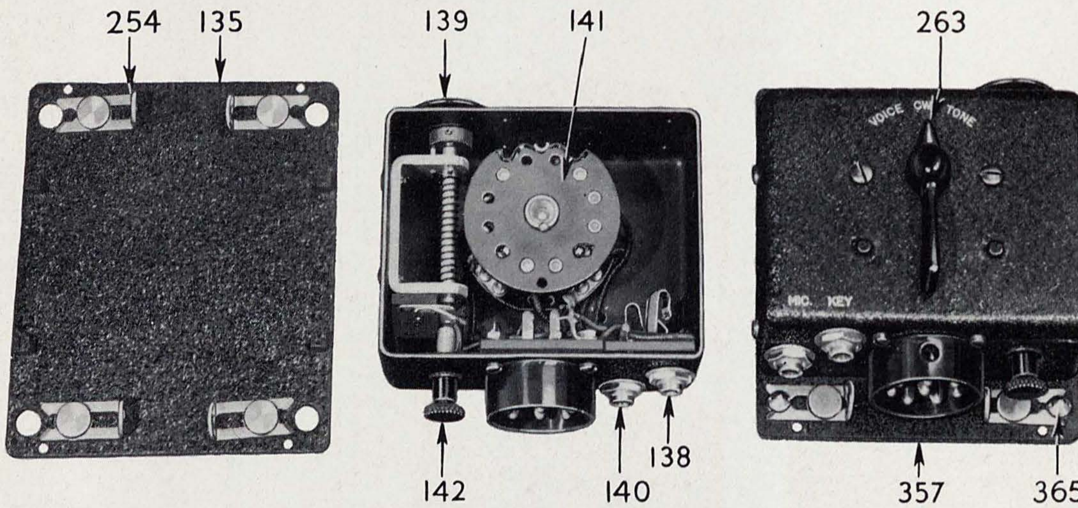

FIG. 13—RADIO CONTROL BOX, TYPE BC-AE-232 WITH BASE REMOVED AND WITH BASE AND MOUNTING, TYPE FT-118 IN PLACE

DYNAMOTOR UNIT, type BD-AK-83 (Including Mounting, type FT-141)

Dynamotor Unit, type BD-AK-83 consists of a dynamotor proper mounted on a box containing a filter circuit and a series resistor. A photograph of the Dynamotor Unit is shown in Fig. 1, and an interior view in Fig. 14. The circuit is shown in Fig. 17 and the wiring in Fig. 18; a diagram showing dimensions and weights is shown in Fig. 19, and a diagram of the various details of the dynamotor in Fig. 21.

The dynamotor is of the totally enclosed type having a low-voltage commutator and brushes at one end, with a high-voltage commutator and brushes at the other end. Current is fed to the low-voltage commutator and to the common field winding from the 12-14.25 volt d-c source. Current is drawn from the high-voltage commutator at 300-375 volts, depending upon the value of the applied low voltage. Four leads pass from the machine into the box, two serving as low-voltage input leads to the machine and two as high-voltage output leads from the machine. Terminal 38 of the power plug is a positive 12-14.25 volt supply terminal, and is wired through radio-frequency choke 149 to the low-voltage commutator. Choke 149, and the condenser section 147a shunted across this commutator form a radio filter section to suppress radio-frequency disturbances from this supply line. The high-voltage commutator feeds terminal 31 through filter resistor 146; the high-voltage output is also led through the low-pass audio filter section comprising iron-core choke 148 and two condenser sections 147, b, c, to terminal 29. When terminal 29 is externally connected to terminal 30, the drop resistor 152 is in series with the high-voltage output 39. Three condensers 147 are mounted together in one metal case.

Mounting, type FT-141, is a shock-proofed base plate having studs 365 to which the Dynamotor Unit is attached by means of snapslides. The interior of the Unit is protected, when it is not attached to the Mounting, by a sub-base 246, type M-158, which is screwed to the filter box at three points.

JUNCTION BOX, type TM-AH-172 (Including Mounting, type FT-101)

This unit is a central inter-connecting element for all circuits of the Radio Set. It consists of an assembly of receptacles for the Plugs of Cords, types CD-136, CD-137, CD-110, CD-111, CD-112, CD-113, CD-114, CD-304, a fuse block, a relay, one resistor, a condenser and a toggle switch, all mounted in a housing which is attached to Mounting, type FT-101, by means of snapslides. It is shown in Figs. 1 and 15, the circuit is shown in Fig. 17, the wiring in Fig. 18, and the dimensions and weight in Fig. 19.

The base 245 is a metal plate or cover which is attached to the Junction Box by means of three screws to form a protecting closure for the wiring when the Junction Box is not attached to its base. Receptacle plates 159, 161, 163, 165, 167, 169, 171, 174, 175, are parts of sockets adapted to receive the following Plugs: PL-56, PL-60, PL-61, PL-62, PL-104, PL-64, PL-63, PL-76, PL-77. The contacting members of these receptacles and all others in the equipment consist of Pin Plugs 259. The various receptacles and terminals are wired together inside the Junction Box as indicated on the circuit and wiring diagrams. Fuse 151 is a 50-ampere cartridge fuse. It is connected between terminals 44 and 91, in series with the positive 12-14.25 volt supply line. Fuse 366 is a 10-ampere fuse connected between terminal 94 and the filament circuits, only, of the Receiver and Transmitter. It does not carry the dynamotor supply current. Two spare fuses are mounted in clips inside the case. The switch 155 is a toggle switch having two positions: "REC–TRANS" and "REC-ONLY." In the "REC-TRANS" position, which is appropriate for use in Radio Set SCR-AK-183, the filaments of the transmitting tubes are turned on when the receiving tube filaments are on.

Relay 153, mounted in the Junction Box, is a power throwover relay for shifting the high-voltage output of the Dynamotor Unit between the Receiver and the Transmitter. It is a two-position relay operated by opening and closing either key 139 in the BC-232, a microphone switch connected to the tip of jack 138, or a Transmitter remote control switch such as Switch, type SW-108 (not supplied as a part of this Radio Set), at the remote end of Cord, type CD-136. In the "Transmit" position of the relay (remote switch or key closed) the high-voltage dynamotor terminal 29 is connected to terminal 21 of the Transmitter and 40 of the BC-232, but not to the Receiver. In the "Receive" position of the relay (remote switch open) the filtered high-voltage supply terminal 29 is disconnected from the transmitting units and connected to terminal 56 of the Receiver. Resistor 143, mounted in the Junction Box is a damping resistor to reduce the sparking at the relay. A second pair of relay contacts open the side-tone line between 23 and 95 in the "Receive" position to prevent loss of received signal in the side-tone winding of the modulation transformer 124. Condenser 9d is a filter condenser connected across the telephone receiver line. The receptacle for Plug, type PL-77 is wired to connect, through

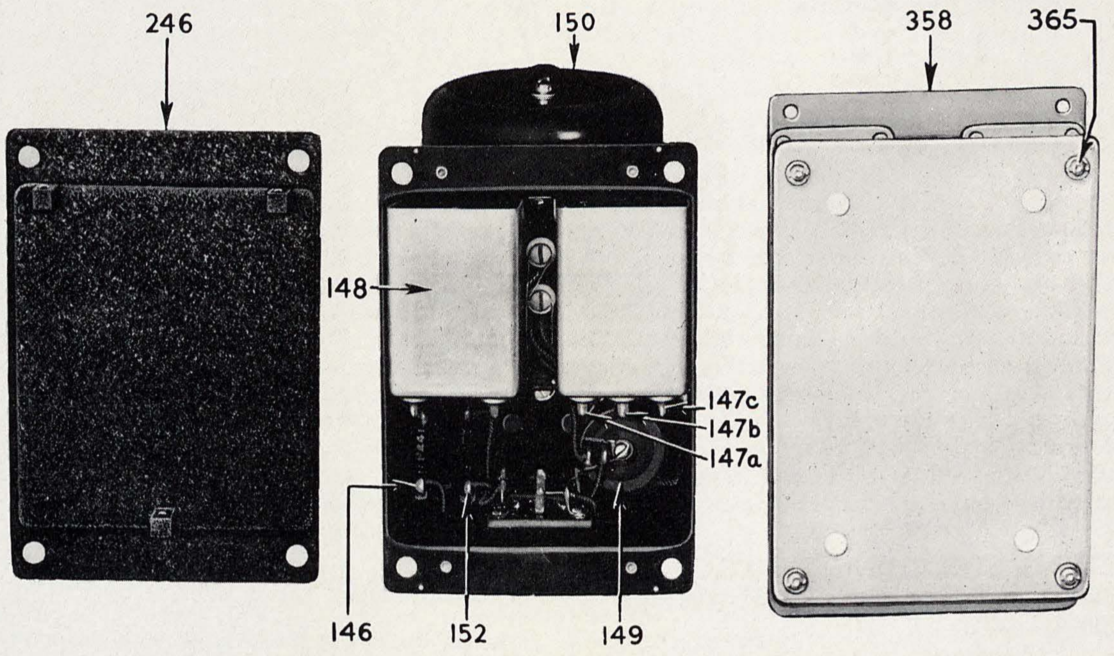

FIG. 14—DYNAMOTOR UNIT, TYPE BD-AK-83 WITH SUB-BASE, TYPE M-158 AND MOUNTING, TYPE FT-141 DETACHED

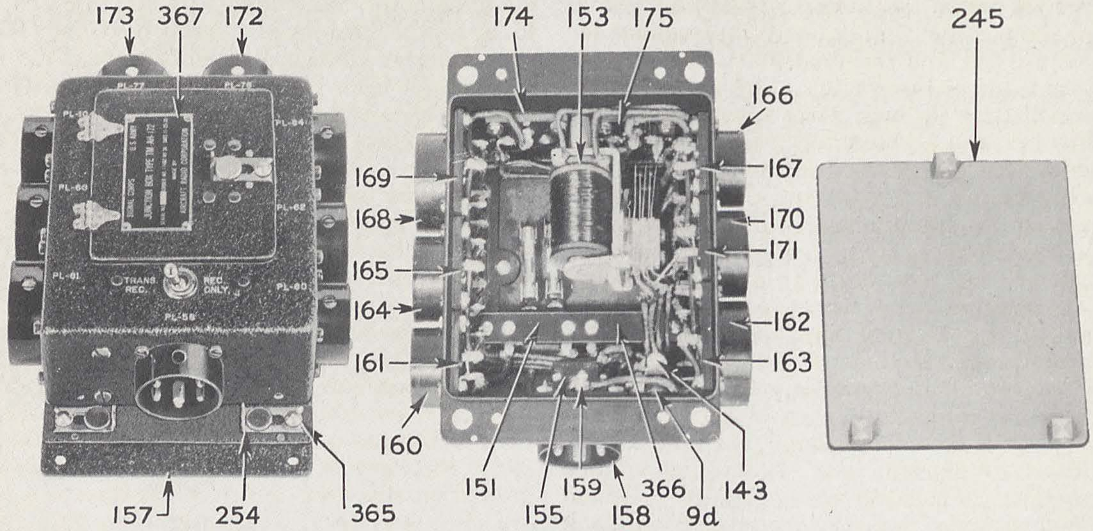

Fig. 15—Junction Box, Type TM-AH-172 with Base and Mounting, Type FT-101 in Place and with Base Removed

Cord, type CD-137, the coil of the Antenna Switching Relay in parallel with the coil of the power relay 153. The receptacle for Plug, type PL-76 merely provides another outlet for the relay control line connected to the various keys and to the microphone tip contact in the BC-232. The remaining receptacles and terminals are wired together inside the Junction Box as indicated in the circuit and wiring diagrams.

Mounting, type FT-101 is a flat mounting plate provided with studs to which the Junction Box is attached by means of snapslides.

ANTENNA SWITCHING RELAY, type BC-AE-198 (Including Mounting, type FT-118)

Antenna Switching Relay, type BC-AE-198 is shown in Figs. 1 and 16. Both the circuit and the actual wiring are shown in the schematic diagram, Fig. 17, and the wiring is further indicated in Fig. 16. The installation dimensions are shown in Fig. 19. It is a disposable unit containing a two-position relay, an antenna binding post, and two binding posts for connection to the antenna terminals of Receiver and Transmitter respectively. It also carries a receptacle for Plug, type PL-77. Its function is to switch a common antenna between Receiver and Transmitter in installations where one antenna is used for both receiving and transmitting. The antenna binding post is connected to the movable contact of one relay element (see Fig. 17). When the relay is non-energized this movable contact rests on a fixed contact which is connected to the "REC" binding post. When the relay is energized this movable contact is brought to a second fixed contact which is connected to the "TR" binding post. In addition the relay has an independent pair of contacts which are open in the non-energized (REC) position and which ground the Receiver binding post in the energized ("TRANS") position. The coil of the relay is connected through Cord, type CD-137, across the coil of the power relay 153 in the Junction Box so that both relays are energized simultaneously by the key on the BC-232, the microphone switch, or the remote switch. The changeover between Receiver and Transmitter thus causes the power relay 153 and the BC-198 relay to perform simultaneously the respective functions of switching the dynamotor voltage between the Receiver and Transmitter and switching the antenna between Receiver and Transmitter.

COOPERATION OF UNITS

In an operating installation where the various units are connected through Cords to the Junction Box and the 12-14.25 volt source as indicated in Fig. 20, to form a complete Radio Set SCR-AK-183, the circuits of the whole system are interconnected as shown in Fig. 17. Each terminal in the Junction Box is connected through a Cord to the terminal bearing the same number on one of the operating units; each of the numbered dots in Fig. 17, except 43 and 44, refers to two correspondingly numbered terminals, one on the Junction Box and one on an operating unit. The numbered circles in the functional diagrams, Figs. 5 and 12, represent the same correspondingly numbered terminals. The following discussion may be read in connection either with the functional diagrams, Figs. 5 and 12, or the complete schematic, Fig. 17.

Switch 155 in the Junction Box completes the 12-14.25 volt supply line from the BC-231 to both Receiver and Transmitter in the "REC-TRANS" position and cuts off this line to the Transmitter for the purpose of saving power, in the "REC ONLY" position.

Current is drawn from the 12-14.25 volt source through the positive supply line from terminal 44, through fuse 151 and terminal 91 to the BC-231. When the Control Box switch 134 is in the "OFF" position this line through 91 is open and there is no voltage on the Dynamotor Unit, Transmitter, or Receiver for any position of the other controls. With this switch at "MANUAL" or "AUTO" high voltage from the Dynamotor Unit, at terminal 29 may be impressed upon either the Receiver or the Transmitter (but not both at once) depending upon the position of the Junction Box relay 153. The coil of this relay is supplied with 12-14.25 volts from terminal 45, and the circuit is completed to ground independently through each of three manual controls. When this circuit from the relay coil is closed to ground, the relay armature throws to the right (Fig. 17) and high voltage from terminal 29 is led to the Transmitter. When this circuit is open, the relay armature drops back and the high voltage terminal 29 is connected through drop resistor 152 to the Receiver, terminal 56; at the same time a second pair of relay terminals disconnect the low-impedance side-tone winding from across the telephone receivers in the BC-231. For remote switch control of this throw-over operation, Cord, type CD-136, should be plugged into receptacle 172 and the other end of this Cord terminated in a suitable airplane switch (not a part of SCR-AK-183 equipment). The same operation is performed by operating a michrophone switch connected between ground and the tip contact of jack 138 or by operating the telegraph key.

Terminal 57, feeding the plate of the type VT-38 Tube, is energized at all times from terminal 31 of the dynamotor.

When relay 153 is in the "Receive" position the circuits of the Receiver are controlled as follows. With BC-231 switch at "Manual" the supply voltage is impressed through terminals 91, 94, 38 upon the dynamotor, and through 91, 94, fuse 366, and 45 upon the heaters of all the receiving Tubes. The Receiver voltage divider 145, energized from terminal 39, feeds high voltage to the plates of the VT-49 Tubes and screen of the VT-38 Tube; and lower voltage is supplied to the screen grids of the VT-49 Tubes. High voltage from terminal 31 is fed through filter resistor 146 to the plate of the VT-38 Tube. Telephone receivers at jacks 133 are connected to the output circuit of the VT-38 Tube. Variable resistor 132 in the Control Box is open circuited and variable resistor 131 in series with fixed resistor 60 is connected between ground and the cathodes of the first three VT-49 Tubes, through terminals 93 and 46. Variation of this resistance by rotating the knob 265 varies the gain of the radio amplifier. The Receiver sensitivity increases in the direction of the arrow engraved on this knob which is the direction of decreasing resistance. The automatic-gain-control action is suppressed in this position of switch 134 by grounding the grid circuits of the first two VT-49 Tubes through terminals 54 and 90. With the BC-231 switch at "AUTO," the Dynamotor and Receiver power circuits are energized as in the "MANUAL" position. But in the "AUTO" position the manual gain-control resistor 131 is short-circuited to ground, thus grounding the cathodes of the first three VT-49 Tubes. The grid circuits of the first two VT-49 Tubes, connected to terminal 54, are disconnected from ground, and the gain control voltage developed by the detector across resistor 68 controls the bias, and hence the amplification of these tubes. Resistor 132 is employed as a voltage divider, with the end terminals connected to the telephone receivers and the Receiver output line through 55 and 96 connected to the sliding contact controlled by knob 265. Rotating the knob in the "Increase" direction slides the Receiver output line up this resistor and thus impresses more signal voltage upon the telephones.

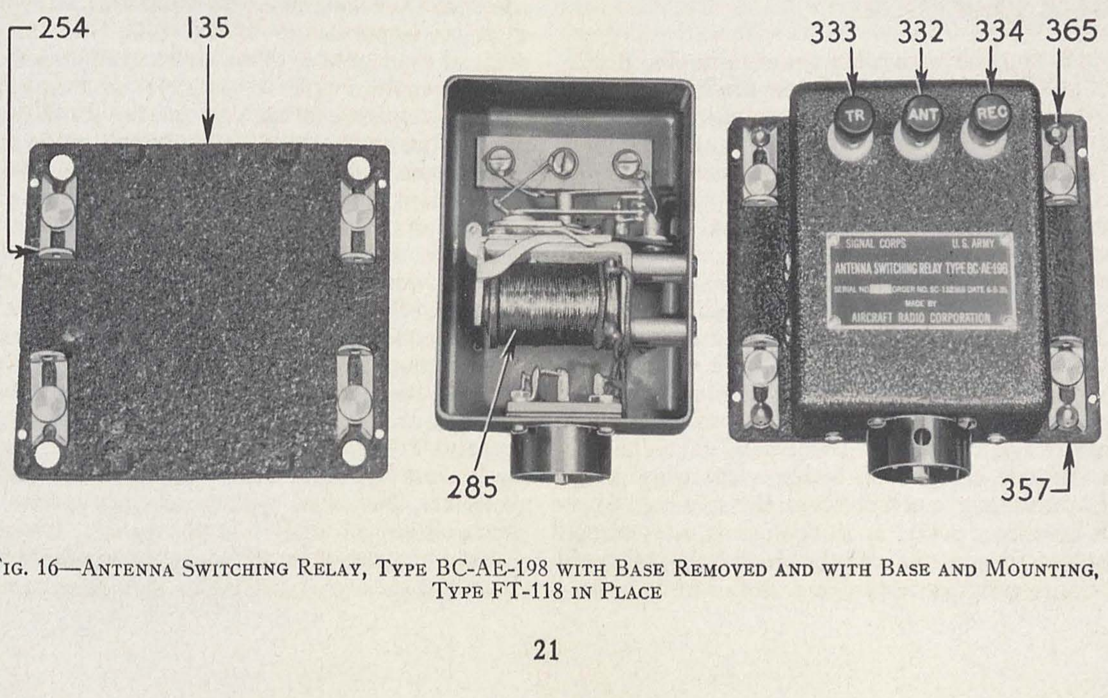

FIG. 16—ANTENNA SWITCHING RELAY, TYPE BC-AE-198 WITH BASE REMOVED AND WITH BASE AND MOUNTING, TYPE FT-118 IN PLACE

The *side-tone voltage* from terminals 23 and 95 is practically independent of the setting of the level-setter 132, regardless of the number of phones connected in parallel at jack 133. Rotation of the knob 265 has no effect upon the *sensitivity* of the Receiver, which automatically decreases as the incoming radio signal increases and vice versa. Resistor 132 is placed in the circuit in the "AUTO" position of the switch because a suitable level of audio signal output can not be permanently predetermined, but depends upon the external noise and the aural acuteness of the operator. The automatic gain-control circuit of the Receiver is so designed that the controlled signal output, is too great for suitable reception, with knob 265 in its maximum "INCREASE" position, except under the most unfavorable conditions.

