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HANDBOOK
SERVICE INSTRUCTIONS

VARIABLE MASTER OSCILLATOR TYPE 115 MODEL 1

(NORTHERN RADIO CO., INC.)

PUBLISHED UNDER AUTHORITY OF THE SECRETARY OF THE AIR FORCE
AND THE CHIEF OF THE BUREAU OF AERONAUTICS

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A

TABLE OF CONTENTS

Section		*Page*
I	**DESCRIPTION AND LEADING PARTICULARS**	1
	1–1. Scope of Handbook	1
	1–3. Purpose of Equipment	1
	1–7. Condensed Factual Data	1
II	**SPECIAL TEST EQUIPMENT AND SPECIAL TOOLS**	5
	2–1. Special Test Equipment	5
	2–3. Special Tools	5
III	**PREPARATION FOR USE AND RESHIPMENT**	5
	3–1. Uncrating	5
	3–4. Installation	5
	3–10. Repacking	7
IV	**THEORY OF OPERATION**	8
	4–1. Functional Operation of Variable Master Oscillator	8
	4–3. Block Diagram Discussion	8
	4–9. Detailed Stage Analysis	9
V	**ORGANIZATIONAL AND OPERATIONAL MAINTENANCE**	17
	5–1. Minimum Performance Standards	17
	5–3. System Trouble Analysis	17
	5–5. Removal of Assemblies	17
	5–7. Disassembly	19
	5–9. Minor Repair and Adjustment	20
	5–16. Lubrication	22
	5–18. Inspection Schedule	22
VI	**FIELD AND FASRON MAINTENANCE**	23
	6–1. Minimum Performance Standards	23
	6–3. System Trouble Analysis	23
	6–5. Disassembly	23
	6–7. Reassembly	23
	6–9. Alignment and Adjustment	23
	6–17. Overhaul Schedule	25
VII	**DIAGRAMS**	25

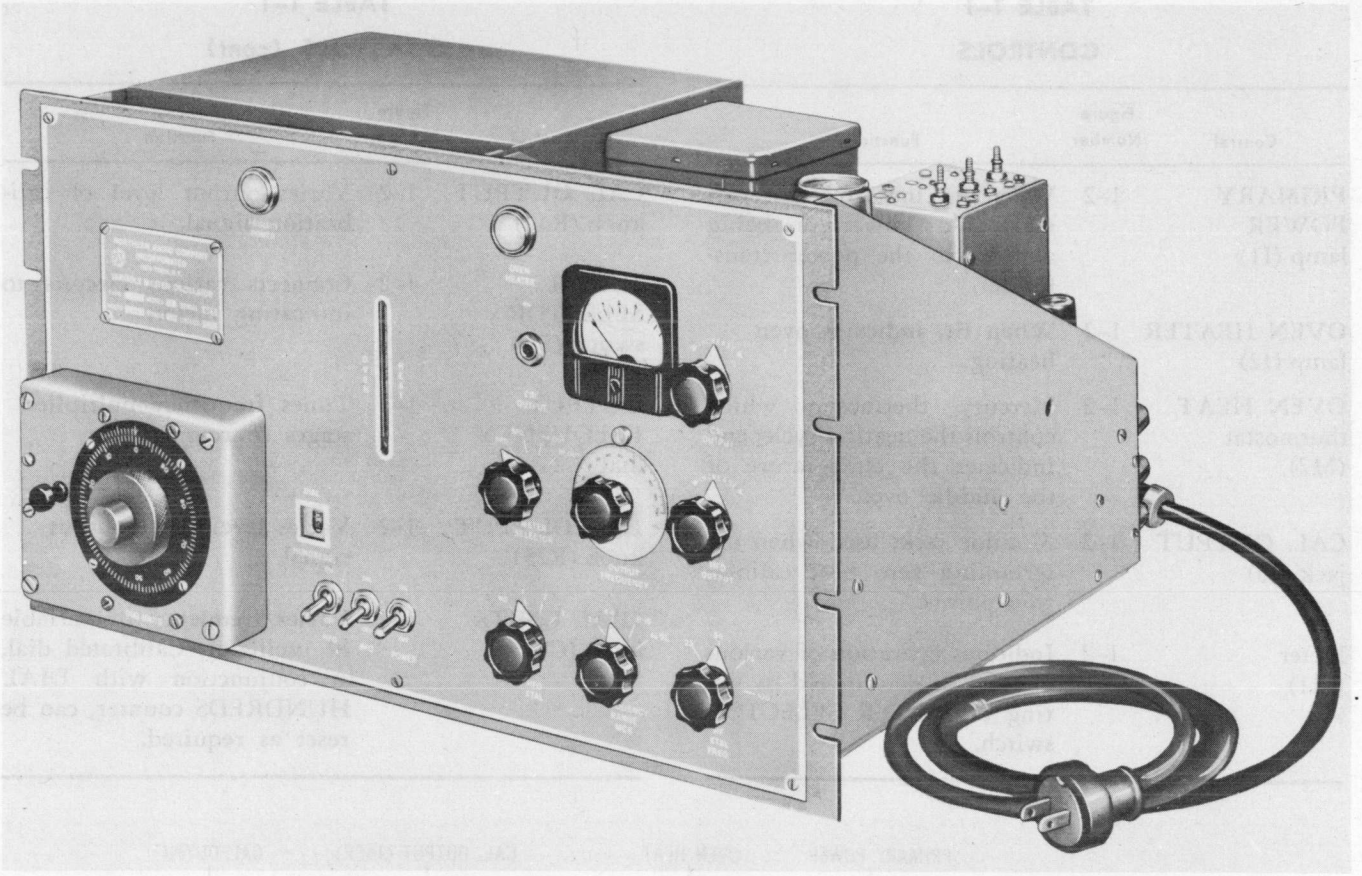


Figure 1-1. Variable Master Oscillator Type 115 Model 1

SECTION I
DESCRIPTION AND LEADING PARTICULARS

1-1. SCOPE OF HANDBOOK.

