PART A

HANDBOOK OF SERVICE INSTRUCTIONS

SECTION I

DESCRIPTION AND LEADING PARTICULARS

1-1. PURPOSE OF HANDBOOK.

1-2. This Handbook is published to aid in the installation, operation, and maintenance of Automatic Antenna Tuners 180L-2 and 180L-3 (see figure 1-1). It includes description of the Antenna Tuners, test equipment and tools required, installation procedure, theory of operation, operators' and technicians' maintenance, and diagrams.

1-3. PURPOSE OF EQUIPMENT.

1-4. a. Antenna Tuner 180L-2 is designed for automatic tuning of open, fixed wire antennas of length between 45 and 100 feet, and the coupling of the 52 ohm output circuit of an aircraft transmitter of 50 to 150 watts power output to such antennas over a frequency range of 2 to 25 megacycles. Most grounded-end antennas of similar length are also fully tunable, but in some instances may require a different fixed shunt capacitance at C-101.

NOTE

Where general test of this instruction book refers hereafter to Antenna Tuner 180L-2, the data also applies to Antenna Tuner 180L-3. A difference data supplement and specific references in the general text provide necessary additional information on Antenna Tuner 180L-3.

b. DIFFERENCE DATA (PURPOSE OF EQUIPMENT). Antenna Tuners 180L-2 and 180L-3 are identical in purpose and design with the exception of an additional antenna transfer relay circuit included in Antenna Tuner 180L-3. This circuit transfers the aircraft antenna directly to a separate receiver when the transmitter is not being tuned or otherwise used; thus, separate components may be operated in the same manner as a transmitter-receiver (transceiver). The 180L-3 has wiring for an antenna grounding relay to ground the antenna of the unused half of a dual installation. When the relay is included, the antenna tuner is called 180L-3A.

c. EQUIPMENT COVERED. The equipments covered in this instruction book include the assembly MOD numbers given in the Assembly Modification Data Sheets on page of the instruction book.

TABLE 1-1

EQUIPMENT SUPPLIED

Name of Unit	Type Designation Collins Part Number (CPN)	Over-all Dimensions (Inches)	Weight (Pounds)
Antenna Tuner 180L-2	CPN 506 1199 004	10-3/8 W x 7-11/16 H x 11-3/8 D	17.3
or Antenna Tuner 180L-3	CPN 522 0092 004	10-3/8 W x 7-11/16 H x 13-7/8 D	18.3
180L-3A	522 0293 004		
Mounting 350D-3	CPN 505 2782 002	10-3/8 W x 1-1/2 H x 10-5/8 D	1.25

1-5. EQUIPMENT SUPPLIED.

1-6. EQUIPMENT REQUIRED BUT NOT SUPPLIED.

1-7. The following equipment is required for installation and operation of Antenna Tuner 180L-2. All or the majority of items listed may be available as existing facilities on the aircraft, or existing accessories of the transmitter concerned.

TABLE 1-2

EQUIPMENT REQUIRED BUT NOT SUPPLIED

Name of Unit	Type Designation Collins Part Number (CPN)	Required Characteristics
Primary Power		Lead-acid storage battery, engine-driven generator, 28 VDC at 2 amperes continuous (in addition to transmitter requirements).
A-C Power		115 V, 400 cps, 15 watts.
Antenna		Fixed-wire, general 45 to 100 foot length.
R-F Input Cable	RG-8/U CPN 424 0006 00	Coaxial cable.
Power, Control	*-WM-3/U SPN 425 0006 00	*-Ten #22 AWG conductors (maximum), two #16 AWG conductors.
R-F Connectors	CPH 49195 CPN 357 9006 00 OR PL-259A CPN 357 9014 00	P-101. Connects to J-101. Also connects R-F Input Cable to Receiver-Transmitters 18S-4, 618S-1.
	CPN 357 9018 00	P-103. 180L-3 only.
Power, Control Cable Connector	SK-C-16-23C-1/2 CPN 371 0012 00 OR SK-C-16-21C-1/2	P-102. Connects to J-102.
Remote Tuneup Indicator		Lamp, Pilot, 28 VDC, or equal. Refer to paragraphs 3-21, 3-22.

*-Eighteen conductors, including two #16AWG, are available in the cable listed; this cable is a standard installation accessory for Receiver-Transmitter 18S-4. Refer to table 3-2, paragraph 3-12.

1-8. GENERAL DESCRIPTION.

1-9. Antenna Tuner 180L-2 is enclosed in a single aluminum case, secured to the main mounting frame by machine screws, (see figure 1-1). Power and control cable connections are made through a multi-contact fixed plug at the lower right of the mounting frame. The plug extends through a front panel cut-away area, as does the 52 ohm radio-frequency line connection which is adjacent at left. An SWR indicator is adjacent to the r-f line connector, and is viewed through a cutaway area. The antenna connector is located on a ceramic plate at upper right of the front panel. Viewed from the top, rear (see figure 1-2) with the case removed, the main chassis contains a series variable capacitor unit, servo amplifier assembly, r-f autotransformer and variable inductor assembly. Viewed from the front (see figure 1-3) with the panel and case removed, the main chassis contains plug-in assemblies including discriminator, r-f autotransformer, control circuit relay panel, three vacuum tubes and a d-c to a-c chopper. The entire Antenna Tuner assembly is retained in Mounting 350D-3. Knurled fasteners at the front of the Mounting tighten clamps into a flange on the base plate of the Antenna Tuner case, bringing pressure against mating fixed flanges at the rear of the base plate and Mounting. The knurled fasteners are secured by safety wire. Vibration isolators and grounding straps are provided by the Mounting. Attachment or removal of the Antenna Tuner is accomplished without use of special tools.

1-10. ELECTRICAL DESCRIPTION.