When relay 153 is in the "TRANSMIT" position the high voltage is cut off the screen grids of all receiving Tubes and the plates of the VT-49 Tubes and for any position on the BC-231 other than "OFF" the circuits of the Transmitter are controlled as follows. At all three positions of switch 141 on the BC-232, terminal 34 supplies 12-14.25 volts to the filaments of all Transmitter Tubes. At all three positions of switch 141 the modulator and radio oscillator tubes are supplied with high voltage from terminal 21 and the radio amplifier tube is supplied with high voltage, either from terminal 21 through the modulation transformer or from terminal 20 direct. At the "VOICE" position of switch 141 terminal 32 is grounded, preventing tone oscillations in the modulator stage; any modulating voltage impressed at 51 in the BC-232 passes through microphone transformer 123, modulator Tubes, type VT-52, and modulation transformer 124 to the plate circuit of the VT-25 radio amplifier Tube, modulating the output of the Transmitter. At the "TONE" and "CW" positions of the switch 141 terminal 32 is ungrounded, and the modulator tubes generate tone oscillations. At the "TONE" position, terminal 20 is connected to terminal 22, and audio voltage from the modulator stage is impressed through the modulation transformer 124 in the plate circuit of the VT-25 radio amplifier Tube. At the "CW" position, terminal 20 is disconnected from 22 and high voltage is impressed on 20 direct from 21 through 40 in the BC-232. The modulator stage still generates tone frequency for use in providing side tone, when the key is pressed, but the emission from the amplifier stage is unmodulated. At all switch settings on the BC-232, side-tone voltage is fed from terminal 23 through relay 153 and 95 to the telephone receivers at jack 133.

The only element of Antenna Switching Relay, type BC-AE-198, which is connected into the Junction Box is its coil. This coil is connected through Cord, type CD-137 and Plug, type PL-77, in parallel with the coil of the power relay 153. When the power relay is thrown between "T" and "R" (Fig. 17) the movable contacts of the relay are thrown between "TRANS" and "REC."

The Radio Set is set for receiving at all positions of the Control Box switches, except when either the microphone switch, a switch on Cord, type CD-136, or a key, is closed.

III. INSTALLATION

INITIAL PROCEDURE

While applicable to all types of aircraft, Radio Set SCR-AK-183 is primarily designed for single-seat types and the problems of installation and arrangement are chiefly centered about the rigid requirements which are associated with pilot operation. Before installation of the radio equipment the aircraft engine, generator and accessories, *must* be completely shielded and bonded if satisfactory radio results are to be obtained. The specifications and requirements for shielding and bonding set forth in Air Corps Technical Orders are adequate for airplanes in which this Radio Set is to be used. It must be realized that the interference with signal reception, which is produced by the radiation of electrical disturbances from the engine ignition system, charging generator, unbonded contacting metal surfaces, etc., bears no direct relation to the sensitivity of the radio Receiver. The *relative* magnitude of such disturbances at the receiving antenna in comparison with the incoming radio wave field is the factor of prime importance. If the radio field intensity is equal to or greater than the local electrical noise level, reception will be possible with any radio receiver sensitive enough to operate on that radio field. The more sensitive the radio receiver, the weaker the radio signal which it will receive, but only so long as the local noise or interference level is less than the incoming radio waves can the signal be heard. Frequently a highly sensitive radio receiver is considered to be "noisy" when the airplane is in flight simply because it will receive both radio signals and local disturbances which are weaker than those receivable on a relatively insensitive receiver. The proper criterion of a complete job of bonding and shielding is that with the airplane in flight (or with the engine running on the ground) in clear cold weather when static is negligible, no sound will be audible in the telephone receivers except radio signals, when the receiver volume control is set at maximum. If the airplane is maintained in this condition, extremely long distance ranges of reception may be obtainable with this equipment.

RECEIVER AND TRANSMITTER RECEIVING AND TRANSMITTING ANTENNAS

The Receiver and Transmitter Mountings should be permanently mounted at the chosen locations in the airplane (see Fig. 19) and the Receiver and Transmitter attached to them by means of the snapslides on the mounting brackets. These units may then be unsnapped and removed for inspection or replacement. The snapslides *must all be firmly engaged* on their respective studs and securely closed. Each snapslide stud is provided with a transverse hole at a point which is above the snapslide when the latter is engaged. After the snapslides are closed, safety wires should be passed through these holes and through the holes in the ends of the snapslides. Care should be taken in safety-wiring these snapslides not to twist the wires too tightly, as this will tend to spring the snapslides open.

Radio Set, SCR-AK-183 may be operated with separate receiving and transmitting antennas, or with a single antenna. If separate antennas are employed, Antenna Switching Relay, type BC-AE-198 has no function, and need not be installed or connected through Cord, type CD-137 to the Junction Box. The principles governing the location of antennas and equipment will be discussed mainly with reference to single-seat airplanes because when a suitable arrangement is found for this class of installation, the extension to larger types is relatively simple.

(1) *Operation on Separate Antennas for Receiving and Transmitting.*

The choice of location for the Receiver and its Mounting in an airplane is governed by several factors: (1) accessibility for Coil Set and Tube replacements; (2) proximity to a suitable location for the receiving antenna lead-in; (3) avoidance of sharp bends in the Tuning Shaft and Cords; (4) weight distribution. Item (1) is of vital importance if Coil Sets are to be changed in flight. When the equipment is to be confined to missions involving communications within one frequency band this is of less consequence. Item (2) is particularly important when the equipment is to be used in the high-frequency band. The best results cannot be obtained at any frequency if the lead to the receiving antenna is run around the interior of the fuselage for several feet before connecting to the antenna binding post, and this is particularly harmful at high frequencies where dielectric losses are greater. A receiving antenna suitable for the entire frequency range of the receiver will not have a large capacity, and additional capacity to the fuselage between the lead-in insulator and the antenna binding post shunts the Receiver and may seriously reduce the signal energy reaching it. If for physical reasons it is impossible to position the Receiver binding posts closer than about one foot away from the lead-in insulator, the harmful shunting effect of this lead may be reduced by: (a) making it as small a copper wire as is consistent with mechanical strength; (b) choosing a thinly insulated or bare conductor. Heavy rubber insulation on this lead increases its capacity. There is no justification from a radio standpoint for the practice of using rubber-covered ignition cable for this lead. Furthermore, this lead should not be taped to metal longerons or ribs if this can be avoided. The ideal installation would have the Receiver connected to the antenna lead-in by means of a single conductor not larger than No. 18 B & S gauge, this conductor being insulated with thin rubber or a wax-impregnated fabric wrap, and suspended in air throughout its length. Conductors of B & S gauge sizes 16 and 18 are suitable for radio receiving antenna connections inside the airplane; the capacity of such a conductor is relatively small, and this lead should not be located so that it is likely to be struck or subjected to stresses involving the tensile strength of the wire. If it is necessary that this lead be longer, and supported along its length, every effort should be made to space it away from metal structure members by at least one half inch. Glass or porcelain insulators or cleats are ideal for this purpose, but if they are not available, it is preferable to use dry wooden blocks impregnated in parafin wax as spacers, rather than to lash this conductor direct to metal members. To item (3) must be added the caution to provide sufficient slack in every Cord, Shaft and conductor attached to the Receiver so that the Receiver is free to move in every direction with respect to its Mounting. If even a single taut wire is attached to the Receiver case the airplane vibration will be transmitted direct to the Receiver and the effect of the shockproofing will be lost. The ground binding post should be connected by a slack wire to the nearest metal member of the fuselage, using a firm clean joint, preferably soldered. The location and external length of the receiving antenna is usually dictated by considerations of safety and convenience, but a few general principles can be followed. Length of the antenna wire in feet is of no value in itself, nor is electrostatic capacity to the fuselage of any value unless this capacity is obtained in a certain way. An insulated antenna wire lashed along the outside of a metal monococque fuselage possesses large capacity, but it would not pick up radio signals effectively. The radio antenna is essentially a capacity structure, operating against the bonded airplane frame as a counterpoise. Its effectiveness as a collector of radio waves increases as the length is increased, but only provided that this increase in length is in a direction *away* from the metal of the airplane. Increasing its capacity by bringing any part of the antenna *closer* to the airplane usually does more harm than good. Increasing its capacity by increasing the amount of conducting surface of the portion separated from the airplane, *without decreasing that separation,* tends to improve the antenna as a radio collector. A five-foot vertical mast antenna mounted in the fuselage of the airplane forms a suitable receiving antenna for the BC-229 Receiver provided that the lead to the Receiver inside the fuselage is not too long. Also, this type of antenna should be located not less than two feet away from the base of the vertical fin, if installed back of the cockpit. On high-speed airplanes a single wire slanting from the lead-in insulator in the headrest fairing up to a stub mast on top of the rudder is sometimes used. This antenna is fairly effective if broken by a strain insulator from 6 to 10 inches ahead of the stub mast, but is not a particularly good radio antenna unless this stub mast extends at least 12 inches above the top of the rudder. A flat-top antenna consisting of a top section strung between the wing tip and rudder, with a down lead connected to this top section at a point well ahead of the rudder is an effective receiving antenna for all biplanes and high-wing monoplanes. It is a good general rule that the remote ends of any wire antenna should not be brought to close proximity with metal end supports. If they are attached to these supports by stays, the strain insulators separating the stays from the antenna wires should be spaced by one foot or more from the metal supports if possible. Down leads from flat-top antennas supported by a high-wing should be brought into the fuselage as near the *bottom* of the fuselage as possible, since this increases the effective spacing of the top section from the fuselage. Attention is next directed to the transmitting antenna. The transmitting and receiving antennas form a complementary system, and theoretically a sacrifice in the electrical efficiency of one will harm the system just as much as a sacrifice in the other. But it is a fact of considerable importance that the reduction of the transmitting antenna below a certain minimum of size and efficiency will render the Transmitter practically inoperative on account of the unavoidable physical limitations inherent in the method of coupling this unit to its antenna. The Transmitter must always be used with an antenna at least large enough to draw from the set enough radio current to deflect the antenna-current ammeter, since this deflection is the only direct evidence available to the operator as to the activity of his own Transmitter. For practical reasons, therefore, it may be permissible to reduce the receiving antenna to a structure far below that which would be required for effective transmission, in cases where a compromise is demanded somewhere in the system. Three characteristics of the transmitting antenna are important: (1) it should have sufficiently high capacity, at the operating frequency, *in the portion spaced away from the airplane*, so that the greater part of the radio energy goes out into the space part of the antenna, and is not dissipated internally in the coupling circuit or fuselage; (2) the antenna resistance should be due largely to radiation and not conductor or dielectric losses; (3) the directions of minimum radiation should be at angles from the airplane which will coincide with the direction of the receiving airplane only in the least probable attitudes of flight. It should be noted here that these desirable characteristics are exactly the same (though described in different terms) as those outlined above for a good receiving antenna. Conditions (1) and (2) might be simultaneously fulfilled by an antenna operated at its fundamental (quarter-wave) frequency against the airplane as counterpoise. But when a number of different transmitting frequencies are to be employed and antennas of adjustable length (trailing wires) are unacceptable, the extremely rapid variation of the capacity and resistance of a built-on antenna with frequency, when operated near its fundamental, makes this mode of operation inflexible and difficult to maintain. Experience has shown that with a Transmitter of fixed power, operating an antenna at a considerable frequency separation *below* its fundamental with a lower radiation resistance and higher antenna current is just as effective as operating at the fundamental frequency with a correspondingly lower antenna current, *provided* the dielectric and other loss resistances are kept small in the antenna. This principle cannot, of course, be carried to extremes. An antenna which is close to a metal airplane member throughout its length might draw a large current through the Transmitter ammeter on account of its high capacity, but the radiation would be practically nil, the excessively high current being itself an indication of negligible power spent in radiation. In quantitative terms, the BC-230 Transmitter in combination with an antenna, operates with the greatest overall efficiency as a generator and radiator of radio waves in the frequency band 6200 to 7000 kc if the antenna has a capacity of from 90 to 150 micromicrofarads, and a resistance of from 5 to 10 ohms within this frequency range. Of this resistance, not more than 3 ohms should be dielectric or loss resistance. (The dielectric losses are by far the greatest causes of non-useful power dissipation in the frequency band 6200-7700 kc.) Condition (3) is the most difficult of all the requirements to fulfill, particularly on high speed airplanes. Any conceivable simple antenna will have a certain directivity; it would have at least two directions of minimum radiation even in free space. This free-space directivity may be further complicated by "shadow effects" due to shielding by a metal monococque fuselage, metal struts, flying wires, etc. Furthermore, whenever transmitting airplane is in such an attitude relative to the receiving airplane that the transmitting lead-in on one is approximately at right angles to the receiving lead-in on the other, a minimum of received signal will be obtained. Theoretically, the type of antennas best calculated to minimize signal variations due to maneuvers of the airplanes would be straight conductors supported by masts which are vertical in level flight of both the transmitting and receiving airplanes. A height of five feet away from the fuselage is about the maximum tolerable length, and while such a structure can be coupled effectively into the Receiver its capacity is so low that the Transmitter will not feed it efficiently.

A transmitting antenna which will fulfill the general requirements outlined above, in the frequency band 6200-7700 kc, consists of a "T" structure having a flat-top section which is between 16 to 18 feet long, with a down lead about 9 feet long to the lead-in insulator. If an "L" antenna is used its total length from the lead-in insulator to the end of the top section should be 20 to 25 feet. *Such an antenna will not radiate efficiently in the bands 2500-5000 kc.* These lower frequency bands can be used most effectively only on airplanes of sufficient size or wingspread to allow the use of an antenna of approximately twice the size outlined for the 6200-7700 kc band. In other words, the total length of wire should be of the order 35-50 feet including the down-lead, for use in the lower frequency band. An antenna consisting of a "V" shaped flat top about 25 feet long on each leg, with a down lead about 10 feet long may be used with fair success in this band.

NOTE: *The lead inside the fuselage to the Transmitter antenna binding post must be short, and must be either bare or insulated with high-quality insulation regardless of the location of the Transmitter.* This lead cannot be run around the airplane inside the fuselage, since the power output and antenna radiation at these high frequencies will be affected to a controlling extent by the length and capacity of this lead. Rubber or fabric covered conductors must not be used if they can possibly be avoided. The ideal form for this lead is a conductor of No. 16 or No. 18 bare wire, insulated by beads of glass or porcelain. If such insulation is not available, and the lead may come in contact with metal, rubber insulation may be used without rendering the Transmitter inoperative, but it will reduce the radiated power. Wherever space is available, this lead should be supported by glass or porcelain stand-off insulators. The portion adjacent the Transmitter should not be drawn taut. While it is seldom possible to make an ideal arrangement, the following general rule should serve as a guide in all cases: Try to keep the capacity elements of the antenna all *outside* the fuselage and minimize the capacity of all conductors inside the fuselage; where such capacity exists inside the fuselage, let the dielectric (insulators) consist of air, glass, or porcelain wherever possible. All insulators should be glass or porcelain. *Under no circumstances should phenolic insulators such as bakelite be used here.* If ceramic insulators are not obtainable, hard rubber is preferable to bakelite. The ground binding post of the Transmitter is bonded to the fuselage by a permanent short lead, which should have sufficient slack so as not to impair the shockproofing action of the Mounting.

When using separate antennas the Receiver may be mounted back of the seat, with its axis of length across the fuselage, and its antenna binding post wired to a separate lead-in insulator. The receiving antenna may be smaller than the transmitting antenna, as outlined above, and may consist of a simple mast.

(2) *Operation on Single Antenna.*

If Receiver and Transmitter are to operate from the same antenna through the use of the BC-198 Switching Relay, it is essential that the Receiver and Transmitter be mounted close to each other, in order to meet the requirement stated above that *the lead inside the fuselage to the Transmitter binding post must be short.* For best results the separation between these units should not exceed about one foot. For example, satisfactory operation using a single antenna cannot be obtained if the Transmitter is mounted in the cockpit of a pursuit type airplane and the Receiver is mounted back of the seat, as is common practice when separate antennas are employed. If the structure of the airplane is such that these units must be separated to such an extent, the use of a single antenna for transmitting and receiving should not be attempted. If these units can be mounted close together, preferably side by side, the BC-198 Relay should be so positioned and mounted that its binding posts are not over one foot away from the antenna binding posts of both Receiver and Transmitter and also as close as possible to the lead-in insulator of the common antenna. Cord, type CD-137 should be bonded to the metal members of the airplane at frequent intervals along its length. Three short leads should be used to connect (a) the antenna to the "ANT" binding post of the Relay; (b) the Receiver "A" binding post to the "REC" binding post of the Relay; (c) the Transmitter "A" binding post to the "TR" binding post of the Relay. The ideal form for these three leads is a conductor of No. 16 or No. 18 bare wire insulated by beads of glass or porcelain. If supports are necessary these leads should be supported by glass or porcelain stand-off insulators. *Do not use heavy rubber-covered wire for any leads to or from the BC-198 Relay, and do not tape these leads to metal members of the airplane.* The "G" binding posts of Receiver and Transmitter must be grounded by short leads to the nearest metal members of the airplane. *With regard to the dimensions of the single transmitting-receiving antenna, this antenna should be designed to provide the best operating conditions for the Transmitter.* In other words, the instructions given in the preceding paragraph for the *Transmitting antenna* should be followed in building a transmitting-receiving antenna for use with the BC-198 Relay.

