Complete (17 AUG 58)

Course 3012

Radio Mechanics

VOLUME 1

AIRBORNE LIAISON RADIO COMMUNICATIONS EQUIPMENT

Prepared by
Air Training Command

AIR UNIVERSITY

USAF EXTENSION COURSE INSTITUTE

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RADIO MECHANICS

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Volume

1 AIRCRAFT LIAISON RADIO COMMUNICATIONS EQUIPMENT

2 AIRCRAFT COMMAND RADIO COMMUNICATIONS EQUIPMENT
- Part A
- Part B
- Part C

3 AIRBORNE RADIO AIDS TO NAVIGATION
- Part A
- Part B

4 AIRCRAFT COMMUNICATIONS SYSTEM MAINTENANCE
- Part A
- Part B

5 AIRCRAFT CONTROL AND RADIO RELAY
- Part A
- Part B

6 NAVIGATIONAL AIDS

7 POINT-TO-POINT COMMUNICATIONS
- Part A
- Part B
- Part C

8 GROUND COMMUNICATIONS SYSTEM MAINTENANCE
- Part A
- Part B

Preface

In this volume you begin your study of radio equipment that is carried in aircraft. Most of the radio units on an aircraft are used for communication and aerial navigation purposes.

Communication equipment is used for communication between aircraft and ground personnel and between pilots of aircraft during flight. On large aircraft (bombers), intercommunication between crew members is also necessary (telephone system). Some types of communication equipment carried in the large multipersonnel aircraft, such as medium and heavy bombers and cargo planes, are the AN/ARC–8 Liaison Set, the AN/ARC–3 Command Set, and the AIC2A Interphone Equipment.

Typical avigation (aerial navigation) equipment includes the AN/ARN–7 or AN/ARN–6 Automatic Radio Compass direction finders, the RC–193–A Marker Beacon Receiver, the AN/ARN–5 and RC–103–A Instrument Landing System Receivers, and BC–695–G Identification Friend or Foe (IFF) equipment, plus radar and automatic bomb-release and fire-control radio equipment.

A study of airborne radio equipment requires a recognition of the problems peculiar to aircraft installations and a realization of the capabilities and limitations of equipment designed for airborne use. Aircraft radio equipment must be of minimum size and weight, and must be sturdily constructed, compensated for temperature, humidity, and barometric variation, and designed to operate from the plane's electrical supply. These and other requirements place limitations on the equipment. Design and engineering research, however, continually expand the capabilities and reduce the limitations.

The liaison radio equipment (AN/ARC–8) to be studied in this volume consists of a receiver, a transmitter, and associated components. In the Air Force, the AN/ARC–8 is employed for communication between a plane and the commanding base station and is carried on bombers, where it is used mainly by the radio operator. The Navy, however, uses it for liaison and command, that is, for communications between planes; and the pilot operates the set from the remote-control box in the cockpit. Chapter 1 will describe the BC–348 receiver and chapter 2 the AN/ARC–13A transmitter.

With the exception of the laboratory work this volume parallels, in general, the resident course (30150) given radio mechanics at Scott Air Force Base, Illinois.

At the end of each chapter you will find several review questions. These are study aids, and correct answers are provided at the end of the pamphlet. Please do not submit your answers to the USAF Extension Course Institute for grading or enter into correspondence concerning these questions.

Keep this pamphlet for your own use.

This course is published in a series of 8 volumes with a total credit value of 264 hours (88 points). This volume is valued at 18 hours (6 points).

Contents

LIAISON RECEIVER (BC–348)

THE FIRST PIECE of radio equipment to be studied in this course is the receiver unit, BC–348, of the liaison set AN/ARC–8. Since the receiver is a typical superheterodyne employing, for the most part, conventional circuits and tubes which you have previously studied, we shall not present a detailed discussion of each stage. A general description of the circuits will, however, be presented, with emphasis on features peculiar to this set. Unless otherwise stated, all references to a schematic will mean the complete schematic of the BC–348 (Chart C–790). The schematic diagram will be labeled "Radio Receiver BC–348–(*) or BC–224–(*)." The BC–348 and the BC–224 are practically identical receivers except that the BC–348 operates from a 28-volt primary source, while the BC–224 operates from 14 volts. The asterisk (*) means all models of this receiver, that is, BC–348–H, –K, –L, –R, and BC–224–F, –K. In our discussion we shall refer to the receiver simply as the BC–348.

1. Nomenclature of Equipment

Since this is the first complete set of equipment which you have encountered in your study up to this point and because all following chapters of this course (3012) will be concerned with various pieces of airborne and ground radio equipment which will be referred to by number, we will briefly consider the system of numbering used by the services. (A complete discussion in lesson form will be given later in the course.)

There are two general nomenclature systems in present use: the AN system—joint Army, Navy, and Air Force—and the older SCR system—Signal Corps Radio. The AN does not necessarily mean that the equipment is used by the Army, Navy, and Air Force, but simply that the type number was assigned under this system. The equipment may or may not be used by several or all branches of the service. The SCR system is being rapidly replaced by the preferred AN system.

A number in which the AN precedes the slant bar indicates a complete set, such as AN/ARC–8, in which AN means Army, Navy, and Air Force nomenclature system and ARC–8 means Airborne Radio Communications, set No. 8. This set consists of a transmitter set (AN/ART–13), a radio receiving set (BC–348), and the required interconnections such as plugs, cables, and junction boxes. In the nomenclature BC–348, the BC means *basic component,* referring to the older SCR system. The SCR would be prefixed if both the transmitter and receiver were numbered by the older system. In the AN system, the receiver is the AN/ARR–11.

In the AN system, when a basic component is indicated, AN is replaced by a component indicator. In the example, T–47/ART–13, T–47 is transmitter No. 47, that is, the transmitter unit only. The slant bar now means *part of* or *used with.* A second example will further illustrate this point. DY–17/ART–13 means that dynamotor unit DY–17 (component indicator) is part of or is used with the AN/ART–13.

From the above discussion, it is apparent the first three letters following the slant bar are equipment indicators: the first letter indicates the installation (airborne, ground, mobile), the second letter the type of equipment, and the third the purpose of the set or equipment.

2. General Description

Although Receiver BC–348 is a complete unit, it is made up of separate components and has a number of controls with which it will be well to become acquainted before you study the circuits and various stages. Therefore, a short description will be given of the Radio Receiver BC–348, the Receiver Case, the Panel Items and Controls, the Dial and Mask Assembly, Jones Plug PL–103, and the AVC-OFF-MVC switch.

Radio Receiver BC–348. This receiver is a locally controlled, 8-tube, 6-band superheterodyne receiver. The receiver is capable of voice, tone (mcw), and cw reception with manual or automatic volume control. The dynamotor is mounted within the receiver cabinet. Figure 1 shows a front view of the receiver in its cabinet with all the controls on the front panel. When the set is equipped with headsets, tubes, dial lights, and fuses and when the antenna, ground, and 28-volt source connections are properly made, the

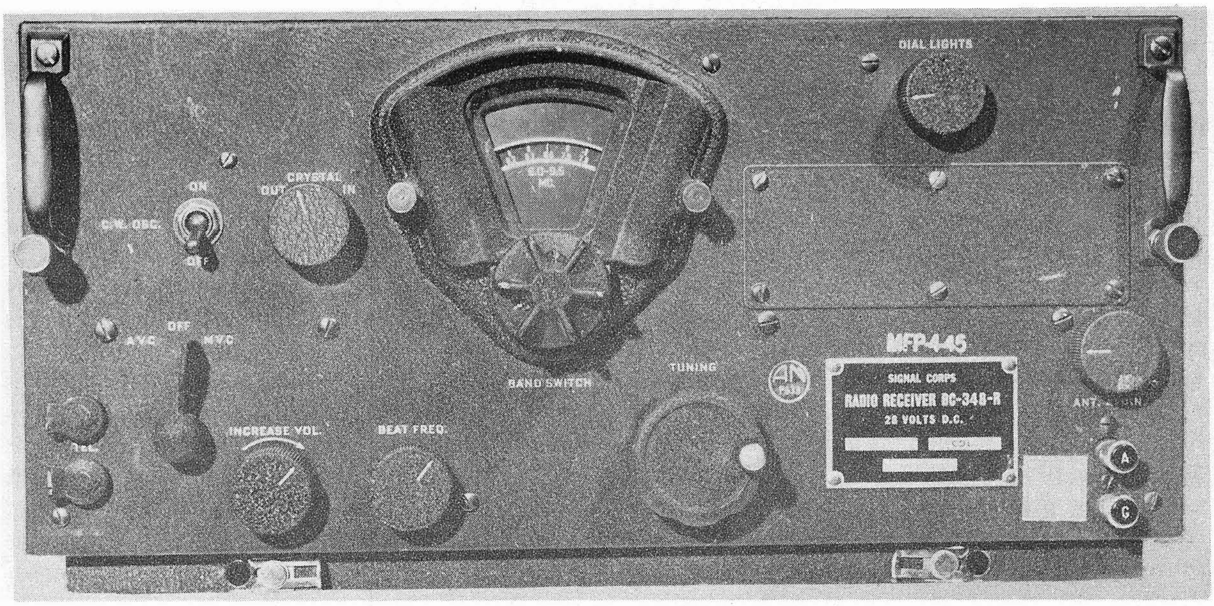


FIGURE 1. Radio Receiver BC–348, Front Panel.

receiver is a complete and operative set. The six frequency bands are as follows:

Band 1: 0.2 – 0.5 Mc (megacycles)
Band 2: 1.5 – 3.5 Mc
Band 3: 3.5 – 6.0 Mc
Band 4: 6.0 – 9.5 Mc
Band 5: 9.5 – 13.5 Mc
Band 6: 13.5 – 18.0 Mc

No provision has been made for ac operation.

Receiver Case. The case is of spot-welded aluminum construction with black wrinkle finish. The front panel is connected to the receiver chassis, which can be removed from the case when the two thumbscrew rods located directly beneath the handles on each side are loosened. Figure 2 shows the bottom view of the case, and figure 3 shows the receiver chassis. The opening shown in the bottom center of the case permits entrance of plug PL–103, and the four mounting studs are for attaching the case to the mounting, FT–154 (see fig. 4).

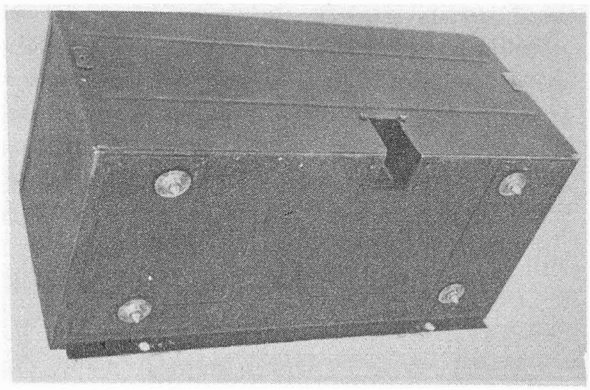


FIGURE 2. Receiver Case, Bottom View.

Panel Items and Controls. From figure 1 or figure 3, the following panel items may be seen: (1) antenna and ground binding posts, (2) antenna alinement control ANT ALIGN, dial lights rheostat control DIAL LIGHTS, tuning control TUNING, band switch control BAND SWITCH, dial window housing, which covers the dial lights, beat-frequency control BEAT FREQ, crystal filter control OUT-CRYSTAL-IN, volume control INCREASE VOL, CW OSC control, two telephone jacks, TEL, and the AVC-OFF-MVC switch.

Dial and Mask Assembly. The dial and mask assembly is mounted on the aluminum casting which carries the gearing of the tuning capacitor drive and the detent (a catch). The dial is divided into six frequency bands. The dial and tuning capacitor are so geared to the tuning control shaft that the tuning capacitor covers the frequency range indicated on the dial for each band in approximately 90 revolutions of the tuning knob. A mask with suitably located and marked windows is mounted before the dial. The mask is controlled by the band-change switch and is positioned by the detent.

FIGURE 3. Front View of Receiver Chassis.

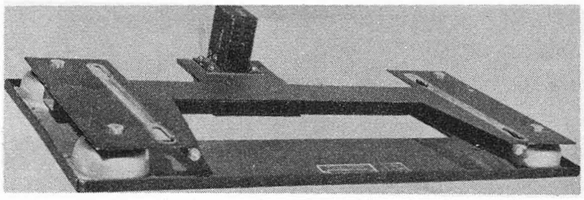


FIGURE 4. Mounting FT–154, with PL–103.

Jones Plug PL–103. The plug PL–103, attached to the mounting by screws, is provided with eight terminals which are accessible upon removal of the rear cover of the plug housing. The positions and uses of these terminals are shown in the receiver schematic.

The AVC-OFF-MVC Switch. The set is turned on and off with the AVC-OFF-MVC switch. A signal is always tuned in with the switch in the MVC (manual volume control) position and the volume control advanced far enough to give the desired signal strength. It is possible to *block* the receiver on strong signals at the MVC position if the volume control is set at maximum. To tune, simply select the desired band and adjust the tuning control for maximum output at the desired frequency. Then adjust the antenna-align dial for the loudest signal. If desired, AVC (automatic volume control) may now be selected. It may be necessary to adjust the volume control again for desired output. After a signal is tuned in as outlined above, it is necessary merely to close the cw oscillator switch and adjust the beat frequency control for cw reception. If extreme selectivity is desired, the crystal filter is switched in. The filter is intended for use in cw reception, but the added selectivity may at times help to receive modulated signals through heavy interference.

3. Block Diagram

A block diagram is a very definite aid in understanding how the circuits or stages of receivers or transmitters are related to one another. With the aid of block diagrams, it is often easy to trace the path of a signal or electrical impulse through a piece of equipment.

The block diagram (see fig. 5) shows in proper sequence the various stages and coil assemblies that constitute the receiver. Each rf coil assembly (antenna, first and second rf) contains all the tuning and coupling coils, compensating and trimmer capacitors, and switches, inclosed within a shield can. In the schematic these units are shown inclosed by dashed lines.

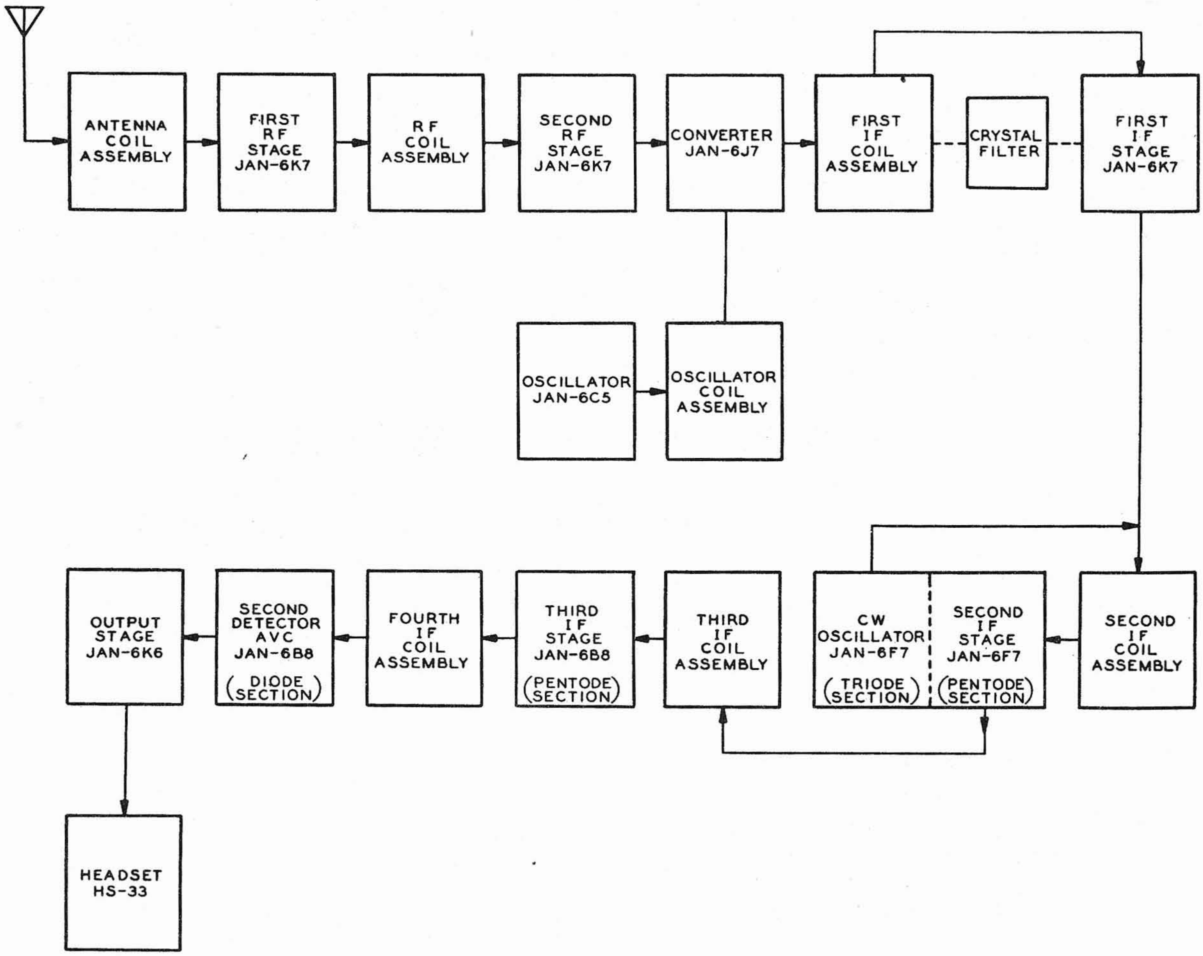


FIGURE 5. BC–348, Block Diagram.

Path of the Signal. From the antenna input, the signal is amplified by two rf preselector stages. The high degree of selectivity obtained before mixing practically eliminates adjacent-channel and image interference. The signal is coupled into the 6J7 mixer circuit, where it is heterodyned with the local oscillator signal to produce the intermediate frequency (915 kc). The signal is coupled into the first i-f coil assembly and coupled to the i-f tube either through the i-f transformer or through the crystal filter bridge circuit. The signal is amplified by two more i-f stages. The second i-f tube is a triode-pentode whose triode section operates as the cw oscillator. The output of the third i-f stage is transformer coupled into the two diode sections of the same tube (6B8), which functions as the third i-f, second detector, and delayed avc diode. The audio voltage developed across the diode-detector load resistor is resistance coupled into the grid of the single audio power output stage, which inductively couples the audio voltage into the headsets. (You should look up the characteristics of the tubes used in this set in any receiving-tube manual. If you don't already have one, the purchase of a tube manual for your personal use would be a worthwhile investment; no radio mechanic should be without one.)

4. Operation of the Circuit

Refer to the BC–348 schematic circuit diagram (Chart C–790) and to table 1 for component values while you study the following sections on circuit operation.

TABLE 1A

SYMBOLS, NAMES, AND VALUES OF CAPACITORS (C) USED IN THE BC–348 RECEIVER

Symbol	Description	Value ($\mu\mu$f)
1–A –B –C –D	Ganged tuning capacitor sections	16–241
2	Antenna tuning	75
3–1. . .8,	Trimmers	50
4–1 –2 –3		
5–1. . .6,	Trimmers	25
6–1. . .4,		
7–1 –2		
11–1. . .18,	Bypass, 500 v dc, paper capacitors,	10,000
12–1. . .4,	$\pm$ 10 percent (tolerance)	
13–1–2		
14–1–2, 15		
16	Mica, 500 v dc, $\pm$ 2 percent, oscillator series	5,000
17–1–2		500
18		1,700
19		2.650
20		210
21–1–2–3	Mica, 500 v, $\pm$ 3 percent, rf series	200
22–1–2–3	Mica, 400 v, $\pm$ $1\frac{1}{2}$ percent, rf series	400
23–1. . .4	Mica, 500 v, $\pm$ 10 percent, rf shunt	40
24–1–2		25
25	Mica, 500 v, $\pm$ 5 percent, rf shunt	65
26–1–2		95
27–1–2		70
28	Mica, 500 v, $\pm$ 5 percent, coupling	100
29–1–2	Mica, 500 v, $\pm$ 10 percent, shunt	1,250
30–1–2	Mica, 500 v, $\pm$ $\frac{1}{2}$ percent, coupling	2
31–1–2	Mica, 500 v, 10 percent, af coupling and primary shunt	1,500
32, 33	Mica, 500 v, $\pm$ 5 to 10 percent, tuning	200
34–1. . .3		260
35–1. . .4		240
36		47
37–1–2		150
38		75
39		750
40	Mica, 500 v, $\pm$ 0.2 percent,	4.8
41	osc. temp. compensating	3.5
42	Ceramic, 500 v $\pm$ 3 to 5 percent,	20
43	osc. temp. compensating	65
44		90
45		35
46		40
47	Ceramic, 500 v, $\pm$ 3 percent, osc. series	85
48–1A –1B	Paper, 250 v, $\pm$ 15 percent, filters	0.5 μf
48–2A –2B		
48–3A –3B		
49–1A,B,C		
49–2A,B		
49–3A,B		
49–4A,B		

TABLE 1B

SYMBOLS, NAMES, AND VALUES OF RESISTORS (R) USED IN THE BC–348 RECEIVER

Symbol	Description	Value
55–1 . . . 4	Insulated, ± 10 percent, ½ watt	470 Ω
56–1 –2		1,000 Ω
57–1 . . . 7		4,700 Ω
58–1 . . . 4		10 kΩ
59		12 kΩ
60		15 kΩ
61		56 kΩ
62		68 kΩ
63–1 . . . 4		100 kΩ
64		180 kΩ
65–1 . . . 4		470 kΩ
66		560 kΩ
67		1.5 MΩ
68		220 kΩ
69		75 Ω
70		47 kΩ
73	Insul., ± 5 percent, 1 w	2,400 Ω
74	Insul., ± 10 percent, 1 w	10 kΩ
75	Insul., ± 10 percent, 1 w	27 kΩ
76–A	Insul., ± 10 percent, 1.5 w	3 Ω
76–B	Insul., ± 10 percent, 1.9 w	190 Ω
77	Insul., ± 10 percent, 3.7 w	60 Ω
78	Variable, ± 10 percent, 0.1 w	3,500 to 10 Ω
79–A	Vol. control (front), ± 10 percent, 0.2 w	20 kΩ to 10Ω
79–B	Vol. control (back), ± 10 percent, 0.2 w	350 kΩ to 50Ω
80	Variable, ± 10 percent, 4 w	200 Ω
140	Fuse (Fu 35), pri. protect	5 amp, 25 v

TABLE 1C

SYMBOLS, NAMES, AND VALUES OF FILTER CAPACITORS IN THE DYNAMOTOR UNIT OF THE BC–348 RECEIVER

Symbol	Description	Value (μf)
303–A –B	Paper, 250 v, ± 20 percent	0.5
304	Paper, 400 v, ± 20 percent	1.0
305–1 –2	Mica, 500 v, ± 10 percent	0.01

Switches. Before beginning your study, carefully observe the schematic representation of the band-change switches (130, 131, 132, 133-A and 133-B, 134, 135-A and 135-B, 136, 137, 138, 139). Each section is a 6-position single-wafer switch. As shown in the schematic, the receiver is operating on Band 1. The switches move in the direction the arrows point (to the right and up) to select any one of the other five bands. To make one ganged tuning capacitor tune all bands, various values of series and shunt capacitors with proper values of inductance are switched in. *S*128 is a double-pole single-throw switch (CW OSC–ON–OFF). *S*129 is the AVC-OFF-MVC switch. The four sections of *S*129 physically consist of two wafers, three positions on each side. *S*129 is shown in the AVC position, and *S*128 and *S*127 are in the open positions.

Antenna Coupling Circuit. The antenna input circuit is capacitively coupled to the first tuned-grid circuit by means of the antenna alinement capacitor (*C*2). As the schematic shows, *C*2 is coupled directly to the control-grid cap on the tube. The center tap of the antenna coil (*L*90) also couples to the grid through the left-hand section of the band switch, *S*130. The tuning capacitor section 1–A is connected across *L*90 through *S*131. Capacitor *C*13–1 and resistor *R*63–1 form a decoupling filter. *C*13–1 provides an rf path to ground for the tuning coil *L*90, and *R*63–1 completes the dc path to ground through the davc (delayed automatic volume control) circuit, *R*68 and *R*67, when *S*129 is in the AVC position.

Protection from Static. To protect the input circuit, resistor *R*65–1 provides a leakage path for static charges which may collect on the antenna. The grid circuit will withstand the application of 250 volts dc and an rf voltage of 30 volts rms without damage. If the grid should be overdriven, the resulting current through *R*63–1 will build up a protective negative grid bias.

Radiofrequency Circuits. The two rf stages employ variable-mu tubes (supercontrol pentodes, 6K7). The rf gain of each of the six bands is kept uniform by the proper turns ratio of the rf coils. A signal of relatively small amplitude is applied to the grid of the first detector tube to prevent cross-modulation interference. Thus, the main purpose of the rf stages is selectivity.

5. The First Detector (Mixer or Converter)

Tube JAN–6J7 (VT–91) has a sharp cut-off characteristic. The grid-tuned circuit consists of the powdered-iron-core coil *L*97, tuning capacitor section 1–C, and trimmer capacitor 3–5. The grid is connected to *L*97 through switch *S*134. The plate circuit of the first detector, VT–91, is tuned to an i-f of 915 kc. It is coupled to the first i-f stage, VT–86, through the first i-f slug-tuned transformer. This transformer consists of the primary (plate) coil shunted by *C*32 and secondary coil *L*117 shunted by fixed capacitors *C*33 and *C*39, which are center-tapped to ground. These components are all within the shield can. *C*11–6 is the plate rf bypass, and *R*57–3 is the plate-decoupling resistor; the two components form an effective filter to keep the rf current variations of this stage out of the common high-voltage line.

6. The Heterodyne (Local) Oscillator.

This is a typical tuned-grid circuit, plate inductive feedback, employing a 6C5 triode tube. Good frequency stability is obtained for wide variations in temperature by the use of temperature-compensated ceramic fixed capacitors 40 through 46 inclusive. Individual inductances and trimmers are employed for each band. On Band 1 the grid-tuned circuit consists of the following components:

(1) One of the three coils that form the oscillator tuning and coupling transformer. (These coils are all numbered 111 and are wound together on the same coil form. The grid and mixer coupling coils are shown together in the schematic, while the plate feedback coil is drawn at the extreme right of the schematic.)

(2) Tuning capacitor section 1–D.

(3) Padder capacitors 10 and 47.

(4) Compensating capacitors 41 and 42 and trimmer capacitor 6–1.

The proper connection of components to the grid of the tube is made through switches 139 and 136 and coupling capacitor 28, as the schematic shows. The plate is connected to the feedback coil through a 75-ohm compensating resistor and band switch 138. A cold-cathode type of voltage-regulator tube (125) is connected across the high-voltage supply to the oscillator plate circuit. This tends to keep the plate voltage constant and therefore minimizes frequency drift. The oscillator output is coupled to the cathode circuit (cathode injection) of the first detector VT–91 through coil $L111$, whose low impedance insures frequency stability with variations in load or detector circuit tuning. On the four lower bands, the oscillator tracks above the signal (carrier) frequency by the i-f value. On the two higher bands (5 and 6), the oscillator tracks below the signal frequency, resulting in a more uniform tuning ratio over these bands and higher image-rejection ratio.

The Oscillator Tube (VT–65) Circuits. The rf signal (ac) and dc circuits of this stage are traced as follows for Band 1 and $S129$ in the AVC position.

Control grid (g_1, *pin 5*). The signal circuit is from the grid through $C28$ and $S136$, then through the primary of $L111$ and $R60$ to ground (or through the parallel path which includes the tuning capacitor, 1–D, to ground). The part from ground directly to the cathode completes the circuit. The dc path is from g_1 through the grid-leak resistor 63–3 to ground and then to the cathode (pin 8).

Plate. The signal circuit is from the plate (pin 3) through compensating resistor $R69$, through $S138$, through feedback coil section of $L111$, through the bypass capacitor (12–3) to ground, and back to cathode. The dc current (electron flow) circuit takes the same path up to the junction of $C12$–3 and $L111$. Then the circuit is traced through the plate decoupling resistor (56–1), through dropping resistors 59 and 75 to the $B+$ terminal (210 v) at the dynamotor rf coil 301, and then through $L301$ and the dynamotor high-voltage winding to ground and back to the cathode of VT–65. All the other tube circuits are traced in a similar manner. Circuit tracing is most important in troubleshooting any receiver.

7. The Intermediate-frequency Amplifier

The i-f circuit consists of three low-gain stages coupled by four highly selective, double-tuned circuit transformers. They are tuned to 915 kilocycles by means of adjustable powdered-iron cores and fixed capacitors. The high selectivity in these transformers is due mainly to the increased permeability resulting from the use of iron cores. The lowered tank (tuned) circuit impedance obtained by the relatively large fixed tuning capacitors provides an inherently stable amplifier. A 6K7 tube is used for the first i-f amplifier, while the pentode section of the 6F7 is used for the second i-f stage. The pentode section of the 6B8, as the third i-f amplifier, supplies a relatively high-level signal to the diodes of the same tube.

The cw Oscillator Stage. This stage employs the triode section of the 6F7 (second i-f amplifier tube) in a tuned-grid, plate-inductive, feedback circuit. The grid coil is slug tuned. Capacitor $C9$ is the fine beat-frequency control knob on the front panel and covers a range of 4 kc each side of zero beat. The effects of temperature variations are minimized by a temperature-compensated tuned circuit. The cw oscillator has a very weak output so that harmonic and stray oscillator pickup may be kept at a minimum. The output is capacitively coupled to the plate circuit of the second i-f amplifier by a *pigtailed* lead connected to the oscillator grid. Amplification by the third i-f stage, whose gain is not controlled either manually or by avc, provides sufficient output from the cw oscillator to the diode detector. This value of oscillator output is somewhat below the level at which the avc operates, thus permitting the use of avc even for cw reception.

Continuous-wave Oscillator Switch $S128$. When this switch is closed (ON position), plate voltage is supplied to the oscillator and the avc time constant is increased by the additional capacitor 123C being connected into the circuit. The plate voltage is connected from the screen-grid line of the first and second i-f and the first rf tubes. The same switching connection connects the load resistor 58–4. This drops the screen voltage to the first and second i-f and the first rf tubes to a value that reduces the sensitivity enough to keep the over-all receiver noise essentially constant. The connection of the cw oscillator plate to the screen-grid line has other advantages that may not be obvious. With delayed avc operation (switch 129 in AVC position), the avc bias will, of course, increase proportionally with the strength of the signal. To compensate for this increased bias, especially on strong signals, the cw oscillator output (when used) should also increase. This is accomplished by a fixed bleeder system ($S129$ in AVC position and $S128$ closed) consisting of resistors 57–6, 74, 70, and 79–A. A strong signal building up the avc bias causes a considerable decrease in screen current and therefore an increase in screen voltage. This increases the cw oscillator voltage, thereby increasing its output in proportion to the signal level at the second detector.