1-2. This handbook of service instructions covers the theory of operation, servicing, and maintenance of Variable Master Oscillator Type 115 Model 1, manufactured by the Northern Radio Company, Incorporated, New York, N. Y. Instructions for the complete mechanical disassembly of the unit are included so that maintenance personnel can perform their work quickly and accurately.

1-3. PURPOSE OF EQUIPMENT.

1-4. The variable master oscillator, shown in figure 1-1, can be operated as a fixed or variable frequency exciter. As a variable frequency exciter, it provides signals whose frequency stability is equivalent to that obtainable with non-temperature controlled, crystal oscillators. As a fixed-frequency exciter (crystal oscillator) it operates with stability equivalent to that of the crystals employed, and is used where pre-assigned frequencies are required.

1-5. The oscillator can be used for exciting a transmitter, for supplying local oscillator injection voltage to receivers, or for other applications where r-f signals are required for testing and measuring purposes. Front panel controls are provided for the selection, adjustment, and control of the various r-f outputs which are available.

1-6. The variable master oscillator consists of a high frequency (hf) oscillator that can be operated at any one of three pre-set crystal frequencies in the range of 2 to 4 mc, or any continuously variable frequency in the range of 2 to 4 mc. Either hf oscillator output can be applied to a series of frequency-multipliers that are connected in combinations suitable for obtaining frequencies in the range of 2 to 32 mc. A separate low-frequency crystal oscillator, operating in the range of 450 kc to 475 kc, supplies a stable output that can be used in a receiver as the beat frequency oscillator (bfo) signal for the reception of cw signals.

1-7. CONDENSED FACTUAL DATA.

1-8. CONTROLS. Table 1-1 lists the controls of the variable master oscillator. See figures 1-2 and 1-3, as indicated, for the location of these parts.

TABLE 1–1

CONTROLS

Control	Figure Number	Function
PRIMARY POWER lamp (I1)	1–2	When lit, indicates that primary a-c power is being applied to the power transformer.
OVEN HEATER lamp (I2)	1–2	When lit, indicates oven heating.
OVEN HEAT thermostat (M2)	1–2	Mercury thermostat which controls the heating cycle, and indicates the temperature of the middle oven.
CAL. OUTPUT jack (J6)	1–2	Monitor jack, used when determining zero beat calibration points.
Meter (M1)	1–2	Indicates operation of various circuits, as determined by setting of METER SELECTOR switch.

TABLE 1–1

CONTROLS (cont)

Control	Figure Number	Function
CAL. OUTPUT knob (R42)	1–2	Varies output level of calibration signal.
METER SELECTOR switch (S5)	1–2	Connects various circuits to indicating meter.
OUTPUT FREQUENCY dial (C24)	1–2	Tunes frequency-multiplier stages to resonance.
HFO OUTPUT knob (R25)	1–2	Varies level of hf output signal.
DIAL UNITS knob (C1)	1–2	Varies frequency of variable hf oscillator. Calibrated dial, in conjunction with DIAL HUNDREDS counter, can be reset as required.