1-11. Antenna Tuner 180L-2 contains components and assemblies capable of producing electrical configurations which will tune out inductive or capacitive reactances encountered in standard fixed-wire aircraft antennas within a general range of 45 to 100 feet in length, at frequencies between 2 and 25 megacycles. Antennas of shorter dimensions may not be fully tunable in some frequency regions; the limiting factor is the maximum available inductance for series-resonating the reactance of the antenna. Use of extremely short antennas is not recommended, since efficiency of the equipment and the associated transmitter will be reduced. The Antenna Tuner also contains apparatus to match the antenna resistance to the 52 ohm output impedance of the transmitter. Phasing and loading operations are completely automatic after an r-f signal is received from the transmitter. The control circuits consist of two discriminator circuits which determine the course of action to follow in phasing and loading the antenna circuit; two servo amplifiers to build up information received from the discriminators, and suitable relays and switches to control the phasing system motors. The Antenna Tuner receives its power from the primary power supply (28 volts), a B+ source of 400 or 250 volts such as the transmitter plate supply circuits, and 115 volts, 400 cycles per second, from an aircraft source, or from a transmitter power unit.

1-12. MECHANICAL DESCRIPTION.

1-13. Both inductive and capacitive series elements of the antenna resonating circuits in Antenna Tuner 180L-2 are variable. The inductor consists of a ceramic cylinder upon which a silver ribbon is wound from an aluminum short-circuiting cylinder. The two cylinders are driven by a d-c motor. The series capacitor of the capacitive element is driven by a d-c motor; the fixed shunt capacitor is connected by a relay circuit. The impedance matching element of the r-f system is a roller coil (autotransformer) which is driven by an a-c motor. Several gear trains are employed between motors and driven elements to produce correct shaft speeds. The detailed parts of the over-all assembly are arranged in logical groups on several removable chassis to facilitate servicing. Plug-in connections are used between subassemblies in nearly all cases.

1-14. PRINCIPLE OF OPERATION.

1-15. After the operator selects a new frequency by setting the channel selector switch of a radio set control panel, keying the transmitter places the Antenna Tuner in operation. The transmitter carrier is held on during the tuning process, which is completed in 30 seconds or less under normal conditions. (Refer to paragraph 3-18). Tuning time may be reduced by preselection of K-710. (See paragraph 4-44 page 30). The variable inductor and variable capacitor (plus the shunt capacitor, in some cases) act to produce resonance of the antenna circuit. Then the r-f autotransformer acts to match the obtained impedance, which automatically produces proper loading of the transmitter (assuming the latter has been properly adjusted to operate into a 52 ohm load). When the tuning cycle is complete, the transmitter carrier is turned off. The Antenna Tuner thereafter automatically compensates for changing antenna characteristics at any time the transmitter emits a signal. If a tuning cycle is not completed within 45 seconds after the transmitter is keyed, a thermal delay relay, K711, will interrupt the transmitter keying and stop the antenna tuner. Wait 30 seconds after the thermal relay has stopped the tuner before attempting to tune to a new frequency.

1-16. OPERATING AND ADJUSTMENT CONTROLS.

1-17. Since Antenna Tuner 180L-2 is an automatic tuning device, there are no operating and adjustment controls. Operation of the equipment is normally performed as a function of radio set control, and initiated by use of the radio set control panel. (Refer to paragraph 3-18.)

1-18. ELECTRICAL CHARACTERISTICS.

1-19. Frequency Coverage: 2 through 25 megacycles.

Sources of Power: Primary power supply, 27.5 VDC; transmitter plate supply, 400 or 250 VDC, and aircraft supply, 115 V, 400 cps, single phase.

Power Requirements: Primary power supply, 3.5 amps max; 400 VDC, 35 milliamperes maximum; 115 V, 400 cps, 15 watts.

Input Impedance: 52 ohms

Output Power: $P_{INPUT} \times 0.75 \times \frac{275}{275 + Q_A}$

where, $Q_A = \left| \frac{R_A{}^2 - X_A X_C + X_A{}^2}{R_A X_C} \right|$

X_C = Absolute value of the reactance of a 20 mmfd capacitor for 180L-2 and 30 mmfd capacitor for 180L-3 at the frequency at which the efficiency calculation is to be made.

R_A = Antenna resistance

X_A = Antenna reactance (use appropriate sign)

1-20. VACUUM TUBE COMPLEMENT.

Symbol Designation	Tube Quantity, Tube Type	Circuit Function
V-601A (1/2 of)	1-5751	First loading amplifier
V-601B (1/2 of)		First phasing amplifier
V-602A (1/2 of)	1-5751	Second loading amplifier
V-602B (1/2 of)		Second phasing amplifier
V-603A (1/2 of)	1-5814	Third loading amplifier
V-603B (1/2 of)		Third phasing amplifier

1-21. FUZE COMPLEMENT.

1-22. There are no fuses in Antenna Tuner 180L-2.

SECTION IV

THEORY OF OPERATION

4-1. GENERAL.

4-2. Automatic Antenna Tuner 180L-2 contains all components needed for the fully automatic coupling of a medium-powered aircraft transmitter with a 52 ohm output impedance to an open, fixed-wire antenna of length between 45 and 100 feet, over a frequency range of 2 to 25 megacycles. Most grounded-end antennas of similar length are also fully tunable, but in some instances may require a larger fixed shunt capacitance than that furnished at frequencies in the 2 to 4 megacycle range.

4-3. Refer to figure 4-1, the block diagram of Antenna Tuner 180L-2. The Antenna Tuner consists of series reactive elements for tuning (a variable inductor and a series vacuum capacitor, also variable), a variable r-f autotransformer for loading, analyzing (discriminator) and control circuits for tuning and loading, shunt antenna capacitance, and an SWR indicator bridge.

4-4. The general tuning operations performed by the Antenna Tuner take place as follows when the transmitter has provided retune information to the control circuits. An antenna which appears inductive to the transmitter causes the phasing discriminator to produce an error voltage output; this voltage when passed through a servo amplifier, causes a motor (B-401 or B-501) control circuit to operate. The series reactive elements (L-401 and C-501) are driven toward minimum inductance and capacitance until the antenna is resonated. If the antenna appears capacitive to the transmitter, the opposite takes place.

4-5. If the antenna resistance appears to the transmitter as less than 52 ohms, the loading discriminator produces an error voltage output; this voltage, when amplified, causes a motor (B-301) control circuit to operate. The variable r-f autotransformer (T-301) is driven toward minimum (toward the grounded end of its winding, located nearest the front panel and gear assembly) until the antenna resistance appears to the transmitter as 52 ohms. If the antenna resistance appears as more than 52 ohms, the opposite takes place.