(3) *Loop Antenna for Receiver.*

There is no relation or connection between the loop socket 175 on the Receiver and any antenna which may be connected to the "A" binding post either directly or through the BC-198 Relay. Reception on a loop is possible only when the antenna-loop switch on the front of the Receiver is turned to "L." If a suitable loop is connected to the loop terminals 63, 65, this loop may be used for obtaining radio bearings in the frequency range

200-1500 kc. *A loop which is effectively shielded must be used with the BC-229 Receiver.* By "effectively shielded" is meant a loop either having its conductor enclosed in a metal housing or positioned in close proximity to metal members of the airplane throughout at least a portion of its length. There is no ground in the circuit inside the Receiver between its loop terminals. The function of the jack outlet marked "DFI" on the front of the Receiver is to provide a means of visual course indication when the Receiver is used with a loop for homing or direction finding. This jack (96 of Fig. 5) is connected in series with the cathode circuit of the first two VT-49 amplifier Tubes of the Receiver. It accommodates a Plug, type PL-47, PL-55, or equivalent. If a d-c milliammeter (scale 0-20 milliamperes) is connected to this jack it will indicate the plate and screen currents of these two Tubes. When the Receiver is set for automatic gain control ("AUTO" on the BC-231) this current varies from a maximum of about 10-15 milliamperes in the presence of weak incoming signals to a minimum value which may reach zero in the presence of very strong incoming signals. This variation in cathode (plate-screen) current of these tubes is a rough measure of the strength of signal impressed upon the Receiver input terminals, since the automatic-gain-control action of the Receiver decreases the gain by decreasing the space current, in these tubes progressively as the incoming carrier increases. Thus if the received signal is fed into the Receiver from a directive loop, the "loop minimum" position will be indicated by a minimum of current through the meter in the "DFI" jack, and "loop maximum" will be indicated by a maximum of this current. *The simple arrangement described will not yield right and left indications or sense indications,* since a swing of the loop in either direction causes the meter current to decrease from its maximum reading. *The Receiver must be set for automatic gain control when used for visual course indications as outlined above.*

RADIO CONTROL BOX, type BC-AH-231
~~RADO~~ RADIO CONTROL BOX, type BC-AE-232

The BC-231 (Receiving) must be accessible to the operator whether the equipment is pilot-operated and remotely controlled, or locally controlled. The BC-232 (Transmitting) is used for key transmission and selection of the type of emission from the Transmitter, and not for the changeover operation between send and receive. If communications are to be confined to voice only, the BC-232 need therefore not be as accessible as the BC-231 if it is necessary to favor one at the expense of the other. During any series of communications the switch on the BC-231 must be used to turn the equipment off and on, and the volume control knob will also be used constantly. These units have no shock-proofing and are attached to their Mountings (type FT-118) by means of snapslides. The mountings may be screwed directly to the cowling or to a panel inside the cockpit (see Fig. 19 for mounting holes).

DYNAMOTOR UNIT, type BD-AK-83

The location of the Dynamotor Unit is a matter of comparative indifference so far as the operation of the Unit itself is concerned, but it is inadvisable to mount it closer than two feet from the receiving antenna lead-in. The Dynamotor Unit should be mounted in an upright position with Mounting FT-141, so located or positioned as to be horizontal in normal flight. The Unit should be so located that its Cord is no longer than necessary since this Cord carries a relatively heavy supply current. The voltage drop in this Cord when carrying 6 amperes should, in no case, exceed .5 volt. Mounting, type FT-141, is permanently fixed in the airplane and the Unit may be removed for inspection or replacement by releasing the snapslides (see Fig. 19). The snapslides of the Dynamotor Unit must be each safety-wired to their respective studs.

JUNCTION BOX, type TM-AH-172

As in the case of the Dynamotor Unit, the Junction Box Mounting is permanently mounted in the airplane and the Junction Box is attached to it by snapslides. While the Junction Box can be removed from the airplane by detaching all the Cords which go into it, it is desirable that it be sufficiently accessible, and that enough slack be left in the Cords adjacent to it so that it may be unsnapped from its Mounting and inverted while the Radio Set is operating in order to check the voltages on the various circuits. In locating the Junction Box with relation to the various other items it should be borne in mind that the Cords to the Dynamotor Unit and to the BC-231 Control Box, both carry the Dynamotor supply current, and should be kept as short as practicable.

NOTE: *The toggle switch 155 on the front of the Junction Box must be set at its left hand position* "REC-TRANS" *in order to operate both the Receiver and the Transmitter.*

TUNING AND CONTROL UNITS SHAFTS

Certain Signal Corps Tuning and Control Units are required for the operation of Radio Set SCR-AK-183 and their proper location is indicated diagrammatically in Fig. 20. The Receiver will normally be remotely tuned by means of Tuning Unit, type MC-125 and Tuning Shaft, type MC-124. The Tuning Unit should be mounted near the BC-231 (Receiver) Control Box since it will be used during the operation of the Receiver. The Tuning Shaft may be bent more than once throughout its length but no bends should be permitted of radius less than 6 inches. The Shaft may be firmly secured to a rigid support at frequent intervals along its length, except at points close to its attachment to the Receiver. If both these precautions are not observed it will be difficult to tune the Receiver accurately. When properly installed, even with lengths of 20 feet or more of Shaft, *both dials should rotate smoothly* as the crank of the Tuning Unit is turned without appreciable backlash. When the Shaft is attached to the outlet 261 on the Receiver and to the Tuning Unit, the reading of the Tuning Unit dial must be made to coincide with the reading of the Receiver dial by rotating one of them before the final coupling is made.

The loop-antenna switch on the front of the Receiver and the Dual Coil Unit switch may be operated remotely by means of Control Unit, type MC-139 or Control Unit, type MC-135, and Control Shaft, type MC 134 if desired. These Control Shafts differ from the Tuning Shaft in that they have direct couplings between their respective switches and the Control Unit levers, and are consequently stiffer than the Tuning Shaft. *Any bends in a Control Shaft must be of the greatest possible radius.* In the case of the Dual Coil Unit the Control Shaft carries a considerable load (the gang which is in the Coil Unit) and extra precautions must be observed on installation. *Before* mounting MC-135 Control Unit, the spline of this Unit should be inserted into the Control Shaft and the switch should be turned clockwise to be certain that the gang switch in the Coil Unit is in its clockwise position. The Coil Unit will then be set for the LOW range. Disengage the MC-135 and re-engage it so that the lever is in the most desirable of the four positions for the LOW range. Rotate the dial until LOW is indicated by the pointer and then tighten up on the coupling nut. Do not attempt to rotate the dial of the MC-135 after this operation. The dial should then be secured in position by screws attached to the Unit. When properly assembled, the changeover between the high and low bands of the Coil Unit by means of the lever on the MC-135 should be positive and reversible.

Tuning and Control Shafts can be obtained from depots in any required length and should never be cut unless proper equipment is available for re-attaching the splines. Each Shaft consists of a casing terminating in a ferrule and a coupling nut; this houses the shafting, terminating in an assembly of a spline on a spline-ferrule. The shafting is made up of tightly wrapped steel wires which *will not hold their shape unless they are soldered or swaged together at the ends.* All tuning and control shafts should be taped and bonded.

CORDS

The Cords which inter-connect the various units will be normally lashed or clamped to structural members of the airplane along their length. There is one important point to be observed in the installation of these Cords. They are armored with metal braid and their outer surfaces may produce an electrical noise in the Receiver unless they are carefully bonded to metal airplane members wherever they are likely to touch or rub thereon. In the best installations these Cords are bonded at intervals of approximately 18 inches and the intervening lengths, between bonds, are wrapped with friction tape or similar insulation, to eliminate all possibility of Receiver "noise" arising from this source. The battery Cord, type CD-110, terminates at its battery end in a pair of open terminals. *These must be connected to the 12-14.25 volt line as near to the battery as practicable.* If a conductor of any length whatever carrying current from the charging generator to the battery is included in the circuit between the positive conductor of CD-110 and the battery terminal, this may produce electrical noise in the Receiver which will come from the voltage regulator. In case it becomes necessary to alter or assemble a Cord, the attachment of the Plug should be made as indicated below. The Plugs for these Cords consist of a shell, insulator body, spring, bushing, washer, nut and screw. Cut the Cordage off squarely across the end. Then cut the metal shielding braid back a distance of $1^3/_{16}$ inch from the end; with a sharp knife or scissors cut the rubber jacket back a distance of $^3/_4$ inch from *the end taking care not to damage the rubber insulation of the individual conductors.* Then clean the insulation on each individual stranded conductor back a distance of $^5/_{32}$ inch from the end. Disassemble Plug by removing the screw and nut. Pass the nut, washer and shell over the cleaned end of the cable, in the order named. Having threaded the cable through these parts, "tin" the end of the braid with hot solder, fit the bushing over the end of the cable and braid, so that the braid is covered to a distance of $^3/_8$ inch, and sweat the braid into the bushing so that a secure soldered contact is made between the bushing and the braid. Tin each individual contact insert and solder the cleaned ends of the conductors into these inserts. Both the inserts and the conductors must be thoroughly tinned before this operation. Do not allow surplus lumps of solder to remain on these inserts or on any part of the bakelite insulation. When all conductors are securely soldered, bunch the insulated portions together so that they will not rub on shell when Plug is reassembled. Draw the shell up to the shoulder on the bushing and fasten it securely by tightening the nut. As this operation is performed, the hairpin spring must be held in close contact with the inner surface of the shell, with the two studs protruding through the holes in the top of the shell. As the shell is drawn up to the shoulder of the bushing, the insulator body, now attached to the cable, should be drawn into this shell so that the spring passes into and is held in, the square groove in the top of the insulator body. Line up the screwhole in this shell with the threaded hole in the bottom of the insulation and complete the assembly by tightening the screw in this hole. *Do not use Acid Flux or Paste in soldering; use only Resin Flux. If acid flux is used in soldering the conductors, the Plug will ultimately break down in service.*

IV. PREPARATION FOR USE

ADJUSTMENT OF RECEIVER INPUT ALIGNMENT CONDENSER

The final installation operation of the Receiver is the alignment of the antenna circuit of the Receiver by means of the input condenser 80, adjusted by knob 244. Set the switch 83 on its "A" position. If the antenna used is so large that its characteristics vary widely with frequency over the operating range, this adjustment must be made for each Coil Set. If the antenna is small, or consists of a rigid mast, one adjustment may give satisfactory results for all Coil Sets. The Receiver is operated with the switch at "MANUAL". A signal is tuned in at the high-frequency end of one of the bands, preferably on Coil Set, type C-171. The volume control *must* be progressively retarded during the adjustment to keep the signal at the lowest audible level. Knob 244 is turned until the signal is a maximum. Then the Receiver tuning must be readjusted for maximum and knob 244 adjusted again for resonance. If the Receiver is to be operated for a considerable period in the low-frequency bands only, this antenna alignment may be performed near the maximum dial (frequency) setting on the low-frequency Coil Set. But for use throughout the entire range, the antenna alignment must be performed on one of the high-frequency bands.

Do not operate the Receiver with any Coil Set, if it is impossible (owing to the size or arrangement of the Antenna and Lead-in) to adjust Knob 244 for Resonance, as indicated by maximum signal. The overall sensitivity will be low and the results will be unsatisfactory unless Condenser 80, controlled by Knob 244 is accurately adjusted.

A fixed loop may be connected to the Receiver loop terminals at all times without affecting the performance of the Receiver on an antenna, and vice versa, but switch 83 must be operated to change between antenna and loop. For homing operations on a fixed frequency it is possible to eliminate the necessity of also readjusting the input alignment condenser 80 when the Receiver input is thrown from antenna to loop *by making the loop capacity and inductance on installation of such a value that the Receiver is resonant at the setting of condenser 80 which is correct for the receiving antenna installed on the airplane.* No general design rule can be given for this "matching" the antenna and loop for the two positions of the switch 83, since the inductance and capacity of the loop will depend upon its size, number of turns, mounting, and length of leads to the Receiver. This "matching" process can, however, be carried out experimentally with very little trouble in practical installations if the loop is operated only at a low or medium frequency and the number of turns are so determined as to make the loop inductance approximately 0.1 millihenry. If, after the condenser 80 is properly set to align the Receiver for the chosen fixed antenna it is necessary to turn knob 244 of condenser 80 to the *right* (increasing capacity) to obtain maximum signals when the switch 83 is set on the "Loop" position, a small fixed condenser should be connected in *parallel* with the loop leads to the Receiver. If, after condenser 80 is properly set for the antenna, it is necessary to turn knob 244 to the *left* (decreasing capacity) to obtain maximum signal on loop, the number of turns in the loop should be decreased.

ADJUSTMENT OF TRANSMITTER

The Transmitter must be tuned and adjusted on the ground for operation at the desired transmitting frequency. It should be tuned over dry soil; otherwise the tuning of the antenna circuit may change when the plane leaves the ground. *The Transmitter cannot be properly tuned inside a hangar.* Three controls must be adjusted for any given frequency: (1) the frequency control 241; (2) the antenna coupling tap, adjusted by sliding contact 130; (3) the antenna tuning condenser, adjusted by knob 243. The frequency control 241 (which operates the variable condenser of the radio master oscillator) should be set at the desired transmission frequency by comparison with the chart, and then locked with lock screw 250 and left alone. Then the antenna coupling and tuning (coil tap 130 and condenser knob 243) must be adjusted by trial to give the most favorable combination of antenna carrier current, indicated by ammeter 129, and modulation. *Proper adjustment of the antenna circuit is particularly important in the case of the BC-AH-230 Transmitter because operation with the wrong setting of the coil tap may result in dynamotor overload and poor modulation even though the antenna circuit is tuned to resonance. The following explanation should be studied and carefully applied.*

With the switch on the BC-232 set on "VOICE," the frequency control set at the desired frequency, and the antenna and ground connected to the proper binding posts, find a position for the coil contact 130 at which maximum (resonance) antenna current may be obtained by rotating condenser knob 243, note the value of antenna current at this setting. Then remove the Transmitter Coil Set, change the position of contact by one or two turns, replace the Coil Set and retune to resonance with knob 243, noting the new resonance value of antenna current. Repeat this operation of adjusting contact 130 and retuning to resonance until the position has been found for the coil contact at which the antenna current reaches its highest value when the circuit is tuned to resonance by condenser knob 243. It will be noted at most operating frequencies that the antenna current at resonance does not change appreciably between one turn of the antenna coil and the next adjacent turns on each side, throughout a certain region on the coil in the vicinity of maximum power output. *But at certain locations of contact 130, better modulation will be obtained than at other locations, and good modulation is just as important in voice transmission as high antenna current.* In the absence of any direct means of checking modulation, the direct plate current of the amplifier tube, measured on a d-c milliammeter plugged into jack 128 on the Transmitter, may be used as a practical indicator of the extent to which the radio amplifier may be modulated without distortion. *In general, the greater the amplifier plate current, at resonance, when the Transmitter is tuned and operating on* "VOICE," *the smaller will be the power available for modulation, and the smaller the modulation capability of the Transmitter.* But the radio carrier current (indicated by antenna ammeter 129) generally decreases with decreasing plate current drawn by the amplifier; thus a compromise must be made, in choosing the final location for the coil contact 130. In choosing this compromise location, the following practical data will be of assistance. They apply to a Transmitter operating at 14 volts supply voltage with average tubes. *For 12 volts supply the corresponding plate currents are 20% lower than those given below.*

With settings of the coil contact at which the amplifier plate current is less than about 25 milliamperes the radio output will be modulated up to 100% with negligible distortion.

With settings of the coil contact at which the amplifier plate current is between 25 and 30 milliamperes the radio output will be modulated to about 90% with negligible distortion.

With settings of the coil contact at which the amplifier plate current is between 30 and 35 milliamperes the radio output will be modulated to about 80% with negligible distortion.

With settings of the coil contact at which the amplifier plate current is greater than about 35 milliamperes the output cannot be modulated above 70–75% without serious distortion and such settings should be avoided.

All the above values apply to operation at antenna resonance, obtained by tuning with knob 243. If the antenna circuit is mistuned, all plate currents will be abnormally high and satisfactory modulation cannot be obtained at any antenna coupling. Consideration of the above tabulation indicates a working rule for final choice of position for the antenna coil contact, as follows:

At any given frequency the coil contact 130 should be set for the highest antenna current (on meter 129) which can be obtained, at resonance, without drawing an amplifier plate current, at resonance, which exceeds about 34 milliamperes at 14 volts supply or about 28 milliamperes at 12 volts supply. This will permit modulation of at least 80%, with normal modulator tubes, at a carrier current output which is practically the maximum attainable. It will be noted that moving the coil contact down toward the coil base from the point just specified (i. e. *decreasing* the coupling to the antenna) usually decreases the amplifier plate current at resonance and improves the modulation, but at the expense of decreased antenna current. This observation suggests the following rough rule for tuning the Transmitter in the absence of a d-c milliammeter for measuring the amplifier plate current:

If a d-c milliammeter is not available for indicating plate currents when the Transmitter is being tuned, set the coil contact 130 on the turn which gives the maximum antenna current at resonance, then move it down toward the base of the coil (restoring resonance at each move by adjusting knob 243) until the antenna current on meter 129 is reduced by a small amount, say 5%, below its maximum resonance value. In other words, operate the Transmitter with the antenna coupled through contact 130 by an amount slightly *less* than the coupling which gives an absolute maximum of antenna current.

In the BC-AH-230 Transmitter a choice of two *sidetone levels* is available, owing to the provision of a tap on the side-tone winding of transformer 124. As supplied, the Transmitter is connected for an average side-tone level of approximately 10 volts across 4000 ohm phones. This voltage may be reduced by 50%, if desired, by transferring the soldered connection from terminal 7 of transformer 124 to terminal 6.

WARNING: **The Transmitter must never be operated, except during the tuning process, with the antenna mistuned from resonance. The Tubes and Dynamotor Unit are liable to damage and proper modulation cannot be obtained, unless the antenna circuit is operated at resonance as indicated by the antenna ammeter.**

TRANSMITTER FREQUENCY CALIBRATION

The frequency calibration chart mounted on the back of each Coil Set applies only to the combination of that Coil Set and the Transmitter bearing the same serial number. The calibration is affected to a certain extent by the electrode capacities of the Tube, type VT-25, used in the radio oscillator socket (second from the front of the Transmitter as shown in Fig. 10). The particular oscillator tubes with which the calibration charts were made are supplied with the Transmitters on Order No. 17875-NY-39 in specially stamped cartons, each marked with the serial number of the Transmitter with which that tube is to be used as oscillator. *When a Transmitter is first placed in service be sure that the VT-25 Tube placed in the radio oscillator socket is the one stamped with the serial number of that Transmitter, and taken from the similarly identified carton.* This tube only should be used as the radio oscillator throughout the life of the tube. With any other tube in the oscillator socket the calibration errors may be as great as 1% at the high-frequency ends of some frequency bands.

While it is true that the transmitter frequencies can be readjusted by means of the compensating or "trimming" condenser 120 when the oscillator tube is replaced with a new one, *such readjustment should not be made* except by competent personnel and then only when there is available a crystal-controlled frequency standard of which the frequencies are known with a maximum error of not to exceed 0.05%. The Frequency Meter Sets SCR-211-T1 and SCR-211-A have an accuracy of better than the above value. See "REPLACEMENT OF OSCILLATOR TUBE IN RADIO TRANSMITTER" in Section "VI. SERVICING AND REPAIR".

V. OPERATION

GENERAL

The theory of performance of the various units of the Radio Set has been described in detail under "Detailed Functioning". This section will be confined to a discussion of how these units are operated or manipulated by the user to produce this performance.