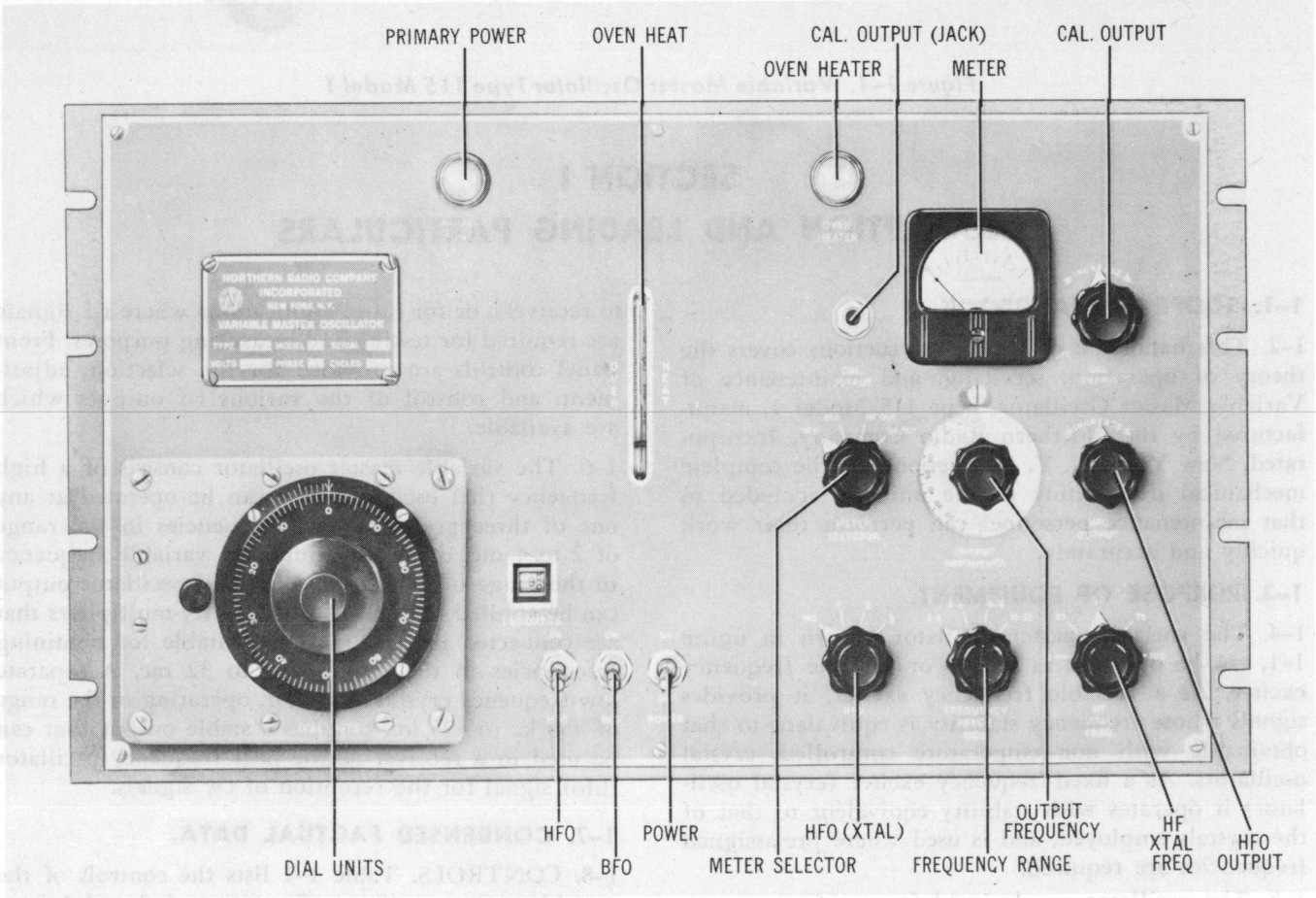


Figure 1–2. Variable Master Oscillator, Front Panel Controls

TABLE 1-1

CONTROLS (cont)

Control	Figure Number	Function
HFO switch (S2)	1-2	In ON position, energizes buffer amplifiers. This applies output of either hf oscillator to frequency-multiplier stages. Operated in conjunction with HFO XTAL switch.
BFO switch (S3)	1-2	Turns BFO section on and off.
POWER switch (S1)	1-2	In ON position, applies primary power to transformer, and oven thermal control system.
HFO XTAL switch (S6)	1-2	In MO position, applies output of variable hf oscillator to buffer amplifiers. In positions 1, 2, or 3, energizes crystal hf oscillator, selects desired crystal, and applies output of crystal oscillator to buffer amplifier. Operated in conjunction with the HFO switch.
FREQUENCY RANGE MCS switch (S7)	1-2	Connects the frequency-multiplier stages, as required, to obtain the desired frequency range.
HF XTAL FREQ. knob (C6)	1-2	Vernier control to change the frequency of the hf crystal oscillator. Numbers have no significance, except for logging purposes with specific crystals.
HFO jacks (J5, J7, 8)	1-3	Coaxial jacks that provide r-f output signals.
P.P. fuse (F1)	1-3	Main fuse for line protection.

TABLE 1-1

CONTROLS (cont)