If the antenna reactance or resistance are beyond the range of the Antenna Tuner's basic operation, as explained above, the control circuits place shunt capacitance (C-101) across the antenna and repeat the basic tuning operation.

The control circuits of the Antenna Tuner provide a keying circuit for the transmitter, and a remote tune-up indicator circuit, once an automatic cycle has been started by selection of a transmitting channel, until the antenna is tuned.

4-6. A modified Schering bridge circuit is used in the SWR (standing wave ratio indicator) element. One pair of bridge arms is resistive, the other capacitive. The bridge is balanced when the input impedance of the Antenna Tuner is 52 ohms resistive, and zero indication results on the SWR Indicator (M-701). Capacitive arms of the bridge include C-701 through C-704 (refer to figures 7-10 and 7-11) and the resistive arms consist of R-701 through R-710, then 10-ohm resistors in parallel. The bridge detector is CR-701. M-701 is an r-f voltmeter, with a scale of arbitrary units. Indications will normally be below the red mark when the antenna is tuned.

4-7. ELECTRICAL DESCRIPTION, ANALYZING CIRCUITS.

4-8. FUNCTION OF DISCRIMINATORS. The discriminator circuits are capable of analyzing the antenna impedance and initiating network corrections to match

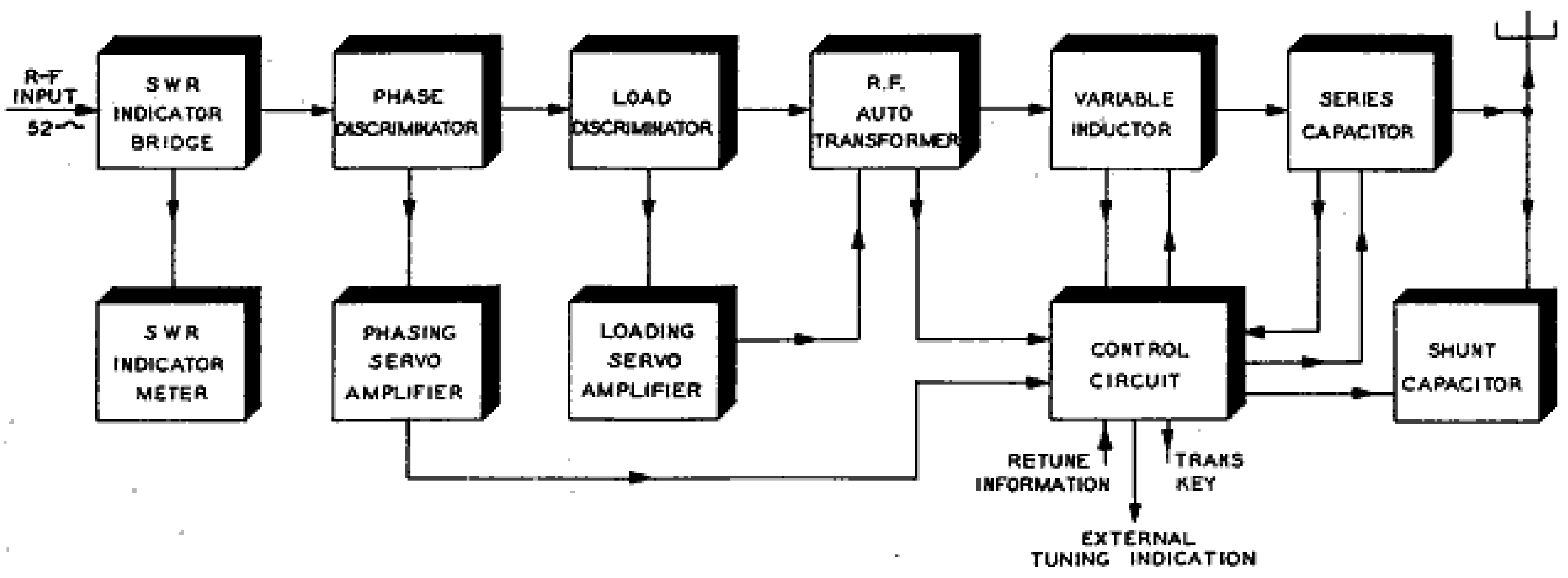

Figure 4-1. Block Diagram, Antenna Tuner 180L-2

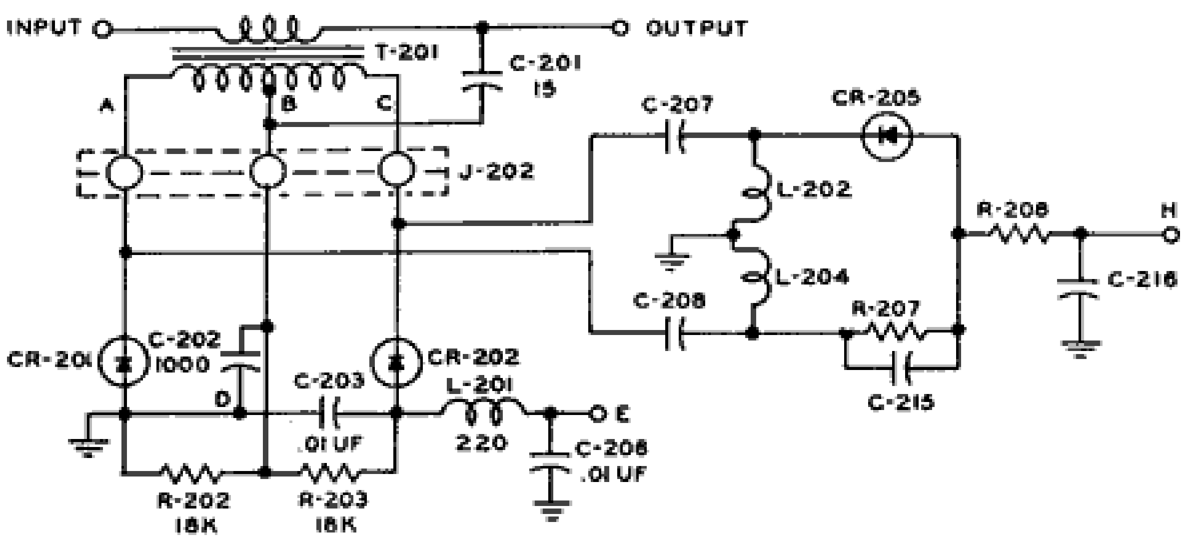

Figure 4-2. Phasing Discriminator and AVC Circuit, Schematic Diagram

the antenna to the transmitter impedance of 52 ohms resistive. The phasing discriminator determines whether the reactance is inductive, capacitive, or zero. The loading discriminator determines whether the antenna load is 52, more than 52, or less than 52 ohms. Both discriminators produce polarized outputs proportional to the phasing and loading errors. These outputs are fed through the servo amplifiers, to the phasing and loading system motors, to tune the antenna.

4-9. **PHASING DISCRIMINATOR.** The phasing discriminator is transformer-connected to the antenna transmission line (see figure 4-2) and its output is connected through the phasing servo amplifier to the series elements of the Antenna Tuner. The primary of the input transformer is a straight section of silver-plated brass rod. A six-turn secondary is closely coupled in the primary field by a high frequency iron core placed around the primary rod. The circuit is wired symmetrically around the center of the secondary, and subcomponents are chosen so that the transformer is essentially without load.