The Crystal Band-pass Filter. This filter provides additional selectivity preceding the first i-f stage. The filter uses a balanced capacitance bridge circuit which may be adjusted internally to provide a band width of 0.8 to 3 kc at "10 × down from resonance," which means that at 0.8 to 3 kc on either side of the resonant i-f the signal input value has to be 10 times greater than the resonant value for the same output. The tapped tuned circuit (*L*118 and *C*34–1) matches the impedance of the crystal bridge to the first i-f grid. The phasing control *C*8 balances out (neutralizes) the capacity of the crystal holder. This prevents the bypassing, around the crystal, of signals other than the crystal resonant frequency. The proper adjustment of the phasing control also aids in eliminating the audio image (the same audio note on the other side of zero beat). The receiver is then said to be adjusted for *single-signal* operation. The filter is operated as a series resonant circuit. The selectivity is minimum with the crystal input circuit (*L*117, *C*33, and *C*39) tuned to resonance, since at resonance the impedance of the tuned circuit is maximum. It may be recalled that for maximum selectivity the total impedance in series with the crystal (both input and output circuits) must be low. The selectivity is controlled by the secondary core of the first i-f transformer, *L*117, which is adjusted by the manufacturer for a band width of about 2 kc.

Second Detector. The 6B8 twin-diode pentode tube (VT–93) operates as the second detector (demodulator), delayed avc diode, and third i-f amplifier. The third i-f supplies a relatively strong signal to both diode plates. Diode plate No. 5 operates as the second detector. Its output audio voltage is developed across resistor 79–B. On AVC position of *S*129, the detector load (79–B) is also used as the volume control.The davc diode plate (No. 4) conducts whenever the peak signal amplitude exceeds the delay (bias) voltage across resistors 57–7 and 56–2. The avc is then developed across resistor 67 and applied to the grids of the first and second i-f stages and the two rf stages. *R*68 and *C*11–14 form the avc filter.

Audio Output. The signal diode audio voltage is coupled directly from the tap of *R*79–B to the grid of the audio output tube, VT–152 (6K6), through coupling capacitor *C*31–1. The output of the signal diode is relatively free from distortion, since it is operated on the linear portion of its characteristic curve, which gives it large signal-handling capacity. Driving the output tube directly from the diode-detector simplifies the dynamotor ripple filtering and eliminates possible microphonics resulting from high audio amplification. The high diode level further provides relatively high bias voltage, insuring an unusually flat avc characteristic with the desired time delay. Resistors 79–A and 79–B form a dual volume control. *R*79–A operates only when switch 129 is in manual position. *R*79–A is actually a gain control, since it varies the cathode bias of the rf and the first and second i-f amplifier tubes. Both controls have linear resistance tapers providing smooth variation of sensitivity. The method of biasing the output tube provides automatic load compensation. The bias is obtained from the resistance across the dynamotor filter reactor, 123–B. Thus, any tendency towards a decreasing load on the dynamotor results in a slight decrease in bias of the output tube with a compensating increase in load current. The output of the 6K6 is large enough to operate a number of headsets in parallel.

Noise Compensation. The characteristic increase of internal receiver noise, when tuning from the low-frequency to the high-frequency end of the band, has been corrected by means of variable resistor 78 (in second rf cathode circuit). This noise compensator resistor 78 is mechanically connected to the shaft of the ganged tuning capacitor with an electrical connection to give minimum resistance at the low-frequency end of the band. The cathode return lead of the second rf amplifier tube connects to *R*78. As the receiver is tuned towards the high-frequency end of the band, the resistance of *R*78 and the bias voltage across it increase. The gain of the second rf stage is thereby decreased proportionally as the rf tuned circuit impedance increases. This arrangement tends to keep the noise level and the receiver sensitivity essentially constant over the tuning ranges.

The Dynamotor and Associated Radiofrequency Filters. These components are assembled in one unit. The rf filters are of the unbalanced type for use with a primary supply in which the negative side is grounded. The dynamotor supplies all the high-voltage dc required for the operation of the receiver plus a maximum of 20 milliamperes for use in operating accessory equipment. The dynamotor is rated at an input of 1.23 amperes at 27.9 volts and at an output of 70 milliamperes at 220 volts with a regulation of 12 percent.

8. Break-in Operation

In the complete liaison set, the receiving equipment is interconnected with the transmitting equipment so that they are coordinated for *break-in* operation. That is, the receiver can be operated when the transmitter is either off or on, provided that neither the telegraph key nor the microphone switch is depressed. It is impossible for the transmitter and receiver to be operative at the same time. When the keying relay in the transmitter is energized, it causes the transmitter to operate and at the same time opens the receiver screen-grid supply. You will notice that in the schematic, although the screen-grid supply line ends at terminal 6, which is part of plug PL–103, terminal 2 of PL–103 is the high-voltage point to which the screen supply line must be connected. Terminals 6 and 2 are actually connected through contacts 1 and 11 of transmitter keying *K*102 in its normal position (de-energized). Other contacts of the same relay connect the common antenna to the receiver and remove the ground connection from the receiver antenna terminal. When the receiver is inoperative, only the transmitter side tone (speech monitoring explained in chapter 2) will be heard in the headset. In the complete liaison installation, then, the receiver is always ready for operation except when the transmitter keying relay is energized.

Table 1 groups resistors and capacitors of the same value and similar construction. Figures 6, 7, and 8 are top, bottom, and rear views of the chassis.

9. Testing and Trouble Shooting

To perform effective trouble shooting on this set, you must, of course, know how it operates normally. You may recall that a receiver's performance is determined by its sensitivity, selectivity, distortion, and signal-to-noise ratio. The essential items of equipment required to perform these tests are a signal generator, an output meter, and a volt-ohmmeter (preferably a vacuum-tube volt-ohmmeter).

The usual difficulties experienced are those due to the breaking down of various parts after a normal period of service, for example, worn-out tubes, leaky or shorted capacitors, open resistors, or loose or broken connections.

Sensitivity. The *normal sensitivity*—number of microvolts input to produce 10 milliwatts (6.3 volts) modulated 30 percent at 400 cycles with a 300-ohm resistance load—of the receiver is 9

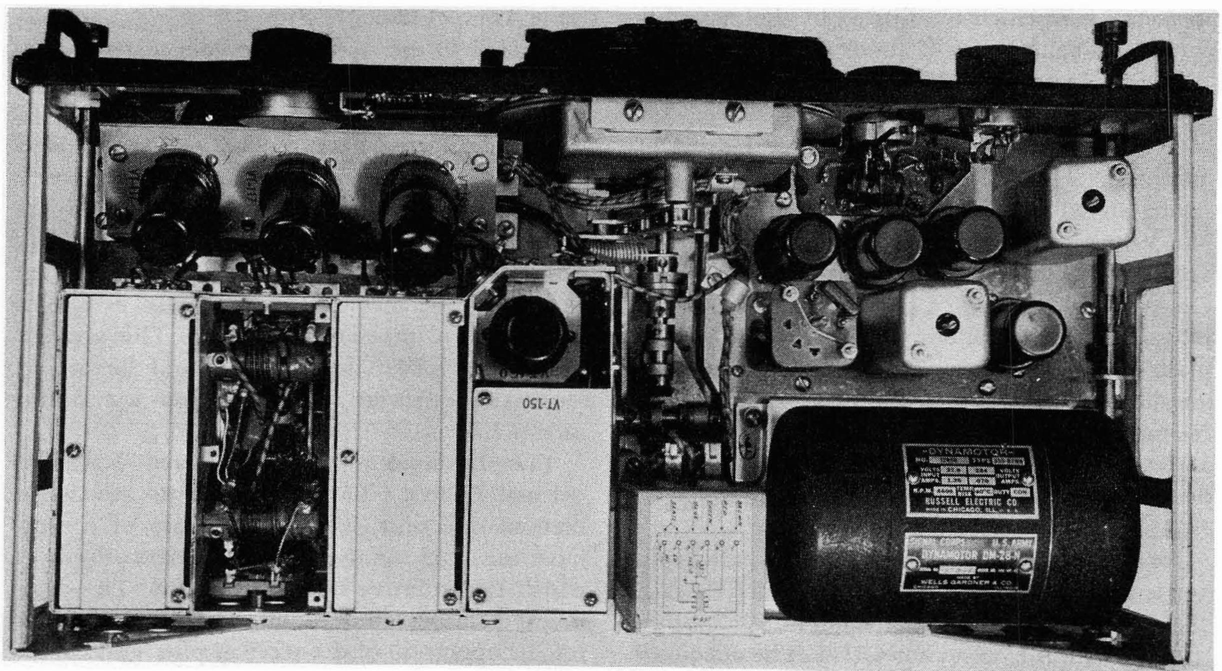


FIGURE 6. BC–348, Top View of Chassis.

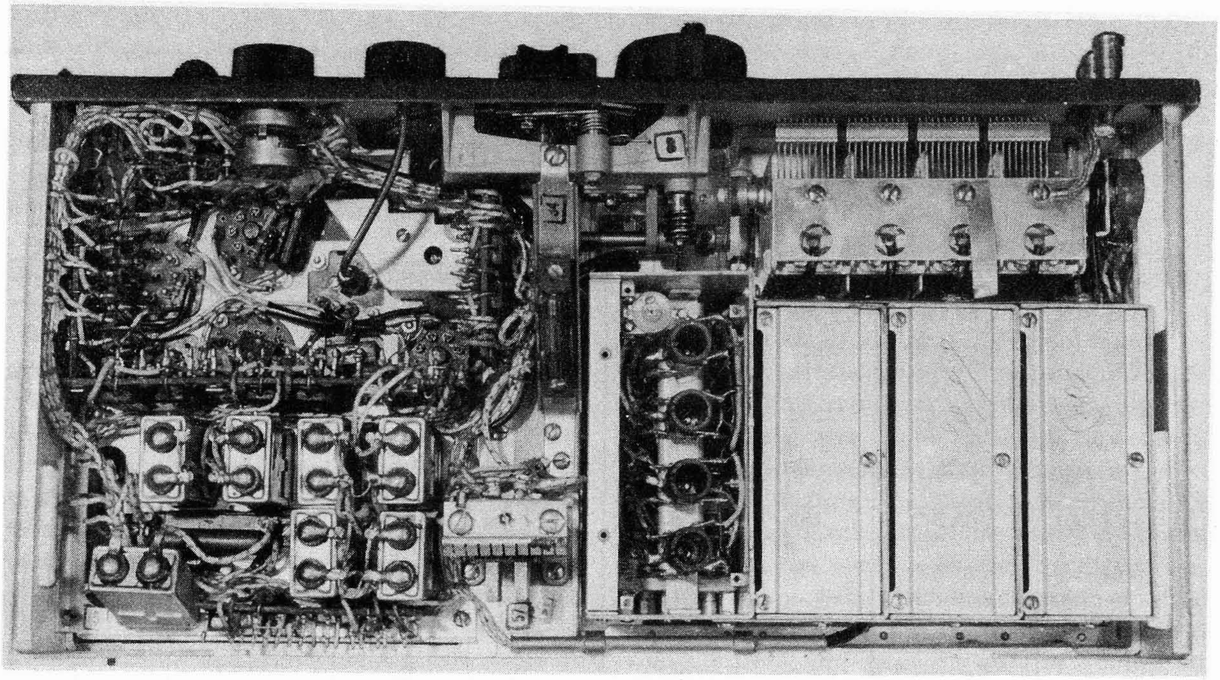


FIGURE 7. BC-348, Bottom View of Chassis.

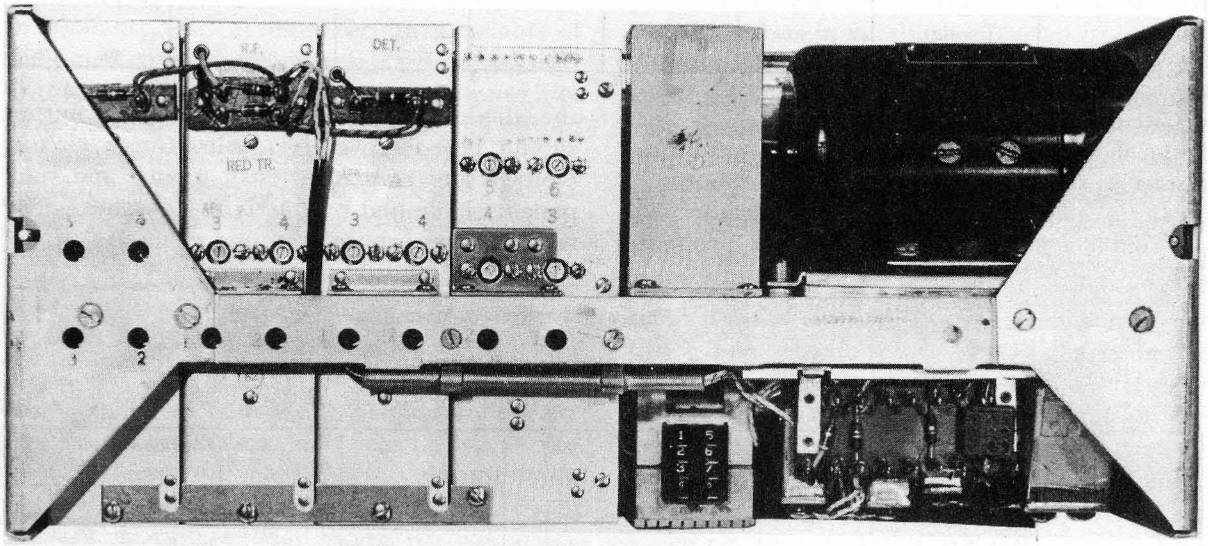


FIGURE 8. BC-348, Rear View of Chassis.

microvolts or less when measured under the following conditions:

(1) AVC-OFF-MVC switch at MVC, 28 volts input, cw oscillator on, crystal filter out, pure cw input from the signal generator applied between antenna-ground terminals through a 100-$\mu\mu$f dummy antenna, and volume control set to produce 0.3-milliwatt noise output.

(2) The sensitivity will vary with time because of tube aging. No attempt should be made to realine the set unless the sensitivity is found to be worse than 17 microvolts with good tubes.

Weak or No Signals on All Bands, Modulated Reception. The first tests to be made are as follows:

Dynamotor terminal voltages (about 28-v and 227-v output).

Tubes—either with a tube tester or by substitution.

Socket voltages (see table 2).

TABLE 2

VOLTAGE TO GROUND, CW OSCILLATOR OFF

Stage	Tube (JAN)	Plate volts	Screen volts	Cathode volts	Heater volts	Plate current (ma)	Screen current (ma)
1 rf	6K7	184	70	2.6	6.3	4.1	1.0
2 rf	6K7	177	86	3.2	6.3	4.8	1.3
1 det	6J7	202	96	4.2	6.3	0.23	0.08
Osc	6C5	58	. . .	0	6.3	1.6	. . .
1 i-f	6K7	182	82	3.1	6.5	4.7	1.2
2 i-f	6F7	207	82	3.1	6.5	4.5	1.4
3 i-f	6B8	207	72	21.0	6.5	2.5	0.6
Output	6K6	197	207	0	6.5	18.0	3.2
2 det	6B8 (diode)	8.0					

Circuit wiring and components.

If the above tests are checked as OK, proceed with a stage-by-stage signal-tracing check as follows:

Audio amplifier. Through a capacitor (0.5 μf), couple a 400-cycle voltage of about 2 volts to the diode detector plate. The audio output should be well over two volts. Check circuits (voltage and resistance tests), wiring, and components if desired output is not obtained. (See table 3 for resistance-to-ground values.)

TABLE 3

RESISTANCE TO GROUND, CW OSCILLATOR OFF

Stage	Tube (JAN)	Cathode (Ω)	Plate (Ω)	Screen (kΩ)	AVC-OFF-MVC switch setting: MVC Grid (kΩ)	AVC-OFF-MVC switch setting: AVC Grid (kΩ)
1 rf	6K7	490	5,200	80	100	1,800
2 rf	6K7	480	5,200	75	100	1,800
1 det	6J7	15,000	5,600	75	0	0
Osc	6C5	0	41,000	. . .	100	100
1 i-f	6K7	520	5,600	70	500	1,800
2 i-f	6F7	470	500	70	500	2,250
3 i-f	6B8	6,200	500	180	5	5
Output	6K6	0	1,080	0.480	700	

Intermediate-frequency amplifier. With the modulated signal (30 percent with 400 cps) of the generator set at 915 kc, connect it properly to the grid cap of the first detector tube through a 0.01-μf capacitor. A rough check of the proper operation of the i-f amplifier (three stages) is indicated by a comfortable audio signal in the headsets with low input from the signal generator (about 30 microvolts of input for 10 milliwatts of output). If the amplifier does not respond properly, a stage-by-stage check should be made, starting at the third i-f grid and proceeding towards the first detector. Each stage should show a decided gain.

Heterodyne oscillator. If the i-f and audio amplifiers are checked as OK and still no signals are heard on any band, check the heterodyne oscillator by observing the cathode voltage at the socket of the first detector tube, VT–91, when grounding the stator of the oscillator section (1-D) of the tuning capacitor. If no change in voltage is noted with this test, check the oscillator circuit for defects.

Radiofrequency amplifier. Assuming all circuits up to the rf section are operating properly, test the rf amplifier as follows. Set the band switch to the band lacking sensitivity. Connect the signal generator through a 0.01-μf capacitor to the antenna post. Set the modulated signal accurately to the alinement frequency (usually the high end of the particular band). With the receiver tuning control set at or near this frequency, tune slowly around this point until the maximum response with the least signal input is obtained. Now couple the tube generator to the grid of the first rf tube and then to the second rf tube. A progressive decrease in output indicates proper operation of the preceding rf stage or circuits.

Weak or No Signals on All Bands, cw Reception. (Modulated reception normal) This symptom evidently indicates a faulty cw oscillator (VT–70). To test and adjust the oscillator, couple the 915-kc signal (modulation off) to the grid of the first detector tube and switch the cw oscillator on. Set the bfo (beat-frequency oscillator) control at midposition and adjust the oscillator tuning coil 121 for zero beat. If no cw beat is heard, check the circuits for defects. With the cw oscillator on, the screen voltage of the first and second i-f tubes drops to about 45 volts. (*Note:* Before measuring voltages, select MVC position, tune to 200 kc, and set the volume control to maximum.)

For resistance measurements to ground, select MVC position and disconnect the power plug *before* you start checking.

Alinement Procedure. This is typical for this set. That is, the i-f stages are alined first, followed by the alinement of the heterodyne oscillator and rf stages. The alinement should always be checked after you test the stages and make the necessary repairs. The i-f amplifier alinement check consists in capacitively coupling a low-level input signal of 915 kc to the first detector grid and adjusting the i-f tuning cores of both primary and secondary windings of the first, second, and third i-f transformers and the tuned circuit of the crystal filter for maximum output. The fourth i-f transformer is slightly overcoupled, resulting in double response peaks symmetrically located about 5 kc on each side of the 915-kc alinement frequency. Because of its broad characteristic, it is generally not necessary to aline this transformer. (*Note:* For more specific alinement data and special maintenance procedures, you may refer to the maintenance handbook, No. 16–40BC224–2, for this receiver, should you have the opportunity to perform maintenance work on it.)

10. Selectivity

At the beginning of the last section, you learned how the sensitivity of this set was measured. Since the selectivity of the set is an equally important characteristic, we shall complete this chapter with a brief discussion of the procedure used in making the selectivity measurement for the BC–348. You may recall that the selectivity of a receiver determines the extent to which it is capable of separating the desired signal from other frequencies. This measurement is made as follows:

STEP 1. With the receiver and signal generator both tuned to 200 kc, adjust the generator output to obtain a receiver output of 10 milliwatts into a 300-ohm resistive load. Use 30 percent modulation, 400 cycles.

STEP 2. Increase the voltage of the signal generator to two times (2 ×) the value obtained above.

STEP 3. Change the generator frequency above and below resonance until the receiver output drops to 10 milliwatts in each case. The difference between these two frequencies will be the band width at 2 × down (selectivity). As a specific example, suppose that at 201.25 kc the output meter reading decreased to 10 milliwatts and again at 198.75 kc, with the input voltage at twice the resonant value; the difference is then 201.25 − 198.75 = 2.5 kc, which is the band width at twice the resonant input. Additional data on the selectivity characteristic of the receiver may be obtained by using generator outputs of 10, 100, or 1,000 times the value obtained in step 1 and repeating steps 2 and 3. The entire procedure is repeated for each band with the generator set at the high end of each band, for example, Band 2—1.5 kc, Band 3—3.5 kc. On Band 1 only, the selectivity is determined for both ends of the band. At 2 × down, the selectivity at 200 kc (low end) is 2.5 kc and at 500 kc (high end) is 500 kc. For the other five bands, the selectivity is 7.0 kc. These are average values for a perfect operating receiver and must be employed with caution.

SUMMARY

In this chapter you were given a general description of a typical liaison receiver—the BC-348. The various views of the set show, as far as possible, the actual appearance of the receiver. The block diagram gave you an over-all picture of the set, showing the number of stages and the sequence in which they are connected from the antenna (signal input end) to the headphones (signal output end). You studied the electrical circuits with the aid of the complete schematic and were shown how to trace the various circuits in the schematic. The purposes of the major components were given, and you were shown which circuits are controlled by the avc switch, in the AVC or MVC position. You learned a general trouble shooting procedure, which consists in analyzing the symptom and finding the trouble from the schematic. Having completed this first chapter in the study of radio equipment you should now realize the importance of the schematic diagram in the study of any piece of radio equipment.

REVIEW QUESTIONS

The following questions are study aids. Your answers are not to be submitted to the USAF Extension Course Institute for grading. Correct answers will be found at the end of this text.

1. List the VT numbers of the tubes used in the BC–348 with their corresponding commercial numbers and the purpose of each tube.
2. List the controls on the receiver front panel.
3. How is the receiver tuned?
4. What is the advantage of having two preselector stages?
5. What type of tube is the 6K7?
6. What components are used to tune the local oscillator grid circuit on Band 3?
7. With the switches as shown in the BC–348 schematic (Chart C–790), trace the dc grid circuit of the first i-f amplifier.
8. Which are the cathode bias resistors used in each i-f stage?

LIAISON TRANSMITTING SET (AN/ART-13A)

THE RADIO TRANSMITTING Set, AN/ ART-13A, that you will study in this chapter completes the Airborne Radio Liaison Set, AN/ ARC-8. The complete transmitting set consists of the transmitting unit, the dynamotor power unit, the remote control unit, the antenna loading unit, and the antenna shunt capacitor unit. Accessory equipment for proper operation includes a carbon or dynamic microphone, a telegraph key, a headset, fixed and trailing wire antennas, and all required cables and wiring.

You will be shown the electrical and mechanical operation of the transmitter (T-47A/ART-13) and the dynamotor unit (DY-17/ART-13) and the purpose of the various controls on the transmitter front panel. The complete schematic diagram of the transmitter (Chart C-256-A) includes the remote control box, which merely parallels the corresponding controls on the transmitter front panel and is used only when it is necessary for the pilot to operate the set.

The theory of operation of the major circuits will be given with the aid of simplified diagrams, but the corresponding circuits in the complete schematic must be traced out so that their relationship with the whole electrical circuit will be clearly understood.

11. General Description of Transmitting Units

Radio Transmitting Set AN/ART-13A is a medium-power aircraft radio transmitter designed to provide radio communication by voice, modulated continuous-wave telegraphy (mcw), or continuous-wave telegraphy (cw). Either a carbon or a dynamic microphone may be used for voice emission. The audio system is capable of modulating the carrier 90 percent for mcw or voice emission. Code may be sent at keying speeds up to 30 words per minute. Transmission frequencies in the ranges of 200 kc to 600 kc and 2,000 kc to 18,100 kc may be selected. Transmission frequencies may be changed by adjusting the controls by hand or by using the build-in automatic frequency-changing mechanism known as the *autotune.* The autotune also makes it possible to change the frequencies from a remote-control position. The autotune can select any one of eleven preset transmission frequencies in about 25 seconds. One of the frequencies selected may be in the low range (200 to 600 kc) and the other ten in the high range (2,000 to 18,100 kc).

Transmitter T-47A/ART-13A. A subassembly type of construction has been used in this transmitter because it is much easier to remove

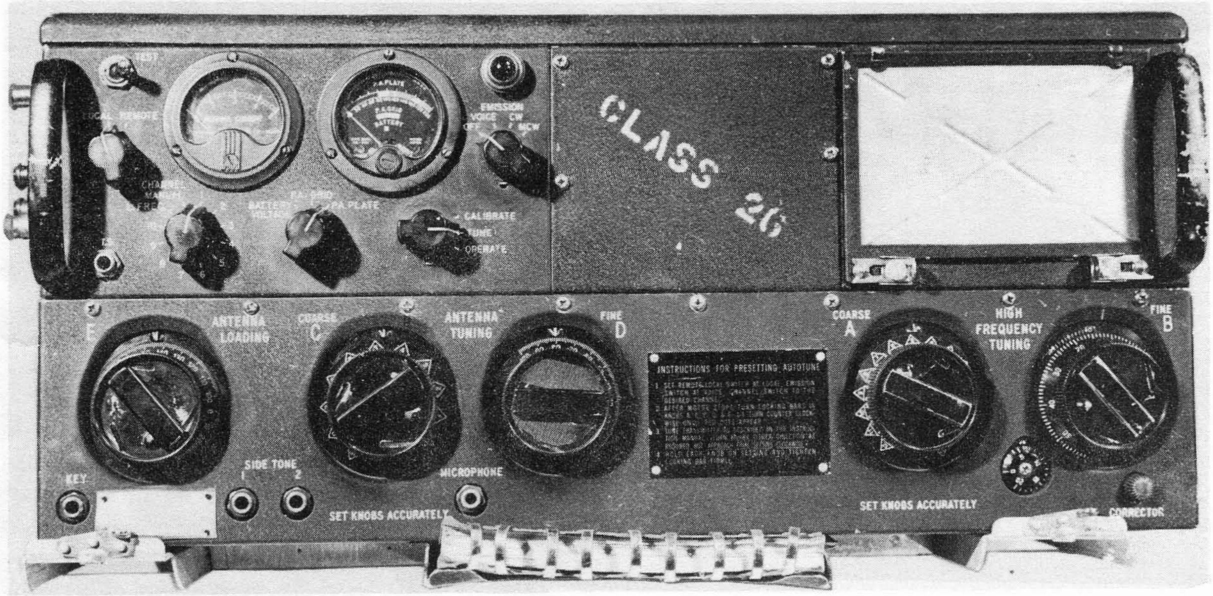


FIGURE 9. Radio Transmitter T-47A/ART-13.

the component parts without major disassembly of the unit. Figure 9 is a front view of the transmitter showing the purpose of the controls, and figure 10 shows the subassembly construction. You may see in figure 10 that the audio amplifier unit, the mcw-cfi (calibration frequency indicator) unit, and the low-frequency oscillator unit are connected to the transmitter by multiterminal plugs (Jones type). Particular attention was given to the mechanical layout of all components (parts) so that they could be replaced quickly and easily. All the vacuum tubes may be reached when the top cover of the transmitter case is removed. Figure 11 is the tube replacement diagram.

The low-frequency oscillator unit 0–17/ART–13A is not a part of the transmitter, but may be installed upon removal of panel MX–128/ART–13. The antenna loading unit CU–32/ART–13A and an additional cable are required for low-frequency operation. Since the low-frequency range is not generally used by the Air Force for liaison

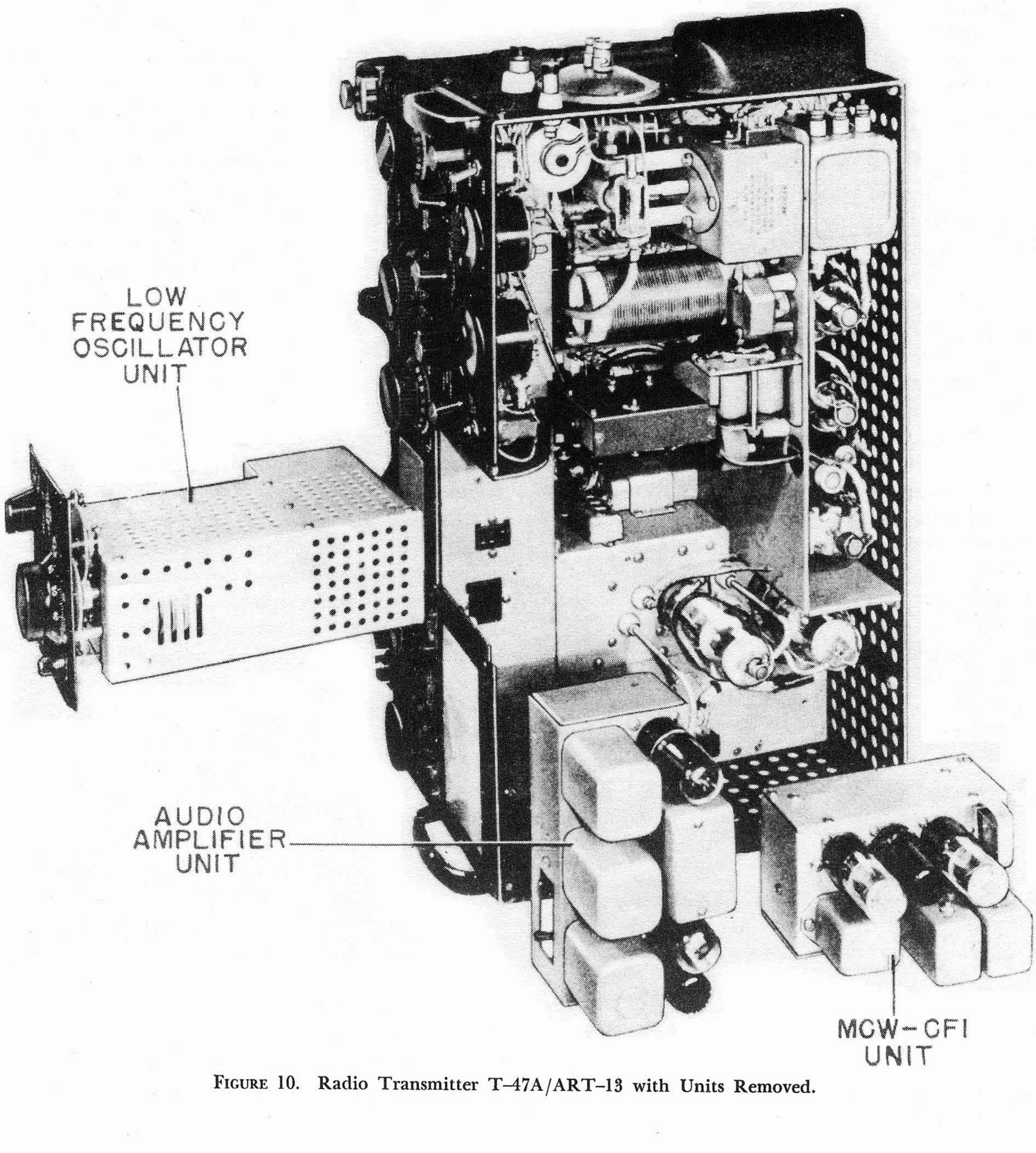


FIGURE 10. Radio Transmitter T–47A/ART–13 with Units Removed.