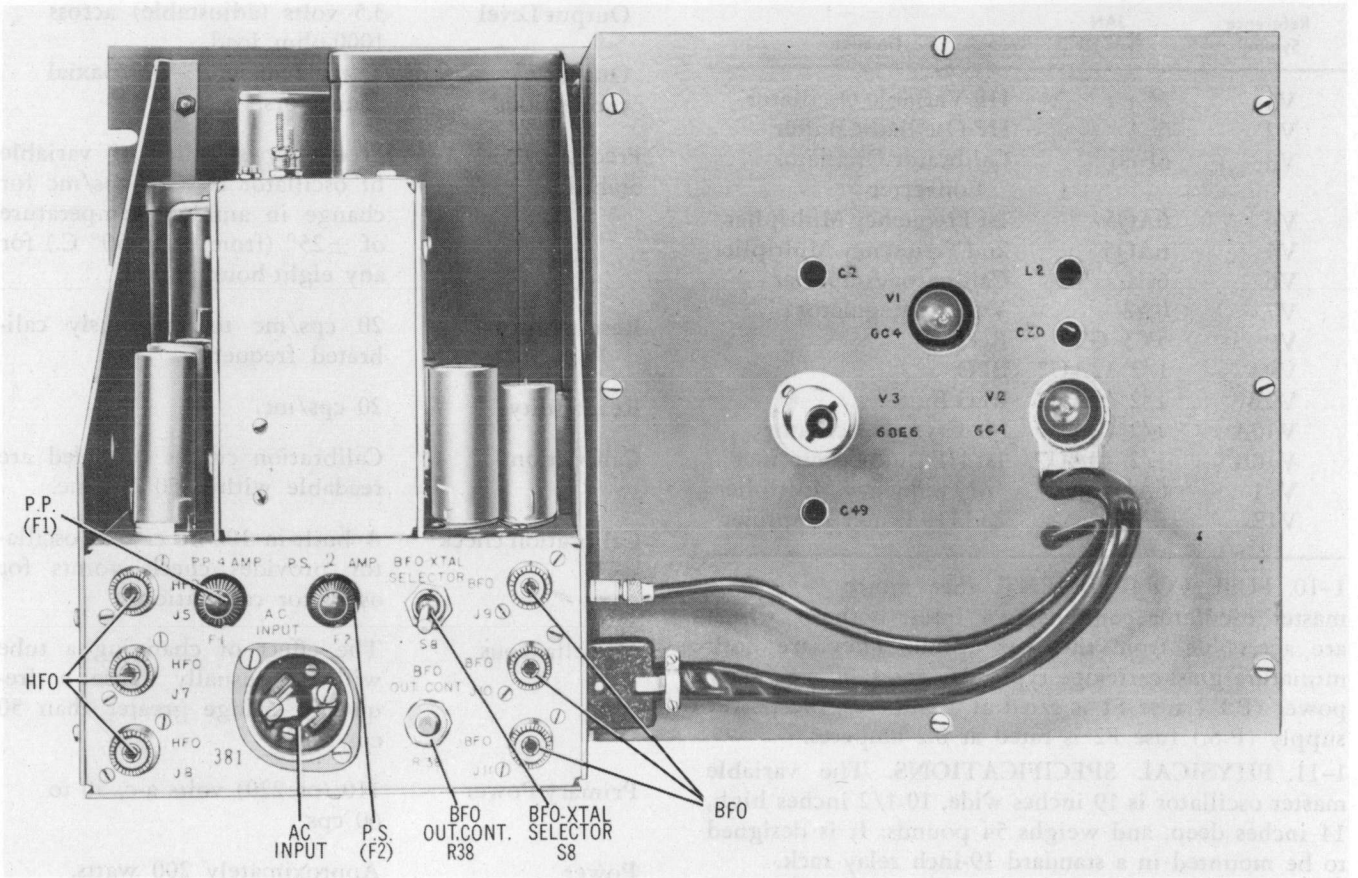


Figure 1-3. Variable Master Oscillator, Rear Panel Controls

TABLE 1–1

CONTROLS (cont)

Control	Figure Number	Function
P.S. fuse (F2)	1–3	Secondary fuse for circuit failure protection.
BFO–XTAL SELECTOR switch (S8)	1–3	Connects one of two crystals into BFO circuit.
BFO OUT. CONT. adjustment (R38)	1–3	Controls magnitude of BFO output signals.
BFO jacks (J9, J10, J11)	1–3	Coaxial jacks that provide BFO output signals.
AC INPUT jack (J1)	1–3	Primary power receptacle.

1–9. TUBE COMPLEMENT. (See figures 5–2 and 5–3.) Table 1–2 lists each variable master oscillator tube and its function.

TABLE 1–2

TUBE COMPLEMENT

Reference Symbol	JAN Type No.	Function
V1	6C4	HF Variable Oscillator
V2	6C4	HF Oscillator Buffer
V3	6BE6	Calibrator Oscillator-Converter
V4	6AQ5	1st Frequency Multiplier
V5	6AQ5	2nd Frequency Multiplier
V6	6C4	Calibrator Amplifier
V7	0A2	Voltage Regulator
V8	5Y3 GT	Rectifier
V9A	1/2 12AU7	BFO
V9B	1/2 12AU7	BFO Buffer
V10A	1/2 12AU7	HF Crystal Oscillator
V10B	1/2 12AU7	1st HF Buffer Amplifier
V11	6AQ5	3rd Frequency Multiplier
V12	6AQ5	2nd HF Buffer Amplifier

1–10. FUSE COMPLEMENT. (See figure 1–3.) The master oscillator contains two fuses, both of which are accessible from the rear apron. They are both miniature glass-cartridge type 3AG fuses. The primary power (P.P.) fuse F1 is rated at 4 amperes, the power supply (P.S.) fuse F2 is rated at 0.2 amperes.

1–11. PHYSICAL SPECIFICATIONS. The variable master oscillator is 19 inches wide, 10-1/2 inches high, 14 inches deep, and weighs 54 pounds. It is designed to be mounted in a standard 19-inch relay rack.

1–12. TECHNICAL DATA. Table 1–3 contains the technical data for the master oscillator.

TABLE 1–3

TECHNICAL DATA

Output Frequency Range	2 to 32 mc.
HFO	
Variable HF Oscillator Output Frequency	2 to 4 mc.
Crystal Frequencies	2 to 4 mc.
Crystal HF Oscillator Output Frequency	2 to 4 mc.
Output Voltage Waveshape	Essentially sinusoidal for all frequencies.
Output Level	2 watts at 2 to 4 mc, 0.5 watt at 4 to 32 mc.
Output Connections	Three female 83–IR coaxial jacks.
Output Impedance	75 ohms.
BFO	
Frequency Range	450 to 475 kc.
Output Level	3.5 volts (adjustable) across 1000-ohm load.
Output connections	Three female 83–IR coaxial connectors.
Frequency Stability	Frequency stability of variable hf oscillator is ±20 cps/mc for change in ambient temperature of ±25° (from 0° to 50° C.) for any eight-hour period.
Resettability	20 cps/mc to previously calibrated frequency.
Readability	20 cps/mc.
Calibration	Calibration curves provided are readable within 50 cps/mc.
Calibration check	A built-in 100-kc crystal oscillator provides check points for oscillator calibration.
Miscellaneous	The effect of changing a tube will not usually cause a frequency change greater than 50 cps/mc.
Primary Power	110 (or 220) volts a-c, 50 to 60 cps.
Power Consumption	Approximately 200 watts.

SECTION II
SPECIAL TEST EQUIPMENT AND SPECIAL TOOLS

2-1. SPECIAL TEST EQUIPMENT.

2-2. No special test equipment has been procured by the government specifically for use with the master oscillator.

2-3. SPECIAL TOOLS.

2-4. One special Allen wrench NRC257, shown in figure 2-1, is packed with the equipment. It is used to loosen the set screws on the flexible coupling located between the oven and the front panel (see figure 5-2).

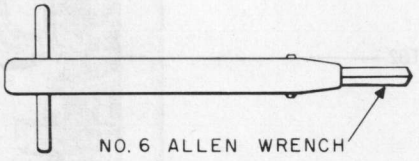


Figure 2-1. Special Allen Wrench NRC 257

SECTION III
PREPARATION FOR USE AND RESHIPMENT

3-1. UNCRATING.

3-2. GENERAL. The variable master oscillator is packed in a wooden export packing crate whose gross weight is 100 pounds. The case is 29 inches wide, 22-3/4 inches high, and 15 inches deep. In order to unpack the crate, follow the procedure described in paragraph 3-3.