4-10. **BALANCED CONDITION, PHASING DISCRIMINATOR.** Vector diagrams (See figures 4-3 and 4-4) show the balanced and unbalanced condition of the phasing discriminator. When the voltage and current of the transmission line are in phase (see figure 4-3), as shown by vectors E_L and I_L in the diagram, then E_{AB} leads I_L by exactly 90 degrees, while E_{CB} lags I_L by 90 degrees, since the transformer is essentially without load. The voltage across BD is in phase with E_L since C-201 and C-202 constitute a voltage divider. The germanium diodes CR-201 and CR-202, with their load resistors R-202 and R-203, are connected between points AD and CD, respectively. C-203 provides an r-f ground for CR-202. Voltage E_{AD} is the vector sum of E_{AB} and E_{BD} while the voltage E_{CD} is the vector sum of E_{CB} and E_{BD}. These are the voltages which actually are measured by the diodes and their loads. The diodes and their loads thus produce a d-c voltage almost proportional to the r-f voltage which appears across them (they are connected into the circuit with opposite polarities). Both load resistors are bypassed for r-f by C-203. With the transmitter keyed, and due to the detecting action of CR-201, a positive voltage drop appears across R-202. Also, due to CR-202, a negative voltage drop appears across R-203. The phasing discriminator error voltage appears at point E. Since the voltage at R-202 is positive and the voltage at R-203 is negative, the voltage at E represents the sum of the two. If the voltage drops are equal in magnitude, the error voltage is zero. This is the balanced condition, when the detecting action of CR-201 and CR-202 is the same.

4-11. **UNBALANCED CONDITION, PHASING DISCRIMINATOR.** Assume that the current leads the voltage

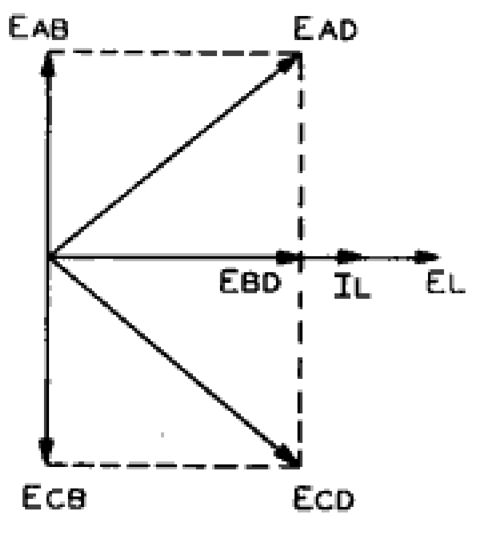

Figure 4-3. Balanced Condition, Phasing Discriminator, Vector Diagram

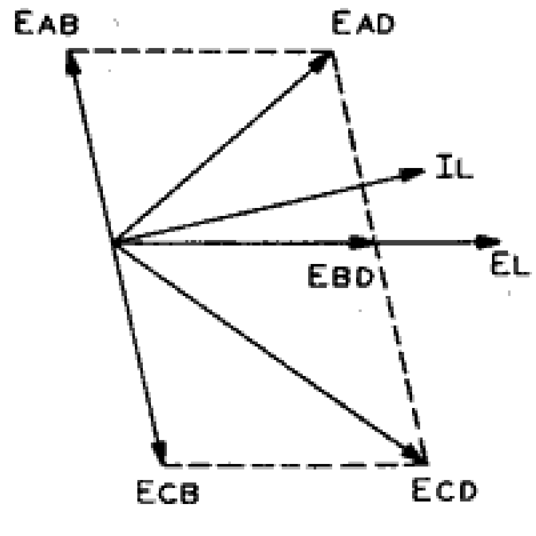

Figure 4-4. Unbalanced Condition, Phasing Discriminator, Vector Diagram

slightly, as shown in the second vector diagram (see figure 4-4). E_{BD} is still in phase with E_L. The voltage across AB still leads the current in the primary by 90 degrees. Vector sums of E_{AB} and E_{BD}, E_{CB} and E_{BD} still produce voltages E_{AD} and E_{CD}, but they are no longer equal. The d-c voltage developed across R-203 is greater than the voltage developed across R-202. In effect, the sum of voltages at both diode load resistors becomes negative, and the negative error voltage appears at E. With current leading voltage, the error is capacitive; that is, the antenna reactance is capacitive. The negative error voltage at E is used through means of the servo amplifier and control circuits to drive the series elements until less capacitive reactance or more inductive reactance is obtained. If the current lags the voltage, E_{AD} becomes greater in magnitude than E_{CD} and a positive error voltage appears at E; the antenna reactance is inductive. The positive error voltage is used to drive the series elements until less inductive reactance or more capacitive reactance is obtained. When current and voltage are in phase, no error voltage appears at E, and driving of the series phasing elements stops.