Radio Control Box, type BC-AH-231 turns off all power to the equipment. When this switch 134, is in the OFF position the Dynamotor Unit is disconnected and power is thrown off the filaments of both Receiver and Transmitter for all positions of all other controls. With the switch on BC-231 in either of the two positions at which the dynamotor runs (AUTO and MANUAL), this switch determines the type of reception, the switch on the BC-232 determines the type of transmission, and the application of the dynamotor output voltage (whether to the Receiver or to the Transmitter) may be determined by the operator, by using either a remote control switch plugged into the Junction Box, the microphone switch, or the key. The following is a summary of the power connections accompanying each position of the main switches:

Radio Control Box, type BC-AH-231:

- OFF: Dynamotor *off*. Receiver and Transmitter filaments *off*.
- MANUAL: Dynamotor *on*. Receiver and Transmitter filaments *on*. Plate voltage *on* either Transmitter or Receiver.
- AUTO: Dynamotor *on*. Receiver and Transmitter filaments *on*. Plate voltage *on* either Transmitter or Receiver.

Radio Control Box, type BC-232: (With switch on the BC-231 at MANUAL or AUTO and a control switch closed to transmit):

- TONE: Transmitter filaments *on*. Plate voltage *off* Receiver. Plate voltage *on* all Transmitter Tubes. Modulator generates tone oscillations.
- CW: Transmitter filaments *on*. Plate voltage *off* Receiver; *on* all Transmitter Tubes. Modulator generates tone oscillations.
- VOICE: Transmitter filaments *on*. Plate voltage *off* Receiver; *on* all Transmitter Tubes. Tone oscillations suppressed.

RECEIVER OPERATING TEST

After installation and before flying with the radio equipment a Receiver operating test should be made, for which detailed instructions follow:

1. Plug a Coil Set into the Receiver corresponding to a frequency band in which signals will be available for test purposes. See that the full frequency range on the tuning dials can be swept through for the chosen position of the Tuning Unit pointer without encountering the stops on this unit. The Tuning Unit should turn easily and smoothly and should not be forced at any time.

2. Plug telephone receivers into a jack on the BC-231. Turn the switch to MANUAL. The dynamotor should start and as soon as the receiving tubes are warm, a slight hum should be heard in the telephones indicating that the Receiver is operating. The first test should be made without running the airplane engine. When the Receiver is in operating condition at full voltage, atmospherics and electrical disturbances are usually heard at the maximum INCREASE position of the volume control. Under most conditions the Receiver cannot be expected to operate satisfactorily on signals so weak that *maximum sensitivity* is required to make them audible, because such signals are usually below the atmospheric noise levels.

3. Tune in signals by rotating the Tuning Unit crank. As the Receiver is tuned, adjust the volume control knob for suitable signal intensity.

4. Switch to the AUTO position of the control switch after a desired signal is tuned in. The signal intensity in the telephones will *not necessarily be the same* for the same setting of the volume control in the AUTO and MANUAL positions. In the AUTO position, reset the knob for a suitable level in the telephones. If the mean radio field strength is high enough to require substantial retardation of the control knob for a comfortable signal output in the MANUAL position, the signal output in the AUTO position will be maintained constant by the automatic gain control of the Receiver. *Do not attempt to tune in signals with the switch on* AUTO. Since the amplifier gain varies with the strength of the amplified radio voltage in this position, the resonance effect in the amplifier is apparently broadened so that the proper tuning point cannot be found in the AUTO position except for very weak signals. The AUTO position is not designed for constant use throughout a series of communications on different frequencies, but only as an aid to reception after a signal has been tuned in on the MANUAL position.

5. Before flying with the Receiver, the installation should be further checked with the airplane engine running. If with the volume control set at

maximum in any position of the tuning dial the electrical noise in the telephones is increased on starting the airplane engine, this indicates imperfect shielding of the ignition or generator system, or difficulty with the voltage regulator of the charging generator. If circumstances render necessary the operation of the Receiver under these conditions only those radio signals can be satisfactorily received which are of greater electrical intensity than the local disturbance.

6. The switch on the BC-231 should never be left in the MANUAL or AUTO positions when the Receiver is not in use.

TRANSMITTER OPERATING TEST

After installation and before flying with the radio equipment a Transmitter operating test should be made, for which detailed instructions follow:

1. With telephone receivers in the jack in the BC-231, plug a microphone into jack 138 in the BC-232, and set the controls at MANUAL and VOICE. The dynamotor should run and the Receiver should operate.

2. Press the switch on the microphone. A click should be heard in the phones and the antenna-current ammeter should deflect to a reading of at least 0.5 ampere. Talk into the microphone. Voice side-tone should be heard in the phones and the antenna-current ammeter should vibrate with the modulation from the voice. If the antenna current does not vary with voice modulation either the Transmitter is not being modulated or it is improperly tuned. (See instructions for tuning on pages 28 and 29.)

3. Throw the BC-232 switch to TONE, and press either the microphone switch or the key. A steady tone should be heard in the phones and the antenna current should increase appreciably above the value observed on VOICE. If the antenna current does not increase on TONE the Transmitter is improperly tuned. (See instructions for tuning on page 29.)

4. Throw the BC-232 switch to CW and press either the microphone switch or the key. A steady tone should be heard in the phones but the antenna current should be the same as on VOICE.

MICROPHONE TECHNIQUE

Voice communication from an airplane is always characterized by restricted ranges of operation as compared with communication by CW and tone telegraph. Signal fading, airplane noises, electrical interference, atmospherics, and the like, all conspire to rob a voice-modulated radio signal of its intelligibility. For that reason it is of the utmost importance that voice communication, when used, should originate at the microphone under the most favorable possible conditions. All audible flight noises are picked up by the microphone and transmitted through the radio set. It is impossible to eliminate them to a marked degree without also eliminating the intelligence-bearing frequencies of the human voice. The only expedient under the control of the operator, for discriminating against flight noises, in favor of his voice, is to keep his lips close to the microphone. Flight noises cannot be drowned out by shouting into the microphone; this is a bad practice from all standpoints since it produces fatigue and distortion in the human larynx and also overloads the equipment. The following simple rules may be depended upon, if followed consistently, to produce the best results in voice transmission from any radio equipment:

(1) *Hold the microphone close to the face, with lips just touching the surface. Keep the head in a vertical position while transmitting so that the plane of the microphone face is substantially vertical.*

(2) *Do not shout. Forget the noise surrounding you and imagine that you are talking directly into the ears of the listener.*

(3) *Finish each word completely before starting the next.*

(4) *Emphasize with a distinct hiss all sibilants such as "S", "C" and "Z".*

(5) *Emphasize all terminal consonants such as "T" and "G".*

(6) *Speak slowly.*

CHOICE OF FREQUENCY

Radio communication ranges are limited by signal "fading" (see below), atmospherics, and steady decay of received signal with distance. The best frequency for transmission between two given points varies with the altitude, the distance, and the time of day, but there are a few general rules which, if kept in mind, will greatly assist in minimizing the importance of this general variability. For short distances, up to 50 miles, communication is improved with increasing altitude between two airplane stations or between airplane and ground, at all frequencies. At extreme distances, say over 150 miles, if communication is possible at all it will be little affected by altitude of either station. For plane-to-plane communication at short distances, up to 20 miles there is little choice between frequencies in the low bands (2500–5000 kc) and frequencies in the high bands (5000–8000 kc). For plane-to-ground communication at any distance less than about 100 miles frequencies in the low bands are better than frequencies in the high bands. Communication over distances of 200 miles or more, at any altitude of either station, may be possible with frequencies in the high bands but should not be expected on frequencies in the low bands. As to the distinction between day and night, the lower frequencies are better *on the average* at night, and the higher frequencies are better by day; this rule applies generally to distances of the order of 100 miles and more. For short-distance work with a ground station, frequencies in the lower band should be used, if possible, without regard to the time of day. Frequencies in the upper part of the low band, say 4000–5000 kc, are best for general utility purposes, plane-to-plane, or plane-to-surface, over a variable distance range.

CHOICE OF TYPE OF TRANSMISSION

The CW position of the BC-232 selector switch will give the same antenna current as the VOICE position. The TONE position will give the same carrier power output as the VOICE position but it will be modulated 100% at 1000 cycles. *For long-range communication, or communication through interference, CW is most effective,* TONE *next, and* VOICE *least effective.* It should be borne in mind, however, that although CW telegraphy will give the greatest distance range, and the greatest range through interference, it requires an oscillating receiver at the receiving station and because of its sharper tuning *it is sometimes more difficult to establish initial communication by CW than by* TONE *telegraphy.*

OPERATING ROUTINE

The operating routine of the equipment, and the choice between different types of transmission will be dictated primarily by tactical requirements and considerations external to the radio equipment. There are a few general rules which, if followed to the greatest possible extent, will increase the number of successful radio flights.

(1) Do not take off with airplanes with whom communication is desired, without first establishing communication on the ground. This is particularly important if communication is to be carried on with airplanes transmitting at different frequencies.

(2) Whenever possible, with an assembly of airplanes, which are to work on the same assigned frequency, tune in all the Transmitters on the ground by adjusting them until their carrier frequencies all beat together in a common Receiver used for monitoring purposes. The calibration of the Transmitters cannot be depended on to within greater accuracy than .05%, and this represents enough frequency separation to require retuning of the Receiver between the various transmitter frequencies.

(3) Do not expect uninterrupted communication between airplanes which are maneuvering unless thay are close together. For consistent communication at distances greater than about five miles the communicating airplanes should be in substantially level flight. Vertical banks are usually the attitudes of minimum received signal between two communicating airplanes unless they both bank in the same direction. Furthermore, a "dead spot" of communication may be observed when the receiving airplane is off the pole of the transmitting down-lead, either above or below.

(4) Operations may be accelerated if orders are acknowledged by single pre-coded signals on the telegraph key.

(5) *Do not expect to obtain distance ranges on* VOICE *in excess of twenty-five miles consistently.* In the absence of atmospherics and local disturbances, plane-to-plane ranges as high as one hundred miles may be obtained. But this Radio Set is designed for a voice distance range of twenty-five miles, and greater ranges, even though sometimes unavoidable, are not conducive to secrecy of communication. The distance range on key will be normally greater than the distance range using external voice modulation.

(6) The radio field strengths received on the ground will always be less than those received in the air at a given time of day, unless the transmitting airplane is so high that an optical path lies between it and the ground station.

(7) Transmission on these frequencies will vary from month to month and from day to day, owing to the varying characteristics of the medium of propagation. Signal strengths at distances above about fifteen miles will usually be greater in winter than in summer, and may vary widely from hour to hour on a summer day. This variation is unavoidable and has nothing to do with the radio equipment.

(8) Signal "fading" (i. e. rapid variations) will be encountered more and more as the distance of transmission is increased. Sometimes this will be so rapid as to produce severe distortion of modulated signals. It occurs more at long distances, but may be observed at distances as short as ten miles on some occasions. If the quality of the signals suddenly becomes bad at distances of ten miles or more it does not *necessarily* indicate a fault in the apparatus. A test should be made with the transmitting and receiving stations in sight of each other before looking for trouble in the equipment.

VI. SERVICING AND REPAIR

The Radio Set should be given a flight inspection before every radio flight, according to the following routine:

FLIGHT INSPECTION

1. See that the proper Coil Set is in the Receiver.
2. Examine tubes in both Receiver and Transmitter. Be sure that each tube is in the socket marked for that type and that all control grid clips are attached. *Push each tube all the way into its socket.* BE SURE THAT ONLY THE TRANSMITTING TUBES HAVING WHITE BASES ARE IN THE SOCKETS MARKED "VT-25" and that the proper tube is in the radio oscillator socket. See "TRANSMITTER FREQUENCY CALIBRATION" in Section "IV. PREPARATION FOR USE".

3. Inspect all snapslides and see that each Plug is locked in its receptacle.

4. Check operations of switch controls. Set controls at MANUAL and RECEIVE and be sure that Receiver is operating. Listen for dynamotor noise with volume control advanced to maximum. Negligible dynamotor noise should be heard.

5. Check Receiver input alignment by tuning in a weak signal and varying the position of knob 244 to make sure that the input circuit is tuned to resonance.

6. Turn up the engine past the speed at which the charging generator cuts in and check ignition and generator noise.

7. Check headset cord and plug for open or intermittent contacts. Check headset.

8. Set switch on the BC-232 at VOICE and note Transmitter current reading. Modulate the Transmitter. If the Transmitter is operating properly the antenna current will increase with the modulation. Note side tone in headset.

9. Measure supply voltage with the airplane engine running at least 1500 R.P.M.

DO NOT ALLOW RADIO EQUIPMENT TO BE OPERATED IF THIS VOLTAGE IS LESS THAN 12 VOLTS OR MORE THAN 15 VOLTS.

NOTE: Never operate the Radio Equipment on the ground longer than is necessary to complete this inspection. *Never leave the airplane without turning the switch on the BC-231 to* OFF.

SERVICE INSPECTION

1. Check airplane battery with hydrometer.

2. Check operation of voltage regulator of charging generator, adjusting it to assure consistent operation of generator at 12 to 15 volts.

3. Using a high-resistance voltmeter, measure voltages to ground of the various terminals in the Junction Box as listed on page 39. Satisfactory operation cannot be expected unless these voltages are all within about 10 per cent of their rated values.

4. Check bonding of cables and contacts between antenna and ground wires and their respective binding posts on the Receiver and Transmitter.

5. Clean all antenna insulators, particularly those which are exposed to the engine exhaust, and check contacts on the lead-in insulators.

NOTE ON DYNAMOTOR: *If the Receiver is operating satisfactorily with dynamotor noise at a suitably low level, the Dynamotor Unit should be left alone. When this machine is in proper condition, manipulation of the brushes or commutators is apt to do more harm than good.* The dynamotor may require lubrication about every 300 hours of operation. Dynamotor 150, of Dynamotor Unit, type BD-AK-83, should be lubricated at these rare intervals with a light ball bearing grease. Access to the bearings is obtained, when necessary, by removing the end covers ~~211~~ 228 held by screws ~~202~~ 229 (see Fig. 21). Do not put much lubricant in these bearings. Do not use vaseline or any other lubricant not prepared specially for ball bearings, or the machine may not turn over when cold. G. E. Ball Bearing Grease is recommended for use in dynamotor ball bearings. If rough turning or excessive looseness is noticed after bearings are cleaned and greased, the Dynamotor Unit should be replaced and the unsatisfactory one should be shipped to a depot for repairs. *No attempt should be made to replace dynamotor bearings except at authorized repair shops. Never allow oil or grease to get on the commutators of the dynamotor.* Remove dirt, grease or oil from the commutators with a clean dry cloth. DO NOT USE SANDPAPER OR EMERY CLOTH ON EITHER COMMUTATOR. In time the commutators will be covered with a dark or semi-transparent film which is not a cause of noise and should be preserved thereon. The only other parts that are apt to require replacement during the life of the machine are the high-voltage brushes 213, 214 and the low-voltage brushes 208, 209. Removal of the end covers 228 gives access to the brushes. Be sure that the new brush is installed in the same relative position as the original brush. New brushes on both commutators must be run in by operating the machine at normal load for several hours before placing in service. Proper brush seating is essential for satisfactory operation. A dynamotor with new brushes may be noisy and inefficient until brushes are properly run in.

REPLACEMENT OF RADIO OSCILLATOR TUBE IN RADIO TRANSMITTER

The Radio Transmitters when originally furnished are calibrated for use with a particular Tube, type VT-25 in the radio oscillator socket. See "TRANSMITTER FREQUENCY CALIBRATION" in Section "IV. PREPARATION FOR USE". Whenever it becomes necessary to replace the Tube, type VT-25 in the radio oscillator socket the instructions given below should be followed, in order that the calibration charts on the Coil Sets may be used for accurate settings to the desired or specified frequencies.

Use a frequency standard, consisting of a crystal-controlled, or otherwise stabilized oscillator, of which the frequencies are known with a maximum error not exceeding .05%. A "wavemeter" or calibrated receiver is useless for this purpose. The frequency meter must be of the type which emits oscillations of a known frequency. Set this standard oscillator on some even hundred-kilocycle frequency in the upper part of the band 6200-7700 kc, preferably at 7700 kc, using Coil Set C-220 in the Transmitter. If no standard frequency is available between 7000 and 7700 kc, a frequency should be selected near the upper end of the 5000-6200 kc band. Provide a separate receiver, for listening in, tuned to the known frequency of the standard oscillator, or if provision is made for the use of headphones on the standard oscillator, listen in at that point. Provide several VT-25 tubes from which to pick a new oscillator. (*Not all VT-25 tubes may be used in restoring the original calibration, even though they may all be entirely satisfactory otherwise.*) Try the VT-25 tubes successively in the oscillator socket, setting the Transmitter frequency control, with each tube, so that the Transmitter frequency beats zero with the frequency of the standard, keeping the antenna circuit tuned to resonance. Note the frequency dial reading for zero beat, with each oscillator tube. Note the dial reading of the calibration chart, corresponding to the frequency of the standard. Select the tube for which the zero-beat dial reading is the closest to the dial reading of the calibration chart. *In no case should a tube be used as oscillator whose zero-beat dial setting differs by more than about 30 scale divisions from the dial setting given on the chart for that frequency.* With the selected tube in the oscillator socket, and the antenna circuit tuned to resonance, set the frequency control dial exactly on the setting given by the chart for the frequency of the standard source. Insert a screwdriver in the slotted shaft (289, Fig. 11) of the trimmer condenser, 120, which is back of the slide cover (288, Fig. 9) in the Transmitter cabinet. Rotate this shaft slowly to right or left until zero beat is obtained between the Transmitter frequency and the oscillation of the standard source. The Transmitter is then properly adjusted for continued use of the Coil Set calibration charts so long as the selected tube is used in the oscillator socket.

Summarizing the procedure outlined above, it is seen to be divided into three steps as follows: (1) Selecting a frequency on a standard oscillator which is the same as one of the calibration frequencies and listening-in either on the standard oscillator or on a separate receiver tuned to the selected frequency; (2) Selecting a suitable VT-25 tube for use in the Transmitter as the replacement in the Transmitter oscillator socket; (3) Adjusting the Transmitter trimmer condenser for use with this tube. The following is an example of how this process works in practice:

> The frequency standard is set at 7500 kc. Four VT-25 tubes are available for use in selecting a new oscillator. The calibration dial setting for 7500 kc in this Transmitter, with its C-220 Coil Set, is 2440. With Tube No. 1 as oscillator the Transmitter zero-beats with the standard oscillator at dial 2435; with Tube No. 2 the Transmitter zero-beats with the standard at dial 2480; with Tube No. 3, zero beat is obtained at dial 2460; with Tube No. 4, zero beat is obtained at dial 2450. Tube No. 2 should not be used as an oscillator. Tubes No. 1, 3, and 4 may be used, but Tube No. 1 will give the most accurate results on future frequency settings from the chart, with Tube No. 4 second best. Tube No. 1 is placed in the oscillator socket, the Transmitter frequency dial is set at 2440, the chart point; the trimmer condenser 120 is adjusted to give zero beat with 7500 kc, and the calibration chart is used thenceforth throughout the life of this tube.