3-3. UNCRATING PROCEDURE.

a. Remove the packing case top lid by removing the nails with a nail puller.

b. Cut the tape and the seals of the case liner. Be careful not to damage the liner more than is necessary.

c. Cut the tape that seals the top flap of the inner container. Open the container and remove the moisture-vapor proof barrier.

d. Open the innermost container. Remove the master oscillator, envelopes, and desiccant.

e. Place the variable master oscillator, the envelope that contains the line cord, the envelope that contains the coaxial connectors and the Allen wrench, and the two envelopes containing instruction books, in a safe clean place.

f. Save all packing material, including the desiccant, for later use.

3-4. INSTALLATION.

3-5. GENERAL. The master oscillator is designed to be mounted in a standard 19-inch relay rack or other suitable mounting device. If the unit is mounted in a cabinet, allow sufficient ventilation to avoid overheating of parts.

3-6. All tubes are shipped in place. Make sure that the proper tube is seated in each socket (see figures 5-2 and 5-3). Bolt the variable master oscillator to the relay rack frame, using machine-screws, and lockwashers and nuts, if required.

3-7. ELECTRIC CONNECTIONS.

3-8. The variable master oscillator can be operated from either a 110-volt or a 220-volt, 50 to 60 cps, a-c source. It leaves the factory wired for 110-volt operation. If operation from a 220-volt source is required, make the necessary power transformer and oven thermal control system wiring changes. These changes are as follows:

a. Separate the power supply from the electronic chassis by removing the eight screws that secure it. Lift the power supply up, taking care not to damage P12 or J12.

b. Disconnect the strapping between terminals 1, 3, and 2, 4 on transformer T1. Do not unsolder the leads from P12 to terminals 1 and 4.

c. Connect terminals 2 and 3 together.

d. Replace the power supply unit.

e. Remove the shorting straps across resistors R58 and R64 on terminal board TB2 (see figure 3-1).

f. Disassemble the oven as described in paragraph 5-8.

g. On terminal board E6 in the middle oven (see figure 3-2) unsolder the lead connected to terminal 1. Solder this lead to terminal 2. Remove the jumper between terminals 2 and 3.

h. Reassemble and replace the oven by reversing the procedures described in paragraphs 5-6 and 5-8.

3-9. Connect the line cord to the recessed AC INPUT male connector, at the rear of the unit, and to the source of primary power. Fabricate the r-f output