4-12. AVC CIRCUIT. Voltage at points A and C (see figure 4-2), is rectified by CR-205, causing a negative voltage to appear at point H. This feedback voltage, which increases with frequency, is applied to the phasing servo amplifier for stabilization.

4-13. LOADING DISCRIMINATOR. The loading discriminator (see figure 4-5) is composed of CR-203 and CR-204, their associated loads and circuits. The d-c voltage developed across R-204 due to the detection of r-f voltage by CR-203 is proportional to the r-f voltage across the input transformer secondary, at points AC, and therefore is proportional to the primary current. The d-c voltage developed across R-206, due to the detection by CR-204, is proportional to the r-f voltage across R-205. C-210 and R-205 form an RC voltage divider, so that the voltage developed across R-205 is proportional to the r-f voltage in the transformer primary. Since the r-f voltage across the secondary at points AC is linear with respect to frequency, the voltage developed across R-204 is proportional to frequency. The reactance of C-210 is always high with respect to R-205, and C-211 is a very low impedance to ground. Since the impedance through the branch is inversely proportional to frequency, the current in the circuit is proportional to frequency and the voltage appearing across R-205 is also proportional to frequency. Capacitors C-207 and C-208 isolate the d-c voltages rectified in the two discriminator circuits, and keep them from affecting each other. R-f chokes L-202 and L-204 provide a d-c ground return for CR-203.

If the antenna impedance is determined by the discriminator to be 52 ohms, the discriminator output is zero, since the output consists of the sum of the d-c voltage drops across R-204 and R-206. If the impedance is less than 52 ohms, excessive current is drawn and the voltage across the transmission line is low. The voltage drop across R-204 exceeds the drop across R-206 and a positive error voltage results. This error voltage, through means of the servo amplifier, will drive the r-f autotransformer toward minimum. If the impedance is more than 52 ohms, the transmission line voltage is high and the current low. The drop across R-206 exceeds the drop across R-204 and a negative error voltage results. This error voltage, through means of the servo amplifier, will drive the r-f autotransformer toward maximum.

NOTE

During retune operation of the Antenna Tuner it is desirable to unbalance the loading discriminator to obtain certain results which are noted in later text. When the control circuit removes ground from point F (see figure 4-5), L-204 is open-circuited. Therefore, the error voltage at point G is produced principally from the voltage drop across R-206, and is negative.

4-14. SERVO AMPLIFIER. The servo amplifiers receive information from the discriminator circuits and convert this information into a form that can drive the various elements of the Antenna Tuner as

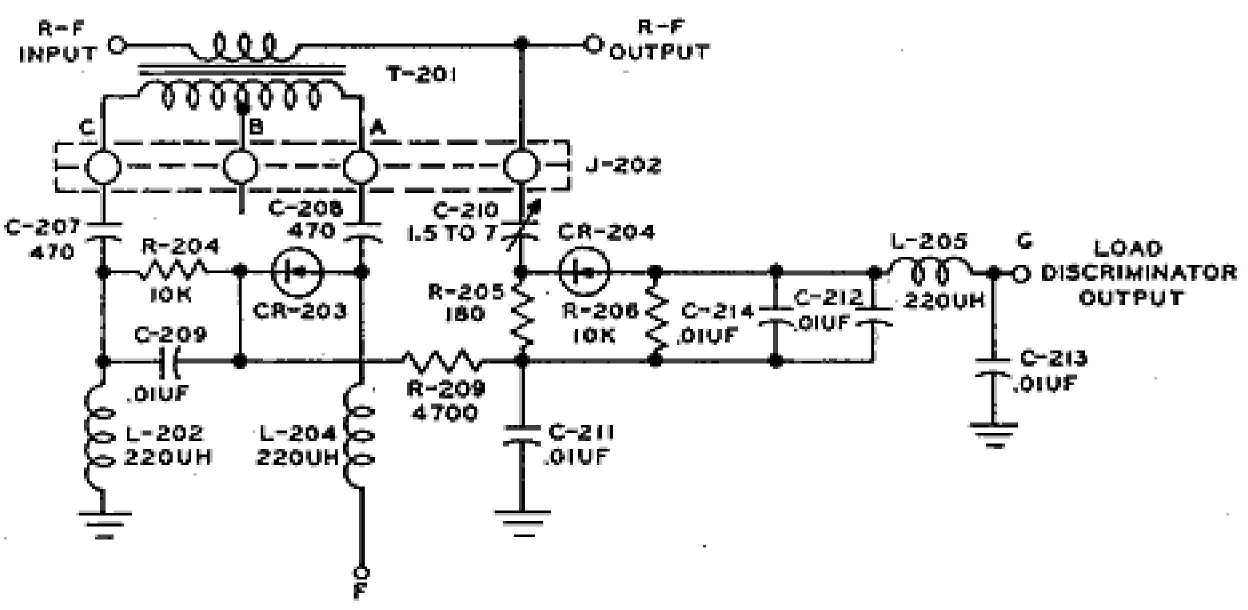

Figure 4-5. Loading Discriminator, Schematic Diagram

directed by the discriminators. The servo amplifier includes two complete amplifier systems, one for the loading system and one for the phasing system, using halves of tubes common to both circuits. Each amplifier consists of an input circuit, a chopper, two amplifier stages and a power output stage. One winding of a two phase motor, driven by the loading amplifier, forms the power output tube's load. The phasing amplifier power output tube has a step-down transformer as its load. The transformer is connected to a two phase motor which drives a switch. Circuits of the two amplifiers are much alike.