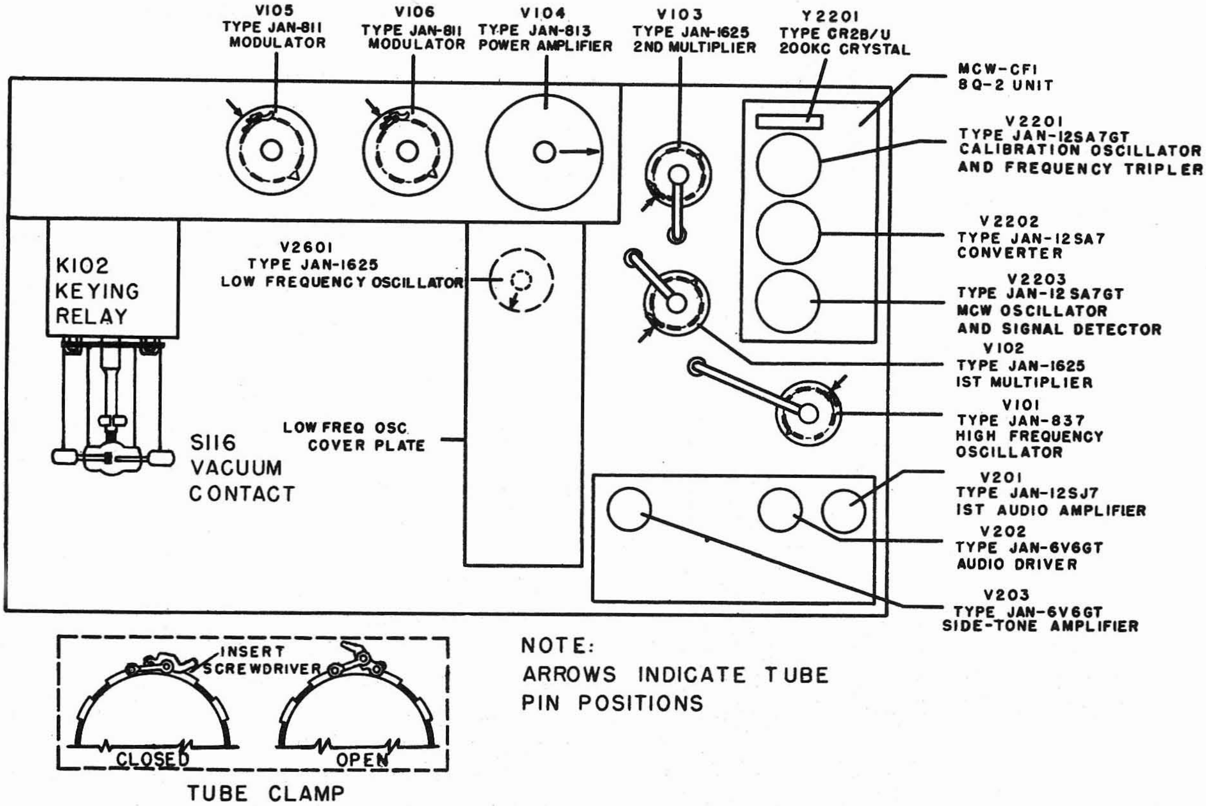


FIGURE 11. Tube Replacement Diagram.

communications, only a brief description of the low-frequency units will be given in conjunction with the block-diagram description that is to follow.

The power delivered to the antenna varies with the frequency and antenna characteristics. The power output is automatically reduced to about one-half the full power output by a barometric switch when an altitude between 20,000 and 25,000 feet is reached. This pressure-operated switch reduces high voltage on the plate of the 813 power amplifier tube and the two 811 modulator tubes. The transmitter will then operate without flashover up to an altitude of 40,000 feet above sea level.

Dynamotor Unit, DY-17/ART-13A. The dynamotor unit is the power source used for operation of the transmitter. (See fig. 12.) It contains the dynamotor, barometric switch, control and overload relays, filters, and fuse for overload protection of the 400-volt supply circuits. A 28-volt direct-current power source is required for operation of the dynamotor as well as for the circuits in the transmitter. Voltages as low as 24 volts dc may be used, but reduced power output and increased time for autotune operation will result.

The dynamotor armature contains two windings and two commutators to give output voltages of 400 and 750 volts dc. At altitudes below 20,000 to 25,000 feet, the barometric switch connects the two windings in series for a voltage of 1,150 volts. At high altitudes, the voltage is reduced to 750 volts by the pressure-operated switch.

Table 4 shows typical power input requirements for a supply of 28 volts dc. Data are shown for different types of emission and for full or reduced power output (above 25,000 feet). All measurements are made with the power amplifier loaded to rated PA plate current.

Control Unit. In the control unit, box C-87/ART-13 (see fig. 13) or panel C-405/A (see fig. 14) provides a means of operating the transmitter from a remote position. By means of two knobs located on the face of the control unit, the following may be controlled: the power supply may be turned on or off, the type of emission (cw, mcw,

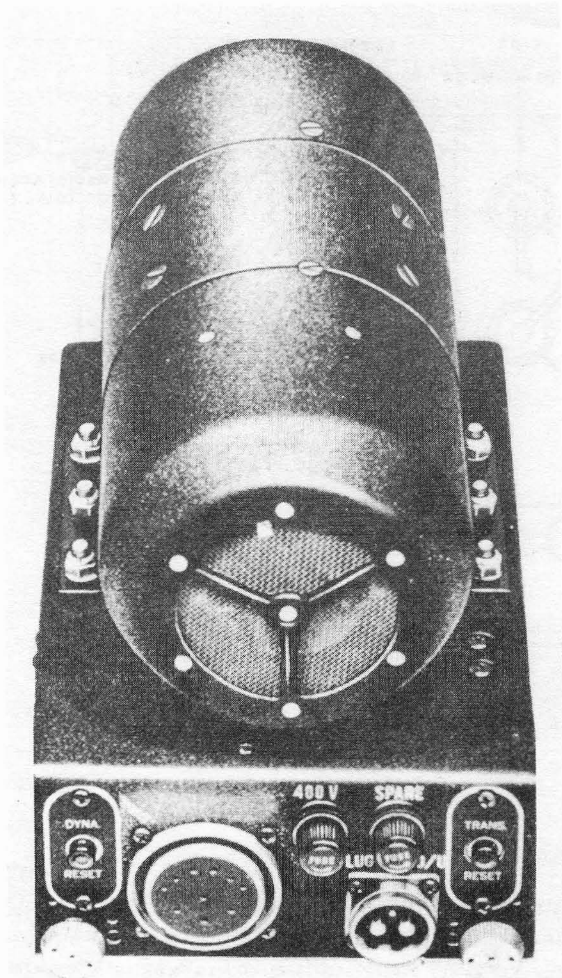


FIGURE 12. Dynamotor Unit DY–17/ART–13A.

or voice) may be selected, and any one of eleven preset transmission frequencies may be selected.

A pilot lamp on the control unit will light when the emission selector switch is in any position other than the OFF position (providing autotune system is at rest). The pilot lamp will light only when the remote control position is in control. On local control the pilot light on the transmitter does the same. If the autotune is operating, the light remains off until the cycle is completed. The pilot lamp, therefore, serves a dual purpose by indicating that the power supply has been connected to the equipment and by letting the operator know when the autotune has completed a frequency change, so that the transmitter is again ready to be keyed or voice-modulated.

The control box (C–87) has a key for keying the transmitter on cw and mcw and a jack for connecting a microphone for voice operation. For installations having standardized control panels, C–405/A replaces the control box and performs all the operation (except key) of control box C–87/ART–13.

Antenna Shunt Capacitor. The antenna shunt capacitor and a single-pole, single-throw knife switch are required for operation into short antennas (less than 50 feet) at frequencies between 2,000 kc and 3,000 kc. The shunt capacitor unit consists of three individual 25-micromicrofarad capacitors mounted on a plate which serves as a common connection to ground. One, two, or all three capacitors may be connected across the antenna circuit, providing capacitance values of 25, 50, or 75 $\mu\mu$f.

Normal Operation (Local). Place local-remote switch on LOCAL position, emission switch on VOICE, and channel switch on desired transmission frequency (given on the transmitter

TABLE 4

POWER INPUT REQUIREMENTS

Type of emission	Freq. (Mc)	Full power (watts)	Reduced power (watts)
Continuous wave	3	780	700
Continuous wave (stand-by)	3	560	560
Tone	3	925	760
Tone (stand-by)	3	560	560
Voice (90 percent mod.)	3	925	760
Voice (stand-by)	3	250	250

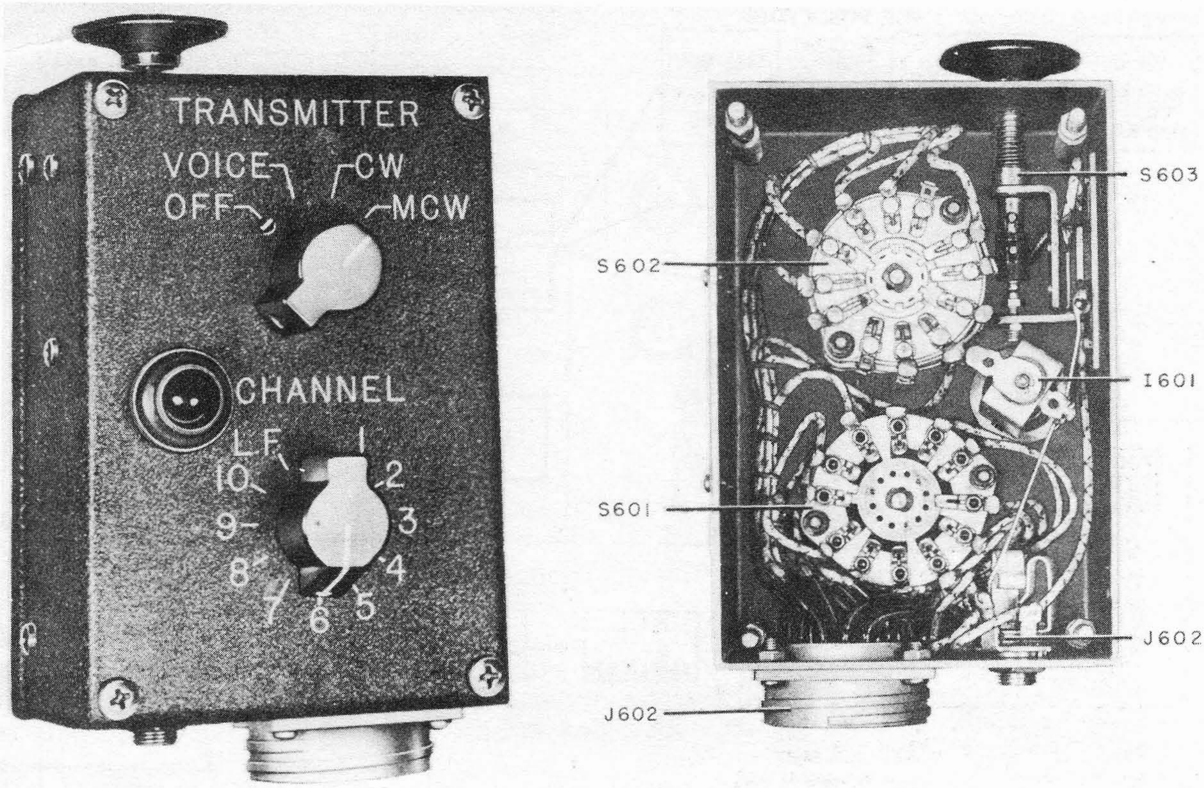


FIGURE 13. Control Unit C-87/ART-13.

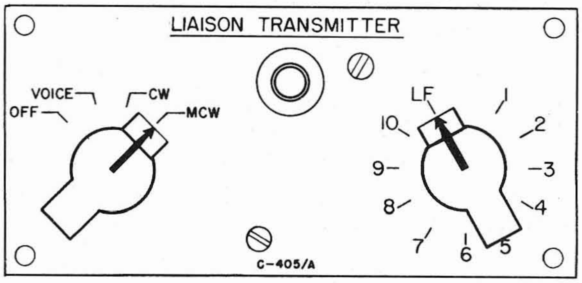


FIGURE 14. Control Panel C-405/A.

chart). When red pilot light comes on, set emission switch to the type of emission desired (voice, cw, mcw). The transmitter is now ready for operation. Use either a key or a standard microphone, as required by the type of emission chosen.

12. Block Diagram of the Transmitter Stages

An understanding of the theory and performance of the circuits can be more easily obtained by first examining the contribution made by each major circuit (or stage) as the signal path is traced from origin to antenna. We shall do this with a block diagram (see fig. 15), which will be explained in the following paragraphs.

Master Oscillator Units. The master oscillator units generate the carrier frequency. When the transmission frequencies in the 200-kc to 600-kc range are required, the low-frequency oscillator (lfo) is used. The oscillator output is fed directly to the power amplifier stage. As previously mentioned, the lfo is an accessory unit to the transmitter. Its low-frequency range is used by Naval aircraft rather than by Air Force aircraft.

In the following references to the master oscillator (MO), we shall be referring to the high-frequency oscillator (hfo) stage unless otherwise indicated. The MO is used to cover the transmission frequencies in the 2,000-kc to 18,100-kc range. This range is covered with the aid of frequency multiplier stages. The oscillator itself operates in the range of 1,000 kc to 1,510 kc.

Frequency Multiplier Stages. The output of the MO is fed into the first multiplier stage, where the frequency is doubled, tripled, or quadrupled as required. For frequencies above

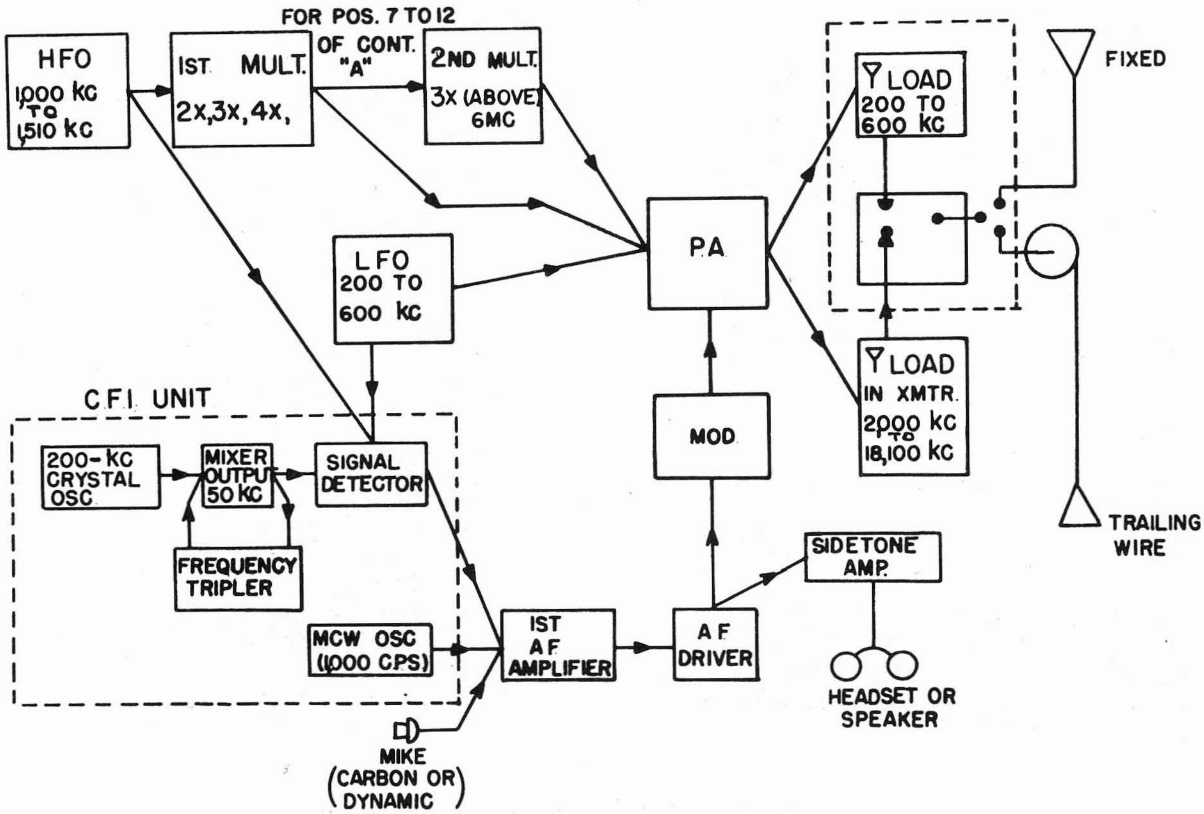


FIGURE 15. Block Diagram of Radio Transmitting Set AN/ART–13A.

six megacycles, the second frequency multiplier is required. The second multiplier acts only as a frequency tripler. For frequencies below six megacycles, the output of the first multiplier is fed directly into the power amplifier stage. Above six megacycles, the output of the first multiplier is fed to the second multiplier. The output of the second multiplier is then coupled to the power amplifier.

Power Amplifier Stage and Loading Circuits. The power amplifier stage (PA) provides power amplification of the modulated carrier. Output of this stage is connected to an antenna loading circuit where power is delivered to the antenna. As the block diagram shows, there are two antenna loading circuits. You will notice that the loading circuits used to tune the transmitter in the frequency range of 2,000 kc to 18,100 kc are in the transmitter, while the low-frequency loading circuits are included in a separate unit. Since the low-frequency range is generally not used for liaison communication, the low-frequency loading unit is not required. The carrier may be radiated from either a fixed antenna or a trailing wire antenna.

Modulator Section. This section includes the following audio stages: first af amplifier, af driver, push-pull modulator, tone oscillator (MCW osc), and side-tone amplifier. The carrier frequency may be keyed for continuous wave (cw) or tone-modulated continuous wave (mcw) emission. The transmitter may also be voice-modulated by means of a carbon or dynamic microphone which is coupled to the first audio amplifier stage. Output from the first af stage is fed to the audio driver stage, which develops enough audio power to drive the modulator stage. The modulator is then coupled to the PA stage for voice modulation.

For mcw (tone) emission, output from a tone oscillator replaces the "mike" output. The signal (about 1,000 cycles) is then amplified by the same stages used for voice modulation. When sending cw, both the master and tone oscillators are keyed, but, since the modulator is not in operation, the tone signal will not modulate the carrier.

A portion of the audio output from the audio driver stage is fed to the side-tone amplifier. Output from this amplifier is used to operate headsets or speaker. The operator can, therefore, listen to himself (monitor) send code or talk. It also provides a means of listening to the output of the cfi unit that is checking the calibration of the master oscillator.

Calibration Frequency Indicator (cfi) Unit. This unit, which is contained in the transmitter, consists of four major circuits. These circuits provide a constant 50-kc signal (rich in harmonics) that may be mixed with the master oscillator output to produce an audible beat note. Calibration of the master oscillator can then be checked at numerous points by *zero beating* the 50-kc standard against the carrier frequency oscillator. A beat note will be heard when the master oscillator frequency or its harmonics are very nearly equal to some harmonic of the 50-kc standard.

The 50-kc signal is generated by a circuit known as a regenerative frequency divider. The circuit produces a 50-kc fundamental frequency and harmonic output voltages while using a 200-kc crystal as the controlling standard. The output of the 200-kc crystal-controlled oscillator and the 150-kc output of a frequency tripler stage are both fed to a mixer stage. The difference frequency (50 kc) is present in the output of the mixer stage. This 50-kc signal is beat against the master oscillator frequency and then detected in the cfi unit to produce an audible beat note. A portion of the 50-kc signal is also used for feedback to the frequency tripler stage to provide the 150-kc output of that stage. The detected beat note is amplified in the first af, driver, and side-tone amplifier stages.

13. Power-control Circuits

We shall first show how the 28-volt dc primary power source (from the aircraft generator) is applied to the dynamotor when the transmitter is turned on (any position of the emission switch except OFF and local-remote switch on LOCAL position). We shall trace the circuits that are completed when the emission switch is placed on VOICE position. Refer to figure 16. The proper names and a brief description of the components (switches, relays, jacks) as numbered in figure 16 will be found in table 5. Once you understand

TABLE 5

NOMENCLATURE OF COMPONENTS IN FIGURE 16

Symbol	Component
*I*101	Indicator lamp
*J*101	Throttle jack
*J*102	Microphone jack
*J*103	Key jack
*J*107	28-volt supply connector to loading coil
*K*101B	Motor control relay contacts
*K*102A	Keying relay solenoid
*K*103A	cw emission relay solenoid
*K*103B	cw emission relay contacts
*K*104A	Voice emission relay solenoid
*K*104C	Voice emission relay contacts
*K*105A	Output circuit selecting relay solenoid
*K*105E	Output circuit selecting relay contacts
*S*104	Test switch, single pole, normally open
*S*106	CTO switch, rotary, three-position
*S*107	Local-remote switch, rotary, two-position
*S*110	Emission selector switch, rotary, four-position
*S*111	One section of autotune limit switch
*S*113D	Keying relay interlocking switch
*K*2701A	Power change relay
*K*2702A	Primary power contactor relay solenoid
*K*2703A	Dynamotor input relay solenoid
*K*2703B	Dynamotor input relay contacts
*K*2704	Barometric switch, altitude voltage control
*K*2705	Transmitter overload relay, pushbutton, 10 amp
*K*2706	Dynamotor overload relay, pushbutton 35 amp
*D*2701	Dynamotor machine
*I*601	Indicator light (Pilot's remote-control box)
*J*602	Microphone jack (Pilot's remote-control box)
*S*603	Telegraph key (Pilot's remote-control box)
*S*602	Emission selector switch (same as *S*110) (Pilot's remote-control box)

the operation of the control circuits from the simplified schematic, locate the same components and trace out the same circuits in the complete schematic of the AN/ART-13A (Chart C-256-A). Refer to figure 9 for the physical location of the various controls on the transmitter front panel.

Primary power applied to the dynamotor is controlled by relays (or contactors) located in the dynamotor unit. Relays *K*2705 and *K*2706 are thermal-operated overload relays which are normally closed. They operate to break the primary circuits when an overload occurs and thus protect

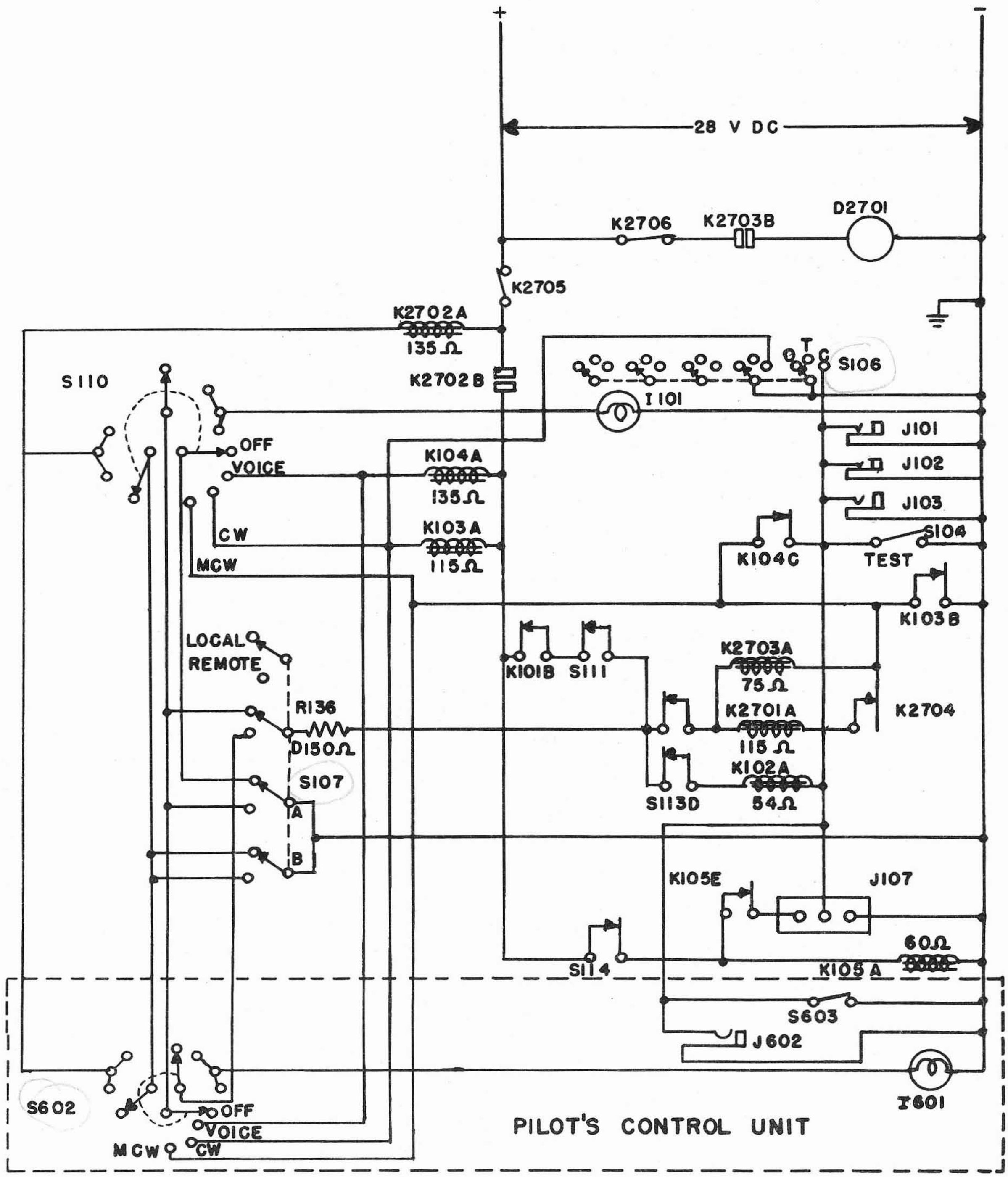


FIGURE 16. Power Control Circuits.

the equipment from damage. To return these relays to their closed position, it is necessary merely to press the RESET buttons located on the dynamotor unit. *K*2704 is a pressure-operated switch rather than a relay and requires no voltage for its operation. It is designed to operate at an altitude of about 25,000 feet. All other relays in the equipment operate from the 28-volt dc power source and may be controlled from either the transmitter or the remote position.

When emission switch *S*110 is set to VOICE position, the 28-volt source will be placed in series with the *K*2702A solenoid. The relay will energize, closing its contacts, *K*2702B. The circuit is traced as follows. From the negative (ground) side of the 28-volt source, we follow the line that leads to contact B of *S*107, then up through *S*110, *K*2702A, and *K*2705 to the positive side of the 28-volt source, completing the circuit. *(Note:* The circuit could also have been traced from the positive side of the source through the switches to ground.) With contacts *K*2702B closed, we now have the circuit completed for the operation of the voice relay *K*104A—through *K*2705, *K*2702B, *K*104A, the contacts of *S*110, and contact A of *S*107 to ground. To apply primary power to the dynamotor (*D*2701), contacts *K*2703B must close by completing the circuit through the relay solenoid *K*2703A. With *S*106 (calibrate-tune-operate switch) in either the TUNE or the OPERATE position, it is necessary to complete the dynamotor input relay to ground through one of the jacks (*J*101, *J*102, *J*103) or by closing the test key *S*104. Assuming that we press *S*104, the circuit is then completed from ground through *S*104, *K*104C—since *K*104A is energized—*K*2703A, *S*111, *K*101B, *K*2702B, and *K*2705 to the positive side of the source. We may conclude that on VOICE position of the emission switch, three relays are energized in the following order: (1) *K*2702—primary power contactor, (2) *K*104—voice relay, (3) *K*2703—dynamotor input relay. Now trace the same circuits on Chart C–256–A, the complete schematic of transmitter AN/ART–13A. Trace the solenoid circuit of *K*2702 first. Start from the grounded contacts RB–2 of *S*110 and complete the circuit to the positive 28-volt input at terminal 2 of *J*2702.

Since the circuits for the CW and MCW positions of the emission switch are very similar to the VOICE position, you should have no difficulty in tracing them.

When the CTO (calibrate-tune-operate) switch *S*106 is set to CALIBRATE position, the circuit for CW relay coil (or solenoid) *K*103A is completed to ground through one section of this switch. With the CW relay energized, its contacts *K*103B complete the circuit to ground for dynamotor input relay coil *K*2703A.

When the local-remote switch *S*107 is placed in the REMOTE position, the control of all power circuits is transferred from the transmitter panel controls to the controls located on the remote control box. In figure 16 the emission switch for the remote control unit is *S*602. It is identical to *S*110 and connected electrically in parallel with *S*110 on the transmitter panel. In either position of *S*107, the pilot lamps (*I*101, *I*601) will light when the emission switch is turned on. Both light circuits are completed through their respective emission switches, the common local-remote switch *S*107, dropping resistor *R*136, safety switch *S*111, and so on to the positive side of the source.

Before leaving figure 16, carefully note the schematic representation of the essential switches—*S*110 (*S*602), *S*107, and *S*106. Emission switch *S*110 is a rotary type and contains four positions—OFF, VOICE, CW, and MCW. The schematic shows three movable arms or contacts which in effect are ganged (physically rotated by a single shaft) and together control three separate circuits. Since this switch completes circuits to ground through *S*107, it is generally called a shorting switch. Physically, the twelve fixed contacts are mounted on two decks (or wafers).