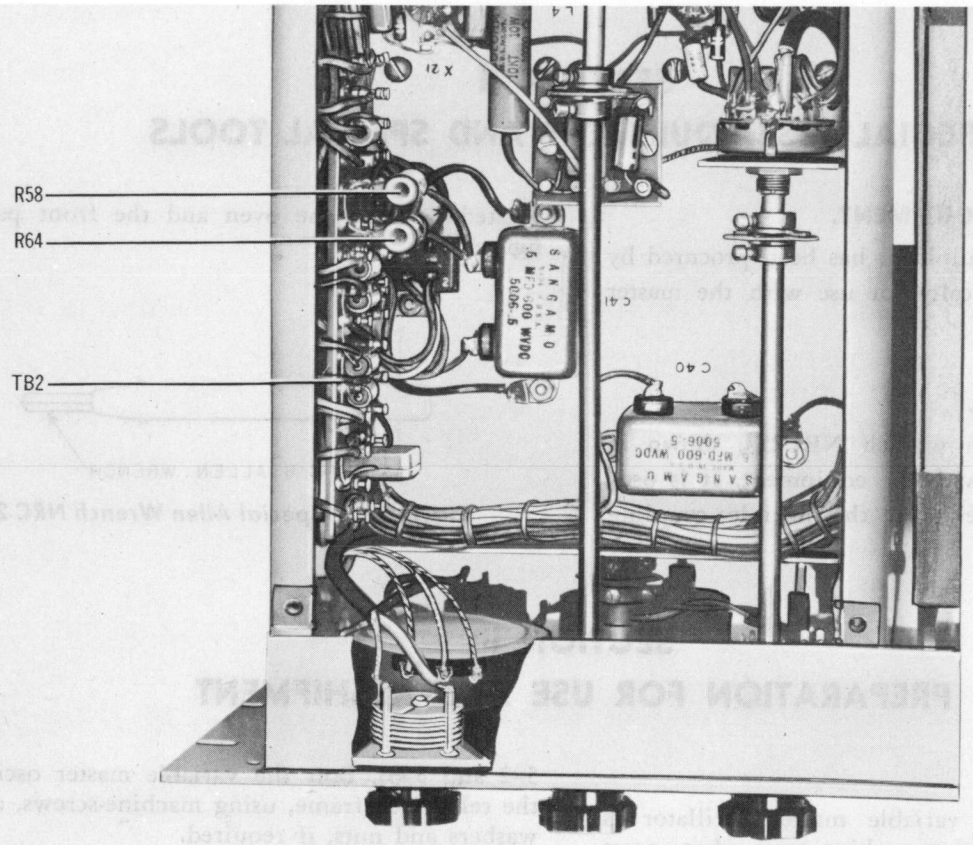


Figure 3–1. Main Chassis, Location of Components

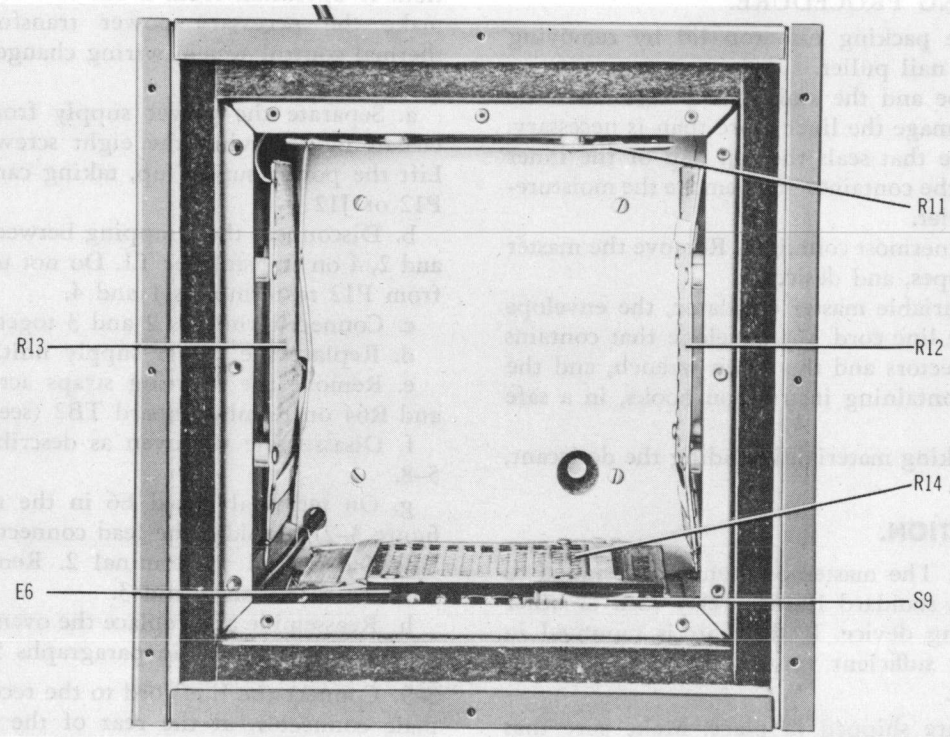
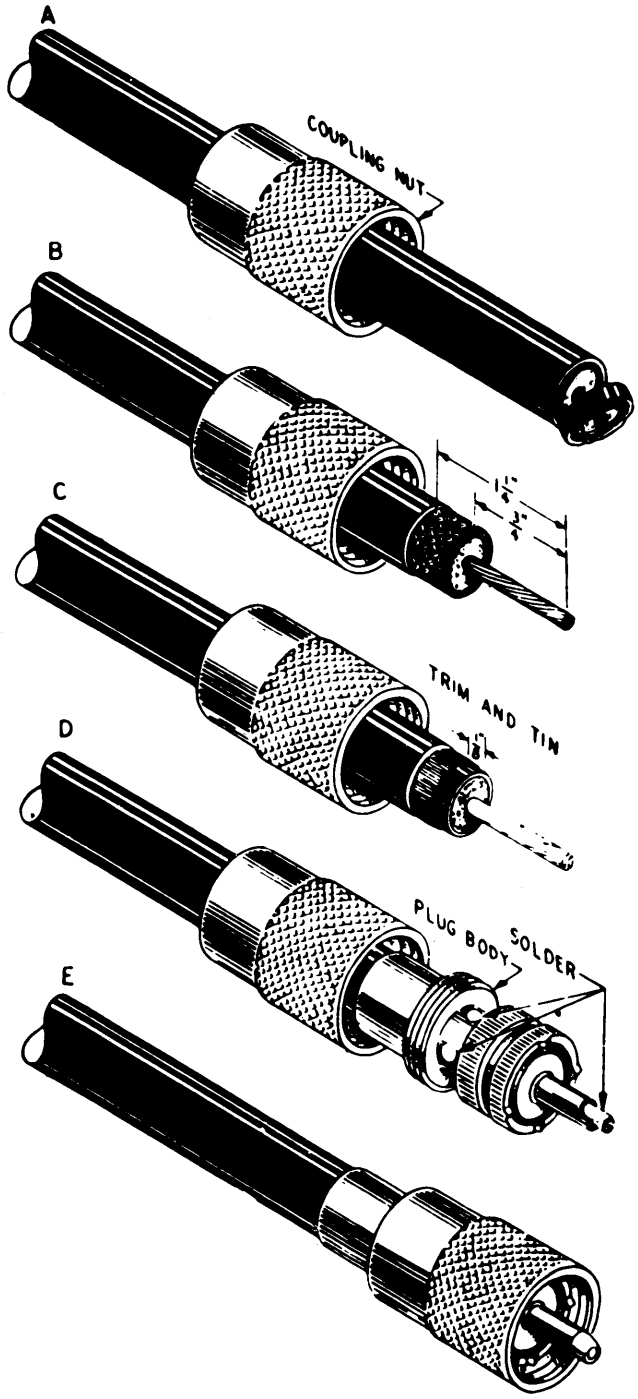


Figure 3–2. Middle Oven, Location of Components

cables as required, as shown in figure 3-3, using the three 83-1SP coaxial connectors supplied. Connect these cables to the HFO and BFO output jacks (see figure 1-3) as required. Each set of three jacks are parallel-connected; therefore it makes no difference which of the jacks is selected for a particular application.

3-10. REPACKING.

3-11. To repack the variable master oscillator, reverse the unpacking procedure outlined in paragraph 3-3.



(A) Square off the end of the RG-11/U cable. Slide the coupling nut over the cable.

(B) Cut the outer jacket of the cable 1¼" from the end. Be careful not to nick the copper braid underneath. Cut the copper braid and inner insulation ¾" from the end.

(C) Fan out, trim, and tin the copper braid.

(D) Screw the plug body over the outer jacket until 1/16" of the inner conductor is exposed. Be careful not to push back the copper braid. Solder the plug body to the copper braid through the 4 holes provided. Solder the inner conductor to the contact sleeve. Remove any excess solder and cut off the inner conductor where it projects past the contact sleeve.