4-15. LOADING SERVO AMPLIFIER CIRCUIT. (See figure 4-6). The d-c error voltage from the loading discriminator is applied to the loading servo amplifier circuit through a lead network, and converted into a 400 cps square wave signal by Chopper G-601. The chopper square wave output leads or lags the 400 cps supply voltage by 90 degrees, depending on the polarity of the discriminator output. Tubes V-601A and V-602A are simple amplifiers. The load for power output tube V-603A is the r-f autotransformer drive motor, B-301. The motor winding is resonated by C-301 to reduce harmonics and increase the load impedance for the power output tube. Motor B-301 is a 400 cps, two phase motor. One phase input is the 400 cps supply voltage; the other is the servo amplifier output. Direction of rotation of the motor depends on whether the servo amplifier output leads or lags the supply voltage by 90 degrees, as determined by the polarity of the discriminator output. A negative discriminator output voltage causes B-301 to drive the r-f autotransformer toward maximum; a positive output causes it to drive toward minimum. R-622 and C-608 provide for decoupling between the plate supplies of the amplifier. R-713 and C-708, located on the control circuit relay panel, provide decoupling between the servo amplifier and the plate voltage supply. C-607 is used to correct unbalance in the square wave, due to the transit time of the chopper reed. Voltage divider R-630 and R-631 provides approximately 3 volts bias for the cathode of V-602. The cathode of power output tube V-603A is connected to approximately +20 volts, and the tube is thus biased to near cutoff when no signal is applied from the discriminator. The coil of Relay K-709, located in the control circuit, is in series with the plate supply of V-603A. Plate current demand of V-603A, at near cutoff, is not sufficient to energize the relay. When a discriminator signal is applied, the bias on V-603A is overcome and the power output tube draws about 10 milliamperes plate current, which is sufficient to energize K-709. Thus, K-709 is energized only when a loading error exists and discriminator information is applied to the control circuit. R-715 is a bleeder resistor which helps to stabilize the plate voltage between signal and no-signal conditions. R-625 and C-620 form an r-f filter. Voltage divider R-632 and R-633 reduces the sensitivity of the loading amplifier when R-633 is grounded by the control circuit, to minimize hunting. If the Antenna Tuner is operated on 250 volts plate supply (refer to paragraph 3-20) instead of 400 volts, R-713 is not in the circuit, but the decoupling function is not necessary.

4-16. LEAD NETWORK. Function of the lead network is to counteract any hunting tendency in the servo system. The network operates to obtain as much phase lead as possible without destroying sensitivity of the circuit. It consists of C-601 shunted by R-602, R-601 and the effective resistance to ground of Chopper G-601.

4-17. PHASING SERVO AMPLIFIER CIRCUIT. (See figure 4-7). The d-c error voltage from the phasing discriminator is applied to the phasing servo amplifier circuit through an audio filter composed of R-611 and C-610 and a lead network, and converted into a 400 cps square wave signal by Chopper G-601. The amplifier circuit functions in the same manner as the loading servo amplifier, except for the use of separate sub-components, the designations of which are apparent by comparison of the simplified schematic diagrams (see figures 4-6 and 4-7). Voltage divider R-629 and R-208 (see figure 4-2) provides negative voltage to the grid of V-602B, which reduces the sensitivity as frequency increases.