After oscillator tubes have been replaced more than once using the procedure outlined above, the trimmer condenser may be appreciably offset from its original calibration position so that in selecting new oscillator tubes the comparisons with the original chart setting on the dial becomes less significant. For this reason it is recommended that when it becomes necessary to replace the oscillator tube in any Transmitter which has had considerable use, the trimmer condenser be inspected for *position*. Remove the Transmitter cabinet and examine the variable plates (rotor) of the trimmer condenser. This trimmer condenser consists solely of the one variable plate and the two fixed plates which are mounted on the side of the frame of the main oscillator condenser (116, 170, Fig. 11). The original factory calibration was made with the trimmer at its mid-capacity position, *i.e.* with the straight edge of the semicircular rotor plate perpendicular to the condenser shelf. At the time of the second, third and subsequent replacements of the oscillator tube by the method described above, the rotor of the trimmer condenser should be restored to its mid-capacity position before selecting the next oscillator tube.

After a tube has been selected and the Transmitter has been adjusted as described above, the selected tube should have a paper "paster" attached to it, with suitable notation placed thereon so that it will not be confused at a later time with the similar type of tube which is used as the radio amplifier tube.

OPERATING DIFFICULTIES AND POSSIBLE CAUSES

The following general principle should be remembered and constantly followed in connection with this equipment:

> WHEN LOOKING FOR TROUBLE IN A RADIO SET ALWAYS EXAMINE ALL THE SIMPLE CAUSES OF FAILURE FIRST.

Many good radio sets have been ruined by internal alterations when the service failure was really due to a cable, a plug, a power supply, or a tube. This Radio Set is electrically a complicated system, depending upon precise design, workmanship and adjustment for its successful operation. Inspections and operations performed on the interior of this equipment, which are suggested in the following paragraphs, should be done *only as a last resort*, and after it is certain that the fault is not to be found outside the Receiver.

1. *Receiver Operative but Noisy.*

Probably the most common cause of poor radio reception in all airplane installations of high-sensitivity receivers is electrical "noises" of both local and atmospheric origin. Operators of the Receiver should learn by experience to identify those "noises" in the telephone receivers which indicate faults in the apparatus or installation. Such identification by ear will greatly facilitate the correction of the fault. The following tabulation may be used as a guide.

(a) Atmospheric (static), external man-made interference. Should be identified on the ground, engine not running. Static will be heard with some Coil Sets at all seasons of the year and most times of day. The general static level grows progressively lower with increasing frequency. The Receiver cannot be adequately tested or inspected in ground locations where power-line interference, motor interference and the like are excessive. Disconnecting the antenna at the Receiver binding post will generally give a satisfactory test, since if the noise encountered is static or power-line interference it will greatly diminish or disappear when the antenna is disconnected.

(b) Dynamotor noise. Should be identified on the ground, engine not running; usually related to the speed of the machine and can be identified by switching the power on and off at the BC-231.

(c) Intermittent contact in phone cord, plug, or contacts to telephone receivers. Should be identified on ground, engine not running.

(d) Loose bond or terminal plug on any Receiver Cord. Should be identified on ground, engine not running.

(e) Ignition noise. Should be identified on ground, engine running, by varying the speed of the engine and by switching from one magneto to the other.

(f) Generator noise. Should be identified on ground, engine running, by advancing throttle to the point at which generator cuts in. If it originates in the generator itself, it will be a characteristic "machine noise"; if it is in the voltage regulator it will probably be intermittent and appear only above a certain critical engine speed (usually 800 to 1,000 R.P.M.). Noise originating in the generator and voltage regulator can be distinguished from ignition noise by the fact that generator and voltage regulator noise is usually suppressed by opening the airplane main line switch.

(g) Vacuum tube noise. Should be identified on ground, engine running; usually a crackling or ringing sound. It will sometimes appear under sustained vibration and never be heard at all when the Receiver setbox is jarred intermittently by hand.

(h) Intermittent contact in an internal circuit of the Receiver. May be identified with the engine running or by jarring the Receiver by hand. Disconnecting the antenna and vibrating the Receiver is not necessarily a test because noises of this character may be increased to audibility by a strong incoming signal.

With regard to (a) it should be noted that it is no uncommon occurrence for man-made interference to be received with destructive force when flying over certain areas, and to be of such a nature that it is easily confused with generator or dynamotor noise on the airplane itself. If "machine" noises are suddenly heard in flight they may possibly be identified with a particular ground area. Also it should be remembered that when flying through mist, rain or snow, a noise is sometimes heard which sounds like a machine noise; it is produced by the impact of the charged particles on the receiving antenna and airplane, and is irremediable.

With regard to (b), the interruption of current in the commutators of the dynamotor machine sets up radio-frequency oscillations in the connecting Cords, which oscillations enter the Receiver by way of the antenna (never through the conductors of the Cords themselves); this fact may be verified by disconnecting the antenna at the Receiver binding post. The transmission of dynamotor noise to the Receiver is related to the condition of bonding of the Cords, particularly at high frequencies. A dirty commutator will produce more noise than a clean one, but complete suppression can never be obtained if the shielded Cords are not thoroughly bonded and grounded. This fact should be remembered when making bench installations of the Radio Set for test purposes. When this noise occurs in an airplane installation the bonding of all Cords to the airplane should be checked for poor contacts. If the noise persists, the commutators of the machine may be cleaned with *a clean dry cloth* while the machine is turning over. *Never use emery on a commutator.* A trace of oil or grease on a commutator may cause more trouble than any dirt deposit. The low-voltage commutator is more apt to produce noise than the high-voltage commutator. Under normal operating conditions the commutators of these enclosed machines should not require cleaning oftener than about 300 hours.

With regard to (f), generator and voltage regulator noise is frequently a more elusive fault than ignition interference. A temporary remedy, if the generator becomes noisy in the air, is to open its field while receiving, but this is not a cure, and should not be permanently tolerated. Complete shielding will not always cure voltage regulator interference. For best results the voltage regulator output should be electrically filtered. A method of doing this, which is effective in many installations, is to connect a condenser of ½ mfd. capacity between the positive generator field terminal and ground, and a second condenser of ½ mfd. between the positive 14-volt output terminal and ground. To be effective this must be done *at the generator*, using the shortest possible leads.

With regard to (g), an intermittent contact inside a tube is sometimes the first indication that its useful life is over. Noises originating in the tubes are *greatly accentuated by the presence of a strong incoming radio signal*, particularly an unmodulated signal, and this may be used as a means of identifying such a noise. The faulty tube must be isolated by replacing the tubes one by one with new ones and observing when the disturbance vanishes.

If the trouble is due to (h), the Receiver must be dismounted and inspected internally for loose connections. To remove the Receiver chassis from its case, first take out the Coil Set, then remove from the setbox the twelve nickel-plated screws. Do not lose the lockwashers from these screws; these washers must all be replaced when the screws are replaced. The front panel may then be separated from the case, which slides backward off the frame. *Black-headed screws and rivets must not be removed from any part of the Receiver.* Do not disarrange the internal wiring of the Receiver during this inspection.

Operating the Receiver at excessively high voltage tends to make it noisy during operation and to increase the residual cause of noise. NEVER ALLOW THE RADIO SET TO BE OPERATED AT A SUPPLY VOLTAGE GREATER THAN 15 VOLTS. Operation at less than 12 volts will not damage the equipment, but the radio reception will be unsatisfactory.

2 *Receiver Dead. No Sounds.*

Having checked all Plug and Cord connections, dismount the Junction Box with Cords attached and check all voltages with reference to the table, page 39. Inspect Junction Box wiring for open circuits. Try another Coil Set. Be sure that Coil Sets are securely seated. If tubes do not light, check fuse 366 and renew if it is open. If dynamotor does not run: (a) check fuse 151 and renew if it is open; (b) substitute another Dynamotor Unit and if it runs, look for an open circuit at the low-voltage brushes of the first machine; (c) check circuit through BC-231 switch in MANUAL or AUTO position, starting at 44 and ending at 38 in Junction Box. If dynamotor runs, but voltage on terminal 29 or 31 is low, check the continuity of high voltage circuits through resistor 146, choke 149, in Dynamotor Unit base. Check condensers 147 for short-circuits. If all voltages on receptacle 165 of the Junction Box are normal, check volume control circuit with switch at MANUAL, through terminal 93 to ground. This circuit should show 200 ohms resistance at maximum INCREASE position of volume control. If this circuit is normal and Receiver is still inoperative it should be dismounted for a bench test.

Remove the Receiver case and inspect the wiring for short-circuits. Check transformer 71 and coil 95 for open circuits between their respective terminals. Check the Coil Set for open circuits between the respective pairs of terminals which are closed by windings. Inspect all contacts of all tube sockets. Mount Coil Set and plug Receiver into a complete Radio Set, throw the power on and with switch at MANUAL, check the voltage on each electrode of each tube by connecting a high-resistance voltmeter between the different electrodes and ground. Compare the readings with those of the table on page 39.

IMPORTANT NOTE: All readings of electrode bias voltages and supply voltages in the Receiver should be made with the switch on MANUAL and the control grid of each of the four VT-49 Tubes connected to ground, and with the control grid clips in place on their respective tubes. If this condition is not fulfilled the Receiver will oscillate, since it is out of its shielding case, and the voltage readings will be abnormal.

If there is no plate voltage on one tube, check the contacts made between the various pin plugs and their respective receptacles on the Coil Set. These pin plugs may become distorted after long use; their ability to make contacts can be restored, unless the springs are fractured, by tapping each plug on the end to spread the contact springs. If the cathodes or screen grids do not show approximately the same voltages as those in the table, check the circuits through the various decoupling resistors in supply lines from 46 to the cathodes, and 56 to the plates. If an ohmmeter is available check the values of these resistors. Check all condensers 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 for internal short-circuits. Check resistors 62, 66, 67, 68, 69, 70, 72, 73 and 98 for open-circuits. Check the continuity of the line starting at the grids of the first two VT-49 Tubes on one side and passing through terminal 54 and through terminal 90 of the Junction Box and Control Box. Check neon tube 87 for a short-circuit. Under normal service conditions this tube will last for the life of the Receiver without replacement. Replace each vacuum tube with a new one of the same type. A tube may lose emission without becoming noisy.

3. *Receiver Operative but Insensitive.*

Check alignment of antenna.

Check Junction Box voltages with the Radio Set turned on. Dead 12-volt batteries are the reason for a large number of communication failures. If voltages are normal, check the Tubes by replacing them with new ones—one at a time.

Try another Coil Set.

As a last resort check the alignment of each tuned amplifying stage. *This operation should not be done in the field, but must be done on the bench, since it is an operation requiring considerable care.* Access to the aligning condensers 59 is obtained through the rotatable snap covers 277 on the side of the Receiver setbox. Connect the Receiver to an antenna (or to a dummy antenna if a local signal source is available) and tune in a signal on any Coil Set at the *high-frequency end* of the scale (75 to 100 scale divisions). Retard the volume control until the signal is just audible. This operation should be performed on a steady tone modulated signal, not on a radiophone signal or a signal that is fading. Align the input circuit carefully with knob 244. Insert screwdriver into the three slotted adjusting screws which control the three condensers 59 and adjust them successively for maximum signal. It is highly desirable, in this operation, that the Output Meter, Model 571, from Signal Corps Test Set, type I-56-A, be used to give visual indication of the Receiver output. Set the Output Meter on its 15-volt scale and plug it into the Telephone Jack on the BC-231.

NOTE: If it is impossible to find a maximum or if the maximum signal is not located very close to the original positions of these screws, the fault is in the circuit or the gang condensers and not in the settings of these condensers and they should be restored as closely as possible to their former positions.

If the tuned stages are in proper alignment, or if it is impossible to tune to maximum signal on the aligning condensers, the fault must be in the circuits of the Receiver or in the gang tuning condenser.

4. *Receiver Oscillates.*

The presence of sustained oscillations in the Receiver is always identified by (a) the heterodyne beat note with incoming signals which varies as the Receiver is tuned; (b) an increase in all noise levels; (c) occurrence at or near the maximum "INCREASE" position of the volume control, with reduction or suppression as this control is retarded. While abnormal in this Radio Receiver, self-oscillation is not always a bar to the reception of signals because if the Receiver is otherwise normal such oscillation can usually be entirely controlled by the volume control. The Receiver will usually oscillate at the maximum "INCREASE" position if the supply voltage source is too high, and this is not an indication of a fault. If the Receiver oscillates at 12 volts in one or more frequency bands, and in a well grounded installation, it indicates a fault.

Check all snapslides on the Coil Set and the tube cover. If any of these snapslides do not make good contact with their respective studs, due to the presence of dirt or other reasons, the Receiver may oscillate.

Check the radio-frequency tubes by replacements with different tubes, *but not old ones.* Occasionally a tube with imperfect internal shielding is encountered; this can cause self-oscillation.

Check all the screws in the Receiver setbox. See that there is a lock-washer under the head of each screw. If one of the nickel-plated screws is omitted or not screwed down tight, the Receiver may be unstable and oscillate.

If the condition of oscillation is permanent and violent, the case should be removed from the Receiver and an internal inspection carried out. Open circuits in the supply lines will not cause oscillation. The various grid and plate voltages should be measured as outlined under section (2) above. Abnormally *high* screen and plate voltage or abnormally *low* control grid bias may be sufficient cause for oscillation.

A sufficient cause for oscillation in the Receiver is an open circuit in one of the various condensers 1, 2, 3, 4, 5, 6, 7, and 8. Since the terminals of these condensers are connected together through other condensers or through resistors of various sizes it is necessary first to disconnect all leads from the ungrounded terminal of each condenser under test. A rough test for capacity between the condenser terminals can then be made, if a capacity meter is not available, by charging the condenser with a 45 volt or 90 volt "B" battery. Ground one side of the battery on the Receiver frame and touch the other side of the battery to the open condenser terminal. Remove the battery connection and touch this terminal with a grounded wire. If the condenser is in good condition it will discharge with a visible flash or spark. A by-pass condenser which is not open or leaky will retain for at least ten seconds enough charge to spark visibly when discharged to ground. When leads to condensers 1, 2, 3, 4, 5, 6, 7, and 8 are unsoldered or restored, *great care must be taken not to melt out the lugs of these condensers.* These lugs must, under no circumstances, be heated for any length of time. If this soldering is done carelessly the condensers may open up internally as a result of the soldering operation.

Another cause for oscillation is poor contact between rotor sections and frame of the gang condenser. A strong spring contact should be maintained in each section. These contacts will be helped by slight lubrication of high-quality *clock oil* and working it in thoroughly by rotating the condenser several times throughout the 0 to 100 range.

5. *Low Transmitter Current.*

Examine all insulators for short-circuits, moisture, and carbon deposits and terminals for open or dirty contacts in the transmitting antenna.

Retune the antenna coupling circuit by varying either the antenna condenser or coil tap, or both. Do not allow dirt to get into the antenna coil assembly. Clean the sliding contact on the antenna coil.

Check supply voltage and Junction Box voltages.

Replace with new tubes the radio oscillator and amplifier Tubes, type VT-25. If the radio oscillator tube is to be permanently replaced see "REPLACEMENT OF RADIO OSCILLATOR TUBE IN RADIO TRANSMITTER" in Section ~~IV. MAINTENANCE~~ "VI. SERVICING, etc."

If these tests show no results the Transmitter should be given a bench test. For use in bench testing it is necessary to provide an artificial or phantom antenna, or the tests will mean nothing. *Never operate the Transmitter unless an antenna circuit is connected between the antenna and ground binding posts.* This will ruin the tubes and shorten the life of the whole equipment. The following extra equipment is required for bench testing the Transmitter.

(a) Antenna, type A-55. This is a small phantom antenna having a capacity of 100 mmfd. with a resistance of 5 ohms. If the unit is not available a substitute may be used, for approximate measurements, consisting of a small mica condenser and a wire resistance, connected in series between the Transmitter antenna and ground binding posts.

TABLE I (See Instructions on Pages 37 and 39)

Frequency (kc)	Antenna* Coil Tap	Modulator-Oscillator Plate Current 12 Volts	Modulator-Oscillator Plate Current 14 Volts	Amplifier Plate Current 12 Volts	Amplifier Plate Current 14 Volts	Antenna Current 12 Volts	Antenna Current 14 Volts
6200	10	.077 a.	.088 a.	.028 a.	.034 a.	.80 a.	.95 a.
6500	9	.077	.088	.028	.034	.81	.96
6800	9	.077	.088	.028	.034	.83	.98
7100	8	.078	.090	.028	.034	.83	.98
7400	8	.083	.098	.028	.034	.83	.98
7700	7	.089	.105	.027	.032	.80	.92

* The figures in this column represent the number of turns on the antenna coil between the tap 130 and the base of the coil, setting this tap in each case for the best *combination* of radio power output and modulation. At every point, a somewhat higher tap would give slightly greater power output, but at the expense of greater amplifier plate current and less modulation. *The Antenna coil tap should never be left at a point at which the amplifier plate current exceeds about 36 milliamperes on 14 volts or about 30 milliamperes on 12 volts. On the other hand, the Transmitter should not be so tuned that the modulator-oscillator current exceeds 120 milliamperes at 14 volts or 105 milliamperes at 12 volts.*

TABLE II (See Instructions on Page 40)

TYPICAL JUNCTION BOX VOLTAGES

CONTROLS AT MANUAL, VOICE, TRANSMIT

Voltage to Ground 12 Volts Supply	*Voltage to Ground 14 Volts Supply*	*Terminals*
11.5 v.	13 v.	34, 35, 38, 45, 63, 94
12	14	25, 44, 91
265	305	20, 22, 41, 42
285	325	21, 26, 29, 40
300	340	31, 57

2–7 volts on 33 and 51, depending upon the resistance of the microphone.

(Zero voltage on all other terminals)

CONTROLS AT MANUAL, VOICE, RECEIVE

Voltage to Ground 12 Volts Supply	*Voltage to Ground 14 Volts Supply*	*Terminals*
11.6 v.	13.2 v.	33, 34, 35, 38, 45, 48, 51, 63, 65, 67, 94
12	14	25, 44, 91
216	250	39, 56
310	355	26, 29, 30
260	300	31, 57

(Zero voltage on all other terminals)

NOTE: *All the voltages listed above will vary somewhat with lengths of Cords, age of Tubes, and condition of circuit resistors. Check the Tubes independently and measure circuit resistances and continuity.*

TABLE III (See Instructions on Page 40)

TYPICAL PLATE AND BIAS VOLTAGES IN TRANSMITTER

CONTROLS AT MANUAL, VOICE, TRANSMIT

Tube	*Grid Bias to Ground 12 Volts*	*Grid Bias to Ground 14 Volts*	*Plate Voltage to Ground 12 Volts*	*Plate Voltage to Ground 14 Volts*
Radio Oscillator (VT-25)...........	....	....	180	210
Modulators (VT-52)...............	45	55	265	310
Radio Amplifiers (VT-25)...........	45	55	260	305

TOTAL INPUT TO EQUIPMENT

Supply Voltage	(TRANSMIT, VOICE) *Supply Current*	(RECEIVE ONLY) *Supply Current*
12 v.	7.5 a.	4.8 a.
14	8.5	5.2

NOTE: *All the voltages listed above will vary somewhat with lengths of Cords, age of Tubes and condition of circuit resistors. Check the Tubes independently and measure circuit reistances and continuity.*

TABLE IV (See Instructions on Page 40)

TYPICAL PLATE, SCREEN AND BIAS VOLTAGES IN RECEIVER

CONTROLS AT MANUAL, RECEIVE

Control grids short-circuited to ground. Volume control at max.
All bias voltages measured with respect to ground.