(E) Slide the coupling nut forward until it is free from the internal thread.

Figure 3-3. Cable Fabrication Instructions

SECTION IV
THEORY OF OPERATION

4–1. FUNCTIONAL OPERATION OF VARIABLE MASTER OSCILLATOR.

4–2. The variable master oscillator generates radio frequency (r-f) signals in the range of 2 to 32 mc. It also generates r-f signals in the range of 450 to 475 kc. These essentially sinusoidal outputs can be used in any application or system that requires highly stable r-f inputs (i.e., local oscillator voltage in diversity receivers, transmitter exciter signal, bfo signal, etc.).

4–3. BLOCK DIAGRAM DISCUSSION.

4–4. The variable master oscillator block diagram (see figure 4–1) shows the various circuits in which signals are generated, amplified, frequency-multiplied, and otherwise acted upon. Refer to the paragraphs that follow for a functional description of each of these stages.

4–5. The variable hf oscillator V1 produces r-f signals in the range of 2 to 4 mc. These continuously variable signals are applied through variable hf oscillator buffer amplifier V2 to contacts on HFO XTAL switch S6. Signals from crystal hf oscillator V10A are also supplied to contacts on switch S6. Depending upon the switch position, either the variable frequency signal or one of the three crystal frequency signals is applied through the 1st and 2nd buffer amplifiers V10B and V12 to the 1st frequency multiplier V4. The setting of FREQUENCY RANGE switch S7 determines which of the frequency multipliers shall be operative at any given time, and it thus determines how much frequency multiplication any given signal shall undergo. Table 4–1 lists the output frequency of each of the frequency multipliers, and the output frequency of the frequency multipliers as a unit, for each of the settings of switch S7. As can be noted, the 1st frequency multiplier V4 is operated either as

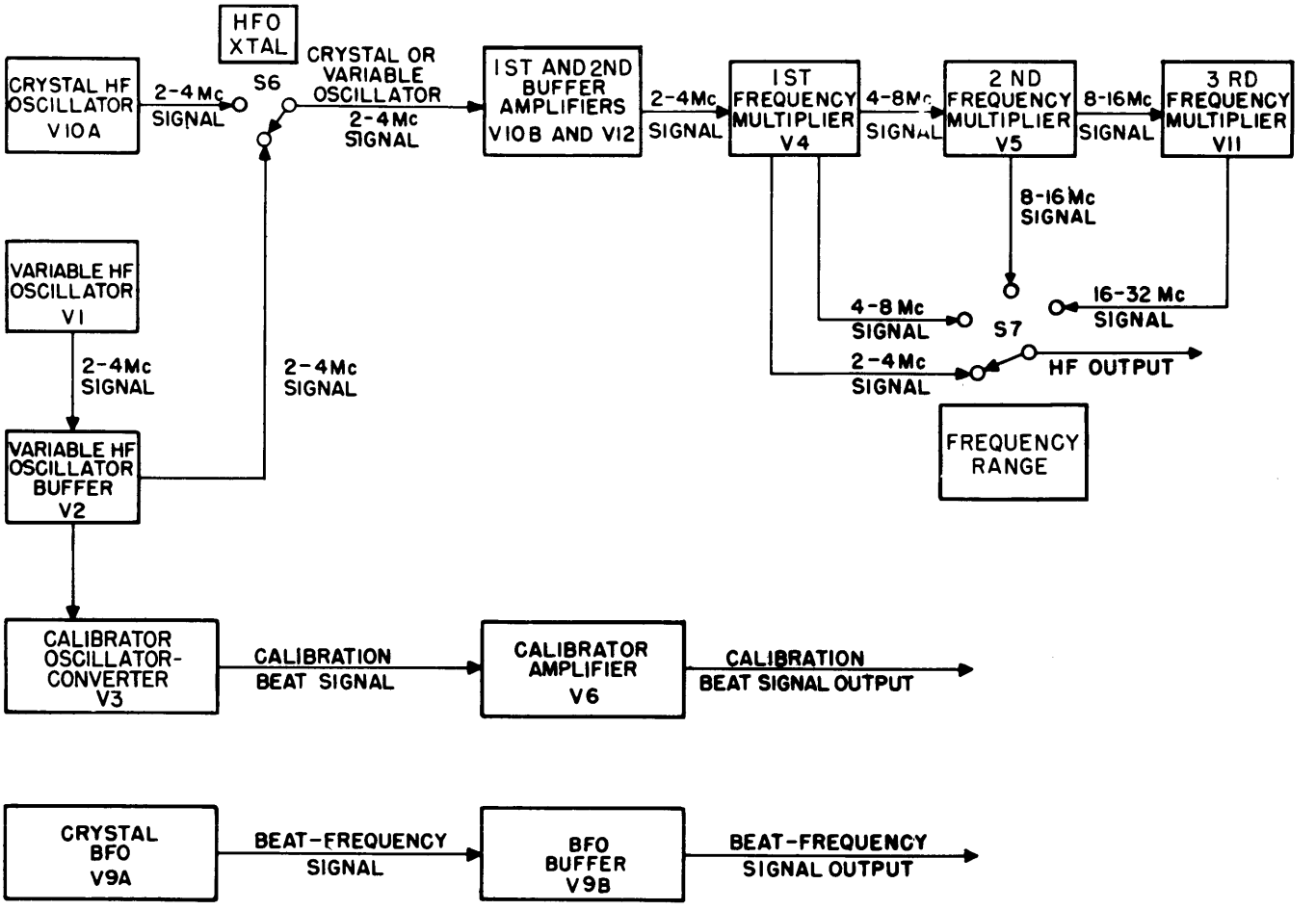


Figure 4–1. Variable Master Oscillat r, Block Diagram

TABLE 4-1

FREQUENCY RANGE OF FREQUENCY MULTIPLIER SECTION

FREQUENCY RANGE Switch (S7) Setting	Output Frequency Range in mc.	Output Range 1st Frequency Multiplier	Output Range 2nd Frequency Multiplier	Output Range 3rd Frequency Multiplier
2-4	2-4	2-4	Inoperative	Inoperative
4-8	4-8	4-8	Inoperative	Inoperative
8-16	8-16	4-8	8-16	Inoperative
16-32	16-32	4-8	8-16	16-32