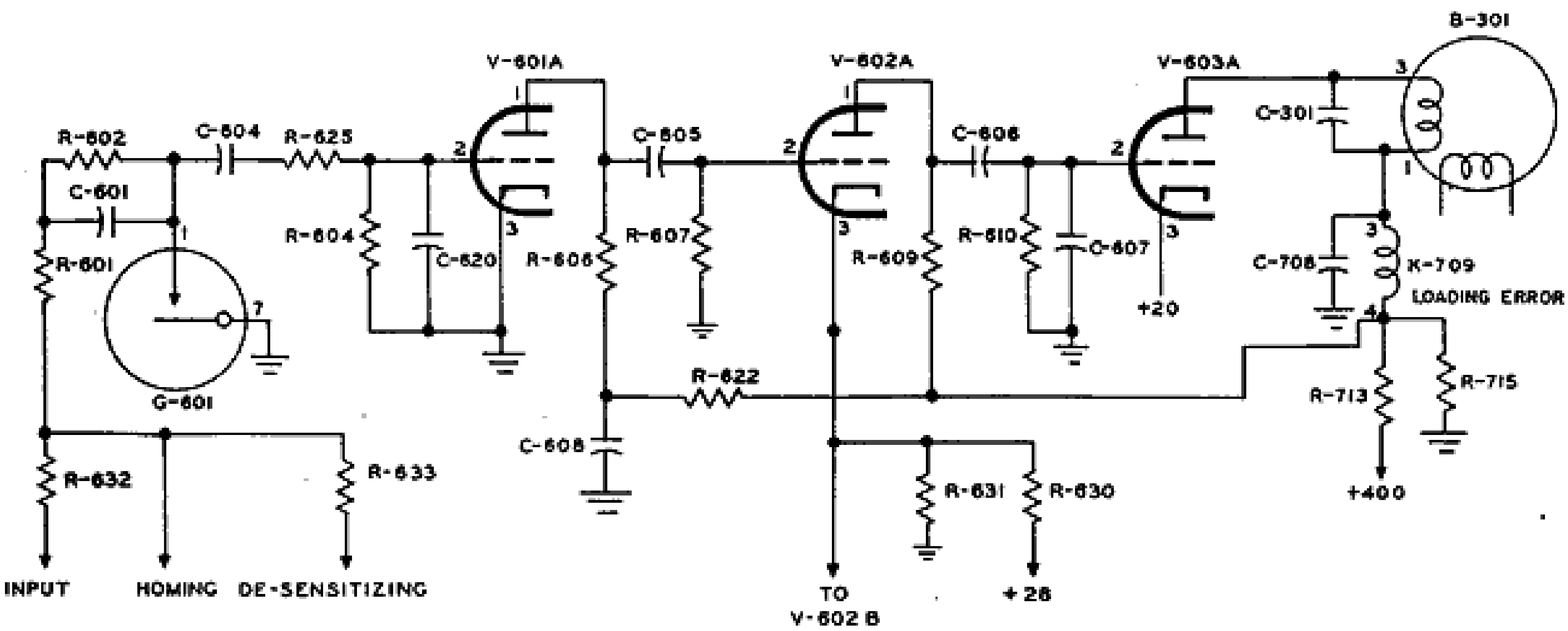

Figure 4-6. Loading Servo Amplifier, Simplified Schematic

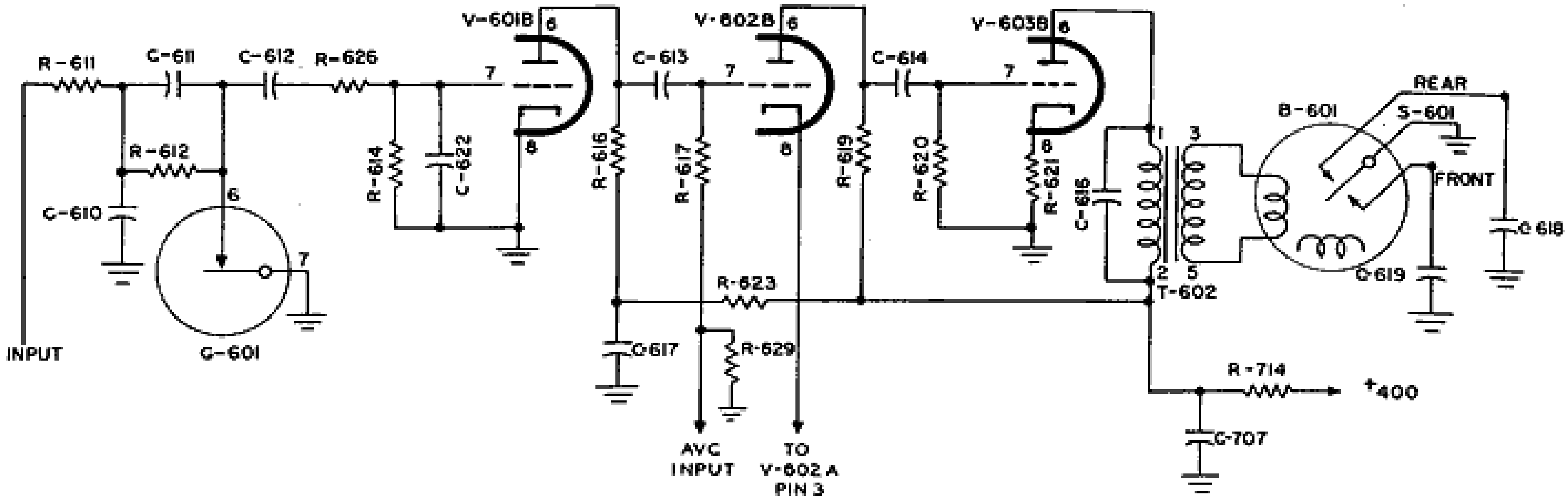

Figure 4-7. Phasing Servo Amplifier, Simplified Schematic Diagram

4-18. OUTPUT CIRCUIT. The plate load of power output tube V-603B is the primary of Transformer T-602. The secondary of the step-down transformer provides one phase input of Motor B-601, which is mounted on the servo amplifier chassis and does not drive the series tuning elements directly. The motor operates S-601, providing proper information to the control circuit. If an inductive error is present, B-601 attempts to run counterclockwise, grounding lead (11) of J-601, and indicating to the control circuit that the error is inductive. If a capacitive error exists, the motor attempts to run clockwise, grounding lead (3) of J-601 and indicating to the control circuit that the error is capacitive. The phasing amplifier can now be described, from the preceding discussion, as an on-off device, control of which is determined by the error voltage level in the input circuit. C-618 and C-619 are included in the amplifier as spark suppressors for S-601.

4-19. ELECTRICAL-MECHANICAL THEORY, CONTROL CIRCUITS.

4-20. GENERAL. Operation of the control circuits is considered, in the text that follows, as a sequence with seven broad subdivisions:

a. Selection of channel or operating frequency.

b. Automatic keying of the associated transmitter, either as a function of channel selection or after a manual start. (See paragraph 3-18.)

c. Homing of the r-f autotransformer to center tap.

d. Starting of the phasing system in a home direction toward minimum values of inductance and capacitance.

e. Further operation of the phasing system in a mechanical cycle, which is interrupted as the phasing discriminator analyzes the specific reactance problem presented by the antenna, and takes control of the phasing system, providing sense information which will bring the antenna to resonance and stop the excursion of series phasing elements; this taking place either at the time when it is possible for series elements alone to phase, or resonate, the antenna, or after the necessity for shunt antenna capacitance has been proved.

f. Further operation of the r-f autotransformer until antenna loading is correct and the antenna system is fully tuned.

g. Interruption of the automatic keying function, leaving the complete radio set ready for operation on a selected channel.

4-21. Explanations of control circuit operation which follow are keyed to a master block diagram, figure 4-8. Other diagrams, texts and tables are used to expand upon the broad subdivisions of the master block diagram. Following this series of explanations, circuits are reviewed by detailed tracing, to assist maintenance personnel toward complete understanding of the Antenna Tuner's operation.

4-22. DEFINITIONS. In the following text, repeated reference will be made to several terms, which are defined as follows:

a. R-F ERROR. The condition in which a phasing or loading error, or both, exists (as further defined below).

b. PHASING ERROR. A condition of r-f error which is further defined as either inductive or capacitive. That is, a condition in which the discriminator is unbalanced by excess inductance or excess capacitance, respectively, appearing in the antenna circuit.

c. LOADING ERROR. The condition in which antenna and series tuning elements present a load of more or less than 52 ohms to the transmitter, and the loading discriminator is therefore unbalanced. This condition of unbalance may also be a forced condition introduced to achieve desired results.

d. CONTROL CIRCUIT ERROR LINE. A control circuit which is grounded at any time r-f error exists. If K-707 is operated, the line allows operation of the maximum reversing relay (refer to paragraph 4-23, below), holds the keying relay, time delay relay and may hold either of the two reversing relays until the r-f error has been reduced to zero.

4-23. RELAY FUNCTIONS. Since control circuit operation involves action of 11 relays, it is most convenient to identify each and describe its function briefly, as a preliminary step. Thereafter in this discussion, reference is generally made to the relay concerned by item number, in the same manner as identification on schematic diagrams. Block diagrams include full identification of each relay.

a. K-701 (COIL-CAPACITOR SWITCHING RELAY).