	Heater		Screen Grid		Plate		Control Grid Bias (Cathode to Ground)	
Tube	*12 Volts*	*14 Volts*	*12 Volts*	*14 Volts*	*12 Volts*	*14 Volts*	*12 Volts*	*14 Volts*
First VT-49....	5.9 v.	6.8 v.	105 v.	121 v.	216 v.	250 v.	5.4 v.	6.5 v.
Second VT-49..	11.8	13.6	105	121	214	245	5.4	6.5
Third VT-49...	11.8	13.6	105	121	212	242	5.4	6.5
Fourth VT-49..	5.9	6.8	210	240	210	240	14.5	16.5
VT-37........	5.9	6.8	...	...	...	...	...	...
VT-38........	11.8	13.6	210	240	235	270	22.5	26.0

NOTE: *All the voltages listed above will vary somewhat with lengths of Cords, age of Tubes, and condition of circuit resistors. Check the Tubes independently and measure circuit resistances and continuity.*

The condenser should be of standard make, rated capacity 100 mmfd. and the resistor should have a d-c resistance of 3.5 to 4 ohms. Antenna, type A-55 is suitable for bench testing throughout the range 4000–7700 kc. The capacity of 100 mmfd. is too small for use throughout the entire range of 2500 to 4000 kc, and if tests are desired in these bands a substitute unit should be used having a higher capacity. A unit having a capacity of 200 mmfd. with a resistance of 5 ohms is suitable for testing throughout the whole of this lower frequency range.

(b) High-resistance voltmeter. The Model 564 instrument from Signal Corps Test Set, type I-56-A, is recommended. The Set Analyzer from Signal Corps Test Set, type I-56-A may be used for all Transmitter plate current readings.

(c) D-c milliammeter, scale 0-150 milliamperes, with plug to fit the Transmitter jacks 127, 128. The foregoing Table I gives a typical set of values of the significant currents in the Transmitter at 12 volts and 14 volts supply. The antenna current is obtained in this case, using Coil Set, type C-220, with Antenna, type A-55 connected between the Transmitter binding posts. The controls are set at "MANUAL" and "VOICE".

The current values given in the above table are not exactly reproducible, but will serve as a general guide to show the average or approximate values that should be obtained when testing the Transmitter.

If no current is indicated by the antenna ammeter for any combination of settings of the controls, when Antenna, type A-55, is connected between the binding posts, this may indicate an open circuit in the antenna ammeter. The continuity of the circuit through the ammeter and the antenna coil may be checked by connecting a *voltmeter* and dry cell between the binding posts A and G.

Never use an external source of voltage in series with an external ammeter, as this may burn out the antenna ammeter if this circuit is complete.

It should be noted that the readings given above for the various plate currents are all for *resonance in the antenna circuit.* If the antenna circuit is not tuned to give a maximum of current as indicated by the antenna ammeter, the plate current readings for all the tubes will have no significance. In general, the antenna tuning adjustment which gives resonance, and maximum current on the antenna ammeter, is the point of greatest efficiency of operation.

If the plate currents depart widely from the above at resonance at a given frequency setting, the Transmitter chassis should be removed from its case (first dismounting the Coil Set), for internal examination. The case is attached to the Transmitter chassis by means of ten nickel-plated screws; no other screws should be removed. Measure with a high-resistance voltmeter the bias voltages across resistor 104. If the plate current is zero from one tube, the various plate supply circuits should be traced from the Junction Box through the BC-232 to the radio oscillator, radio amplifier, and modulator tubes.

It will be noted that in Table I a safe operating limit is imposed not only upon the amplifier plate current but also on the modulator-oscillator plate current. If abnormally high plate currents occur simultaneously at the amplifier and modulator-oscillator jacks, and these currents *cannot be reduced to normal values by adjusting the antenna-coil tap and tuning to resonance with a phantom antenna*, the most probable reason for the trouble is abnormally low output from the radio oscillator, or complete failure to oscillate. Possible causes for failure of the radio oscillator are: defective oscillator Tube, type VT-25; open or short-circuited turns in the oscillator coil assembly (shielded) of the Transmitter Coil Set; open circuit in the oscillator plate resistor 102 or grid resistor 105 in the Transmitter. For these defects the remedies are obvious. It has been found, moreover, that when a Transmitter is stored without motion or vibration for a long period, microscopic particles may collect between the stationary plates of the oscillator tuning condenser, 116, 117, 120, which increase the leakage enough to prevent oscillation. An effective remedy for this is to remove the Transmitter cabinet and "blow out" the plates of the variable air condensers with a current of clean, dry air. This should be done if the symptoms listed above are encountered, and no fault can be found in the Tubes or the circuits. If an ordinary shop air-hose is used the air should first be tested by blowing it through a fine cloth, to make sure that it does not contain dust. *Select a clean, dust-free location* for this blowing-out process, and do not allow the Transmitter chassis to stand around, or be stored, outside of its cabinet.

6. *No Side-Tone on* "VOICE".

The side-tone circuit is connected to the plate circuit of the modulator tubes, so this may indicate lack of modulation. Be sure that both modulator tubes are lighted and firmly in their sockets. *The transmitter cannot be operated if either modulator tube is out.* Try different modulator tubes.

Check the continuity of the microphone circuit from terminal 33 through winding 1–2 of transformer 123 and resistor 101. Check the secondary circuit from the modulator grids through winding 3–4 and resistors 100, 104 to ground. Check jack 127 for an open circuit. Check the continuity from the modulator plates through winding 3–4 of coil 125 and 1–2 of transformer 124.

If the antenna current varies when talking into the microphone, but side-tone is weak or absent the Transmitter output is probably being modulated but the fault is in the side-tone circuit, which should be checked for continuity from the tertiary winding of transformer 124 through terminal 23, relay 153, and 95 to the telephone jacks 133.

7. *No Side-Tone on* "TONE".

Try new modulator Tubes, type VT-52. Check resistor 115 for an open circuit. Check condenser 106 for open circuit and short circuit. Check the continuity of both windings of Coil 125. Check condenser 107 for open and short circuits.

USE OF SIGNAL CORPS TEST SET, type I-56-A

This Test Set includes the following instruments:

- Radio Set Analyzer, Model 665, type 2, with Socket Selector, Model 666, type 1B and Capacity Unit, Model 666, type 2.
- Voltohmmeter, Model 564, type 3B.
- Output Meter, Model 571, type 3A.
- Tube Tester, Model 685, type 2.

The following types and methods of measurement can be made with these instruments to carry out the trouble-hunting and maintenance operations outlined in the preceding sections. For detailed instructions on the use of the controls of these instruments after connections to the Radio Set are made as described below, see the "Instruction Book for Test Set I-56-A".

Transmitter Tube Currents (*Table I*). For measurement of the amplifier and modulator-oscillator plate currents in the Transmitter only an external d-c milliammeter is required. Plug a two-wire cord, on a Plug, type PL-68 or equivalent, into jack 127 for the modulator-oscillator current, and into jack 128 for the amplifier current. Connect the free ends of the cord into the "M.A." pin-jacks at the right-hand side of the Model 665 Analyzer, using the "–" and "250" pin-jacks for modulator-oscillator current and the "–" and "50" pin-jacks for amplifier current. The Socket Selector block and cord are not used. *Follow the instructions given on page 39 of this book* with regard to operating the Transmitter, at resonance, into a suitable artificial antenna; otherwise the plate-current indications will be meaningless. (Antenna currents are measured on the thermal ammeter of the Transmitter.)

Junction Box Voltages (*Table II*). Measure all Junction Box voltages by contacting the terminals with probe cords, the pin ends of which are inserted either in the proper "V" terminals of the Model 564 Voltohmmeter, or in the proper "Volts" pin-jacks at the left-hand side of the Model 665 Analyzer. The Socket Selector block and cord are not used.

Transmitter Plate and Bias Voltages (*Table III*). The radio oscillator grid bias cannot be measured by means of the Test Set. *The amplifier-modulator grid bias cannot be measured with the Transmitter in its case* because of the large series-grid resistor 100. *Do not try to use the Model 666 Socket Selector in the Transmitter for voltage measurements with the power on. This procedure is unsafe and may give misleading results.* Remove the Transmitter case, mount the Transmitter Coil Set in place and retune the Transmitter. Keep the antenna circuit in resonance. Use a high-resistance d-c voltmeter, i.e. the appropriate scales of either the Model 665 analyzer or the Model 564 Voltohmmeter. For the amplifier-modulator grid bias connect the voltmeter across the terminals of resistor 104 (see Fig. 18) or condenser 113. The radio-oscillator plate voltage is measured between the ungrounded terminal of condenser 112 and ground. The values of amplifier and modulator plate voltage given in the table are obtained respectively at terminal 20 of the Transmitter power receptacle and 4 of tone-oscillator coil 125. *Be sure that the Transmitter is operating normally with the antenna circuit tuned for maximum current on the antenna ammeter while these measurements are made.*

Receiver Plate, Screen and Bias Voltages (*Table IV*). It is not necessary to measure directly the plate and screen currents of the Tubes in the Receiver, in looking for circuit faults. The values of control-grid bias on all Tubes are a measure of normal plate and screen-grid currents since all the Tubes except the diode detector are auto-biased. The bias voltages given in Table IV may be measured by means of the Model 666 Socket Selector, *provided that the control grids of all the VT-49 Tubes not in the Socket Selector are short-circuited to ground to prevent self-oscillation of the amplifier.* This Socket Selector consists of a plug with suitable adapters for plugging into any tube socket in place of the tube, the plug being connected through a cord to an external socket block which, together with its adapters, forms a universal tube socket with exposed pin-jack terminals at each tube electrode from which flexible jumper-cords can be run to the desired terminals on the Set Analyzer. With the controls set as specified in Table IV the voltages on the VT-38 and VT-49 sockets are measured as follows: mount 5-prong adapters on the Model 666 Socket Selector block and cord and remove the Tube from the Receiver socket in question; mount the tube in the Socket Selector block and plug the cord into the Receiver socket; connect the appropriate d-c scale of the Analyzer voltmeter between ground and socket-terminals 1 or 5 for the heater voltage, 2 for the plate voltage, 3 for the screen-grid voltage and 4 for the control-grid bias. The procedure for the VT-37 socket is similar except that the only significant voltage is the heater voltage since the other electrodes are not biased. For convenience in checking, all values in the table are recorded as voltage to ground and the negative terminal of the voltmeter may therefore be grounded on any part of the Receiver. The heaters of the tubes are wired in series-parallel so that these positive terminals are alternately 6 and 12 volts to ground.

Vacuum Tube Tests. The tests described in the foregoing paragraphs are not tests of the vacuum tubes, but of the circuits and circuit constants, so it is important that the tubes themselves all have normal volt-ampere characteristics. An *approximate* test of the volt-ampere characteristics of the various types of tubes may be made with the Model 685 Tube Tester. For the Tubes alone follow the instructions given on pages 8 and 9, and in the back, of "Instruction Book for Test Set I-56-A".

Continuity Tests. Many of the continuity tests suggested on pages 34-39 of this book involve circuits ending at tube sockets, and can therefore be made on both Transmitter and Receiver with the Model 665 Analyzer (ohmmeter terminals) in connection with the Model 666 Socket Selector. *All power must be off the equipment when continuity tests are made.* Where a circuit must be checked which does not terminate in either a tube socket or a power receptacle the case must be removed from the unit, and a probe cord used to connect the ohmmeter to the hidden terminal. On page 6 of the "Instruction Book for Test Set I-56-A" instructions are given for the measurement of capacities with the Model 665 Set Analyzer and Model 666 Capacity Unit. The paper dielectric by-pass condensers 1, 2, 3, 4, 5, 6, 7, 8, 78, 107, 109, 112, 113, 147, etc., of this Radio Set may be checked by this method, but not the various mica condensers, because the capacities of the latter are too small to be indicated by the instrument.

VII. LIST OF PARTS

FOR RADIO SET SCR-AK-183

TABLE I

Reference	Name of Part Function and Description	Manufacturer's Name**	Manufacturer's Type	ARC Dwg. No.	Stock No.
	Radio Receiver, type BC-AH-229	A	....	3578-4	2C4229.3
	Mounting, type FT-99	A	....	3834-3	2Z6649
1	*By-pass condenser, screen grids, 0.1 mfd. (2x0.1), paper	A	....	1574-1	2C4229/1 (items 1, 2)
2	*By-pass condenser, plates, 0.1 mfd. (2x0.1), paper	A	....	1574-1	
3	*By-pass condenser, cathodes, 0.1 mfd. (2x0.1), paper	A	....	1572-1	
4	*Filter condenser 0.1 mfd. (2x0.1), paper	A	....	1572-1	2C4229/3 (items 3, 4, 5)
5	By-pass condenser, heaters, 0.1 mfd. (2x0.1), paper	A	....	1572-1	
6	*By-pass condenser, cathode, 0.5 mfd., paper	A	....	1573-1	2C4229/6 (items 6, 7)
7	*By-pass condenser, plate, 0.5 mfd., paper	A	....	1573-1	
8	*By-pass condenser, cathode, 0.5 mfd. (2x0.5), paper	A	....	1575-1	3DA500-15
9	*Filter condenser, 0.004 mfd., mica	B	1461	P437	3DA4-2
11	Coupling condenser, 0.006 mfd., mica	B	1461	P91	3DA6-1
12	Filter condenser, 0.0001 mfd., mica	B	1465	P94	3D9100-9
58	*Amplifier tuning condenser, variable, air (unit of gang)	A	....	2461-4	....
59	*Amplifier aligning condenser, fixed, air (unit of gang)	A	....	2461-4	....
61	*Decoupling resistor, 200 ohms, carbon	D	E	P497	3Z6020-2
62	Bias resistor, 600 ohms, carbon	D	E	P512	3Z6060-1
67	Grid resistor, 2,000,000 ohms, ceramic	K	F1/3	3070-1	3Z6802
68	Plate resistor, 500,000 ohms, carbon	D	E	P493	3Z6750-1
69	A.G.C. filter resistor, 2,000,000 ohms, carbon	D	E	P503	3Z4573 (items 69, 70)
70	Grid resistor, 2,000,000 ohms, carbon	D	E	P503	
71	Output transformer, step-down, 2.9/1 ratio	A	....	2412-2	2C4229/71
72	Filter resistor, 100,000 ohms, carbon	D	E	P501	3Z4571
73	Bias resistor, 2,000 ohms, carbon	D	E	P499	3Z6200-3
78	By-pass condenser, plate, 0.2 mfd. (2x0.1), paper	A	....	1574-1	2C4229/1
79	Compensating condenser, 9 mmfd., mica	A	....	......	....
80	Input aligning condenser, variable, air	A	....	2957-2	....
83	Antenna-loop switch, D.P.S.T.	A	....	1426-2	2C4229/83
84	Antenna binding post	A	....	2716-1	2C6230/84
86	Ground binding post	A	....	2715-1	2C6230/86
87	Neon tube	I	T2	FR6	2Z5893
88	*Bias resistor, 750 ohms, carbon	D	E	P509	3Z6075-2
94	Output filter choke, 0.41 henry	A	....	2465-1	2C4229/95
96	D.F.I. jack, one-way closed circuit	A	....	FR225	....
97	Coupling condenser, 0.001 mfd., mica	A	....	2218-1	2C6230/114
98	Bias resistor, 300 ohms, carbon	D	E	P533	3Z6030-3
99	Decoupling resistor, 5,000 ohms, carbon	D	E	P505	3Z6500-3
145	Voltage-divider resistor, 7,000 ohms, center tap, wire-wound, special finish	A	....	3068-1	3Z5470.1
162	Receptacle ring for Plug, type PL-61, part of Socket, type SO-41.	A	....	1351-1	2Z8741 (items 162, 163)
163	Receptacle plate for Plug, type PL-61, part of Socket, type SO-41	A	....	2810-2	
175	Receptacle plate for Plug, type PL-77, part of Socket, type SO-57	A	....	2963-2	....
240	Receiver dial	A	....	2722-1	2Z3703
244	Input alignment condenser knob	A	....	3007	2Z5760.1
253	Shock-proof cup assembly	A	....	3585-1	2Z6649/10
254	Snapslide	A	....	2540-1	2Z8602
255	Snapslide stud (for coil compartment)	A	....	1089-1	....
256	Snapslide stud (for tube compartment)	A	....	1090-1	....
257	Five-prong tube socket, special	A	....	3536-1	2C4229/257
259	Pin Plug	A	....	2661-1	2Z7059
260	*Control grid clip	N	24	2313-1	2Z2724
261	Tuning outlet (right hand)	A	....	FR122	....
262	Tuning outlet (left hand)	A	....	FR121	....
266	External (male) spline	A	....	3026-1	....
268	Cap nut (for tuning outlet)	A	....	G-169	....
271	Long snapslide stud (for FT-99)	A	....	2441-1	....
272	Tube cover assembly	A	....	FR-239	2C4229/272.1
273	Cabinet assembly	A	....	2456-4	....
274	Front panel	A	....	2392-3	....
275	Dial gear unit	A	....	3036-3	....
276	Tube shield	A	....	G-184	....
277	Aligning condenser cover	A	....	G-617	....
284	Mounting bracket assembly	A	....	F-486	2C4179/118
361	Chart, type MC-146-A	A	....	3805-2	2Z2246A