Local-remote switch *S*107 is a two-position single-deck shorting switch. The four movable contacts are ganged as shown by the dashed line in figure 16.

The CTO switch *S*107 is also a rotary type having three positions and five circuits. Each of the movable ganged contacts control one of the five circuits. Figure 16 shows only those switch connections necessary for the power-control circuits. All switches completely connected are shown on the complete schematic diagram (Chart C–256–A).

Heater Circuits. The heater power circuits of the transmitter are a combination of series and parallel connections. The heaters are supplied with power from the 28-volt dc source. Figure 17 shows the heater connections in simplified form. All heater power is controlled by primary power contacts *K*2702B. The primary overload relay operates to break the heater circuit when an overload occurs in the heater or associated circuits. Note that there are five banks of tubes connected across the source. The number of tubes in each bank depends upon the heater rating of the individual tubes. Series-dropping and shunt resistors are used to obtain the correct values of voltage and current for each tube heater. With the aid of table 6, determine which stages are associated in the individual banks as shown in figure 17 (important in trouble shooting).

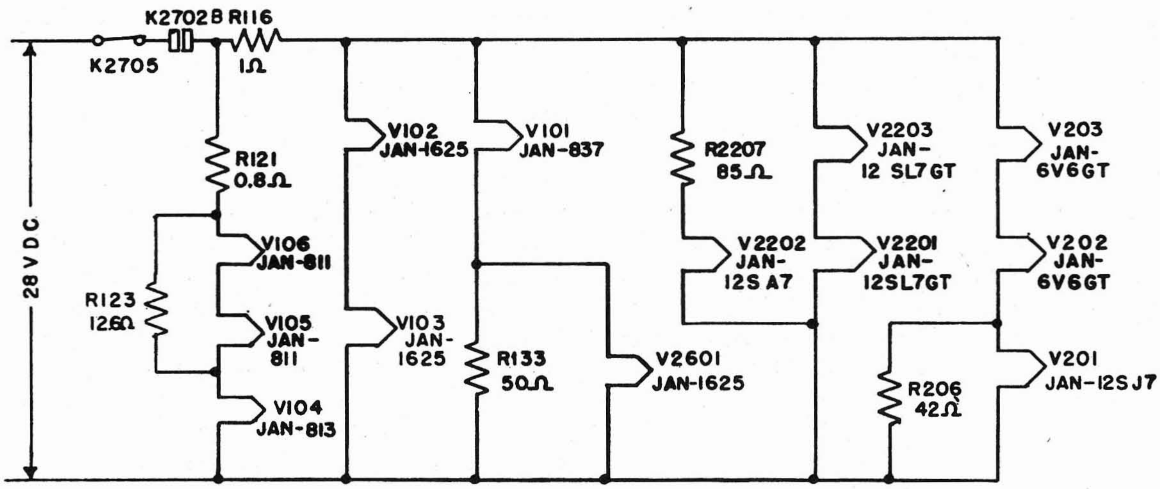


FIGURE 17. Heater Circuits.

TABLE 6

VACUUM-TUBE COMPLEMENT

Symbol	Type number	Purpose
*V*101	837	High-freq. oscillator
*V*102	1625	First multiplier
*V*103	1625	Second multiplier
*V*104	813	Power amplifier
*V*105	811	Modulator
*V*106	811	Modulator
*V*201	12SJ7	Speech amplifier (first af)
*V*202	6V6	Audio driver (second af)
*V*203	6V6	Side-tone amplifier
*V*2201	12SL7	Crystal oscillator and tripler
*V*2202	12SA7	Converter
*V*2203	12SL7	Signal detector and tone oscillator
*V*2601	1625	Low-freq. oscillator

14. High-voltage Circuits

Figure 18 shows, in simplified form, the high-voltage circuits employed in the equipment. The components included in these circuits are the dynamotor machine, filter capacitors and chokes, power-change relay, and high-voltage fuse.

The Dynamotor. The dynamotor armature contains two windings and two commutators to give output voltages of 400 volts dc and 750 volts dc. To obtain the high voltage necessary for the operation of the power amplifier and modulator tubes, the 400-volt output (G_1) is connected in series with the 750-volt output (G_2) of the dynamotor. This is done by the contacts of the power-change relay in its normal (unenergized) position, as shown in fig. 18. The circuit is traced from the positive side (top) of G_1 through *L*2702, the input rf filter choke, contacts of *K*2701, *R*2701B, the voltmeter multiplier resistor (10 watt), and *L*2703, the filter choke, to the negative side of G_2. Then through the generator and *L*2704—the high-voltage (hv) supply filter choke—to the hv terminal. By tracing the same circuit in the complete schematic (Chart C–256–A), you will find that the high-voltage terminal (+1 v,

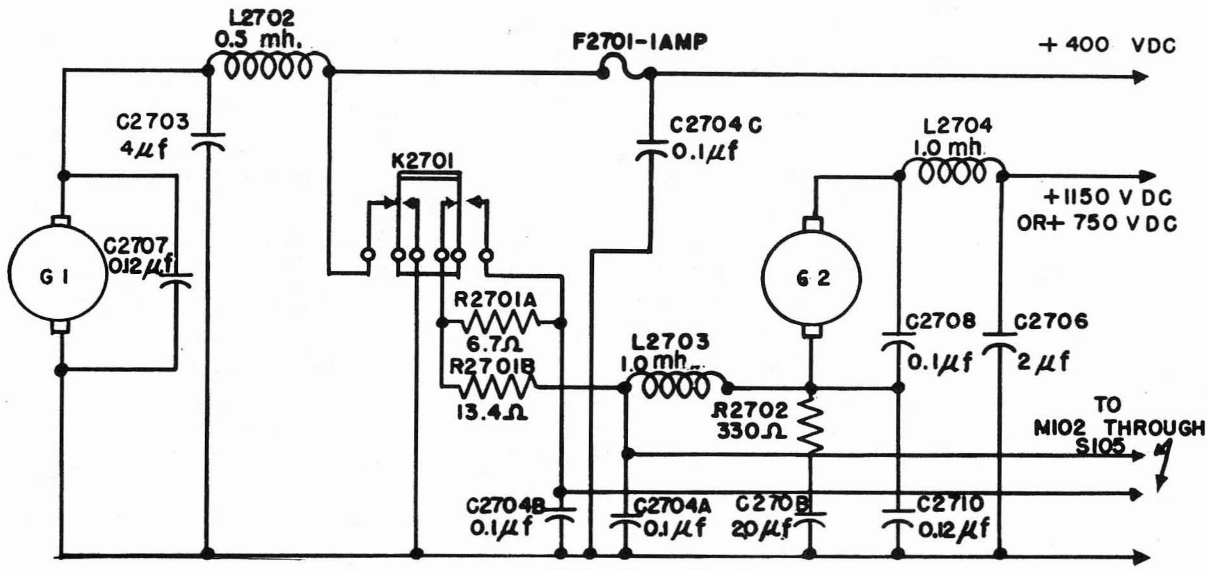


FIGURE 18. High-voltage Circuits.

150 v, or +750 v dc) is No. 10 of *J*2701 (female connector) and *J*108 (male connector).

When the pressure-operated relay *K*2704 closes (at about 25,000-ft altitude), the power-change relay *K*2701, is placed in parallel with the dynamotor input relay, *K*2703. You will recall that *K*2703 was energized when its solenoid was grounded through the test key or through one of the jacks (*J*101, *J*102, *J*103). When that happens, power-change relay *K*2701 will also energize and break the series connection between the two dynamotor windings, which reduces the dc voltage to the PA and modulator to 750 volts.

Filter Capacitors and Chokes. Spark-suppressing circuits (chokes and filter capacitors) are used in the output circuits of the dynamotor to suppress the sparks generated at the motor and generator brushes. If spark frequencies are not properly filtered from the output dc voltage, they will cause a very undesirable modulation of the carrier and will be picked up by any receiver tuned to that carrier.

15. Emission Selection and Carrier Control

We have previously described how the emission selector switch, *S*110, controls the primary power input circuits. You may recall that when *S*110 is turned on (VOICE, CW, MCW), *K*2702 energizes and one of three relays (*K*104, *K*103, *K*2703) will also be energized depending on the particular setting of *S*110. Figure 19 is a simplified diagram of these

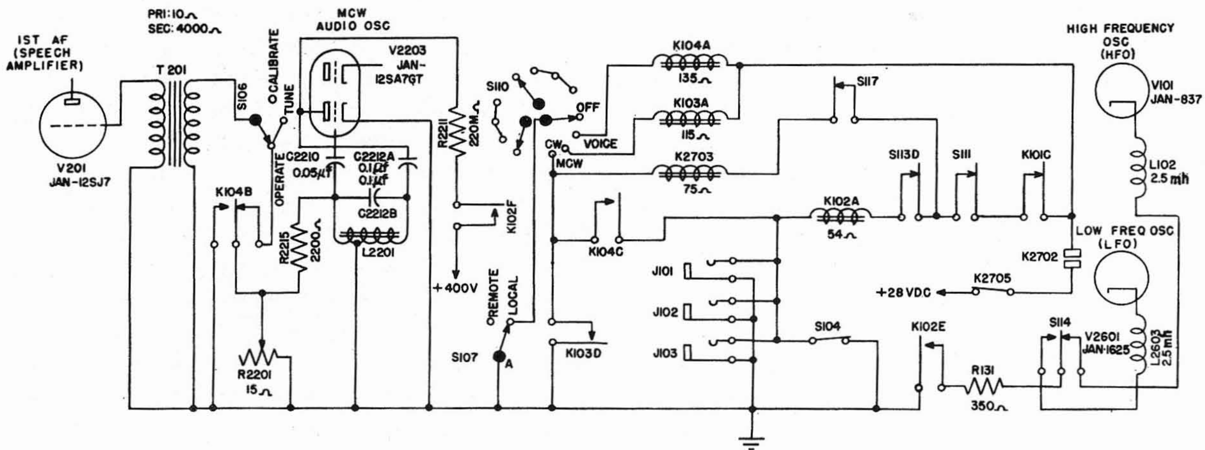


FIGURE 19. Emission Selection and Carrier Control Circuits.

circuits, but throughout the discussion in this section it is important that you trace out the same circuits in Chart C–256–A, the complete transmitter schematic.

On VOICE position of *S*110, relay contacts *K*104B disconnect the output of the mcw oscillator tube, *V*2203, from the input to the speech amplifier. Contacts *K*104C connect the solenoid of dynamotor input relay *K*2703 to the emission control circuits of throttle switch jack *J*101, microphone jack *J*102, key jack *J*103, and the test switch, *S*104. On CW position, relay contacts *K*103D complete the circuit necessary for the operation of dynamotor input relay *K*2703, which in turn, applies primary power to the dynamotor, *D*2701. On MCW position, *K*2703 is operated directly.

The rf carrier is keyed by opening the cathode circuit of the oscillator and removing the screen voltage from the power amplifier. The keying relay, *K*102, has six sets of contacts. Contacts *K*102E complete the oscillator cathode circuit by grounding resistor *R*131. *K*102E and *R*131 serve as a cathode return for both the hf oscillator tube, *V*101, and the i-f oscillator tube, *V*2601 (if used). The desired oscillator circuit is selected by the operation of oscillator selecting switch *S*114, which operates in conjunction with control A.

The mcw oscillator tube, *V*2203, is in operation whenever keying relay *K*102 is energized. The voltage developed across resistor *R*2201 is applied to the input of the first audio amplifier through voice relay contacts *K*104B, the contacts of power-level switch *S*106, and the input transformer, *T*201. Keying relay contacts *K*102F apply plate voltage to the mcw oscillator tube *V*2203. Whenever the carrier is keyed on cw transmission, the output of the mcw oscillator is fed through the first audio amplifier and audio driver to the side-tone amplifier. The keying may then be monitored by listening to the output of the side-tone amplifier.

When power level switch *S*106 is in CALIBRATE position, the mcw oscillator is disconnected from the first af amplifier. At the same setting, *S*106 also removes the screen-grid voltage from the PA tube *V*104 and connects the screen grid to the control grid through a pair of contacts on *S*106. This connection permits control-grid bias (negative dc) voltage to be applied to the screen grid and thereby cuts off output from the PA stage.

The keying relay, *K*102, may be operated by closing one of the keying circuits (*J*101, *J*102, *J*103, *S*104). Keying interlock switch *S*113D is operated in conjunction with output network switch *S*113 and breaks the energizing circuit to the coil of keying relay *K*102 when *S*113 is operated. This removes excitation from the rf circuits to prevent arcing at the switch contacts.

The autotune limit switch section, *S*111, and autotune motor control relay contacts *K*101C are also connected in series with the keying relay coil, so that when *S*111 or relay *K*101 operates, the holding circuit for keying relay *K*102 will be broken and arcing at all switch contacts will be prevented.

16. Audio Circuits

The audio system consists of a two-stage speech amplifier, push-pull modulators, a side-tone amplifier, and an mcw tone oscillator (see fig. 20).

The Speech Amplifier Stages. The first af stage employs a 12SJ7 tube whose output is resistance-capacitance coupled to the input of the 6V6 beam power driver amplifier stage. The 6V6 stage amplifies the audio power sufficiently to drive the larger modulator tubes (811's) connected in push-pull. Since either a dynamic or carbon microphone may be used with this equipment, a "mike" selector switch, *S*201 (spdt switch located beneath the tuning chart on the front panel of the transmitter), is provided for making the proper connections to match the output of either mike to the first af amplifier input circuit. If *S*201 is placed in CARBON position, we have current-limiting resistors *R*202 and *R*201 placed in series with the 28-v source and the carbon mike (through *J*102). *R*202 and *R*201, along with *R*203 and *R*204, form a bleeder across the 28-v source and provide the proper voltage to operate the carbon mike. *R*116, although in the bleeder circuit, is actually more a part of the filament circuit (see fig. 17). *R*203 is a limiting resistor. It reduces the output of the carbon microphone to the level of the dynamic microphone output. Thus, no af gain control is necessary. *R*204 is electrically in parallel with the primary of *T*201 and *R*216 and therefore essentially determines the audio voltage developed across *T*201 primary coil. On DYNAMIC position of *S*201, the dc voltage is removed and the mike jack, *J*102, is connected in series with limiting resistor *R*216 and the primary of input transformer

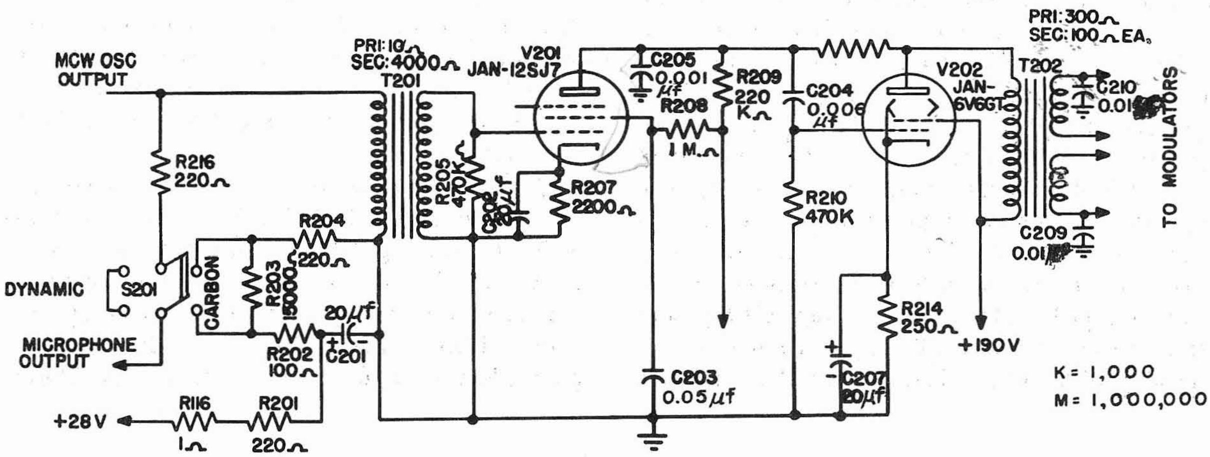


Figure 20. Speech Amplifier Circuits.

*T*201. The output circuit of *V*201 is resistance-capacitance coupled to the grid of the driver stage through *C*204. The output of the driver stage is transformer coupled (*T*202) to the grids of the modulator tubes. This is shown in the simplified modulator circuit in figure 21.

Push-pull Modulators. Two hi-mu triodes are connected in push-pull in the modulator stage and operate Class B. With full voltage applied to the power amplifier, the modulator stage is capable of modulating the carrier at least 90 percent. The JAN–811 is, however, essentially a zero bias tube, and with plate voltages as high as 1,150 v dc it is necessary to apply some bias to the grid circuit to keep the no-signal plate current as low as practicable. The average dc voltage drop through the filaments is used as bias in this case (see fig. 21). Capacitors *C*210 and *C*209, in the grid circuits of the 811's, bypass audio and radio frequencies which are above the normal range of voice frequencies. Both screen and plate circuits of the power amplifier tube *V*104 are modulated. The plate voltage on the modulator tubes is 1,150 volts. Continuous-wave relay contacts *K*103B remove the plate voltage from the modulator tubes when cw emission is selected.

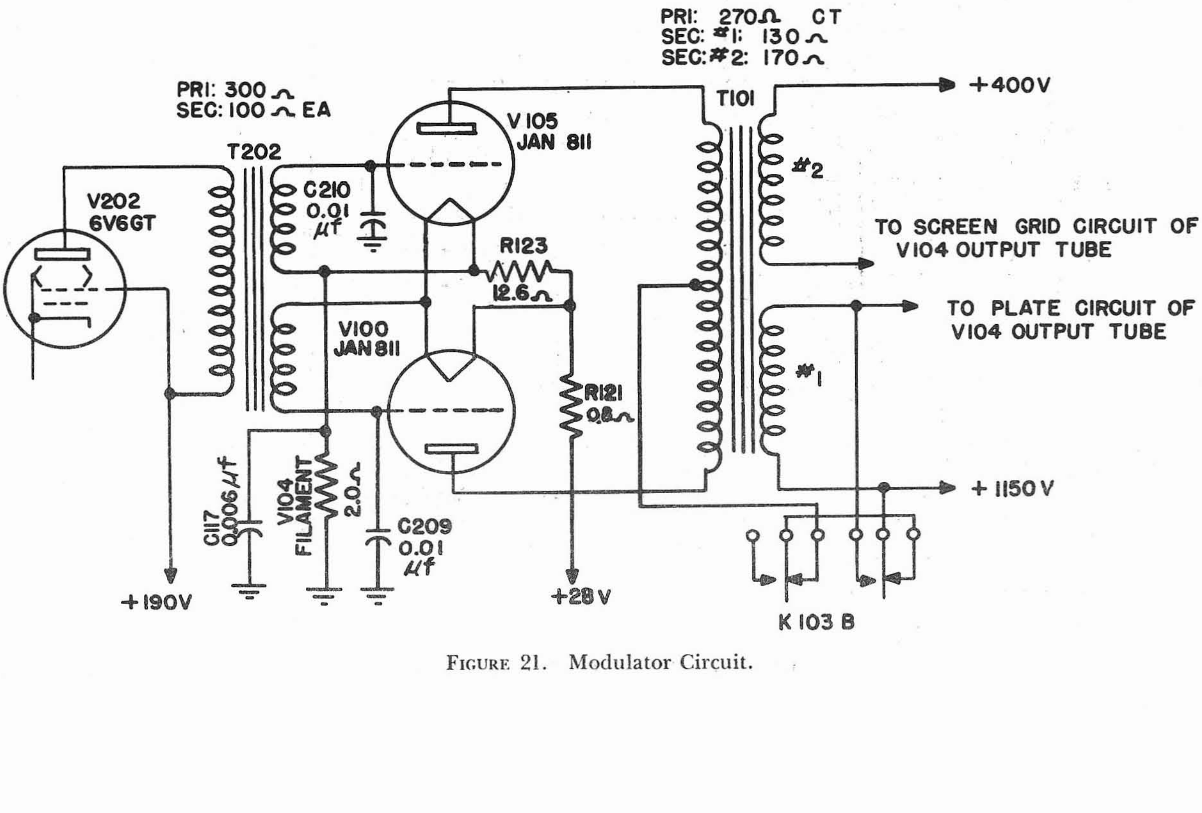


Figure 21. Modulator Circuit.

The Side-tone Amplifier. The output of the driver tube *V*202 is coupled to the grid circuit of the side-tone amplifier *V*203, a 6V6 beam-power tube, through a voltage-dividing system consisting of *C*206, *R*211, and *R*212 (see fig. 22). The signal voltage developed across *R*211 drives the grid of *V*203 to provide enough audio output to operate headphones or speakers. The output voltage developed across the secondary of impedance-matching transformer *T*203 is coupled to the side-tone jack *J*104 through a variable-tap side-tone output switch *S*202 and keying-relay contacts *K*102C. The side-tone amplifier is keyed whenever the keying relay *K*102 is energized. Plate and screen voltages are obtained by tapping the bleeder system (see *R*117, *R*118, *R*119, *R*120 in ART–13A complete schematic, Chart C–256–A) of the low-voltage (400 v) output of the dynamotor.

The mcw Tone Oscillator. One section of the dual triode tube 12SL7–GT is used for the mcw oscillator (see fig. 23), and the other section is used with the cfi unit. The oscillator operates whenever the keying relay *K*102 is energized, which closes contacts *K*102F and therefore applies plate voltage to the tube. The oscillator

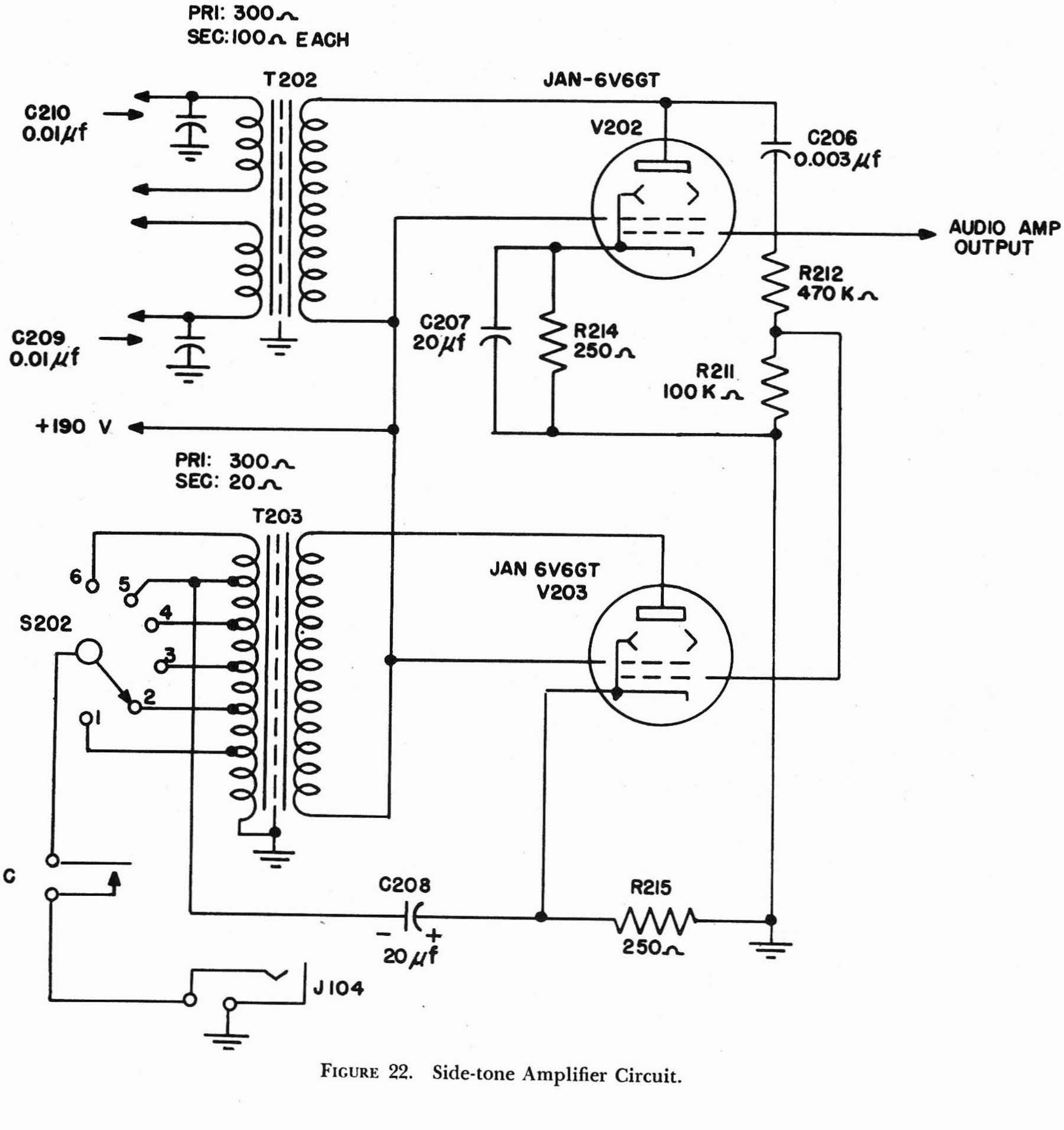


FIGURE 22. Side-tone Amplifier Circuit.

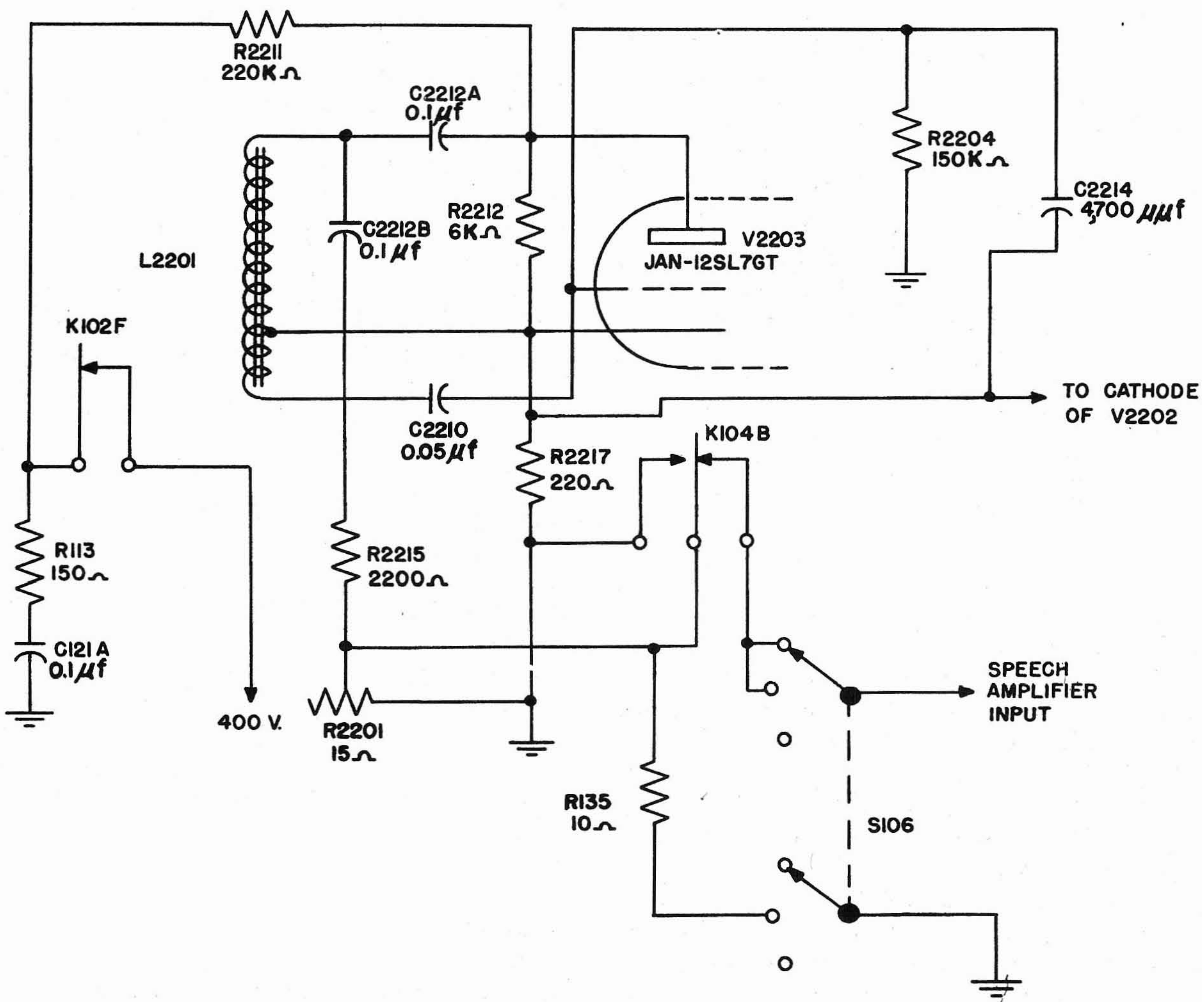


FIGURE 23. Oscillator Circuit for MCW.

output may be varied by adjusting *R*2201. This is a screwdriver adjustment accessible through a hole at the rear of the mcw-cfi unit. The voltage developed across the output control *R*2201 is coupled to the input of the speech amplifier through the voice relay contacts *K*104B and the contacts of the power-level switch *S*106. When the selector switch *S*110 (see fig. 19) is in VOICE position, the VOICE relay energizes and disconnects the tone oscillator from the speech amplifier, but during cw transmission (*S*110 at cw position) the tone oscillator is keyed and its output fed to the speech amplifier and side-tone amplifier for monitoring.

The calibration oscillator unit (cfi) includes (see fig. 24) a twin-triode tube, *V*2201, which operates as a crystal oscillator and tripler; a pentagrid converter, *V*2202, which heterodynes the oscillator frequency (200 kc) and the tripler frequency (150 kc) to produce a 50-kc fundamental frequency (including harmonics), which is used as the calibration standard; and a detector tube, *V*2203, which rectifies some of the carrier and calibration frequency voltages to produce an audible beat note in the headphones. When the *corrector* knob associated with the master oscillator (hfo) tuning is adjusted for *zero beat* (tone decreases in pitch until no sound is heard), the transmitter MO is properly calibrated. (*Note:* The complete tuning procedure will be given later in this chapter.)