1. When not operated, allows Phasing System Motor B-401 (driving Inductor L-401) to run.

2. When operated, allows Phasing System Motor B-501 (driving Capacitor C-501) to run.

b. K-702 (HOMING RELAY). When operated:

1. Runs the r-f autotransformer (T-301, Motor B-301) toward minimum, which is the grounded end of the transformer coil, nearest the assembly's gear train.

2. Disables Motors B-401 and B-501 and relay K-703 and K-704 so they cannot operate during the period of operation of K-702.

3. Operates K-706 (refer to sub-paragraph f., below) when r-f is present in the antenna circuit.

c. K-703 (CAPACITIVE ERROR RELAY).

1. Operates at any time capacitive phasing error is apparent to the phasing disciminator.

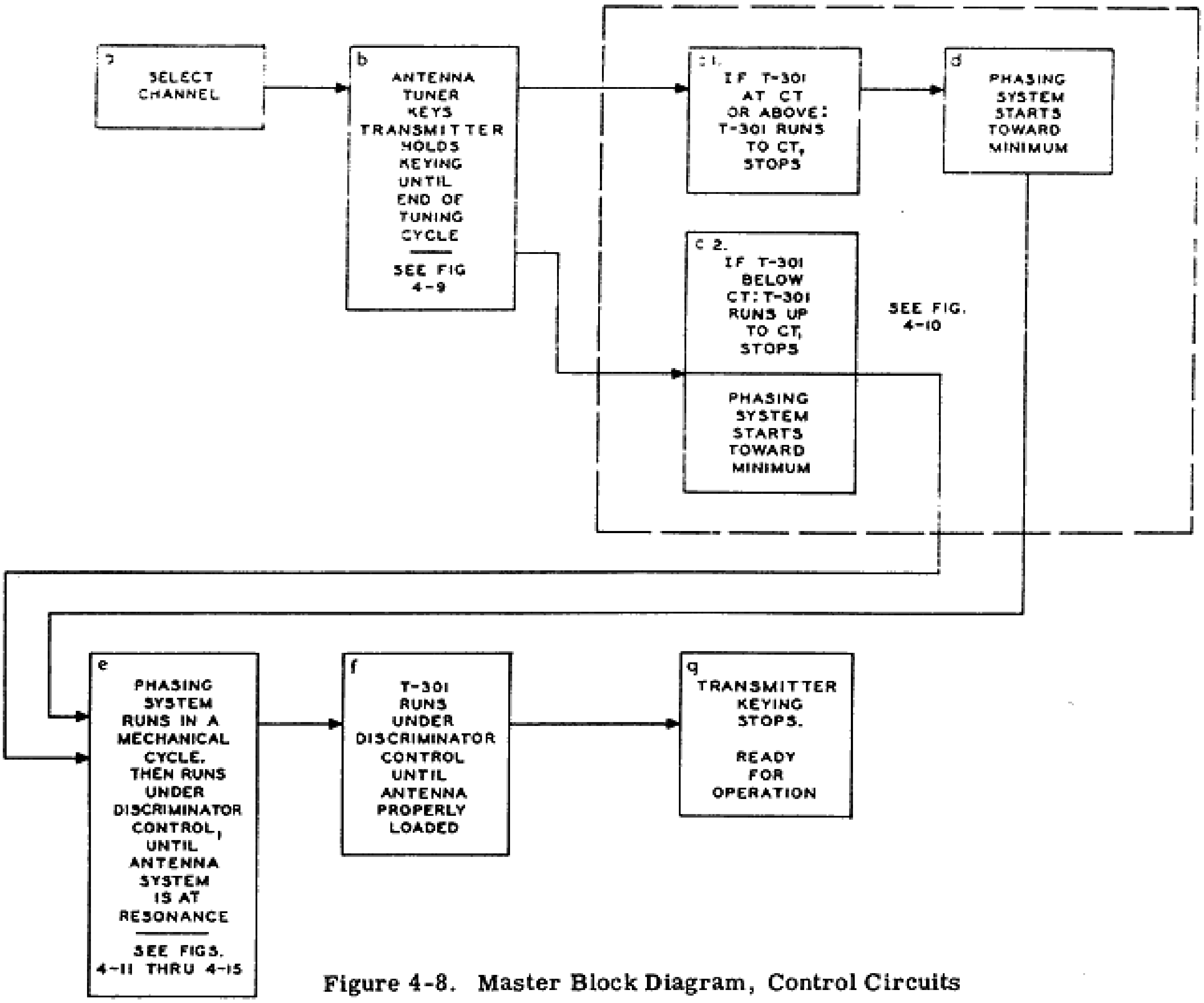

Figure 4-8. Master Block Diagram, Control Circuits

ASSEMBLY MODIFICATIONS INCLUDED IN THIS SCHEMATIC

ASSEMBLY	MOD NO
DISCRIMINATOR	1
AUTOTRANSFORMER	2
SERVO AMPLIFIER	3
VARIABLE INDUCTOR	2
VARIABLE CAPACITOR	1
CABLE	4

NOTES:

1. AUTOMATIC KEYING WHEN TRANSMITTER CHANNELED - CONNECT 1 TO 5 ON TB-704.
2. AUTOMATIC KEYING WHEN KEY PRESSED - CONNECT 2 TO 5 ON TB-704.
3. FOR OPERATION WITH 250 VOLTS (J-102, PIN 14, CONNECT 3 TO 7 AND 4 TO 7 ON TB-704.
4. UNLESS OTHERWISE INDICATED, ALL RESISTANCE VALUES ARE IN OHMS, ALL CAPACITANCE VALUES ARE IN MICROMICROFARADS, ALL INDUCTANCE VALUES ARE IN MICROHENRYS.
   K = THOUSANDS OF OHMS
   MEG = MILLIONS OF OHMS
   UF = MICROFARADS
   MH = MILLIHENRYS
5. REFER TO TABLE FOR ASSEMBLY MODIFICATIONS INCLUDED IN THIS SCHEMATIC.
6. R-635 MAY OR MAY NOT BE ADDED IN PRODUCTION TEST, DEPENDING ON THE SENSITIVITY REQUIRED TO OPERATE S-601.

Figure 7-11. Automatic Antenna Tuner 180L-3A Over-all Schematic Diagram