Radio Set SCR-AK-183

Reference	Name of Part Function and Description	Manufacturer's Name**	Manufacturer's Type	ARC Dwg. No.	Stock No.
	Coil Set, type C-171 (2500-4700 KC) (Receiving)	A	....	2625-3	3C171
13	Coupling condenser, 0.0001 mfd., ±5%, mica	C	5	P520	3D9100-13
66	Grid resistor, 30,000 ohms, carbon	E	D1/3*	P450	2C4199/65
82	Not used.				
89	Tuned input coil assembly	A	....	2556-1	....
90	Tuned coupling coil assembly	A	....	2556-1	....
92	Band-pass coil assembly	A	....	2568-1	....
93	Coil, band-pass coil assembly	A	....	2578-1	....
254	Snapslide	A	....	2540-1	2Z8602
	* *Type designation D1/3 supersedes older type designation K-7 for same unit.*				
	Coil Unit, type C-155-A (201-398 and 4150-7700 KC) (Receiving)	A	....	2814-3	3C155A
13	Coupling condenser, 0.00025 mfd., ±5%, mica	C	5	P516	3D9250-5
66	Grid resistor, 15,000 ohms, carbon	E	D1/3*	P471	3C131/6
82	Voltage, divider condenser, 0.0005 mfd., ±5%, mica	C	5	P515	3D9500-10
89	Tuned input coil assembly	A	....	2736-2	....
90	Tuned coupling coil assembly	A	....	2736-2	....
92	Band-pass coil assembly	A	....	2734-2	....
93	Coil, band-pass coil assembly, high	A	....	2706-1	....
	Coil, band-pass coil assembly, low	A	....	2707-1	....
254	Snapslide	A	....	2540-1	2Z8602
286	Switch shaft	A	....	1009-1	....
287	Switch shaft outlet	A	....	1008-1	....
	* *Type designation D1/3 supersedes older type designation K-7 for same unit.*				
	Radio Transmitter, type BC-AH-230	A	....	3570-4	2C6230.3
	Mounting, type FT-100	A	....	3833-3	2Z6650
84	Antenna binding post	A	....	2716-1	2C6230/84
86	Ground binding post	A	....	2715-1	2C6230/86
100	Filter resistor, 100,000 ohms, carbon	D	G	4555	....
101	Drop resistor, 100 ohms, carbon	D	G	4554	....
102	Drop resistor, 7,000 ohms, wire wound, special finish	A	....	3067-1	3Z6570
103	Load resistor, 10,000 ohms, wire wound, special finish	A	....	3066-1	3Z6610-2
104	Bias resistor, 20,000 ohms, carbon	D	G	4556	....
105	Grid resistor, 30,000 ohms, carbon	D	E	P504	3Z6630-2
106	Coupling condenser, 0.006 mfd., ±5%, mica	B	1461	P91	3DA6-1
107	Tone oscillator condenser, 0.1 mfd. (2x0.1), paper	A	....	1572-1	} 2C4229/3
109	Plate by-pass condenser, 0.1 mfd. (2x0.1), paper	A	....	1572-1	}
110	*Plate by-pass condenser, 0.006 mfd., mica	A	1461	P91	3DA6-1
111	Filter condenser, 25 mfd., electrolytic	A	....	2468-1	2C4229/8
112	Plate by-pass condenser, 0.1 mfd. (2x0.1), paper	A	....	1574-1	} 2C4229/1
113	Grid by-pass condenser, 0.1 mfd. (2x0.1), paper	A	....	1574-1	}
114	Grid condenser, 0.0001 mfd., mica	A	....	2218-1	2C6230/114
115	By-pass resistor, 1,000,000 ohms, carbon	D	G	4553	....
116	Radio oscillator tuning condenser, air (unit of assembly)	A	....	3996-3	....
117	Radio oscillator padding condenser, air (unit of assembly)	A	....	3996-3	....
118	Antenna tuning condenser, air	A	....	2257-3	....
119	Balancing condenser, mica	A	....	2454-1	2C6230/119
120	Compensating condenser, air (unit of assembly)	A	....	3996-3	....
123	Microphone transformer, step-up, 40/1 ratio	A	....	2444-2	2C6230/123
124	Modulation transformer, step-up, 3/1 ratio	A	....	3582-2	2C6230.3/124
125	Tone oscillator coil assembly, two windings, 2/1 ratio	A	....	2644-2	2C6230/125
127	Modulator-oscillator plate-current jack (unit of assembly)	A	....	G-600	} 2C6200/127
128	Amplifier plate-current jack (unit of assembly)	A	....	G-600	}
129	Antenna-current ammeter, 0-1.5 ampere	Q	507	2451-1	2C6230/129
168	Receptacle ring for Plug, type PL-64 (part of Socket, type SO-44)	A	....	1351-1	} 2Z8744
169	Receptacle plate for Plug, type PL-64 (part of Socket, type SO-44)	A	....	2850-2	}
241	Frequency control knob	A	....	G-278	....
242	Frequency control dial	A	....	2721-1	2Z3700
243	Antenna condenser knob	A	....	2138-1	2Z5767.1
250	Frequency control lock screw	A	....	1919-1	2C6230/250.1
251	Antenna condenser lock screw	A	....	G-622	2C6230/250
253	Shockproof cup assembly (for FT-100)	A	....	3585-1	2Z6649/10
254	Snapslide	A	....	2540-1	2Z8602
256	Snapslide Stud	A	....	1090-1	....
258	Four-prong socket	A	....	3534-1	2C6230.3/258
259	Pin-plug	A	....	2661-1	2Z7059
271	Long snapslide stud (for FT-100)	A	....	2831-1	....
278	Cabinet assembly	A	....	2449-3	....
279	Front Panel	A	....	2068-3	....
280	Tube cover assembly	A	....	1663-2	2C6230/280
282	Coil panel assembly	A	....	2453-3	....
283	Balancing condenser cover	A	....	1546-1	....
284	Mounting bracket assembly	A	....	F-486	2C4179/118
288	Compensating condenser cover	A	....	G-617	....
289	Compensating condenser shaft	A	....	Built-in	....
290	Tube Retainer	A	....	3647-1	....

Reference	*Name of Part Function and Description*	*Manufacturer's Name***	*Type*	*ARC Dwg. No.*	*Stock No.*
	Coil Set, type C-216 (2500-3200 KC) (Transmitting)	A	....	2737-2	3C216
121	Antenna coil assembly	A	....	2749-1	....
122	Radio oscillator coil assembly	A	....	2743-1	....
126	Coil resistor, 50 ohms, carbon	D	E	P535	3Z6005-1
130	Antenna tap	A	....	2052-1	....
254	Snapslide	A	....	2540-1	2Z8602
	Coil Set, type C-217 (3200-4000 KC) (Transmitting)	A	....	2738-2	3C217
121	Antenna coil assembly	A	....	2750-1	....
122	Radio oscillator coil assembly	A	....	2744-1	....
126	Coil resistor, 100 ohms, carbon	D	E	P536	3Z6010-5
130	Antenna tap	A	....	2052-1	....
254	Snapslide	A	....	2540-1	2Z8602
	Coil Set, type C-218 (4000-5000 KC) (Transmitting)	A	....	2739-2	3C218
121	Antenna coil assembly	A	....	2751-1	....
122	Radio oscillator coil assembly	A	....	2745-1	....
126	Coil resistor, 75 ohms, carbon	D	E	P507	3Z6007E2
130	Antenna tap	A	....	2052-1	....
254	Snapslide	A	....	2540-1	2Z8602
	Coil Set, type C-219 (5000-6200 KC) (Transmitting)	A	....	2740-2	3C219
121	Antenna coil assembly	A	....	2752-1	....
122	Radio oscillator coil assembly	A	....	2746-1	....
126	Coil resistor, 75 ohms, carbon	D	E	P507	3Z6007E2
130	Antenna tap	A	....	2052-1	....
254	Snapslide	A	....	2540-1	2Z8602
	Coil Set, type C-220 (6200-7700 KC) (Transmitting)	A	....	2741-2	3C220
121	Antenna coil assembly	A	....	2753-1	....
122	Radio oscillator coil assembly	A	....	2747-1	....
126	Coil resistor, 50 ohms, carbon	D	E	P535	3Z6005-1
130	Antenna tap	A	....	2052-1	....
254	Snapslide	A	....	2540-1	3Z8602
	Dynamotor Unit, type BD-AK-83	A	....	2729-3	3H1783C
246	*Sub-Base, type M-158*	A	....	1964-2	3H5358
358	*Mounting, type FT-141*	A	....	2483-2	3H3915
146	Filter resistor, 5,000 ohms, wire wound, special finish	A	....	3065-1	3Z6500-2
147	*Filter condenser, 0.8 mfd. (3x0.8), paper	A	....	1588-2	3H1783/47
148	Filter choke, 8 henries	A	....	1584-2	3H1783/48
149	Radio choke, 0.014 m.h.	A	....	2092-1	3H1783/49
150	Dynamotor	G	....	6157	....
152	Drop resistor, 1,500 ohms, wire wound, special finish	A	....	3064-1	3Z6150-1
164	Receptacle ring for Plug, type PL-62 (part of Socket, type SO-42)	A	....	1350-1	} 2Z8762
165	Receptacle plate for Plug, type PL-62 (part of Socket, type SO-42)	A	....	2809-2	} 2Z8762
200	Frame	G	25624	....	....
201	Pole Assembly, field	G	15994	....	....
202	Coil Assembly, field	G	16950	....	....
203	Screw, pole holding	G	25626-17	....	....
204	Guard, connecting wire	G	12061	....	....
205	Grommet	G	25626-18	....	....
206	Bearing Bracket, L.V.	G	23371-3	....	....
207	Brushholder, L.V. (includes Ref. #210)	G	23610-7	....	....
208	Brush Assembly, L.V.	G	23609-9	....	....
209	Brush Assembly, L.V.	G	23609-9	....	....
210	Screw Cap, L.V. (part of Ref. #207)	G	23607-1	....	....
211	Bearing Bracket, H.V.	G	23371-1	....	....
212	Brushholder H.V. (includes Ref. #215)	G	23610-4	....	....
213	Brush Assembly, H.V.	G	23609-6	....	....
214	Brush Assembly, H.V.	G	23609-6	....	....
215	Screw Cap, H.V. (part of Ref. #212)	G	23607-2	....	....
216	Lock Pin, brushholder, L. V. & H. V.	G	25626-19	....	....
217	Screw, connecting, L. V. & H. V.	G	25626-20	....	....
218	Lockwasher (external teeth)	G	25626-21	....	....
219	Armature Assembly	G	24709	....	....
220	Grease Slinger	G	25230	....	....
221	Ball Bearing	G	25626-10	....	....
222	Bearing Cover Plate	G	23100	....	....
223	Screw, bearing cover	G	25626-23	....	....
224	Tie Rod	G	17042	....	....
225	Nut, tie rod	G	25626-24	....	....
226	Lockwasher, tie rod (external teeth)	G	25626-25	....	....
227	Dowel, bracket locking	G	25626-26	....	....
228	Cover, enclosing	G	16576-1	....	....
229	Screw, cover holding	G	17043	....	3H1781/28
230	Washer, cover screw	G	25626-27	....	....

Reference	Name of Part Function and Description	Manufacturer's Name**	Manufacturer's Type	ARC Dwg. No.	Stock No.
231	Connecting Lead and Terminal, L. V. (#18 Ga. White)	G	25626-28	....	....
232	Connecting Lead and Terminal, L. V. (#18 Ga. Black)	G	25626-29	....	....
233	Connecting Lead and Terminal, H. V. (#22 Ga. Red)	G	25626-30	....	....
234	Connecting Lead and Terminal, H. V. (#22 Ga. Black & White)	G	25626-31	....	....
235	Safety Wire	G	25626-32	....	....
236	Nameplate	G	25623	....	....
237	Drive Screw, nameplate	G	25626-33	....	....
254	Snapslide	A	....	2540-1	....
259	Pin Plug	A	....	2661-1	....
365	Snapslide Stud (for FT-141)	A	....	1959-1	....
	Radio Control Box, type BC-AH-231 (Receiving)	A	....	3624-3	2C3231.3
357	*Mounting, type FT-118*	A	....	2475-1	2Z6668
60	Bias resistor, 200 ohms, carbon	D	E	P497	3Z6020-2
131	Manual sensitivity control resistor, variable, 0-40,000 ohms (part of dual resistor)	D	AA	3474-2	2C3231.3/131
132	A.G.C. level adjusting resistor, variable, 0-30,000 ohms (part of dual resistor)	D	AA	3474-2	
133	Double telephone jack	A	....	2473-1	2C3231/133
134	Rotary switch assembly	A	....	3039-2	2C3231.3/134
135	Base assembly	A	....	2474-2	....
136	Switch stop spring	A	....	....	2C3201.2/136
166	Receptacle ring for Plug, type PL-104 (part of Socket, type SO-84)	A	....	1349-1	2Z8784
167	Receptacle plate for Plug, type PL-104 (part of Socket, type SO-84)	A	....	3596-2	
254	Snapslide	A	....	2540-1	2Z8602
259	Pin plug	A	....	2661-1	2Z7059
263	Switch handle	A	....	G-204	2C3181/329
265	Volume control knob	A	....	3047-1	2C3181/331
365	Snapslide stud (for FT-118)	A	....	G-591	2Z8630
	Radio Control Box, type BC-AE-232 (Transmitting)	A	....	2476-3	2C3231.3
357	*Mounting, type FT-118*	A	....	2475-1	2Z6668
135	Base Assembly	A	....	2474-2	....
138	Microphone jack (unit of assembly)	A	....	2016-1	2C3232/140
139	Telegraph key assembly	A	....	1602-2	2C3182/131
140	Key jack (unit of assembly)	A	....	2016-1	2C3232/140
141	Rotary switch assembly	A	....	2477-2	2C3232/141
142	Key adjusting screw	A	....	G-635	2C3182/135
170	Receptacle ring for Plug, type PL-63 (part of Socket, type SO-43)	A	....	1350-1	2Z8743
171	Receptacle plate for Plug, type PL-63 (part of Socket, type SO-43)	A	....	2866-2	
254	Snapslide	A	....	2540-1	2Z8602
259	Pin plug	A	....	2661-1	2Z7059
263	Switch handle	A	....	G-204	2C3181/329
365	Snapslide stud (for FT-118)	A	....	G-591	2Z8630
	Antenna Switching Relay, type BC-AE-198	A	....	2931-2	2C498.2
357	*Mounting, type FT-118*	A	....	2475-1	2Z6668
135	Base assembly	A	....	2474-2	....
173	Receptacle ring for Plug, type PL-77 (part of Socket, type SO-57)	A	....	1349-1	2Z8757
175	Receptacle plate for Plug, type PL-77 (part of Socket, type SO-57)	A	....	2963-2	
254	Snapslide	A	....	2540-1	2Z8602
259	Pin plug	A	....	2661-1	2Z7059
285	Antenna relay assembly	A	....	2537-1	2C498.2/5
332	Binding post (ANT)	A	....	2806-1	2C498/1A
333	Binding post (TR)	A	....	2808-1	2C498/3A
334	Binding post (REC)	A	....	2807-1	2C498/2A
365	Snapslide stud (for FT-118)	A	....	G-591	2Z8630
	Junction Box, type TM-AH-172	A	....	3656-4	2Z5672.4
157	*Mounting, type FT-101*	A	....	2955-2	2Z6651
9	Filter condenser, 0.004 mfd., mica	B	1461	P437	3DA4-2
143	Filter resistor, 30 ohms, carbon	E	EB	4040	3Z6003-6
151	Fuse, 50 ampere, cartridge	M	3AG	P411	3Z2650.1
153	Power relay assembly	A	....	3569-1	2Z5672.4/3
155	Toggle switch, S.P.S.T.	A	....	2246-1	3Z9845
158	Receptacle ring for Plug, type PL-56 (part of Socket, type SO-36)	A	....	1350-1	2Z8736
159	Receptacle plate for Plug, type PL-56 (part of Socket, type SO-36)	A	....	2732-2	
160	Receptacle ring for Plug, type PL-60 (part of Socket, type SO-40)	A	....	1349-1	2Z8740
161	Receptacle plate for Plug, type PL-60 (part of Socket, type SO-40)	A	....	2723-2	
162	Receptacle ring for Plug, type PL-61 (part of Socket, type SO-41)	A	....	1351-1	2Z8741
163	Receptacle plate for Plug, type PL-61 (part of Socket, type SO-41)	A	....	2810-2	
164	Receptacle ring for Plug, type PL-62 (part of Socket, type SO-42)	A	....	1350-1	2Z8742
165	Receptacle plate for Plug, type PL-62 (part of Socket, type SO-42)	A	....	2809-2	
166	Receptacle ring for Plug, type PL-104 (part of Socket, type SO-84)	A	....	1349-1	2Z8784
167	Receptacle plate for Plug, type PL-104 (part of Socket, type SO-84)	A	....	3596-2	
168	Receptacle ring for Plug, type PL-64 (part of Socket, type SO-44)	A	....	1351-1	2Z8744
169	Receptacle plate for Plug, type PL-64 (part of Socket, type SO-44)	A	....	2850-2	

Reference	*Name of Part Function and Description*	*Manufacturer's Name***	*Manufacturer's Type*	*ARC Dwg. No.*	*Stock No.*
170	Receptacle ring for Plug, type PL-63 (part of Socket, type SO-43)	A	....	1350-1	2Z8743 (170–171)
171	Receptacle plate for Plug, type PL-63 (part of Socket, type SO-43)	A	....	2866-2	
172	Receptacle ring for Plug, type PL-76 (part of Socket, type SO-56)	A	....	1349-1	....
173	Receptacle ring for Plug, type PL-77 (part of Socket, type SO-57)	A	....	1349-1	....
174	Receptacle plate for Plug, type PL-76 (part of Socket, type SO-56)	A	....	2926-2	....
175	Receptacle plate for Plug, type PL-77 (part of Socket, type SO-57)	A	....	2963-2	....
245	Base	A	....	3673-2	....
254	Snapslide	A	....	2540-1	2Z8602
259	Pin plug	A	....	2661-1	2Z7059
365	Snapslide stud (for FT-101)	A	....	2945-1	2Z8630
366	Fuse, type FU-21, 10 ampere, cartridge	M	3AG	P414	3Z1921
Miscellaneous Items					
359	Dial, type MC-145-A	A	....	2728-1	2Z3745A
361	Chart, type MC-146-A	A	....	3805-2	2Z2246A

* Different units performing this function and having this reference number are distinguished from each other in the illustration by the addition of letters a, b, c, etc.

** IDENTIFICATION OF MANUFACTURERS

Code letter in Parts List	Name
A	Aircraft Radio Corporation
B	Aerovox Corporation
C	Cornell-Dubilier Corporation
D	Allen-Bradley Company
E	Continental Carbon Company
G	Continental Electric Company
H	Harvey Hubble, Inc.
I	General Electric Vapor Lamp Company
K	International Resistance Company
M	Littlefuse Laboratories
N	National Company
Q	Weston Electrical Instrument Corporation
S	Isolantite, Inc.