Plate voltage is applied to the cfi tubes from the 400-volt section of the dynamotor when CTO switch *S*106 is set to CALIBRATE position. This starts the 200-kc crystal oscillator. The 200-kc frequency, plus random tube and circuit noises,

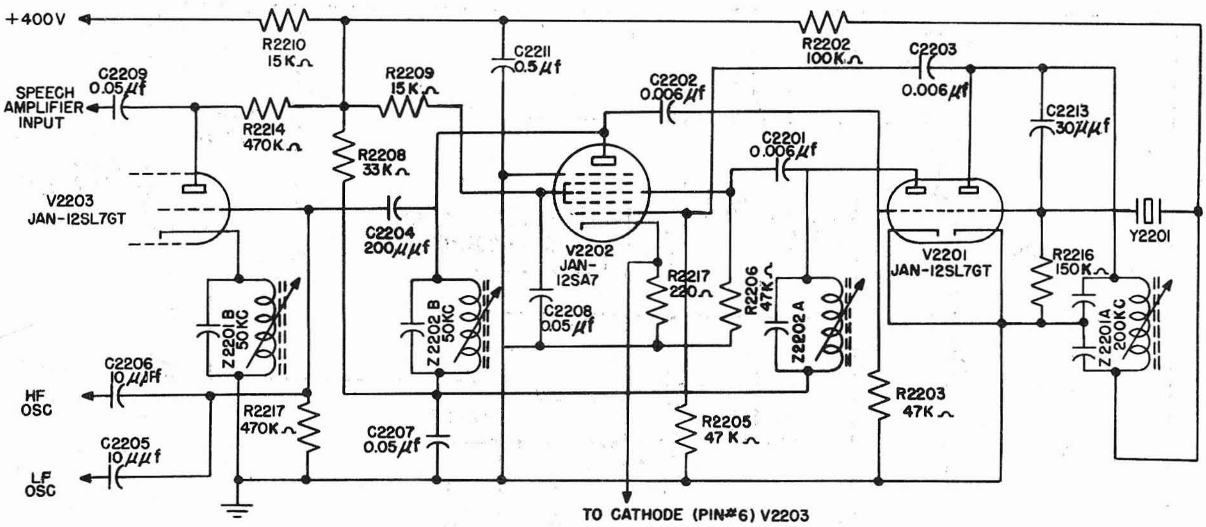


FIGURE 24. Oscillator Circuit for cfi.

is coupled through *C*2203 to the injector grid (g_1, first grid from cathode) of *V*2202. (See fig. 24.) The random tube noises are coupled from the plate of the 12SA7 (*V*2202) through *C*2202 to the grid circuit of the tripler section of the 12SL7–GT (*V*2201, left-hand section). Since its plate circuit is tuned to 150 kc, only the 150-kc component of the random tube noises is amplified. This 150-kc frequency is coupled to grid number 3, of *V*2202 through *C*2201. The plate tank (Z2202B) circuit is resonant to 50 kc, so that the tube will amplify the 50-kc difference frequency produced by combining the 200-kc and 150-kc voltages injected on grids one and three.The 50-kc voltage continues to excite the tripler section of *V*2201. The stable 50-kc fundamental and its harmonics are coupled to the grid circuit of the detector, *V*2203, through *C*2204 to check the frequency of the carrier oscillator.

17. Radiofrequency Circuits (2,000 to 18,100 kc)

The Oscillator Stage. *V*101 is a typical shunt-fed Colpitts circuit using a JAN–837 pentode tube. (See fig. 25.) The frequency range of the oscillator is covered in two bands, 1,000 kc to 1,200 kc and 1,200 to 1,510 kc. The position of the band switch *S*101, which is operated by control A (transmitter front panel), determines the operating band of frequencies. (Locate control A on Chart C–256–A.) On the lower oscillator band, the switch is closed, and this places capacitors *C*101 and *C*135 in the grid circuit. The switch is closed on all odd positions of control A—except position 13—and open on all even positions of the switch. Refer to Table 7 for the frequency range corresponding to each position of control A (high-frequency tuning). Trimmer

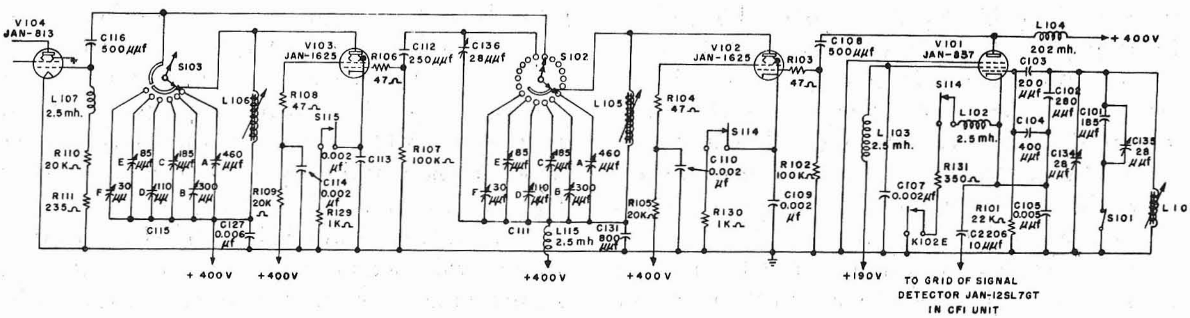


FIGURE 25. High-frequency rf Circuits.

TABLE 7

FREQUENCY RANGE COVERED BY POSITIONS OF TUNING CONTROL A

Control A position	Frequency range (megacycles)
1	2.0 – 2.4
2	2.4 – 3.0
3	3.0 – 3.6
4	3.6 – 4.0
5	4.0 – 4.8
6	4.8 – 6.0
7	6.0 – 7.2
8	7.2 – 9.0
9	9.0 – 10.8
10	10.8 – 12.0
11	12.0 – 14.4
12	14.4 – 18.1
13 (low frequency)	0.2 – 0.6

capacitor *C*135 is used to set the high end of the 1000-to-1200-kc band, and *C*134 for the 1200-to-1510-kc band. The five-frequency tuning adjustment within each band is made by varying the inductance of the slug-tuned coil *L*101 with control B. About 20 revolutions of control B will cover the entire frequency range of the band upon which the oscillator is operating with leeway at both ends of the band. To place the oscillator in operation, its cathode circuit to ground is completed by energizing the keying relay *K*102. *S*114 will be closed on all positions of control A except No. 13. Screen voltage (200 v) is obtained from the 400-v bleeder system of the dynamotor while the full 400 volts is applied to the plate of the oscillator tube.

Multipliers. To obtain the transmitting frequency range of 2,000 to 18,100 kc, the hf oscillator output must be multiplied from two to twelve times. The multiplier stages, *V*102 and *V*103, employ 1625's, beam power pentode tubes. The first multiplier tube may operate as a frequency doubler, a tripler, or a quadrupler. The second multiplier tube operates only as a frequency tripler. The particular oscillator harmonic on which the transmitter is to operate depends upon the positions of the first and second multiplier range switches *S*102 and *S*103, which in turn are set by control A. In the first six positions of control A, only the first multiplier tube, *V*102, is in operation and *S*102 connects this stage directly to the PA, *V*104. The harmonic output of *V*102 for each setting of control A is as follows: positions 1 and 2—second; positions 3 and 4—third; positions 5 and 6—fourth. The same harmonic sequence of operation is followed by the first frequency multiplier for positions 7 through 12, but its output is coupled through *S*102 to the grid of the second multiplier, operating only as a frequency tripler. The tripler is connected to the power amplifier grid through *S*103. *V*102 is now disconnected from the PA by *S*102 (see fig. 25). Range switch *S*103 performs the same functions for the second multiplier. The multiplier stages are tuned by capacitor *C*111 and *C*115, each consisting of six separate capacitors, and the slug-tuned coils *L*105 and *L*106, which are ganged with *L*101. Plate and screen voltage is obtained from the dynamotor 400-volt source.

18. The Power Amplifier

The power amplifier stage employs a type 813 beam-power tube. The 813 transmitting tube operated as a Class C amplifier may have the following maximum characteristics: plate voltage = 2,000 v, screen voltage = 400 v, grid bias = −120 v, plate current = 200 ma, screen current = 40 ma, grid current = 16 ma, driving power = 4.3 watts, and output power is about 300 watts. As it is used in the ART–13A transmitter, however, the operating voltages are somewhat lower, so that rf power output is about 75 watts.

With output circuit-selecting relay *K*105 de-energized (normal position), the plate circuit of the PA tube *V*104 is connected to the output network which is built within the transmitter proper. (See fig. 26.) Voltage for the PA screen is supplied by the 400-v output of the dynamotor through contacts 5 and 13 of *K*102 when the keying relay *K*102 is energized. When CTO switch *S*106 is in CALIBRATE position, the screen voltage is removed and the screen is connected through the right-hand contacts of the CTO switch, *R*137, and rf chokes *L*107 to the grid of the PA tube. (Note that *S*106 in figure 26 is shown in OPERATE position.) This permits the negative voltage on the control grid to be applied to the screen grid and thereby cuts off output from the PA stage. On TUNE position of *S*106, the screen voltage is reduced through *R*124 to protect the tube from overload when the

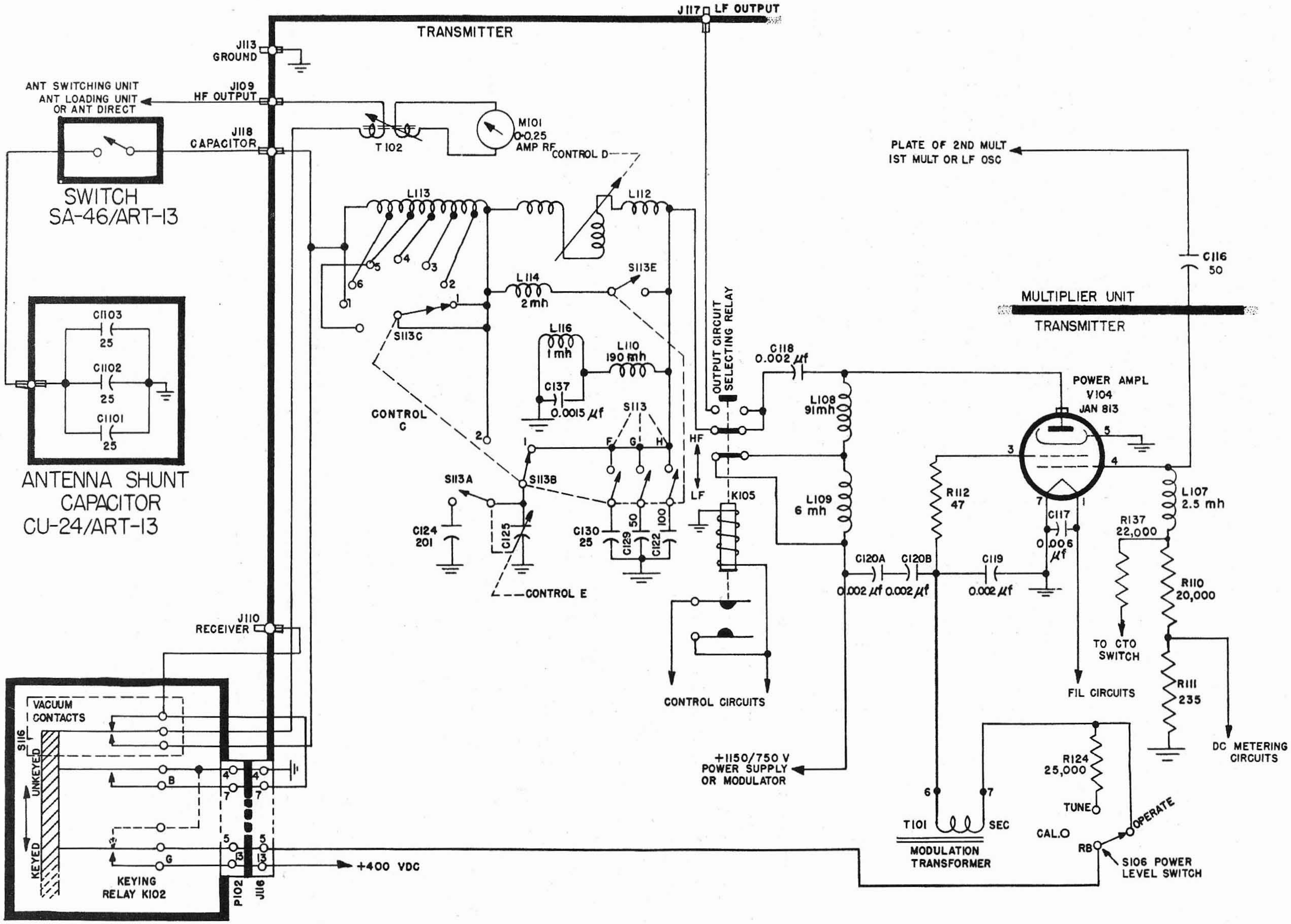


FIGURE 26. Power Amplifier and High-frequency Output Circuits.

transmitter is tuned. In OPERATE position of S106, full screen voltage is applied.

Output circuit-selecting relay K105 is energized only when the low-frequency range of the transmitter is used. It then makes the proper circuit connections to the external antenna loading unit. In its normal (unoperated) position, K105 connects the PA tube to its plate tank and antenna-coupling network in the transmitter proper through capacitor C118. Radiofrequency choke L109 is shorted out. The maximum voltage (1,150 v) from the dynamotor is applied to the plate of the PA tube.

The output network is designed to operate as either a pi or an L section. The multisection network switch, S113, connects the capacitors and coils in the proper positions to permit matching the PA plate circuit to most aircraft antennas at any frequency within the frequency range 2,000 kc to 18,100 kc.

The variometer, L112, is operated by control D. The variable capacitor C125 is operated by control E. These network controls, C, D, and E, are connected to the autotune system but may be operated manually without disturbing the positions of the autotune stop rings if the *channel selector* switch, S108, is placed in the MANUAL position and the autotune system is allowed to operate.

The rotor and stator of plate-tuning capacitor C125 are constructed as separate components. The rotor is electrically connected to the antenna network. Capacitors 124, 130, 129, and 122 are padders and help to resonate the tank circuit to the particular range of frequencies selected. These capacitors and the inductors are connected in the circuit by multisection output network switch S113. Table 8 will help you to understand the operation of S113, which is shown in figure 27. The rather elaborate output tuning system is necessary to tune properly and to load the power amplifier plate circuit when working into fixed antennas of varying lengths (approximately 17 to 60 ft). It may also be necessary to connect the antenna shunt capacitor across the network to tune the transmitter in the range 2,000 kc to 3,000 kc.

The carrier signal voltage is coupled to the PA grid through C116. Inductor L107 is an rf choke. Grid bias for the tube is developed across resistors R110 and R111. The 10-volt dc filament is bypassed for rf by C117. Capacitor C119 is the screen-grid bypass, and R112 serves as a parasitic suppressor. High voltage is applied to the plate through the secondary winding of the modulation transformer, T101, through contacts K105D, and through plate feed choke L108. (*Note:* L109 is used as an additional plate feed choke only in

TABLE 8

FUNCTION OF MULTISECTION OUTPUT NETWORK SWITCH S113

Control C position	S113B	S113C	S113E	S113F	S113G	S113H
1	1	1	open	open	open	open
2	1	2	open	open	open	open
3	1	3	open	open	open	open
4	1	4	open	open	open	open
5	1	5	open	open	open	open
6	1	6	open	open	open	open
7	1	7	open	open	open	open
8	2	7	open	closed	closed	closed
9	2	7	open	open	open	closed
10	2	7	open	open	closed	open
11	2	7	open	closed	open	open
12	2	7	open	open	open	open
13	2	7	closed	open	closed	open

Note: S113A is operated by the rotation of C125 (operated when dial E reads in 0-100 range).

S113D is operated by control C. Switch is closed when control C is set to any of its 13 positions. As control is rotated between positions, S113D opens and disables keying relay K102, thus preventing arcing at other switch contacts.

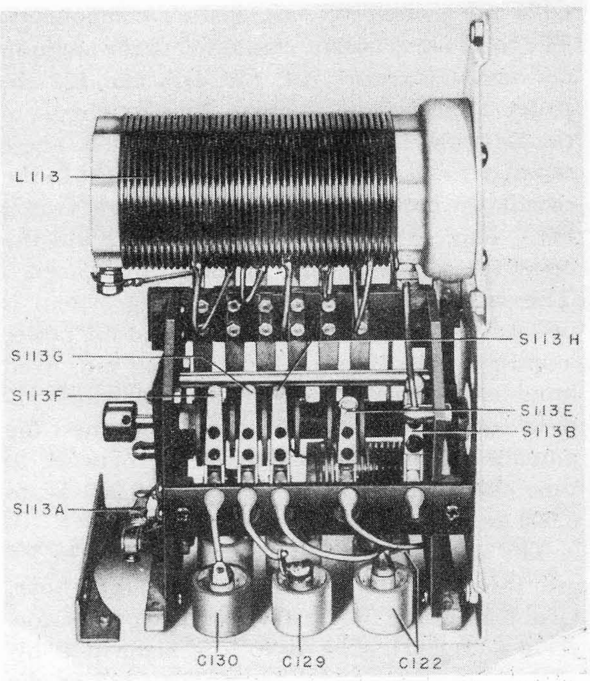


FIGURE 27. Multi-element Switch, Right-side View.

the low-frequency range, 200 to 600 kc. Reference is made to components used in low-frequency operation to avoid confusion in your study, since these components are shown in the simplified schematic as well as the complete transmitter schematic of the AN/ART–13A. Detailed discussion of the low-frequency circuits is given in the Technical Order of this equipment, *Handbook of Maintenance Instructions, Radio Transmitting Set No. AN 16–30ART–13A,* published by the Air Force, 8 March 1949, but not furnished with this course.)

Inductor *L*110 functions as a static-drain choke for the output circuit shunt capacitors and the antenna. The parallel combination of *L*116 and *C*137 forms a high-frequency noise filter. The output network is connected to the antenna through the vacuum switch contacts *S*116 whenever the keying relay *K*102 is energized. In the de-energized position of *K*102, switch *S*116 connects the antenna to the liaison receiver.

Both the screen grid and plate of the PA are modulated when voice or mcw emission is selected for the transmitter. When the transmitter is keyed, a dc voltage (400 v) is applied to one arm of switch *S*106. This arm is grounded when the transmitter is not keyed. (Since the power-control circuits have been discussed, it will be left for you to trace the dc circuits to the plate and screen grid of the PA for each position of CTO switch *S*106.)

*M*101 is a thermocouple-type rf antenna current ammeter (0 to 5 amp). Radiofrequency energy is coupled into the meter circuit through *T*102. When the transmitter is properly tuned, the meter should give a maximum indication. This meter, however, is not essential for tuning, since *M*102 is used for that purpose.

19. Metering Circuits

The dc metering circuits consist of the dc milliammeter (*M*102, 0 to 1 ma), the meter switch (*S*105), and a number of resistors which enable the meter to indicate the relative values of primary power source voltage, PA grid current, and the sum of the PA and modulator plate currents. The meter and meter switch are located on the front panel of the transmitter. You may refer directly to the transmitter schematic (Chart C–256–A) while studying the meter circuits.

When switch *S*105 is in the BATTERY position, a connection is made from the 28-volt plus (terminal 4 of *J*108, at the power supply) to the positive terminal of meter *M*102 through resistor *R*128; a connection is made also from the negative terminal of meter *M*102 to ground, through resistor *R*132. Resistors *R*128 and *R*132 serve as voltmeter-multipliers which convert meter *M*102 into a 0-to-54-volt voltmeter. Therefore, the needle of meter *M*102 is deflected to approximately half-scale (within the light-shaded area marked BATTERY).

When switch *S*105 is in the PA GRID position, a connection is made from the junction of resistors *R*110 and *R*111 to the negative terminal of meter *M*102; a connection is made also from the positive terminal of meter *M*102 to ground, through resistor *R*128. Meter *M*102 is now converted into a 0-to-4-volt voltmeter, and it measures the voltage drop across resistor *R*111. This voltage drop is proportional to the value of the dc current flowing in the grid circuit of the power amplifier because of rf excitation. Since the average grid current is about 8 ma, the normal indication of the meter is approximately half-scale (within the light-shaded area marked PA GRID).

When switch *S*105 is in the PA PLATE position and the power-change relay, *K*2701 (in power supply), is in the high-power position, the series combination of meter *M*102, resistor *R*128, and resistor *R*2701A is connected across resistor *R*2701B, and *R*2701B is connected in series with the two generator windings, *G*1 and *G*2. Thus, meter *M*102, acting as a 0-to-4-volt dc voltmeter, measures the voltage drop across resistor *R*2701B. The amount of current flowing through resistor *R*2701B is equal to the sum of the power-amplifier and modulator plate currents. On cw emission, the average dc plate current is about 150 ma (the modulator is disabled), the voltage drop across resistor *R*2701B is 2 volts, and meter *M*102 indicates half-scale deflection (within the light-shaded area marked CW). On mcw emission, the average dc plate current of the modulator is about 135 ma, the voltage drop across resistor *R*2701B is 3.8 volts, and meter *M*102 indicates 190 (just above, or within, the light-shaded area marked MCW).

When switch *S*105 is in the PA PLATE position and the power-change relay, *K*2701, is in the low-power position, the series combination of meter *M*102 and resistor *R*128 is connected across the series combination of resistors *R*2701B and *R*2701A, which are connected in series with generator *G*2. Thus, meter *M*102, acting again as a 0-to-4-volt dc voltmeter, measures the voltage drop across resistors *R*2701B and *R*2701A. The average dc plate currents of the power amplifier and modulator are now about two-thirds of the previous values, but the voltage drop measured by meter *M*102 is now across a resistor which is 50 percent greater in value. Therefore, the normal indications of the meter are approximately the same as for the high-power condition.

20. Manually Operated Transmitter Controls and Indicators

The purpose of each control and indicator as shown on the transmitter front panel (see fig. 9) will presently be given. Locate each control in the complete transmitter schematic, and trace out the circuits associated with it. We will divide the controls in two groups for our study. In the first group are those that are manually operated and are located in the upper half of the transmitter front panel (except low-frequency oscillator unit controls). These controls are mostly circuit switches. The second group are those that may be controlled manually or by the autotune system and are located in the lower half of the transmitter front panel. They are used in tuning the transmitter.

The controls in the first group are as follows:

Test switch (*S*104) keys the set for adjustments and test purposes.

Local-remote switch (*S*107) transfers control of emission, channel selection, and pilot-light indication to either the transmitter panel or the remote-control box.

T. S. jack (*J*101) provides for plug connection to the throttle switch.

Channel selector switch (*S*108) selects any one of eleven autotune channels which may be pretuned on the manual channel.

Antenna current meter (*M*101) indicates rf antenna current. It is not necessary for tuning and loading the transmitter.

Meter circuit selector switch (*S*105) *and meter* (*M*102) connect circuits to indicate battery voltage, PA grid current, and PA plate current. Satisfactory values of each for normal operation are indicated by shaded areas labeled BATTERY, PA GRID, and PA PLATE on the meter face. The plate meter scale has a *red* shaded area to indicate normal deflection during voice operation, a *white* shaded area for cw operation, and another *white* shaded section for mcw operation.

Power level or CTO switch (*S*106) arranges the transmitter circuits for calibration, tuning, and operation. On CALIBRATE position, the cfi unit is connected to calibrate the rf variable frequency oscillator. On TUNE position, the power amplifier voltage is adjusted to prevent damage to the tube while tuning. On OPERATE position, normal circuit conditions are arranged for final tuning adjustments and actual transmission.

Emission selector switch (*S*110) connects circuits for voice, cw, or mcw transmission and turns the power on and off. The voice position is used for standby operation, voice communication, and calibration. The cw position is used for tuning and continuous-wave transmission. The mcw position is used for modulated continuous-wave transmission.

Pilot light indicates when the set can be keyed and whether local or remote control is being used. It goes out when the autotune cycle starts and lights again when it is completed, thus indicating that the set is ready for tuning or operating.

Output switch (*S*202) selects one of six taps to provide a satisfactory headset level of side tone. It is located beneath the transmitter chart.

Microphone circuit switch (*S*201) connects the input circuit for either carbon or dynamic microphones. It is located beneath the transmitter chart.

Key jack (*J*103) provides connection to the hand key.

Side-tone No. 1 jack (*J*104) provides side-tone output when the transmitter is keyed. Receiver output is also obtained from this jack.

Side-tone No. 2 jack (*J*105) provides an extra unwired jack which can be connected for separate side tone or in parallel with jack No. 1.

Microphone jack (*J*102) provides connection to microphone audio input and keying circuits.

21. Tuning Controls

The second group includes tuning controls A, B, C, D, and E. Each control may be set either automatically by the autotune system or manually. Each control is connected to a corresponding autotune unit. There are therefore, five autotune units, one for each control. Control B is operated by a multiturn (20 turns) unit, while the other four controls are operated by single-turn units. A description of each control follows. (*Note.* Study the descriptions with the aid of the complete schematic diagram of AN/ART–13A, Chart C–256–A.)

Control A (high-frequency tuning—"coarse") selects (1) the high- or low-frequency oscillator by means of cam-operated switch *S*114, (2) the high-frequency oscillator range by operating band switch *S*101, and (3) the multiplier range by setting the first and second multiplier tank capacitor selector switches *S*102 and *S*103. Control A also operates autotune seeking switch *S*109, at the left on Chart C–256–A. (Note that all the switches operated by any one control are shown "ganged" by a dashed line in the complete schematic of the AN/ART–13A.)

Control B (high-frequency tuning—"fine") tunes the oscillator and multiplier stages by moving the tuning slugs in inductors *L*101, *L*105, and *L*106. The control is calibrated and contains a vernier scale for exact adjustment. A *corrector* knob is used to move the vernier scale in alinement with the scale on control B after zero beat has been obtained. That is, the frequency indicated at control B must correspond to the reading given in the calibration tables. Also associated with control B is a revolution counter, since its autotune unit is a multiturn mechanism.

Control C (coarse antenna tuning) gives a coarse adjustment of the amount of capacity and inductance in the antenna network to tune properly and to load the power amplifier. The necessary switching operations are performed by multi-element switch *S*113 (below control D on Chart C–256–A)—sections *B, C,* and *E*—which is operated directly by control C or by autotune unit C. On position No. 1 of C, the network tunes to its lowest frequency and on position No. 13 to its highest frequency. On positions No. 1 to 7 of *S*113C (corresponding to No. 1 to 7 of C), the frequency is increased by decreasing the inductance of *L*113 in steps. (On No. 7, *L*113 is entirely shorted out.) The plate tank circuit during the first seven positions of C is an L-type network consisting of *L*112 (control D) and *L*113 in series with the antenna and the tuning capacitor, *C*125 (control E), connected in parallel with the inductances. From positions 8 through 12, various combinations of padding capacitors are cut in by sections, *F, G,* and *H* of *S*113. In position No. 13, a small inductance *L*114 is connected across variometer *L*112 by operating the switch arm *S*113E. A star cam on the same network switch shaft operates switch *S*113D which disables the rf portion of the complete transmitter by preventing the operation of keying relay *K*102 when the control knob is between switch settings.

Control D operates variometer *L*112 to provide fine inductance tuning of the antenna (or plate tank) circuit.

Control E operates the variable capacitor *C*125 and switch section *S*113A to provide fine control of capacitance in the transmitter antenna load circuits. Operation of *S*113A connects *C*124 in parallel with *C*125 to extend the range.

22. Autotune System

If you turn the transmitter on and set the channel selector switch (*S*108) to one of its given positions, say 3, a motor will start running and the tuning dials start rotating; they will continue until each of the tuning dials has been moved to a predetermined setting to tune the transmitter to the frequency selected for Channel 3, at which time the motor automatically stops. If *S*108 were moved to another position, the tuning cycle would repeat itself and tune the transmitter to another predetermined frequency. This automatic tuning is made possible by the autotune system.

The Collins Autotune System (manufactured by Collins Radio Company). This is an electrically controlled means of mechanically repositioning adjustable elements such as tap switches, variable inductors, and variable capacitors. Any combination of these items such as are used in transmitting equipment can be tuned to any one of eleven preselected frequencies in a period of 25 seconds at a normal room temperature and with a normal supply voltage by the use of the autotune system. Provisions have also been made to permit manual tuning, in case it becomes desirable to operate at some frequency other than those frequencies available by means of the autotune system.

The Autotune Assembly. This assembly consists of a group of positioning mechanisms that perform the same function as a manual tuning knob. Each mechanism provides precise angular setting of the tuning control to any one of eleven angular positions, each of which is readily adjustable. The settings for each frequency and for each control are entirely independent.

The positioning accuracy of the autotune mechanism is of a very high order. Each setting is inherently independent of wear, blacklash, alinement, or supply voltage. The accuracy of the settings is comparable to that of vernier manual controls. The parts are machined within close limits, and, although operation is most precise, there are no delicate adjustments or fragile mechanisms. Permanently lubricated bearings are used in many places, and the assembly is enclosed and protected from dust and corrosion.

As previously mentioned, there are two basic types of autotune mechanisms: one known as the *single-turn* unit and the other as the *multiturn* unit (control B only). Figure 28 may give you some idea of their appearance.

Figures 29, 30, and 31 are bottom, top, and front views of the transmitter. They have been included to help you visualize the physical appearance of the transmitter and the layout of some of the components. Figure 32 shows the components inside the sealed high-frequency oscillator and its autotune unit. Carefully study each figure and locate the components listed in the complete transmitter schematic.

Electrical Characteristics. The electrical sequence of operation of the autotune system is illustrated in figures 33 and 34. Figure 33 is the electrical circuit and figure 34 shows the steps which the autotune system goes through each time the selector switch (*S*108) is changed from one position to another. Follow the steps of figure 34 by reading from 1 to 2A, 2B, 2C, 3A, 3B, 4, and so on; at the same time, trace the electrical circuits on figure 33. The only thing that needs to be said to enable you to trace the circuit is that the current through the field of the motor is constant and does not change direction. Therefore, to cause the motor to reverse direction, the polarity of the armature winding must be reversed.

23. Calibration

We will now see how the transmitter is calibrated and tuned. To *calibrate* a transmitter simply means to adjust the oscillator frequency contols so that the dial settings of the controls will indicate the exact frequency being transmitted. One of the common causes of communication failure is carelessness in adjustments, which makes it impossible to calibrate and adjust the transmitter to the proper frequency output.

In our discussion of the transmitter circuits, you have learned that the calibration frequency indicator (cfi) unit is used to calibrate the transmitter. In this section you will see how this is done as a preliminary step to the actual tuning. Of course, there are also *frequency meters* designed to do the same thing. These frequency meters are accurately calibrated rf oscillators, generally crystal-controlled. Two popular Air Force types are the SCR–211 (see fig. 35) and the TS–164. They are portable self-contained instruments designed to adjust aircraft radio transmitters and receivers to any desired frequency in the range from 125 to 20,000 kilocycles. The SCR–211 is battery powered, while the TS–164 obtains its power from the BC–348 receiver. Both meters use a 1,000-cycle crystal oscillator as the controlling standard. The output of the meters is loosely coupled to the transmitter output, and the transmitter oscillator is adjusted to zero beat with the desired calibrated frequency from the meter. The exact step-by-step procedure is very similar to the procedure used with the cfi unit and associated calibration tables.

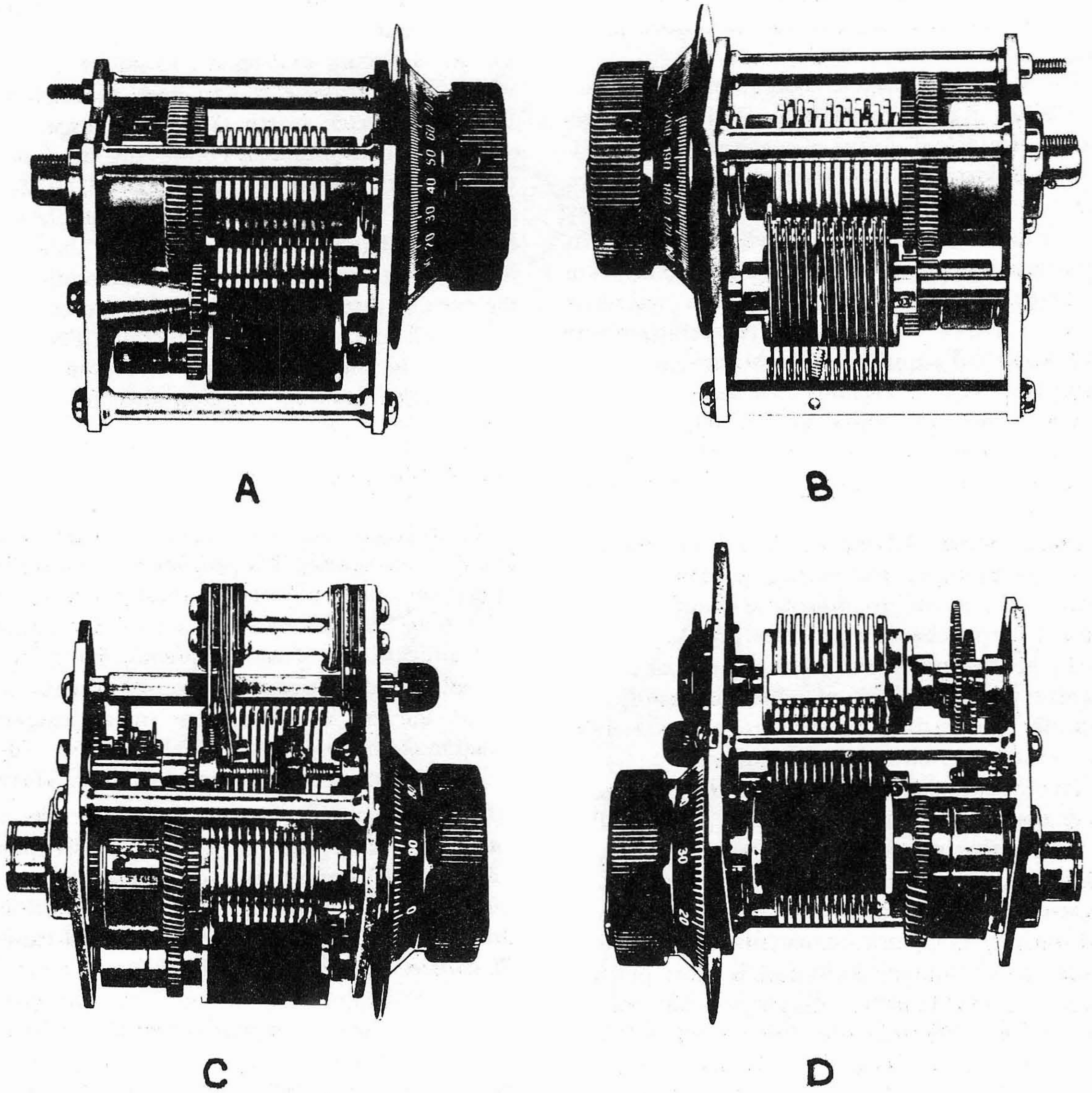


FIGURE 28. Autotune Units. A. Single Turn, Left Side. B. Single Turn, Right Side. C. Multiturn, Left Side. D. Multiturn, Right Side.

Use of Calibration Tables. Table 9 is a sample page from the calibration tables for this equipment. We shall use it for our example.

The calibration tables are required to set controls A and B, which control the frequency of the master oscillator (hfo) and therefore the carrier frequency put out by the transmitter.

Calibrating frequency *check points* have been indicated in the calibration tables by being printed in heavy black type (see table 9). When checking the calibration, use the check point which is numerically nearest to the transmission frequency that is to be used. Heavy ruled lines that appear at intervals in the calibration tables serve to indicate the direction of the nearest check point. For example, for frequencies that appear above (or before) this dividing line, use the first check point that is found by looking back toward the lower frequencies. For frequencies that appear below (or after) the dividing line, use the first check point that is found by looking ahead toward the higher frequencies.

The check points are frequencies at which audio *beat notes* between the output of the master

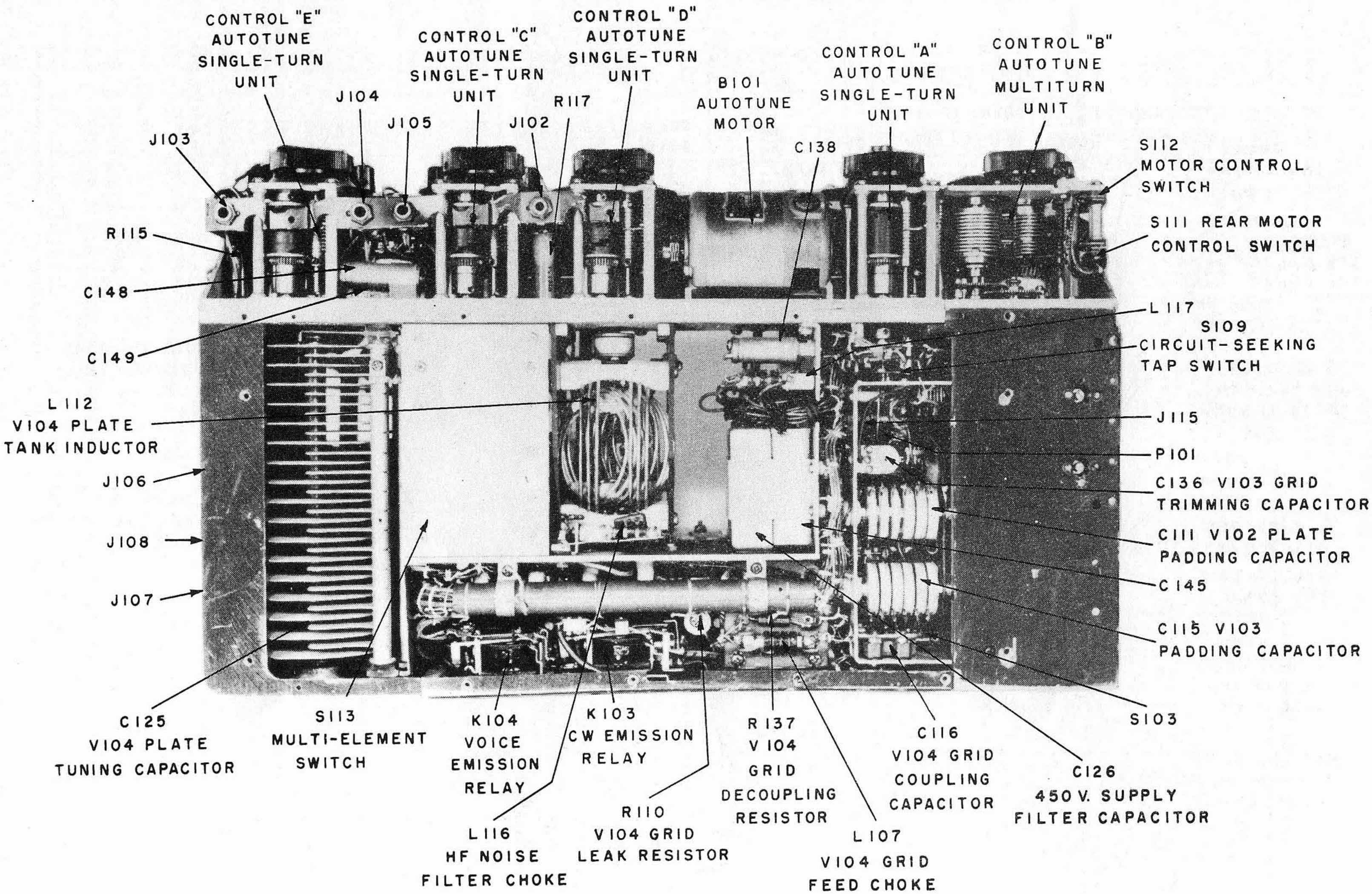


FIGURE 29. Radio Transmitter T-47/ART-13—Bottom View, Panel Removed.

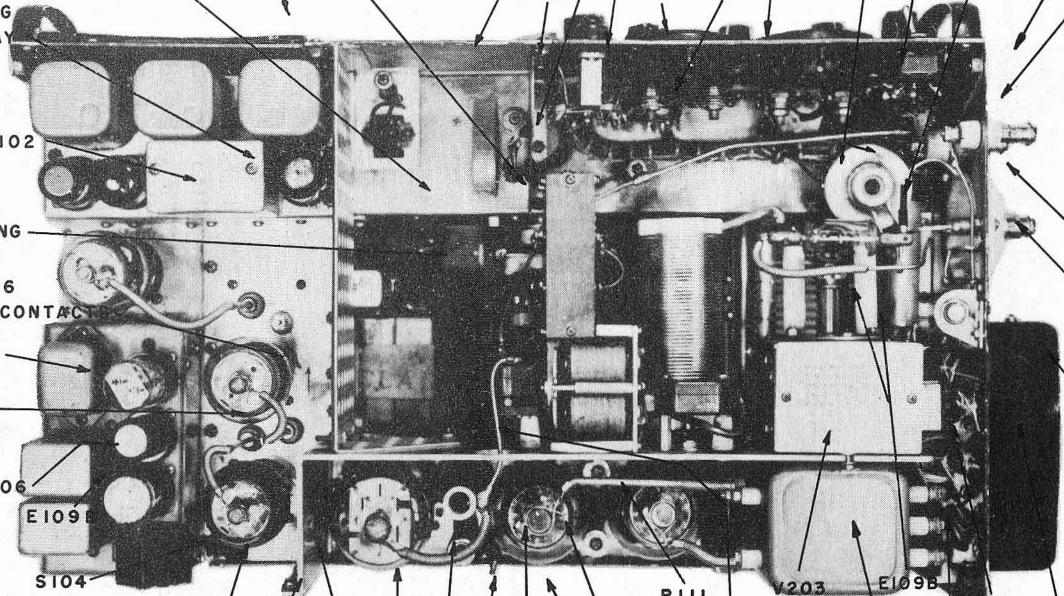


FIGURE 30. Radio Transmitter T-47/ART-13—Top View, Cover Removed.

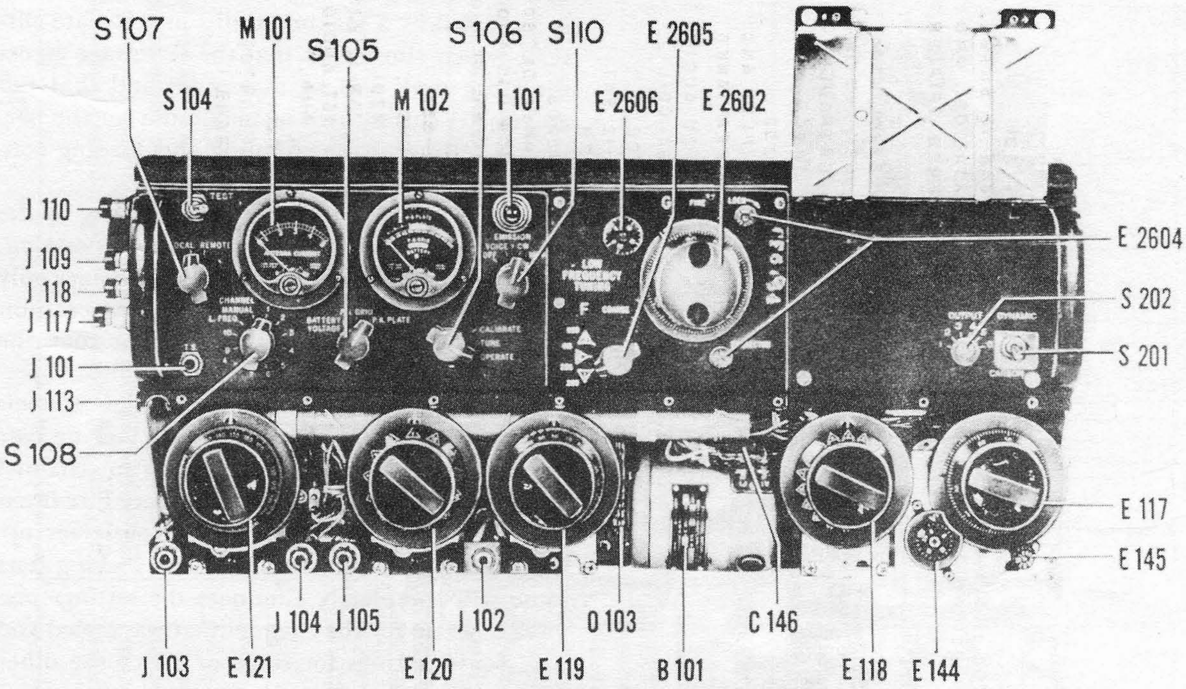


FIGURE 31. Radio Transmitter T-47/ART-13—Front View, Open.

oscillator and the harmonics of the crystal-controlled 50-kc output of the cfi unit may be heard. The beat notes are used for setting the dial and the movable indicator mark for adjusting the calibration of the oscillator. The frequency in the tables is given in kilocycles, with the control positions in the column opposite the frequency. Refer to figure 36 while studying the use of the calibration tables.

The controls A and B are set as indicated in columns A and B of table 9. The first *two* digits of the number in column B are set on the revolution counter, and the balance of the number to the *left* of the decimal is on the dial. The decimal portion of the number (to the right of the decimal point) is set by means of the vernier scale. For example, at a frequency of 3,410 kc, control A is set at 3 and control B is set at 1,114.1 as follows. Set the first two digits (11) by rotating control B until the revolution counter indicates the number of full revolutions, which is *eleven* in this example. Then continue to rotate the dial until 14 on the dial appears opposite the zero indicating mark. To set the decimal (0.1) note line 1 on the vernier, and then further rotate the dial until the first mark (in this case, 15) on the dial, lines up with line 1 on the vernier.

Interpolation. The transmitter can be set between the frequencies given in the table, by the process of *interpolation,* which amounts to multiplying the difference in two successive settings, as given in the table, by the fractional difference represented by the desired frequency. An example will make this clear. Suppose we desire to transmit on 3,411.5 kc. This setting for control B must be between 1,116.6 and 1,119.0, which are the settings for 3,411.0 kc and 3,412.0, respectively. The difference between the two given dial settings is 2.4, and 3,411.5 is half-way (0.5) between the two given frequencies. Thus, 0.5 times 2.4 equals 1.2, which is added to the setting for the lower frequency to give the setting for 3,411.5—in this case, 1,117.8. As a proportion in mathematics, it would be

$$\frac{x}{2.4} = \frac{0.5}{1}$$

$$x = 0.5(2.4) = 1.2$$

24. Tuning Procedure

Tuning of the transmitter consists of calibrating the hfo by means of the cfi unit, which gives the accurate settings of controls A and B for the

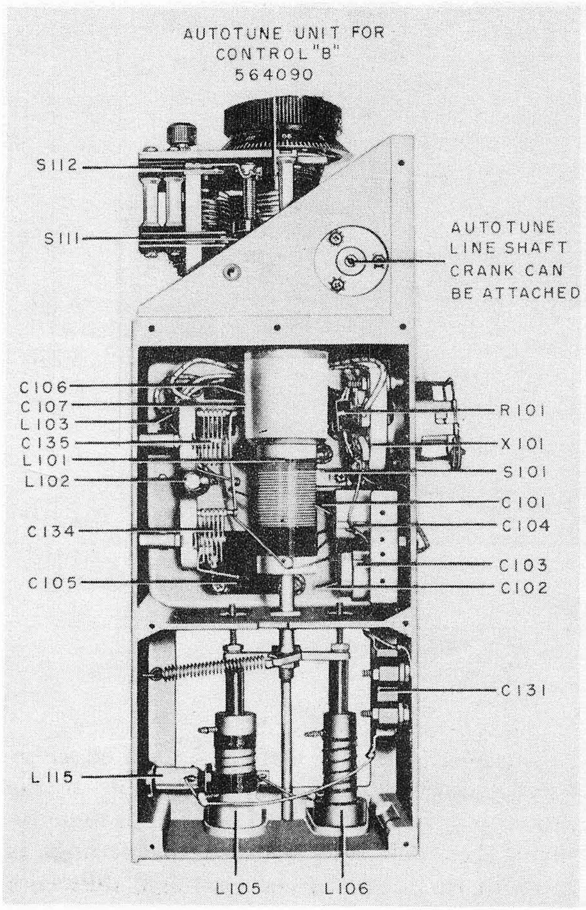


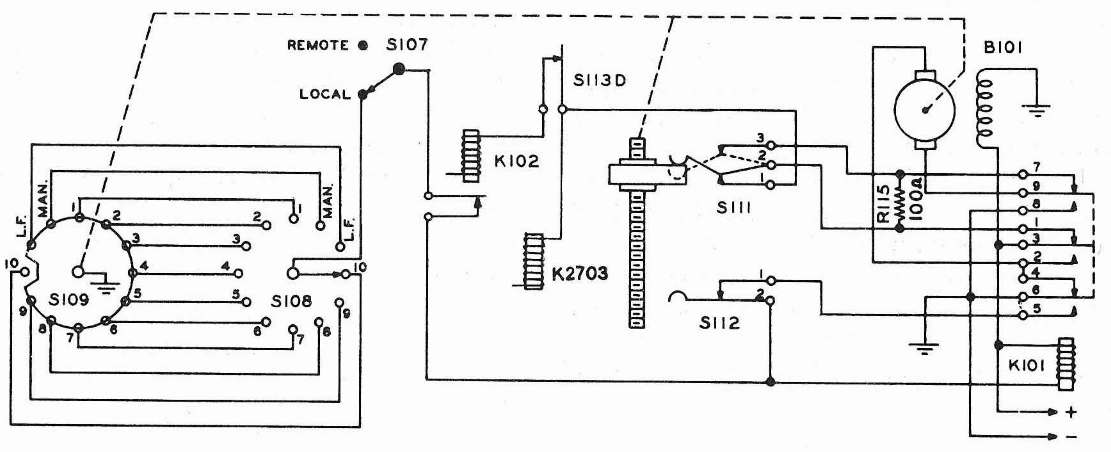
FIGURE 32. High-frequency Oscillator—Side View, Open.

rf circuits and tuning the output circuit to resonance by setting controls C, D, and E. Resonance is indicated by a maximum dip in PA plate current, which also means that the rf voltage across the plate tank will be maximum and that the antenna rf current will be maximum for the particular setting of the coupling and loading control.

The following procedures are for setting up the transmitter for manual or autotune operation. If manual operation is desired, it is necessary only to set the channel switch on MANUAL position and follow these instructions, except that the locking bars should not be moved. Manual operation will not interfere with any of the channels set up for autotune operation if the locking bars are not loosened, nor will setting up any channel in accordance with the following procedure interfere with any other channel previously set up. Channeling the autotune with the locking bars loose will completely eliminate the settings previously set up for the channel that was cycled and may cause settings for some or all of the other channels to shift.

The steps in tuning the transmitter to a desired frequency on any one of 10 high-frequency channels for operation into a fixed antenna are as follows:

(1) Plug the headsets into the side-tone jack and make certain that all keying circuits are open.



B101 – AUTOTUNE MOTOR
K101 – MOTOR CONTROL RELAY
K102 – KEYING RELAY
K2703 – DYNAMOTOR INPUT RELAY
R115 – MOTOR TORQUE RETAINER RESISTOR
S107 – LOCAL-REMOTE SWITCH
S108 – CHANNEL SELECTOR SWITCH
S109 – CIRCUIT SEEKING TAP SWITCH
S111 – REAR LIMIT SWITCH SECTION
S112 – FORWARD LIMIT SWITCH SECTION
S113D – KEYING INTERLOCK SWITCH

FIGURE 33. Electrical Portion of Autotune System.

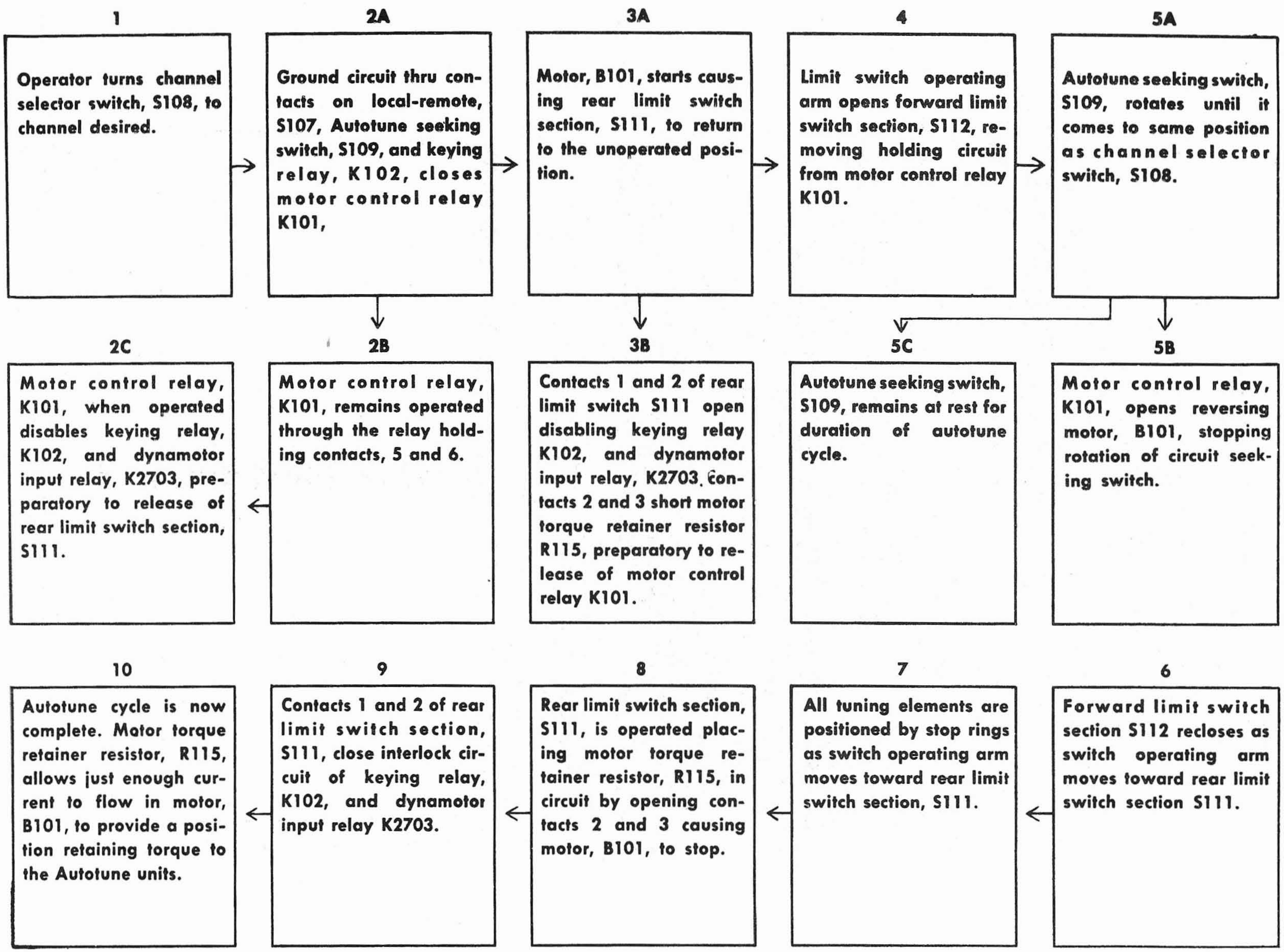


FIGURE 34. Sequence of Autotune Operation.

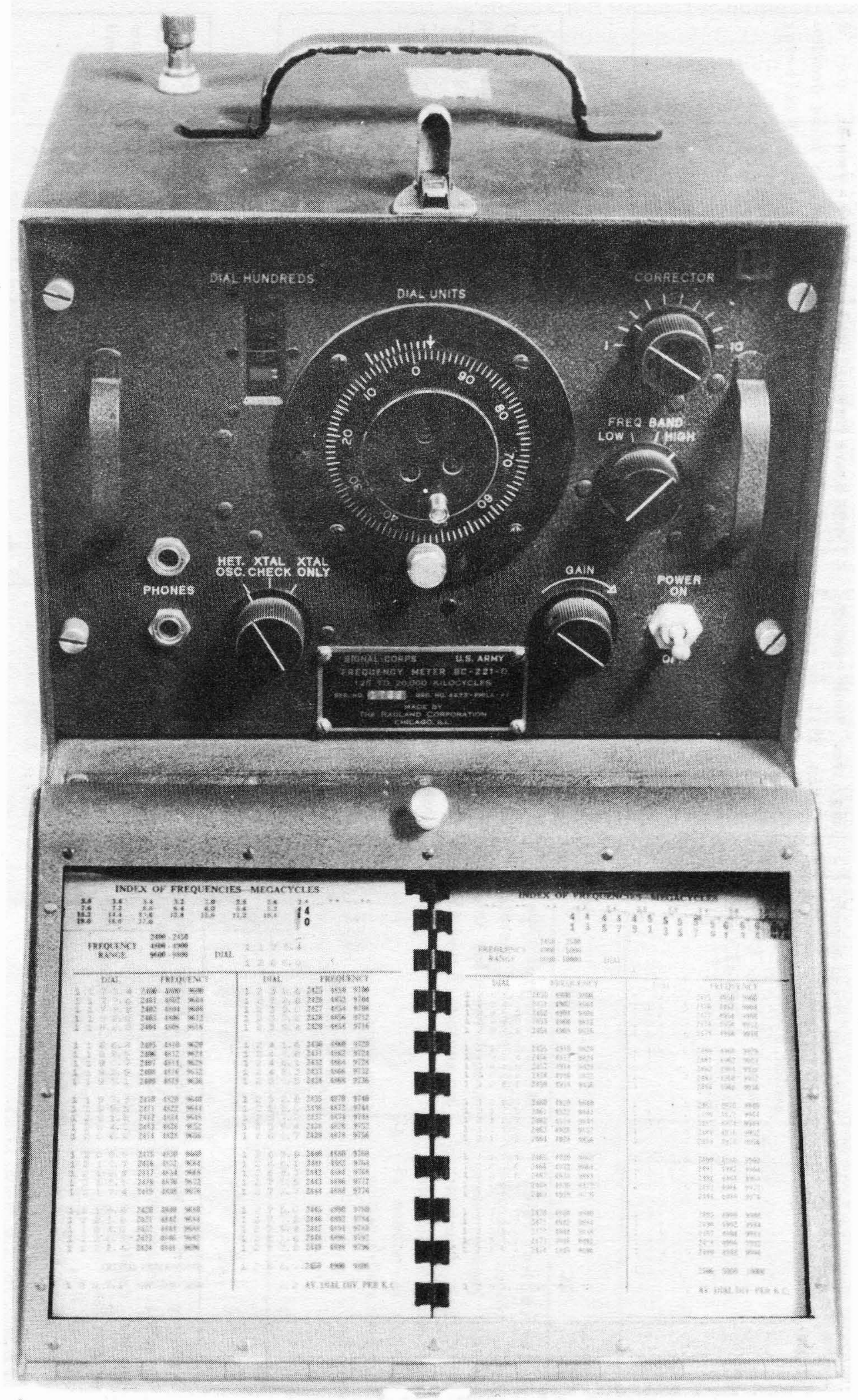


FIGURE 35. Frequency Meter SCR-211 (BC-221).