TABLE II

Name of Part Function and Description	*Manufacturer's Name*	*Manufacturer's Type*	*ARC Dwg. No.*	*Stock No.*
Binding Head Machine Screw #4-36x¼, black nickel plated, special .045″ thick head; 2 per Receiver, 1 per Transmitter	H	....	P205	6L6436-4.28B
Binding Head Machine Screw #4-36x⅛, black nickel plated, special .045″ thick head; 2 per Receiver	H	....	P208	6L6436-2.28B
Binding Head Machine Screw #4-36x⅛, nickel plated, special .045″ thick head; 20 per Receiver Coil Set, 4 per Transmitter Coil Set	H	....	P268	6L6436-2.28
Binding Head Machine Screw #4-36x¼, nickel plated, special .045″ thick head; 4 per Antenna Switching Relay, 4 per Transmitter Coil Set, 4 per Receiver Control Box, 4 per Transmitter Control Box, 2 per Junction Box	H	....	P287	6L6436-4.28
Binding Head Machine Screw #4-36x3/16, nickel plated, special .045″ thick head; 20 per Dual Coil Set (Receiver)	H	....	P317	6L6436-3.28
Isolantite Washer, part of antenna compensating condenser assembly; 1 per Receiver	S	....	1555	2C4229/361
Bushing, Insulator, Isolantite, for Binding Post; 3 per Antenna Switching Relay, 1 per Receiver, 1 per Transmitter	S	....	G615	2C4199/84/1

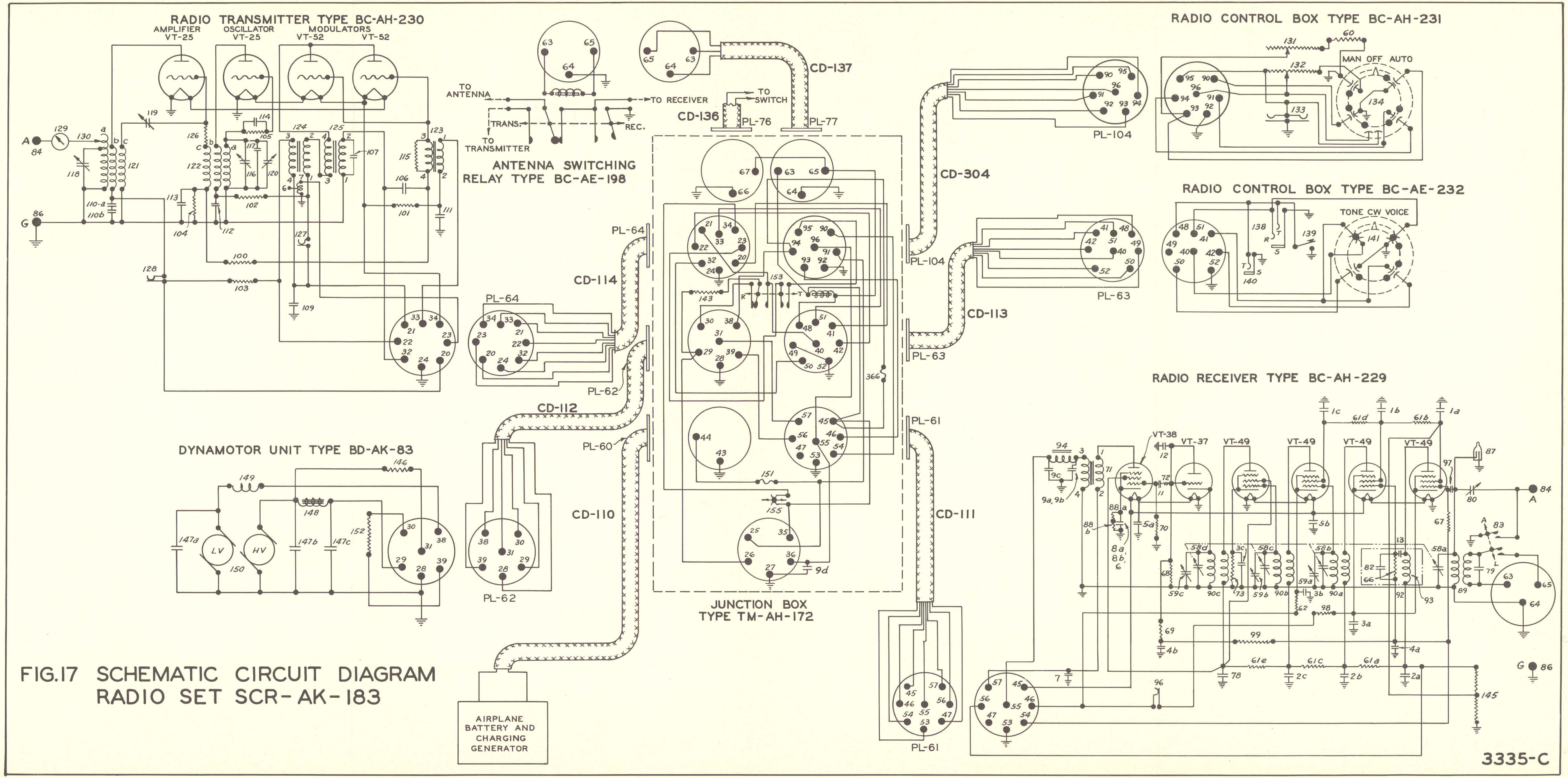

FIG. 17 SCHEMATIC CIRCUIT DIAGRAM
RADIO SET SCR-AK-183

Fig. 17 Schematic Circuit Diagram, Radio Set SCR-AK-183

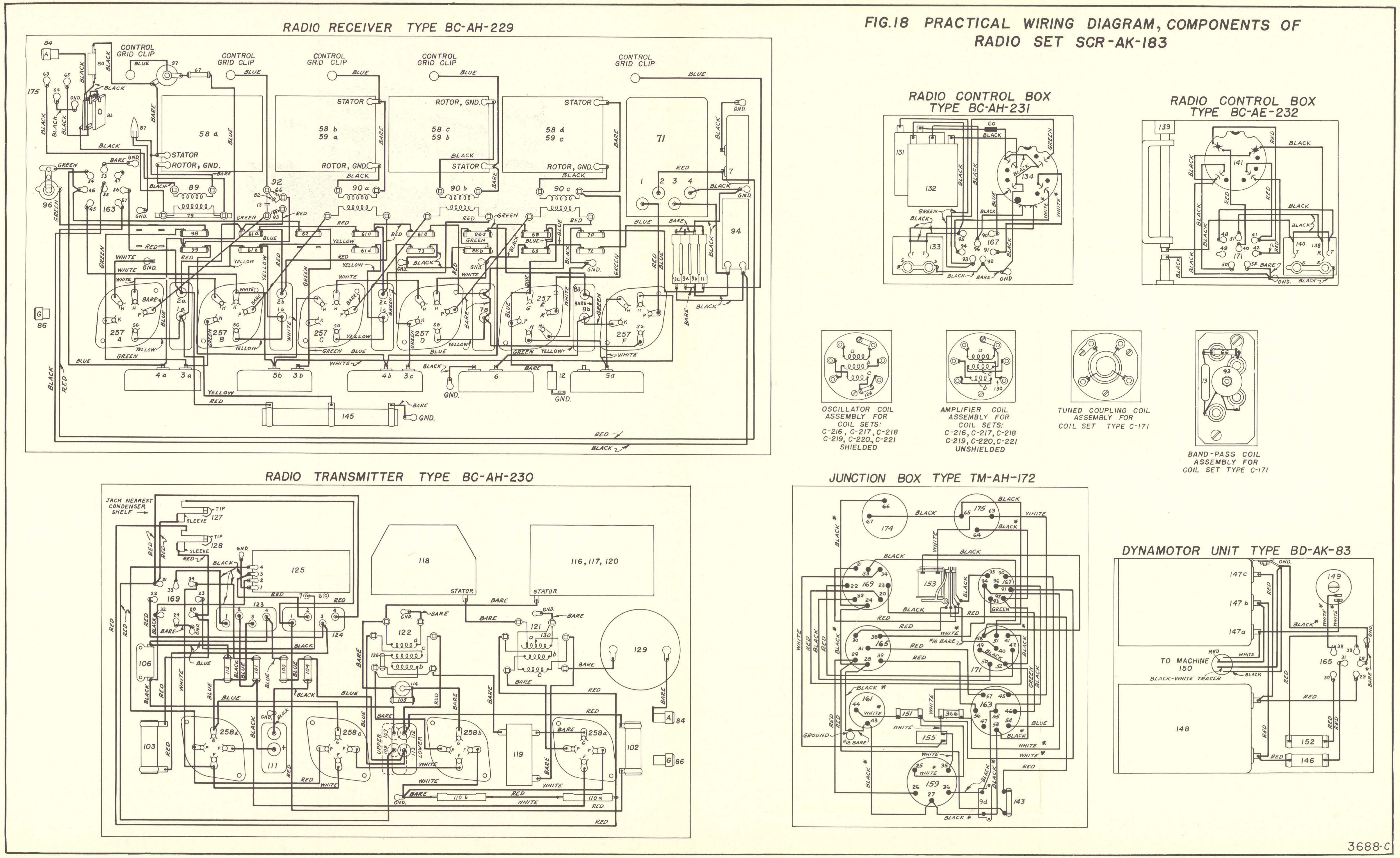

Fig. 18 Practical Wiring Diagram, Components of Radio Set SCR-AK-183

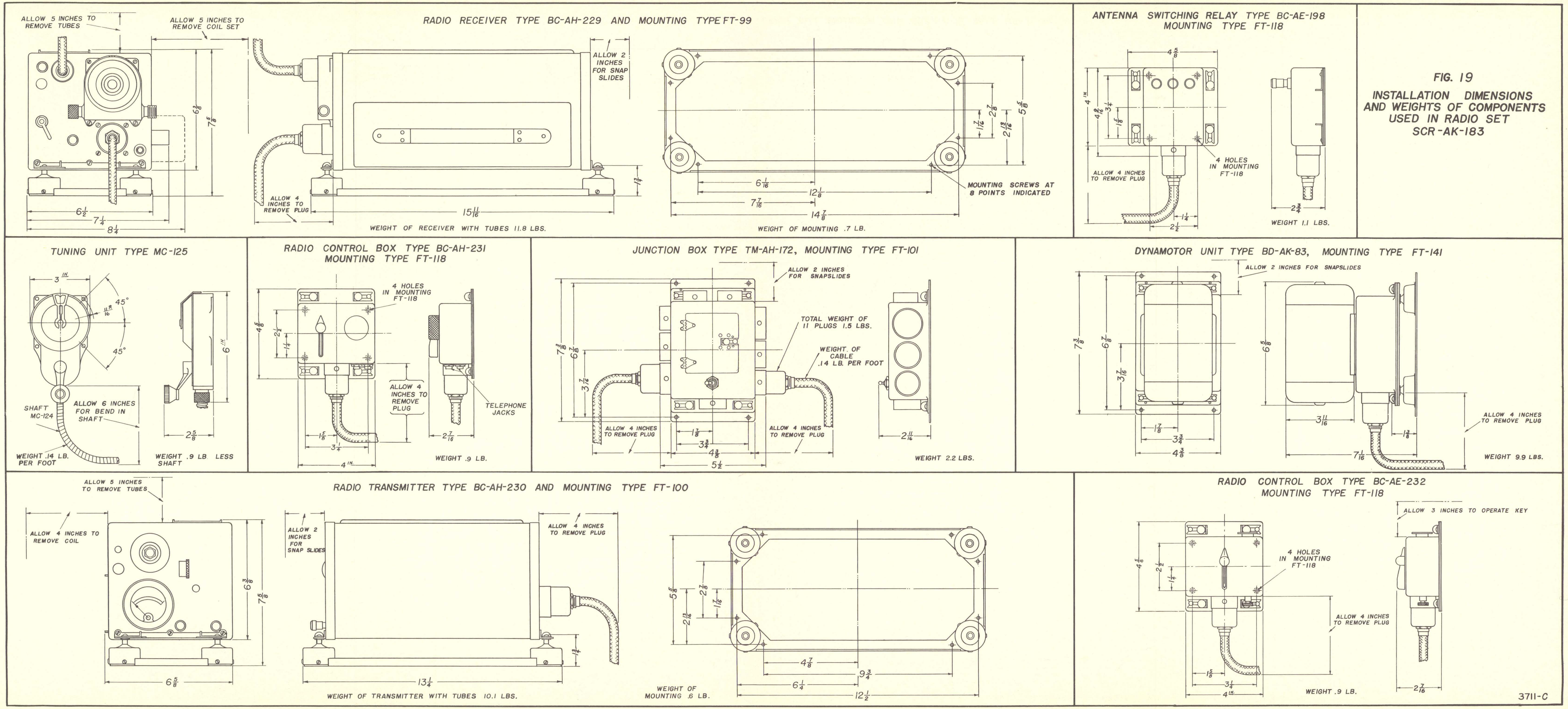

Fig. 19 Installation Dimensions and Weights of Components used in Radio Set SCR-AK-183

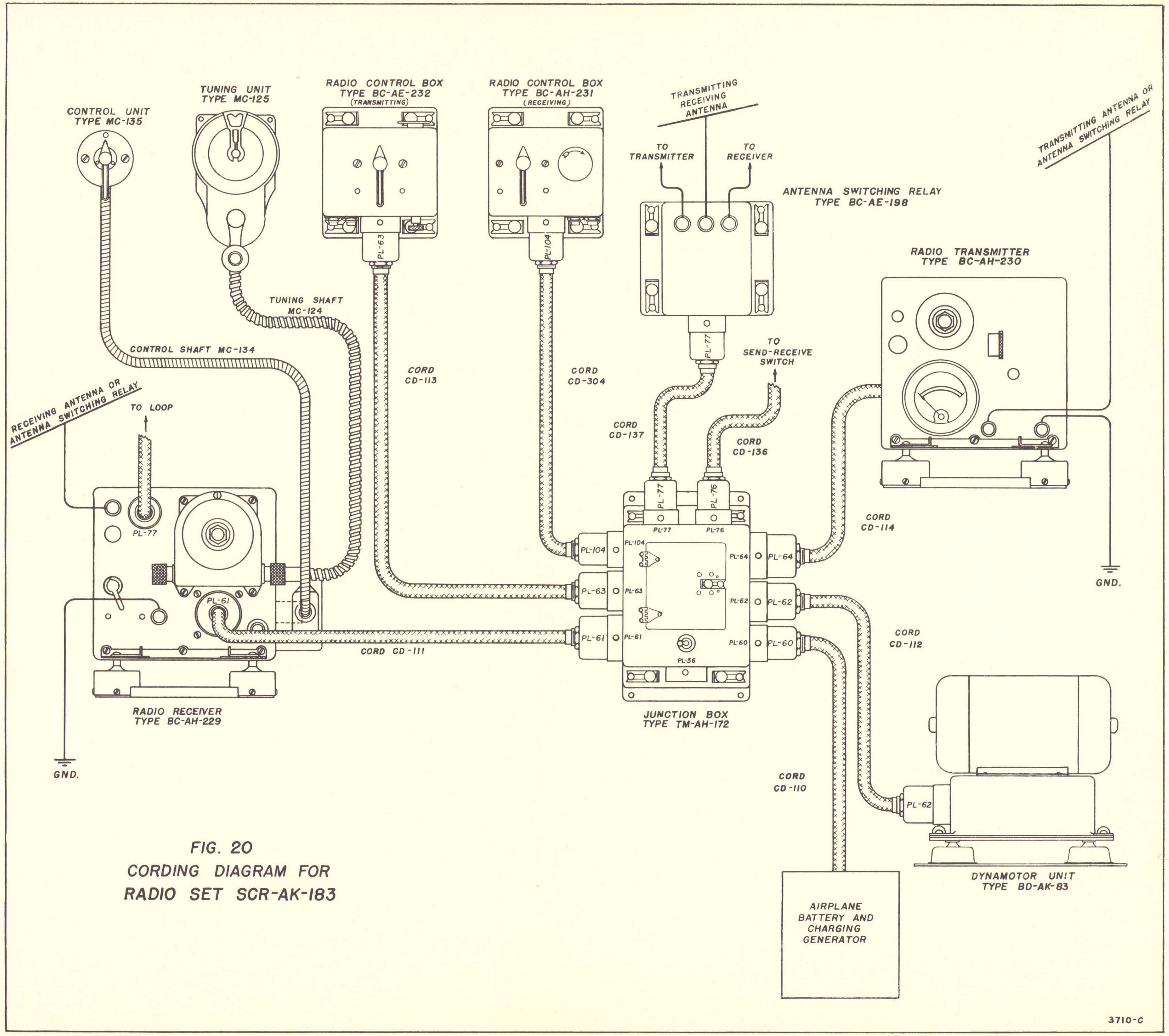

FIG. 20
CORDING DIAGRAM FOR
RADIO SET SCR-AK-183

Fig. 20 Cording Diagram for Radio Set SCR-AK-183

FIG. 21 DYNAMOTOR FOR DYNAMOTOR UNIT TYPE BD-AK-83

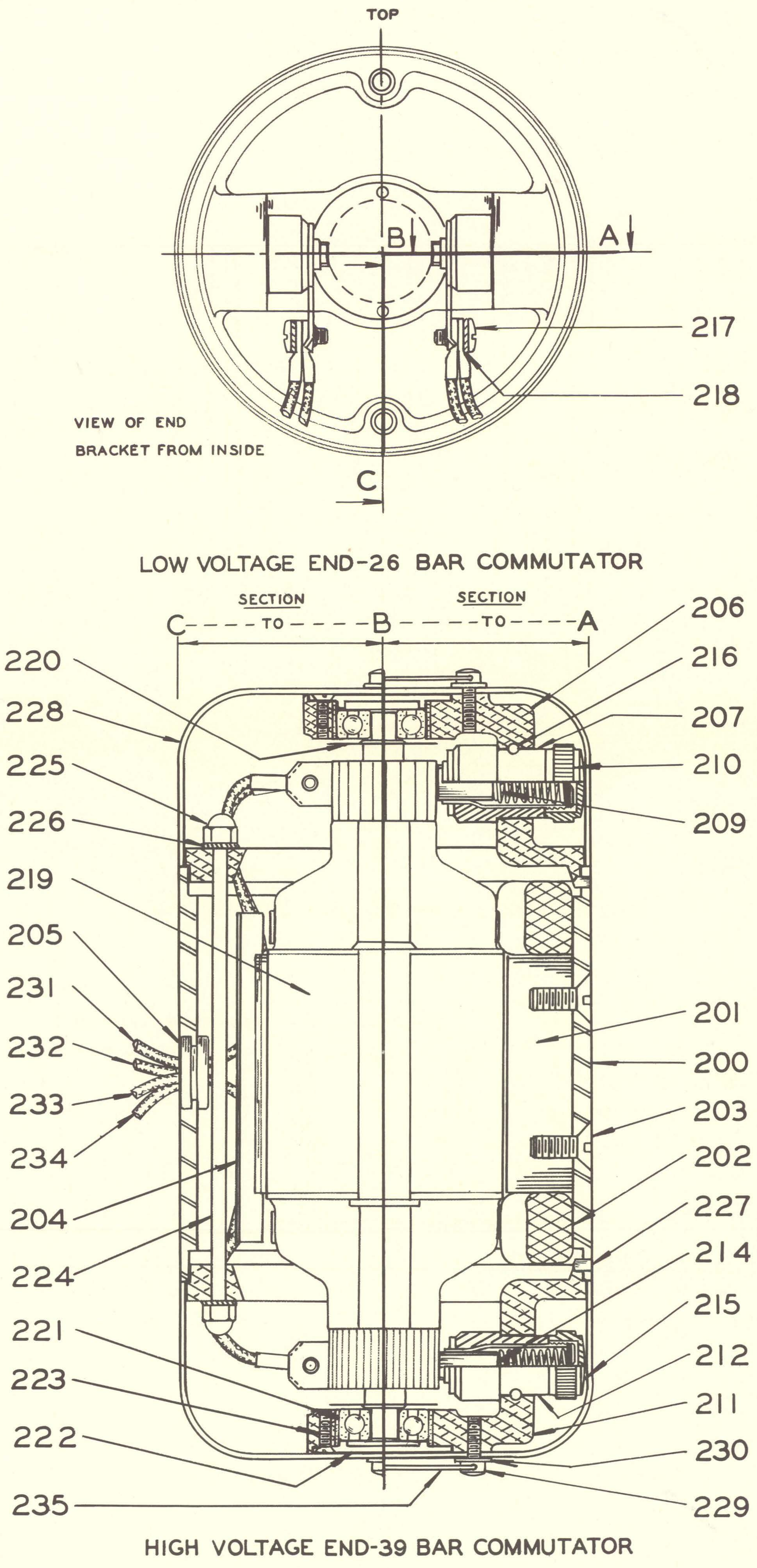

Fig. 21 Dynamotor for Dynamotor Unit, Type BD-AK-83