Table 9

Calibration of hfo, 9,000 kc to 18,100 kc

Frequency: 3200—3300 Kc

Freq.	A	B	Freq.	A	B	Freq.	A	B
3200	3	593.9	3234	3	678.6	3268	3	763.5
3201	3	596.4	3235	3	681.1	3269	3	766.0
3202	3	598.9	3236	3	683.6	3270	3	768.5
3203	3	601.4	3237	3	686.1	3271	3	770.9
3204	3	603.9	3238	3	688.6	3272	3	773.4
3205	3	606.4	3239	3	691.1	3273	3	775.9
3206	3	608.9	3240	3	693.6	3274	3	778.4
3207	3	611.4	3241	3	696.1	3275	3	780.9
3208	3	613.9	3242	3	698.6	3276	3	783.3
3209	3	616.4	3243	3	701.1	3277	3	785.8
3210	3	618.8	3244	3	703.5	3278	3	788.3
3211	3	621.3	3245	3	706.0	3279	3	790.8
3212	3	623.8	3246	3	708.5	3280	3	793.3
3213	3	626.3	3247	3	711.0	3281	3	795.7
3214	3	628.8	3248	3	713.5	3282	3	798.2
3215	3	631.3	3249	3	716.0	3283	3	800.7
3216	3	633.8	3250	3	718.5	3284	3	803.2
3217	3	636.3	3251	3	721.0	3285	3	805.7
3218	3	638.8	3252	3	723.5	3286	3	808.2
3219	3	641.3	3253	3	726.0	3287	3	810.7
3220	3	643.8	3254	3	728.5	3288	3	813.1
3221	3	646.3	3255	3	731.0	3289	3	815.6
3222	3	648.8	3256	3	733.5	3290	3	818.1
3223	3	651.3	3257	3	736.0	3291	3	820.6
3224	3	653.7	3258	3	738.5	3292	3	823.1
3225	3	656.2	3259	3	741.0	3293	3	825.6
3226	3	658.7	3260	3	743.5	3294	3	828.1
3227	3	661.2	3261	3	746.0	3295	3	830.6
3228	3	663.7	3262	3	748.5	3296	3	833.0
3229	3	666.2	3263	3	751.0	3297	3	835.5
3230	3	668.7	3264	3	753.5	3298	3	838.0
3231	3	671.2	3265	3	756.0	3299	3	840.5
3232	3	673.7	3266	3	758.5			
3233	3	676.2	3267	3	761.0	**3300**	**3**	**843.0**

Use check point at 3150 or 3300 Kc, whichever is nearer

Frequency: 3400—3500 Kc

Freq.	A	B	Freq.	A	B	Freq.	A	B
3400	3	1089.7	3434	3	1172.8	3468	3	1255.6
3401	3	1092.1	3435	3	1175.2	3469	3	1258.0
3402	3	1094.6	3436	3	1177.7	3470	3	1260.5
3403	3	1097.0	3437	3	1180.1	3471	3	1262.9
3404	3	1099.5	3438	3	1182.5	3472	3	1265.4
3405	3	1101.9	3439	3	1185.0	3473	3	1267.8
3406	3	1104.4	3440	3	1187.4	3474	3	1270.2
3407	3	1106.8	3441	3	1189.8	3475	3	1272.7
3408	3	1109.2	3442	3	1192.3	3476	3	1275.1
3409	3	1111.7	3443	3	1194.7	3477	3	1277.5
3410	3	1114.1	3444	3	1197.2	3478	3	1280.0
3411	3	1116.6	3445	3	1199.6	3479	3	1282.4
3412	3	1119.0	3446	3	1202.0	3480	3	1284.8
3413	3	1121.5	3447	3	1204.5	3481	3	1287.3
3414	3	1123.9	3448	3	1206.9	3482	3	1289.7
3415	3	1126.4	3449	3	1209.3	3483	3	1292.2
3416	3	1128.8	**3450**	**3**	**1211.8**	3484	3	1294.6
3417	3	1131.3	3451	3	1214.2	3485	3	1297.1
3418	3	1133.7	3452	3	1216.7	3486	3	1299.5
3419	3	1136.1	3453	3	1219.1	3487	3	1302.0
3420	3	1138.6	3454	3	1221.5	3488	3	1304.4
3421	3	1141.1	3455	3	1224.0	3489	3	1306.8
3422	3	1143.5	3456	3	1226.4	3490	3	1309.3
3423	3	1145.9	3457	3	1228.8	3491	3	1311.7
3424	3	1148.4	3458	3	1231.3	3492	3	1314.2
3425	3	1150.8	3459	3	1233.7	3493	3	1316.6
3426	3	1153.3	3460	3	1236.1	3494	3	1319.1
3427	3	1155.7	3461	3	1238.6	3495	3	1321.5
3428	3	1158.1	3462	3	1241.0	3496	3	1324.0
3429	3	1160.6	3463	3	1243.4	3497	3	1326.4
3430	3	1163.0	3464	3	1245.9	3498	3	1328.8
3431	3	1165.5	3465	3	1248.3	3499	3	1331.3
3432	3	1167.9	3466	3	1250.7			
3433	3	1170.3	3467	3	1253.2	3500	3	1333.7

Use check point at 3450 Kc

Frequency: 3300—3400 Kc

Freq.	A	B	Freq.	A	B	Freq.	A	B
3300	**3**	**843.0**	3334	3	927.1	3368	3	1011.0
3301	3	845.5	3335	3	929.6	3369	3	1013.5
3302	3	848.0	3336	3	932.1	3370	3	1015.9
3303	3	850.4	3337	3	934.6	3371	3	1018.4
3304	3	852.9	3338	3	937.0	3372	3	1020.9
3305	3	855.4	3339	3	939.5	3373	3	1023.3
3306	3	857.9	3340	3	942.0	3374	3	1025.8
3307	3	860.3	3341	3	944.4	3375	3	1028.3
3308	3	862.8	3342	3	946.9	3376	3	1030.7
3309	3	865.3	3343	3	949.4	3377	3	1033.2
3310	3	867.8	3344	3	951.9	3378	3	1035.7
3311	3	870.2	3345	3	954.3	3379	3	1038.1
3312	3	872.7	3346	3	956.8	3380	3	1040.6
3313	3	875.2	3347	3	959.3	3381	3	1043.1
3314	3	877.7	3348	3	961.7	3382	3	1045.5
3315	3	880.1	3349	3	964.2	3383	3	1048.0
3316	3	882.6	3350	3	966.6	3384	3	1050.5
3317	3	885.1	3351	3	969.1	3385	3	1052.9
3318	3	887.6	3352	3	971.6	3386	3	1055.4
3319	3	890.0	3353	3	974.0	3387	3	1057.9
3320	3	892.5	3354	3	976.[illegible]	3388	3	1060.3
3321	3	895.0	3355	3	978.9	3389	3	1062.8
3322	3	897.4	3356	3	981.4	3390	3	1065.3
3323	3	899.9	3357	3	983.9	3391	3	1067.7
3324	3	902.4	3358	3	986.3	3392	3	1070.2
3325	3	904.9	3359	3	988.8	3393	3	1072.6
3326	3	907.3	3360	3	991.2	3394	3	1075.0
3327	3	909.8	3361	3	993.7	3395	3	1077.5
3328	3	912.3	3362	3	996.2	3396	3	1079.9
3329	3	914.8	3363	3	998.6	3397	3	1082.4
3330	3	917.2	3364	3	1001.1	3398	3	1084.8
3331	3	919.7	3365	3	1003.6	3399	3	1087.3
3332	3	922.2	3366	3	1006.0			
3333	3	924.7	3367	3	1008.5	3400	3	1089.7

Use check point at 3300 or 3450 Kc, whichever is nearer

Frequency: 3500—3600 Kc

Freq.	A	B	Freq.	A	B	Freq.	A	B
3500	3	1333.7	3534	3	1416.7	3568	3	1499.9
3501	3	1336.2	3535	3	1419.1	3569	3	1502.4
3502	3	1338.6	3536	3	1421.6	3570	3	1504.8
3503	3	1341.0	3537	3	1424.0	3571	3	1507.3
3504	3	1343.5	3538	3	1426.5	3572	3	1509.7
3505	3	1345.9	3539	3	1428.9	3573	3	1512.2
3506	3	1348.4	3540	3	1431.4	3574	3	1514.7
3507	3	1350.8	3541	3	1433.8	3575	3	1517.1
3508	3	1353.2	3542	3	1436.2	3576	3	1519.6
3509	3	1355.7	3543	3	1438.7	3577	3	1522.0
3510	3	1358.1	3544	3	1441.1	3578	3	1524.5
3511	3	1360.6	3545	3	1443.5	3579	3	1527.0
3512	3	1363.0	3546	3	1446.0	3580	3	1529.4
3513	3	1365.4	3547	3	1448.4	3581	3	1531.9
3514	3	1367.9	3548	3	1450.8	3582	3	1534.3
3515	3	1370.3	3549	3	1453.3	3583	3	1536.8
3516	3	1372.7	3550	3	1455.7	3584	3	1539.3
3517	3	1375.2	3551	3	1458.1	3585	3	1541.7
3518	3	1377.6	3552	3	1460.6	3586	3	1544.2
3519	3	1380.0	3553	3	1463.0	3587	3	1546.7
3520	3	1382.5	3554	3	1465.4	3588	3	1549.1
3521	3	1384.9	3555	3	1467.9	3589	3	1551.6
3522	3	1387.3	3556	3	1470.3	3590	3	1554.1
3523	3	1389.8	3557	3	1472.8	3591	3	1556.6
3524	3	1392.2	3558	3	1475.3	3592	3	1559.1
3525	3	1394.6	3559	3	1477.7	3593	3	1561.5
3526	3	1397.1	3560	3	1480.2	3594	3	1564.0
3527	3	1399.5	3561	3	1482.6	3595	3	1566.5
3528	3	1402.0	3562	3	1485.1	3596	3	1569.0
3529	3	1404.4	3563	3	1487.6	3597	3	1571.4
3530	3	1406.9	3564	3	1490.0	3598	3	1573.9
3531	3	1409.3	3565	3	1492.5	3599	3	1576.4
3532	3	1411.8	3566	3	1495.0			
3533	3	1414.2	3567	3	1497.4	**3600**	**3**	**1578.9**

Use check point at 3450 or 3600 Kc, whichever is nearer

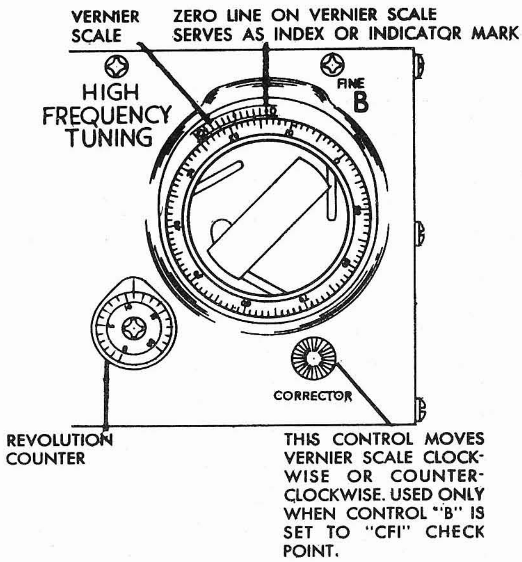


FIGURE 36. Setting Control B to 1,114.1 kc.

(2) Select LOCAL position (*S*107) and turn the set on VOICE position of *S*110 .

(3) Check the primary voltage by moving the meter switch to BATTERY position.

(4) Select the desired channel (*S*108). If autotune operates, let it complete its cycle of operation before proceeding. When the red pilot light comes on, you may continue.

(5) Unlock all five controls by holding the dial and turning the locking bar ¼ turn in a counterclockwise direction. (If manual operation is selected, do not unlock the controls.)

(6) Set control C exactly on 1 (this setting is critical) and D and E on zero.

(7) Aline the indicators on control B.

(8) Set A and B to the nearest crystal check point of the desired frequency (setting of A is critical).

(*Note.* Transmitter will not operate if A and C are not properly set.)

(9) Set CTO switch (*S*106) to CALIBRATE position, and listen to the side-tone circuit for a beat note while rotating control B back and forth about the position given for the crystal check point. Set control B on the position that gives *zero beat* (point where the sound disappears in headphones—rotate the dial in the direction to make the tone of the beat note lower and lower until zero beat is reached), and turn CTO switch to TUNE position.

(10) Set the movable scale (vernier) of B to the crystal check point setting by means of the *corrector* knob.

(11) Set control B to the correct desired operating frequency setting as indicated in the calibration table.

(*Note.* Always approach the setting for control A or B in a clockwise direction, rotating the controls up to, but not past, the correct reading, and then lock *each* control. This is necessary to make the autotune mechanism stop the dial on the correct reading.)

(12) Place the emission switch (*S*110) on CW position.

(13) Check grid drive to the final PA by placing the meter switch on PA GRID position, closing test switch (*S*104) and noting the meter reading. It should read in, or slightly above, the light shaded area marked PA GRID. If it does not, operation is not normal. Control A may be improperly set, or there may be something wrong with the transmitter. In this step, you are actually checking the output of the oscillator.

The above steps complete the calibration, tuning, and checking of the master oscillator. For the balance of the tuning procedure we shall be setting the controls D, C, and E, which consist of inductive and capacitive elements which may be connected as pi or L networks. These networks tune the PA plate and antenna circuits to resonance and provide a controllable degree of coupling between them, in the 2.0-to-18.1-megacycle frequency range.

(14) Place meter switch on PA PLATE position.

(15) Close test switch and rotate control E, seeking a plate-current dip to indicate resonance of the output circuit. (*Caution.* Do not move control E across the space between 100 and 200 or between 0 and 100 while test switch or keying device is closed. The high voltage will damage an internal switch by causing arcing at the contacts.)

(16) If no resonance dip is found, set control C on the next higher position and rotate control E for a dip in plate current. Repeat this step until a dip is found or until control C is set on position 8 and resonance has not been found.

(17) If resonance was found at positions 1 to 7 inclusive on control C, place the CTO switch in OPERATE position.

(18) Load the PA by increasing the reading on control D in steps, re-resonating each time with control E. Continue this process until the dip

falls in the light shaded area marked cw on the plate meter. (*Note.* If it is not possible to load the PA before control E reaches zero under the above conditions, set control E on zero and resonate with control D. This will give the best operation under these conditions.)

(19) Lock controls C, D, and E.

(20) Check tuning and locking by cycling the autotune system and retuning to the same channel.

(21) If no resonance was found before control C was set on position 8, set control E on zero and seek a resonance dip by rotating control D from zero to 100.

(22) If no dip is found, set C to the next higher position and repeat the procedure of rotating D for the dip.

(23) When resonance is found, set CTO switch on OPERATE.

(24) Load the PA by increasing the reading of control E in steps and re-resonating with control D each time until the dip falls in the cw area on the meter.

(25) Lock the controls C, D,and E, and check the cycling.

(26) Repeat the above procedure for each channel that you desire to set up on the transmitter.

(27) No further adjustments are necessary for voice or mcw operation.

25. Preflight Check

Before you can determine if something is wrong with the transmitter, you must know how it operates normally, that is, when its operation is OK. Since you have studied the circuits and tuning procedure, and know how the set should operate, let us assume you are to check the operation of the liaison transmitter by making a preflight check, which means that the equipment is to be given a rapid visual and operating inspection in accordance with the following:

(1) Inspect the antenna wire, connections, and insulators; clean if dirty and replace if defective.

(2) Turn on the set by placing emission switch on VOICE, and select LOCAL operation.

(3) Cycle the autotune by selecting a frequency with the channel switch.

(4) When the cycle is completed, check the settings of controls A, B, C, D, and E against the reading on the transmitter chart with the indicating mark on B previously set so that the zero line is directly above the dial.

(5) Make sure the MIKE switch (*S*201) is in proper position for the microphone being used.

(6) See that the meter switch is on PA PLATE and the CTO switch on OPERATE.

(7) Place the emission switch on cw and close the test switch. The plate current should read in the area marked PA PLATE.

(8) Place the meter switch on PA GRID. The meter should read in the area marked PA GRID. Release the test switch, and place the meter switch on PA PLATE and the emission switch on MCW.

(9) Listen in the side-tone circuit and close the test switch—the side-tone signal should be heard. The plate current should be in or near the area marked MCW. Release test switch.

(10) Place emission switch on VOICE and press the MIKE button. The plate current should read 20 or 30 higher than on cw. Speak or whistle into the microphone. The plate current should read near the area marked MCW and may read full scale on loud signals.

(11) Check the control settings and grid and plate current readings on cw for each of the other channels in use.

26. Trouble-shooting Procedure

Let us assume that a symptom, for example, weak grid drive, shows up during the above inspection and makes the trouble shooting of the equipment necessary. Trouble shooting may be defined as the procedure of testing radio equipment to determine the location and cause of circuit faults. Generally speaking, there is a definite procedure that may be used to find the defect and correct it in any piece of radio equipment. Briefly, the procedure may be outlined as follows:

Visual inspection to find defects that can be seen or observed directly.

Operational check (preflight) to determine the quality of performance.

Electrical check to locate the defective circuit by testing tubes, circuits, voltages, and resistances and by circuit tracing (requires a thorough knowledge of the schematic).

Correction of trouble.

Final performance test. In trouble shooting the transmitter, the meter indications are most important for revealing probable causes for trouble. For example, if the meter indicated no grid current, the most probable cause would be a bad master oscillator tube. Of course, there are other defects that would give the same symptom, but, by proper interpretation of the grid-current meter, you immediately localize the defect to a particular section, stage, or circuit of the transmitter.

Common Troubles. Some common causes of transmitter failure that are easily corrected are as follows:

Loose connection at a plug on one or more of the interconnecting cables or antenna leads.

No power available at the 28-v dc source, caused by loose connections or open circuit breakers.

Blown fuses in the equipment.

Faulty tubes. This is one of the defects that occurs most often and should be corrected first before you proceed to meter checks of the circuits. All the tubes in this transmitter are easily accessible from the top. Before removing the top cover, be sure that the transmitter power is *off* and the keying switches are *open*. Whenever tube failure is suspected, the most dependable method of checking the tube suspected of being bad is to replace it with a tube known to be in good condition. If more than one tube is causing trouble, replace all tubes with new tubes, at least until the bad tubes have been located.

Worn brushes in the dynamotor.

Protective overload relays open because of an overload in the equipment.

Whenever any of the above faults occur, certain unusual features (symptoms) in the performance of the equipment will be noted. If these symptoms are recognized as being caused by a particular fault, the problem of locating the fault is immediately solved.

After eliminating the simple causes of failure, the next step is to determine which portion or circuit of the equipment is affected. The failure of an electrical circuit in most cases will be caused by one or more defective components (resistors, capacitors, inductances, vacuum tubes, relays, switches, and mechanical parts). Resistors generally *open*, capacitors *open* or *short*, and both may change in value. It must be evident that the better you understand what each component does in a circuit, the easier it should be to analyze and find the trouble caused by a faulty component. Where the fault is more difficult to find, you may need to make voltage tests or a signal trace. Since high voltages are present in a transmitter, it is preferable to locate the defective component by making resistance or continuity checks with an ohmmeter.

Table 10 is given to help you analyze defects that would cause faulty operation of the transmitter unit. Your trouble shooting will be done by locating the defective component in the complete schematic and tracing the associated circuit. You will find this excellent practice as a substitute for working on the actual equipment.

27. Supplementary Data

In addition to the tables given in the test material, the following comments and tables are included because they will help you obtain the pertinent facts on the operating characteristics of this particular transmitter.

Table 11 shows approximate values of radio-frequency power output when the equipment is used with fixed aircraft antennas between 17 and 65 feet in length, over the frequency range 3,000 kc to 18,100 kc.

The dynamotor used with Radio Transmitting Set AN/ART–13A is manufactured either by Russell Electric Company or by the General Electric Company. Either machine may be used with dynamotor unit DY–17/ART–13A. The rating and resistance measurements on the windings of each machine are shown in table 12.

The audio input required for 90 percent modulation at 1,000 cps and full power is 1.52 volts for the carbon mike and 0.016 volt for the dynamic mike. The noise level for both microphone inputs is about the same (44 decibels). The distortion is also about the same for both microphones (7 percent). The af frequency response curve is fairly flat (same output for given input) for frequencies from about 500 cycles to 3,000 cycles.

Table 13 shows the voltage values you would read with a 20,000-ohm-per-volt meter. The voltages are taken from the tube terminals to ground.

Table 14 shows the resistance values from the tube terminals to ground. By tracing the same circuit in the complete schematic that the ohmmeter current does when the meter is placed in a circuit, you can check the given resistance reading. This is excellent exercise in circuit tracing, which is most important for effective trouble shooting.

SUMMARY

In this chapter you were first given a general description of the various units that make up the transmitting set AN/ART–13A, with emphasis on the transmitting unit, T–47A/ART–13. You were then given a description of the transmitter block diagram, which showed all the stages in their proper sequence. This was followed by a more detailed analysis of the major circuits with the aid of simplified diagrams. You were also shown how to trace the same circuits in the complete schematic. The purpose of the various controls, switches, and indicators was then presented, followed by a description of the autotune unit. You were given the sequence of the autotune operation and the associated electrical circuit of the system, and next, the calibration and tuning procedure. A discussion on inspecting and trouble shooting the transmitter included a table prepared to show the symptoms produced by the more common causes of transmitter failure.

You should now be able to determine from the schematic diagram what stages and relays are placed in operation and how this is done for each position of the selector (CTO) switch, as well as to trace the circuits of the individual tubes.

With chapter 2 you have completed the study of the complete liaison radio set AN/ARC–8, which includes the necessary equipment for two-way communications, principally the BC–348 receiver and the AN/ART–13A transmitter. You may recall that the equipment employs the same antenna for both the receiver and the transmitter. The antenna is normally connected to the receiver through the vacuum contact (*S*116) located in the transmitter and controlled by the transmitter keying relay *K*102. When the transmitter is keyed, the antenna is switched from the transmitter by the energized keying relay *K*102, and at the same time the receiver screen-grid supply line is opened by the same relay. Thus, the receiver and transmitter cannot be operated at the same time; that is, you cannot receive and transmit at the same time.

REVIEW QUESTIONS

The following questions are study aids. Your answers are not to be submitted to the USAF Extension Course Institute for grading. Correct answers will be found at the end of this text.

1. In what three ways may intelligence be sent with the ART–13 transmitter?
2. What components are contained in the dynamotor unit?
3. Why does the generator section of the dynamotor contain two windings?
4. What two important purposes does the pilot light serve?
5. Enumerate the steps for normal operation of the transmitter (local control).
6. When is the first multiplier coupled directly to the PA? The second multiplier? Explain.
7. What stages are included in the modulation section of the transmitter?
8. On cw both the MO and tone oscillator are keyed. Why doesn't the tone oscillator modulate the carrier?
9. What is the purpose of the side-tone amplifier?
10. What is the cfi unit? How is it used? What is the calibration frequency? How is it obtained?
11. Give the proper name and purpose of (*a*) *K*2705 and *K*2706, (*b*) *K*2704.
12. Using the complete schematic diagram, trace the circuits showing what happens when the emission switch is placed on VOICE position and the local-remote switch at LOCAL position. (*Note:* This is only one problem in circuit tracing. You should be able to do the same thing for any position of the emission switch.)
13. Assuming the operations in question 12 have been completed and the mike has been plugged into jack *J*102 in preparation for transmission, trace the circuits showing what happens when the mike switch (button) is closed. (*Note:* The contact marked *T* in *J*102 is grounded through the sleeve when the button is closed; it serves the same purpose as the test key and throttle switch. Contact *R*

connects directly to the mike transmitter, completing the audio line through the carbon mike button and the grounded sleeve.)

14. How is the dynamotor input relay *K*2703 energized when the power level switch *S*106 is set to CALIBRATE position? Trace the circuit. (Set is on.)

15. What components are included in the high-voltage circuits?

16. Explain how the +1,150-v dc voltage is obtained for the PA and modulator tubes. At which terminal of *J*108 is this voltage obtained?

17. What happens when the pressure-operated relay (*K*2704) closes?

18. Why is it necessary to have spark suppressors in the output circuits of the dynamotor?

19. What purposes does the keying relay *K*102 serve in its de-energized position (as shown in schematic) and energized position?

20. How is the power amplifier disabled when *S*106 is set to CALIBRATE position?

21. Why is the keying relay (*K*102) always de-energized when the autotune motor operates? How is this done?

22. Describe how the carbon microphone is connected to the 28-v source and to the input transformer *T*201. Which resistor essentially determines the signal voltage for the input transformer *T*201?

23. What tubes are required to produce the 50-kc calibration frequency?

24. What is the frequency range of the high-frequency oscillator, *V*101?

25. Give the name and purpose of each switch operated by control A.

26. By tracing the output network circuits operated by control C, determine whether the circuit is an L- or a pi-type network.

27. What is the purpose of the following components: *K*105 (normal position), *C*116, *R*110 and *R*111, *C*119, *R*112, and *L*110?

28. When *M*102 is placed in PA PLATE position, what does it actually measure? How does this indicate the plate current?

29. List the transmitter tuning controls. Which control employs the multiturn unit? What does it do?

30. How is the motor control relay *K*101 energized?

31. When *K*101 operates, how does it de-energize *K*102 and *K*2703? How does *K*101 remain energized after *K*102 de-energizes?

32. Describe the purpose and operation of rear limit switch section *S*111.

33. What is the purpose of keying interlock switch *S*113D?

34. When *S*112 opens, is *K*101 de-energized immediately?

35. How does *R*115 stop the autotune motor?

36. What is the purpose of the vacuum contacts of the keying relay?

37. Why is the mcw oscillator keyed when the set is being operated on cw position?

38. What rf circuits are affected when transmitting on cw?

39. Using the schematic drawing of the AN/ART-13A (Chart C-256-A), show what happens to the set when the emission switch is placed on cw position and the test key is closed.

40. With the power-level switch in CALIBRATED position, is the frequency multiplier operative?

41. In the high-frequency output circuits, inductor *L*110 functions as a static-drain choke for the output-circuit shunt capacitors and the antenna. The parallel combination of inductor *L*116 and capacitor *C*137 forms a high-frequency noise filter for the antenna circuit. Suggest a reason that a static drain choke should be incorporated in an airborne transmitter.

42. When operating on cw position, how is the modulator stage disabled?

43. What protective devices protect the dynamotor unit from damage?

TABLE 10

TROUBLE SHOOTING AT REPAIR STATION

Symptoms	Probable cause of trouble
Red indicator lamp is off, dynamotor will not operate when emission switch is in CW or MCW position, and autotune mechanism does not operate when channel switch is operated.	(*a*) Lamp may be burned out. (*b*) Poor contacts on *S*110 or *S*107. (*c*) Poor connections at power cable (U–7/U) or *J*108.
Dynamotor does not operate when voice emission is used.	(*a*) Dynamotor operates only when "mike" switch is closed—switch may be defective. (*b*) Contacts 1 and 2 of *K*104 are not closed. (*c*) Rear limit switch *S*111 is open, or contacts 1 and 3 of *K*101 are not closed.
Dynamotor does not operate on CW.	(*a*) Contacts 4 and 5 of *K*103 may not be closing. (*b*) Contacts 1 and 2 of *K*104 are not closed.
Autotune mechanism will not operate. Dynamotor operates, and rest of equipment OK.	(*a*) *S*107 set to REMOTE position must be set to LOCAL position when using channel switch on transmitter. (*b*) One of the keying controls is closed. (*c*) CTO switch in CALIBRATE position. (*d*) Poor contact at *S*108 or *S*109. (*e*) Poor contacts on *K*101 or *S*111. (*f*) Contacts 2 and 12 of *K*102 open. (*g*) Defective autotune motor *B*101.
Tube filaments do not light. Dynamotor operates. Red light is on. Autotune operates.	(*a*) Poor contact or broken wire at U–7/U or *J*108. (*b*) Loose connection at tube socket or a defective tube.
Dynamotor overload relay opens. Relay will not stay closed after dynamotor RESET button is pushed, or fuse blows.	(*a*) Short in high-voltage circuits of transmitter. Look for burnt, overheated, or smoking part. (*b*) Short from pin 1 of *J*108 to ground (400 v) causes fuse dynamotor to blow. May be caused by short at following points in transmitter units: (1) PA; (2) hfo, lfo; (3) multiplier; (4) af; (5) mcw-cfi. (*c*) Short from pins 2 or 9 of *J*108 to ground. This is circuit to meter-read PA plate current. Possible short in wiring to meter or at meter switch *S*105. (*d*) Short from pin 10 of *J*108 to ground. May be due to shorts in wiring and components in the PA plate circuit or modulator plate circuits.
Transmitter overload relay (on dynamotor unit) opens. It will not stay closed after RESET button is pushed.	(*a*) Short circuits in a relay armature winding, autotune electrical circuits, or connecting wiring. If short occurs only when emission switch is in one of its positions, check associated relay (cw—*K*103, voice—*K*104) or, in keying, check *K*102. (*b*) Short circuit in tube filament wiring. Look for burnt or smoking part. (*c*) Short circuit in autotune motor or associated switches and wiring.
No rf output on any frequency. Dynamotor operates, there is no overload, and autotune mechanism operates OK. CTO switch is in OPERATE position. (*Important.* Be sure control C is set so that	(*a*) Note whether keying relay (*K*102) operates when TEST key is closed. If it does not, fault is in 28-v supply circuits to this relay. Note whether vacuum contact (*S*116) has a broken or cracked bulb. If continuous arcing occurs,

TABLE 10 *(Continued)*

Symptoms	Probable cause of trouble
numbered position lines up exactly with index line; rf will not be obtained if this control is set between numbered positions.)	glass bulb or seal of vacuum contact has been destroyed. (*b*) If PA grid meter reading is normal and PA plate reading is much higher than normal, fault is in output network. (Check first *S*116, then *K*105.) (*c*) If PA grid meter reading is normal but PA plate reading is zero or very low, the fault is in the screen or plate supply circuits of PA tube (*V*104) or is caused by having control C set between numbered positions. (*d*) If PA grid meter reading is very low or zero, fault is in multiplier stages or oscillator.
Low rf output. PA grid or PA plate meter readings are abnormal. (*Note:* Antenna current reading on rf meter is *not* an accurate indicator of rf output, since the readings will vary with impedance of antenna and frequency.)	(*a*) Be sure CTO switch is in OPERATE position. (*b*) Antenna tuning and loading controls may not be properly set. (*c*) If following conditions cannot be obtained, the fault is in the PA or exciter circuits (oscillator or multiplier stages): PA plate meter reading should rise to at least 50 divisions when control D is detuned from its correct (resonant) setting, provided that PA grid reading is between 40 and 140. (*Note:* If PA plate reading is above 200 and PA grid is not less than 40, then PA tube, *V*104, is causing trouble—it is "soft" or "gassy." Replace it.)
Output is not voice modulated.	(*a*) If voice is heard through side-tone output jack, fault is in audio driver or modulator stages. (*b*) If voice is not heard through side-tone output jack, fault is in speech amplifier circuits of the af unit. Be sure MIKE switch is in correct position for microphone being used.
Autotune operates but does not return controls to the correct positions to which it was originally set.	(*a*) Improper setup of autotune controls. When autotune is set up, be sure that control knobs are rotated clockwise as final setting is approached. If you accidentally rotate knob past the setting, turn it back and again approach final setting by turning clockwise. (*b*) Autotune runs briefly but does not set controls correctly, caused by poor contact at forward limit switch *S*112 or failure of contacts 5 and 6 to close on motor control relay (*K*101). (*c*) Autotune does not return *all* controls to correct settings. Look for mechanical defects in autotune heads or improper synchronization of autotune units and/or circuit switch, *S*109.
Motor can be heard running continuously after control knobs have stopped turning.	(*a*) Forward limit switch (*S*112) fails to open when switch operating arm reaches maximum forward position. (*b*) Rear limit switch (*S*111) fails to open when switch operating arm reaches home stop position. (*c*) Contacts 5 and 6 of motor control relay (*K*101) fail to open after forward limit switch opens.
Dynamotor does not operate when equipment is turned on. (*Note.* When emission switch is in VOICE	(*a*) Transmitter overload relay (*K*2705) or primary power contactor relay *K*2702 is open.

TABLE 10 *(Continued)*

Symptoms	Probable cause of trouble
position, dynamotor operates only when MIKE switch, TEST switch, or THROTTLE switch is closed.)	(*b*) Dynamotor overload relay *K*2706 is open. If after it is re-closed, it opens again, there is a shorted part in the dynamotor chassis or machine. Check for shorts in both the 28-v input and the 400-v and 1,150-v output circuits. Check resistance of dynamotor windings. (*c*) Faulty contacts or defective solenoid of relay *K*2703. (*d*) Worn brushes or defective dynamotors.
Equipment will not operate at all.	(*a*) Overload relay *K*2705 is open (no overload in transmitter). If after it is re-closed, it opens again, check for shorts in wiring from this relay to receptacle *J*2701. (*b*) Primary power relay *K*2702 fails to close when equipment is turned on. Check contacts and for voltage (28 v) at relay solenoid (or armature). If voltage is present, the solenoid is defective.
Radiofrequency interference causing noise in transmitter and associated equipment. (May also disturb other equipment.)	Caused by improper installation of dynamotor brushes. (*Note:* Each brush is numbered, and that corresponding number is stamped on dynamotor frame. If a brush is removed for inspection, always replace it in the same position.)

TABLE 11

RADIOFREQUENCY POWER OUTPUT

Frequency (megacycles)	Power output (watts)	Frequency (megacycles)	Power output (watts)
3.0	60	11.5	90
4.0	80	13.5	90
5.5	90	15.5	75
7.0	90	18.1	65
9.0	90		

TABLE 12

DYNAMOTOR CHARACTERISTICS AND RESISTANCE MEASUREMENTS

Manufacturer and type	Rated input	Rated output	Shunt field resistance (ohms)	Series field resistance (ohms)	Resistance of armature winding between brushes		
					27-volt winding (ohms)	400-volt winding (ohms)	750-volt winding (ohms)
Russell dynamotor (Type 500D35WA)	27 volts, 32 amp	400 volts, 0.75 amp 750 volts, 03.5 amp	28.5	0.003	0.09	25	74
G. E. dynamotor (Model 5DY81AC1)	27 volts	400 volts, 0.75 amp 750 volts, 0.35 amp	40	0.033	0.07	20	100

Table 13

Voltage to Ground From Vacuum-tube Terminals

WARNING: In measuring voltages, extreme care should be exercised to prevent personal injury. Operating voltages in parts of this equipment are dangerous to human life. Be sure that insulation of leads and test prods on voltmeter are rated high enough to protect personnel when used to measure voltages up to 1,200 volts. Avoid high-voltage measurements when other methods of circuit checking can be used.

1. Use 20,000 ohm/volt meter to measure all voltages.
2. Set power-level switch on OPERATE position to measure voltages on all tubes except *V*2201, *V*2202, and *V*2203. When measuring voltages on these three tubes, set switch on CALIBRATE position.
3. Set emission selector switch on MCW position.
4. Tune and fully load transmitter for operation on any frequency in 6,000 to 7,200 kc, frequency range for measurements on all tubes except *V*2601. When measuring voltages on tube *V*2601, transmitter should be tuned and loaded for operation at 400 kc.
5. Hold telegraph key (or "test switch") closed when making all measurements.

Tube base terminal number	*V*101 JAN–837	*V*102 JAN–1625	*V*103 JAN–1625	*V*104 JAN–813	*V*105 JAN–811	*V*106 JAN–811	*V*201 JAN–12SJ7	*V*202 JAN–6V6GT	*V*203 JAN–6V6GT	*V*2201[b] JAN–12SL7GT	*V*2202[b] JAN–12SA7	*V*2203[b] JAN–12SL7GT	*V*2601[c] JAN–1625
1	Heater 11	Heater 13.5	Heater 0	Filament 10	Filament 10	Filament 23	Shield 0	N.C.[a] 0	N.C.[a] 0	Grid No. 1 –5.6	Suppressor 4.0	Grid No. 1 –2.6	Heater 0
2	Shield 0	Shield 0	Shield 0	N.C.[a] 420	N.C.[a] 0	N.C.[a] 0	Heater 0	Heater 18	Heater 23	Plate No. 1 85	Heater 10.6	Plate No. 1 75	Shield 0
3	Screen 200	Screen 300	Screen 350	Screen 420	Grid 10	Grid 16	Suppressor 0	Plate 190	Plate 190	Cath. No. 1 0	Plate 75	Cath. No. 1 0	Screen 210
4	Grid –4.2	Grid –50	Grid –200	Grid –40	Filament 16	Filament 16	Grid 0	Screen 200	Screen 200	Grid No. 2 –20.4	Screen 124	Grid No. 2 0	Grid –15
5	Suppressor 0	N.C.[a] 50	N.C.[a] –200	Beam form. 0	. . .	. . .	Cathode 1	Grid 0	Grid 0	Plate No. 2 100	Grid No. 1 –21.5	Plate No. 2 120	N.C.[a] 18
6	Cathode 14.5	Cathode 37	Cathode 65	N.C.[a] 0	. . .	. . .	Screen 18	N.C.[a] 0	N.C.[a] 0	Cath. No. 2 0	Cathode 4.0	Cath. No. 2 4.0	Cathode 18
7	Heater 23.5	Heater 23.5	Heater 13.5	Filament 0	. . .	. . .	Heater 12	Heater 12	Heater 17.5	Heater 0	Heater 0	Heater 12.6	Heater 12.5
8	. . .	. . .	. . .	. . .	. . .	. . .	Plate 55	Cathode 8.5	Cathode 8.5	Heater 12.6	Grid No. 3 –2.7	Heater 25.2	. . .
Top cap	Plate 410	Plate 430	Plate 420	Plate 1,150	Plate 1,150	Plate 1,150	. . .	. . .	. . .	. . .	. . .	. . .	Plate 420

[a]N.C. Indicates that this socket terminal does not connect to an element of the tube but serves merely as terminal post.

[b]Set power-level switch on CALIBRATE position when measuring voltages on tubes *V*2201, *V*2202, and *V*2203.

[c]Tune and load transmitter for operation on 400 kc before measuring voltages on tube *V*2601.

TABLE 14

RESISTANCE TO GROUND FROM VACUUM-TUBE TERMINALS (OHMS)

1. Set control A to position 7 (6.0 Mc to 7.2 Mc)
2. Set emission switch to MCW position

Tube base terminal	*V*101 (837)	*V*102 (1625)	*V*103 (1625)	*V*104 (813)	*V*105 (811)	*V*106 (811)	*V*201 (12SJ7)	*V*202 (6V6GT)	*V*203 (6V6GT)	*V*2201[b] (12SL7GT)	*V*2202[b] (12SA7)	*V*2203[b] (12SL7GT)	*V*2601[c] (1625)
1	4.0[a]	4.5[a]	0	0.3	0.2	0.4	0	0	0	33,000	330	470,000	0
2	0	Inf.	Inf.	175	Inf.	Inf.	0	4.0	2.5	Inf.	15	Inf.	Inf.
3	1,250	20,000	20,000	200	90	85	0	1,550	1,530	0	0	28	1,250
4	22,000	100,000	100,000	20,000	0.3	0.3	4,000	1,300	1,280	33,000	0	150,000	15,000
5	0	100,000	100,000	0	...	...	2,200	470,000	100,000	Inf.	47,000	100,000	Inf.
6	Inf.	1,000	1,000	0	...	...	1,000,000	0	Inf.	0	330	330	Inf.
7	3	3	4.5	0	...	...	5	5	4.5	0	0	15	3
8	...	...	...	...	...	...	160,000	250	250	15	47,000	27	...
Top cap	70	110	65	325	330	325	...	...	...	...	...	...	125

[a]When making this measurement, calibrate-tune-operate switch must be in CALIBRATE position.
[b]Set control A to position 13(lf) before making measurements on tube *V*2601.
[c]Remove mcw-cfi unit from transmitter for these readings.

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ANSWERS TO REVIEW QUESTIONS

CHAPTER 1

1. Tubes used in the BC–348 Receiver:

VT–86	6K7	First and second rf and first i-f amplifiers
VT–91	6J7	Converter or mixer
VT–65	6C5	Local oscillator
VT–70	6F7	Second i-f and cw oscillator
VT–93	6B8	Third i-f and second detector, avc
VT–152	6K6	Audio output

2. Antenna and ground binding posts, antenna alinement, dial lights, tuning, band-switch, beat-frequency, crystal filter, volume and cw oscillator controls, dial window housing, two telephone jacks, and AVC-OFF-MVC switch.

3. With the switch at MVC, select the desired band and adjust the tuning control for maximum output at the desired frequency and the antenna-align dial for the loudest signal. If AVC is needed, now turn the switch to it and readjust the volume control.

4. A high degree of selectivity is obtained, which practically eliminates adjacent-channel and image interference.

5. The 6K7 is a triple-grid, remote cutoff, amplifier tube designed for service in the rf and i-f stages of a receiver. (For operating characteristics refer to any standard receiving tube manual.)

6. The components used for tuning the oscillator grid circuit on Band 3 are 113, 43, 6–3, 18, 1–D (refer to Chart C–790).

7. The grid circuit of the first i-f is traced from the grid cap of the 6K7 through coil 118 and *R*65–2 into the AVC line, which you follow to a junction that leads through the avc decoupling and load resistors 68 and 67 to ground. To complete the circuit to the cathode, start at the ground symbol to the right of *R*79–A, trace through the second section (from the right) of *S*129 to the common cathode line, and follow this line to the right through *R*55–3 to cathode pin 8 of the 6K7, completing the circuit (Chart C–790).

8. The cathode bias resistors for the i-f stages are 55–3, first i-f; 55–4, second i-f; 56–2, third i-f (Chart C–790).

CHAPTER 2

1. Intelligence may be sent by voice, continuous wave, and modulated continuous wave.

2. The dynamotor machine, barometric switch, control and overload relays, filters, and 400-volt supply fuse are contained in the dynamotor unit.

3. The generator section of the dynamotor contains two windings to give output voltages of 400 and 750 volts dc.

4. The pilot light indicates that power is being supplied and lets the operator know when the autotune cycle is completed.

5. (*a*) Select LOCAL position of local-remote switch.
   (*b*) Select VOICE position of emission switch.
   (*c*) Select desired frequency channel.
   (*d*) Wait until red pilot light comes on; then select desired emission.
   (*e*) Plug in mike or key as required by emission selected.

6. Up to 6 megacycles, only the first multiplier is required and is therefore coupled directly to the PA. Above 6 megacycles, the output of the first multiplier is fed to the second multiplier, which is now coupled to the PA.

7. The modulation section of the transmitter includes the first af (speech amplifier), the af driver, the push-pull modulator, the tone oscillator, and the side-tone amplifier.

8. On cw, since the modulator is not in operation, the tone signal will not modulate the carrier.

9. The output of the side-tone amplifier is used to operate headphones so that the operator can monitor his code or voice. It is also used for listening to the output of the cfi unit when calibrating the master oscillator.

10. The cfi unit is a frequency meter constructed as a subassembly of the transmitter. It is used

to calibrate the master oscillator. The calibration frequency is 50 kc and is obtained by beating a 200-kc crystal oscillator standard frequency with a 150-kc frequency generated by the cfi unit.

11. (*a*) *K*2705—Transmitter overload relay.
*K*2706—Dynamotor overload relay.
Both relays are thermal-operated overload relays which are normally closed. They protect the equipment by opening the 28-v circuits when an overload occurs.
(*b*) *K*2704—Barometric switch. This relay is actually a pressure-operated switch and requires no voltage for its operation. It is designed to operate at about 25,000 feet. This reduces the modulator or PA plate voltage from 1,150 to 750 volts.

12. The rotating arms RB and RA of emission switch *S*110 are connected to ground through contacts B and A of switch *S*107 when it is on LOCAL position, as shown in the schematic. Arm FB of *S*110 is connected through contact D of *S*107 through voltage-dropping resistor *R*136 to a junction point that connects to the positive 28-volt line. In VOICE position, each rotary arm of *S*110 is at its No. 2 contact.

Starting from the grounded contact RB–2 of *S*110 (ground is the negative side of power source), follow the line that leads to terminal number 7 of *J*108 and *J*2701 through the primary contactor coil (or solenoid) *K*2702, through circuit breaker *K*2705 to terminal 2 of *J*2702. (This is the positive 28-v terminal that is connected to the central power system of the aircraft through a connecting power cable, U–7/U.) The completed 28-v circuit causes *K*2702 to energize, closing its contacts. The closed contacts connect the +28-v side of the primary power source to terminals 4 and 6 of *J*108. (We could trace the circuits from the positive terminals to ground, but, since the switches complete the required circuits, it is simpler, in this case, to trace the circuits from ground.)

For the next circuit, start at the ground contact RA–2 of *S*110 and trace to the right to the first junction point. (You have a choice of tracing in two directions, but there is only one correct path—the wrong path leads to the remote control box, which is an open circuit on local control.) From the junction point, trace through the coil of voice relay *K*104 down to another junction point. (Here again you have a choice of paths, but, since you are trying to complete the 28-v circuit for *K*104, you will take the line that leads to the power unit.) From this second junction point, you will then trace to the right to a third junction, which leads to No. 4 of *J*108, thus completing the 28-v circuit for the voice relay (*K*104), causing it to energize and close contacts 2 and 4.

13. When the mike button (or test key) is closed, the dynamotor runs because its circuit is completed, first, from ground through mike switch or test key (*S*104), up through contacts 2 and 1 of *K*104, and down to No. 8 of *J*108, through *K*2703 solenoid to No. 3 of *J*108. Then follow the line that leads up through contact 1 and 2 of *S*111, through contacts 1 and 3 of *K*101, and back down the schematic to terminal 4 of *J*108, which is connected to +28 v at No. 2 of *J*2702, through the closed contacts of *K*2702. This completes the 28-v circuit for energizing dynamotor input relay *K*2703 and causing the dynamotor to run. The dynamotor circuit is completed from No. 2 of *J*2702, through *K*2706 and *K*2703, the dynamotor field windings, and motor section (*M*) of the dynamotor to ground. The dial indicator light circuit is also completed from ground through the light, through contacts FB–2 of *S*110, through contact D–1 of *S*107, and through voltage-dropping resistor *R*136 to a junction point (same as for *K*2703) that connects to the −28-v line, thus completing the circuit.

Since the voice relay is energized, its contacts (No. 4 and No. 5), ground the output of the tone (mcw) oscillator to make it inoperative. The circuit is from the top (1) of coil *L*2201 (oscillator tank cfi unit), through terminal 7 of *J*111, and through contacts 5 and 4 of *K*104 to ground.

The voice circuit is completed from the microphone through contact R of microphone jack *J*102, *S*201, and *R*216, through the primary of the mike input transformer *T*201 to ground. To modulate the carrier, simply talk into the mike.

14. When *S*106 (power-level or CTO switch) is set to CALIBRATE position, its contacts, FB–1,

complete the circuit to ground for cw relay coil *K*103, whose contacts 4 and 5 complete the circuit to ground for *K*2703 solenoid, energizing it, and the dynamotor will run.

15. The dynamotor machine, the filter capacitors and chokes, the power-change relay, and the high-voltage fuse (*F*2701) are included in the high-voltage circuit.

16. The 400-v output (*G*1) is connected in series with the 750-v output (*G*2) of the dynamotor through the normally closed contacts of the power-change relay, *K*2701. The 1,150 volts is available at terminal 10 of *J*108.

17. The closing of *K*2704 places *K*2701 in parallel with *K*2703 (dynamotor power input). *K*2701 will energize each time *K*2703 energizes. *K*2701 contacts then break the series connection between the two dynamotor windings, reducing the high dc voltage to 750 volts.

18. Spark suppressors are used to prevent any high-frequency static effect from modulating the carrier, since this would be heard as an undesirable noise in the receiver tuned to that carrier.

19. Keying relay *K*102 armature contains six contacts, Nos. 2, 5, 3, 1, 6, and 4. (Refer to Chart C–256–A.) No. 1 is not used. The vacuum switch (*S*116) contacts are also controlled by the keying relay solenoid. In the de-energized position, *K*102 does the following:
(*a*) Through its contacts 2 and 12 the autotune motor relay (*K*101) is completed to ground whenever a channel is selected by *S*109. The switch itself does the grounding.
(*b*) Grounds mcw oscillator plate circuit through contacts 5 and 4.
(*c*) Connects the antenna to the receiver through *S*116 contacts.
In its energized position, *K*102 does the following:
(*a*) Ground is removed from mcw oscillator, and the plate circuit is connected to 400-v supply through contacts 5 and 13.
(*b*) Completes the cathode circuit of the MO to ground through contacts 3 and 9, *R*131 (cathode bias resistor), *S*114, and *L*102.
(*c*) Connects output of the side-tone amplifier (terminal 5–*J*112) to side-tone jack *J*104 through contacts 6 and 8.
(*d*) Connects the antenna to the transmitter (*S*116) and shorts receiver antenna to ground through contacts 7 and 4.

20. The PA is disabled by removing its screen-grid voltage and connecting its screen grid to the control grid. This is done by a pair of contacts on *S*106. The bias voltage thus applied to the screen grid cuts off the output from the PA stage.

21. When the autotune motor operates, the keying relay is de-energized to prevent arcing at the high-voltage switch contacts which would damage the contacts. Limit switch *S*111 and contacts 1 and 3 of *K*101 are in series with *K*102 coil. When *K*101 and *S*111 operate, the holding circuit for *K*102 is broken.

22. The carbon microphone is properly connected to the 28-v source and signal input circuit when *S*201 is in the DOWN position. The circuits completed are as follows:
(*a*) From ground through mike button, through contact R of *J*102, through one section of *S*201, through *R*202, *R*201, and *R*116 to +28-v source. These resistors in series with the microphone limit the current and help determine the voltage drop across the microphone.
(*b*) In parallel with the mike and forming an alternate path to ground are *R*203 and *R*204. These two resistors, along with the other three in series with the mike, form the complete bleeder system.
(*c*) The third important circuit is the mike signal circuit. The mike is the source of audio voltage. This voltage is a limiting resistor and reduces the output of the carbon mike to the level of the dynamic mike output. The series combination of *R*2116 and the primary of *T*201 are in parallel with *R*204. Thus, *R*204 essentially determines the signal voltage for the input circuit.

23. A twin triode tube, *V*2201, that operates as a crystal oscillator and tripler circuit, a pentagrid converter that mixes the crystal frequency (200 kc) with the tripler frequency (150 kc) to produce the 50-kc fundamental standard frequency with its harmonics, and a detector (one triode section of *V*2203) which

rectifies some of the carrier and calibration frequency voltages to produce the beat rate in the headphones.

24. The frequency range of the bfo is covered in two bands: 1,000 kc to 1,200 kc, and 1,200 kc to 1,510 kc.

25. *S*101—hfo band-change switch is closed on all odd positions of control A. This places *C*101 and *C*135 across the oscillator tank circuit, which increases the total capacity and therefore the oscillator operates at its lowest range (1 to 1.2 Mc).
*S*114—low-frequency high-frequency oscillator selector switch completes the cathode circuits to ground for the bfo and first multiplier. It closes only on position No. 13 (lfo).
*S*115—second multiplier grounding switch is closed on positions 7 through 12 of control A. It then completes the second multiplier cathode to ground through *R*129.
*S*102—first multiplier range switch connects plate *V*102 to the grid of PA on positions 1 through 6 of control A. Secondly, it decreases the capacity of the tuned circuit as control A is rotated clockwise, thereby increasing the output frequency. It operates as a doubler on positions 1 and 2 of control A, as a tripler on positions 3 and 4, and as a quadrupler on positions 5 and 6. On position 7, it connects the first multiplier plate to the second multiplier grid and breaks the connection to the PA.
*S*103—second multiplier range switch performs operations for the second multiplier stage similar to those that *S*102 performs for the first multiplier stage.

26. When control C is in any of its first 7 positions, the output circuit is an L network. For positions 8 through 11, the output circuit is a pi network. In position 12, control C opens sections *F, G,* and *H* of switch *S*113 and the output circuit becomes an L network. In position 13, the output network is again a pi network. The various combinations of series inductance and shunt capacity which determine resonance result in different degrees of coupling to the antenna.

27. *K*105 (normal position)—Connects the PA tube to its plate tank and antenna coupling network through *C*118.
*C*116—PA grid-coupling capacitor.
*R*110 and *R*111—grid-leak bias resistors for PA tube.
*C*119—Screen-grid by-pass.
*R*112—Parasitic suppressor.
*L*110—Static drain for the output circuit shunt capacitors.

28. The meter acting as an 0-to-4-volt dc meter measures the voltage drop across resistor *R*2701B. The amount of current flowing through the resistor is the sum of the PA and modulator plate currents. Since the voltage drop is proportional to the current, it indirectly measures the plate current.

29. The tuning controls are A, B, C, D, and E. Control E employs the multiturn unit. This control tunes the oscillator and multiplier stages by moving the tuning slugs in inductor *L*101, *L*105, and *L*106. This control is calibrated and contains a vernier scale for very exact adjustment.

30. *K*101 is energized through contacts 12 and 2 of the keying relay *K*102, *S*107, *S*108, and the circuit-seeking tap switch *S*109 to ground.

31. *K*102 and *K*2703 are de-energized when contacts 3 and 1 of *K*101 open. This breaks the positive 28-volt line. *K*101 remains energized through its holding contacts 6 and 5 and front limit switch *S*112.

32. In its normally closed position (as shown in the schematic), it completes the 28-v line (contacts 3 and 1 of *K*101) to *K*102 and *K*2703. When opened by the screw-operated arm, its contacts 2 and 3 close and short motor torque retainer resistor *R*115 out of the circuit. The operating arm moves across and opens *S*112, which de-energizes *K*101, which in turn reverses the motor and stops rotation of *S*109. The return of the operating arm to the original position places *R*115 again in the circuit, thereby stopping the autotune motor *B*101.

33. *S*1130 is operated by control C and prevents operation of the keying relay *K*102 between settings of control C when *S*107 is in local position.

34. No, *K*101 still is grounded through *S*109, so that motor will continue to run until the open segment of *S*109 is positioned opposite the contact of the channel selected by *S*108.

35. *R*115 drops the voltage to a value at which the motor will not operate but allows just enough current to flow through to retain torque for the autotune units.

36. The purpose of the vacuum contacts is to key the high-frequency output circuits and to connect the antenna circuit to the receiver when the transmitter is in the unkeyed position. Vacuum contacts are used to reduce arcing.

37. The mcw oscillator is coupled to the side-tone amplifier, and the output is amplified and coupled to the headsets. This provides the operator with a signal which can be heard, and he can listen to the intelligence which is being transmitted.

38. When transmitting on cw, the cathode circuit of the rf oscillator and the screen-grid circuit of the PA are keyed by contacts 9, 3 and 5, 13, respectively.

39. Selecting cw position completes the circuit which operates the cw relay *K*103 and the circuit which starts the dynamotor running. This circuit extends from ground through contact 1B of *S*107 to contacts RB–3 of *S*110, to terminal 7 to *J*2701, through the coil of *K*2702, through circuit breaker *K*2705 to terminal 2 of *J*2702. This closes the contacts of *K*2702, connecting terminal 4 of *J*2701 to +28 volts. A circuit from ground is also completed through contact 1A of *S*107, through contact RA–3 of *S*110 to terminal 9 of *K*103, to terminal 10 of *K*103, to terminal 4 of *J*2701. This energizes *K*103, completing a circuit from ground through contacts 5 and 4 of *K*103, to terminal 8 of *J*2701, through the coil of *K*2703 to terminal 3 of *J*2701, through contacts 2 and 1 of switch *S*111, through contacts 1 and 3 of *K*101, to terminal 4 of *J*2701, which starts the dynamotor.

When the test key is closed, keying relay *K*102 becomes energized. The circuit is from ground through the TEST key, through coil *K*102 to switch *S*113D, to the +28-volt side of the coil of *K*2703.

The oscillator circuit is completed by grounding the cathode of the oscillator. The circuit is from ground through contacts 3 and 9 of *K*102, through *R*131, terminal 8 of *J*115, and the closed contacts of *S*114 to terminal 6 of *J*115, and through coil *L*102 to the cathode of the high-frequency tube, JAN 837. The same path for ground is used for both the low-frequency and high-frequency oscillators. The oscillator is selected by *S*114, which operates in conjunction with control A.

The mcw oscillator is operated when the keying relay *K*102 is operated. The audio voltage developed across *R*2201 is applied to the input transformer of the first audio amplifier, tube *V*201. The circuit is from terminal 7 of *J*111, through contacts 5 and 6 of the voice relay, *K*104, to contacts FC–3 of power-level switch, *S*106, to contact 2 of the input transformer, *T*201. The mcw oscillator is keyed by breaking the plate voltage line to the mcw oscillator tube, *V*2203. This circuit is from the plate of *V*2203 to terminal 5 of *J*111, through contacts 5 and 13 of relay *K*102, to terminal 1 of *J*2701, through the contacts of *K*2701, to the high-voltage terminal of *G*2.

The screen-grid voltage is removed from the power amplifier, *V*104, when the key is closed. This circuit is from the screen grid, pin 3 of the *V*104, to terminal 6 of transformer *T*101, to terminal 7 of the same transformer, through contacts RB–3 of *S*106, through contacts 5 and 13 of *K*102, to terminal 1 of *J*2701, and to the high-voltage winding *G*2 of the dynamotor.

When the key is closed, the output from the loading network of the power amplifier is connected to the antenna; when the key is open, the antenna is connected to the receiver. This circuit when the key is closed may be traced from terminal 7 of *L*113 through the vacuum contacts to *J*109 to the antenna binding post of the transmitter; when the key is open, a connection is made from the antenna binding post through *J*109, through the vacuum contacts to the receiver binding post, and through *J*110.

When the transmitter is keyed, the output of the mcw oscillator is fed to the side-tone amplifier and connected to the side-tone jack, *J*104, so that the operator can monitor the code which he is sending. This circuit starts from ground through the side-tone jack, *J*104, through contacts 8 and 6 of the keying relay *K*102 to terminal 5 of *J*112, to terminal 7 of *S*202.

40. On CALIBRATE position, the frequency multiplier is inoperative because the RA section of *S*106 opens the plate and screen circuits.

41. A static-drain choke provides a dc path to ground for the antenna circuits so that static charges, which may be electrostatically induced or developed by electrical storms, can quickly leak off to ground. This prevents a dc flashover if the static charge should become excessively large and tends to minimize the noise.

42. On cw position, the modulator is disabled by removing the high voltage from its plate-return circuit. The circuit extends from tap 2 on the modulation transformer, *T*101, to contact 3 of cw relay *K*103.

43. The dynamotor is protected from damage by the dynamotor overload relay, *K*2706, and a 1.0-amp fuse, *F*2701.

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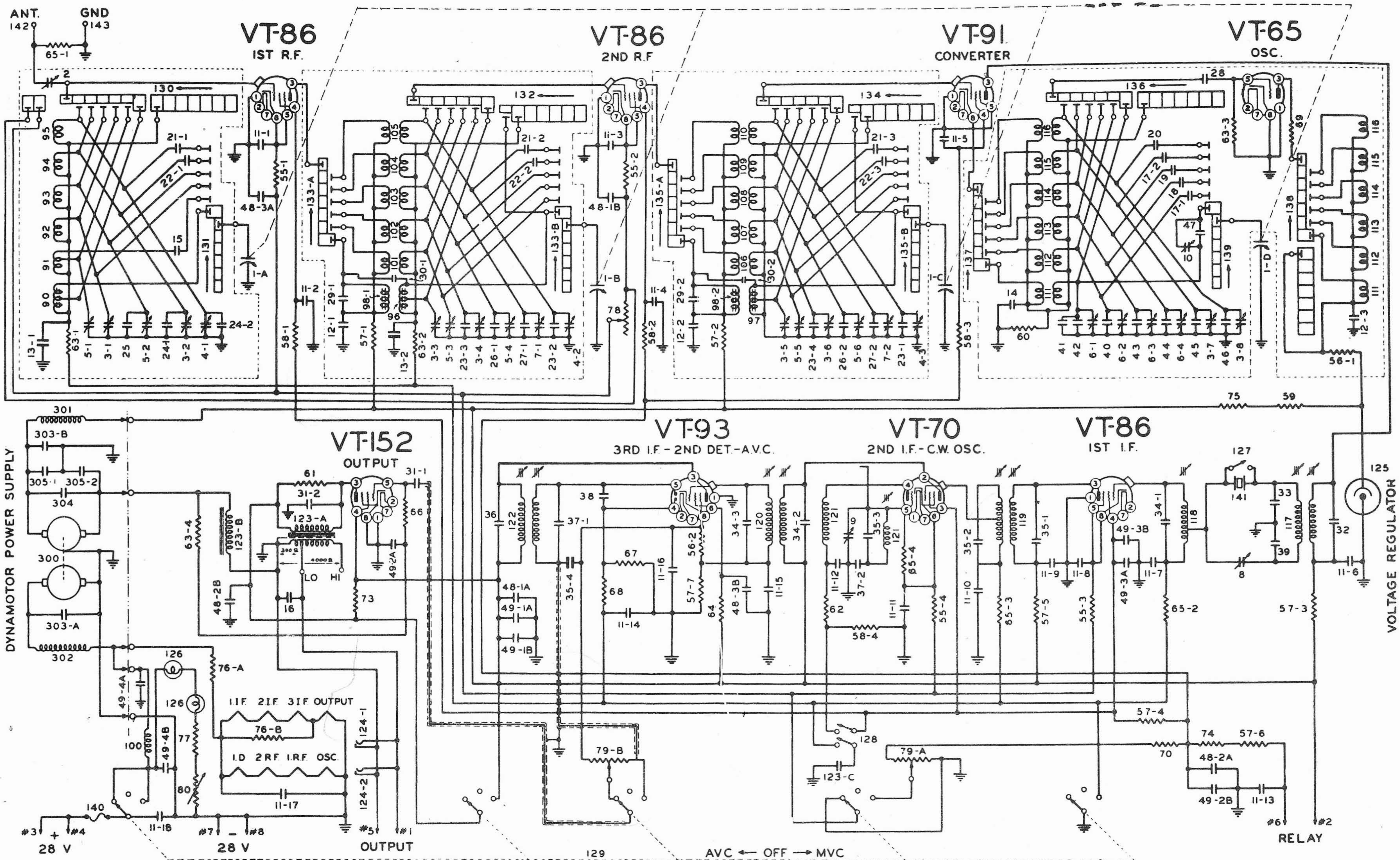

SCHEMATIC DIAGRAM---RADIO RECEIVER BC-348-(*) OR BC-224-(*)

S212S/Scott AFB, Ill./26 Aug 43/3M