a straight amplifier or as a doubler for the first two settings of the switch. At this time, the 2nd and 3rd frequency multipliers V5 and V11 are inoperative. For the third switch setting, the output of the 1st frequency multiplier is applied to the 2nd frequency multiplier instead of to the contacts on the FREQUENCY RANGE switch. At this time the 1st and 2nd frequency multipliers are operating as doublers. Therefore, the output frequency of the 2nd frequency multiplier is four times the input frequency of the 1st frequency multiplier. With the switch in the fourth position, the 3rd frequency multiplier V11 becomes operative. The output of the 2nd frequency multiplier is applied to V11 instead of to the contacts on switch S7, therefore the output frequency is eight times the input frequency applied to the 1st frequency multiplier.

4-6. The variable master oscillator is equipped with a 100-kc crystal oscillator that is used for the calibration of the variable hf oscillator fundamental frequency (2 to 4 mc). Calibrating oscillator-converter V3 provides beat signals at twenty main check points spaced at 100-kc intervals. It also provides beat signals for sub-check points located midway between main check points. The weak signals produced at other than main and sub-check points are not used for calibration purposes. A portion of the variable hf oscillator buffer signal is applied to V3 where it is beat with the calibrating oscillator signal. The modulation products are applied through calibrator amplifier V6 to the CAL. OUTPUT jack on the front panel.

4-7. A low frequency r-f signal (450 kc to 475 kc) is produced in the crystal bfo tube V9A and applied through bfo buffer amplifier tube V9B to the BFO output jacks on the rear panel.

4-8. Regulated d-c potentials are applied to the various stages from the output of the power supply (not shown) which consists of rectifier V8 and voltage regulator V7.

4-9. DETAILED STAGE ANALYSIS.

4-10. GENERAL. The detailed stage-by-stage analysis of the master oscillator is contained in the paragraphs that follow. In order to understand the operation of each stage, simplified schematics have been included. They should be referred to while studying the text. See figure 7-1 for the complete schematic diagram.

4-11. VARIABLE HF OSCILLATOR. (See figure 4-2.) This stage consists of a grounded-plate Hartley oscillator. The tuned circuit consists of main tuning capacitor C1, fixed capacitor C56, trimmer capacitor C2, inductor L3, and slug-tuned inductor L2. R-f potentials from the tuned circuit are applied to the grid of tube V1 through the signal bias r-c combination of capacitor C3 and grid leak resistor R1. The cathode of V1 is held above r-f ground by the potential across its tap on inductor L3. The plate is grounded for rf by capacitor C4. A decoupling circuit consisting of coil L8 and capacitor C57 (see figure 7-1) prevents undesirable feedback through the filament circuit.

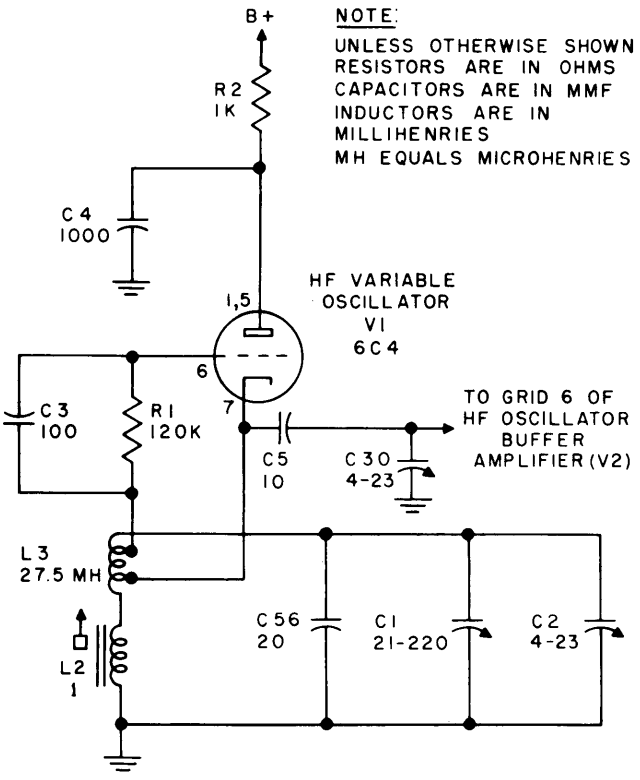


Figure 4-2. Variable HF Oscillator, Simplified Schematic

4–12. VARIABLE HF OSCILLATOR BUFFER. (See figure 4–3.) The buffer stage has a high input impedance to prevent variations of frequency in the oscillator due to load variations. The oscillator output voltage from the cathode of tube V1 is applied to the grid of tube V2 through coupling capacitor C5. Capacitors C5 and C30 are a voltage-dividing network for the voltage input to the buffer. Capacitor C30 is adjusted so that V2 does not draw grid current, which would reflect as a variable load on V1. Resistor R3 is the grid leak resistor for tube V2. The plate voltage is filtered by capacitor C46 and resistor R4. The output from the cathode of tube V2 is applied to contact MO of section C of switch S6 (see figure 7–1).

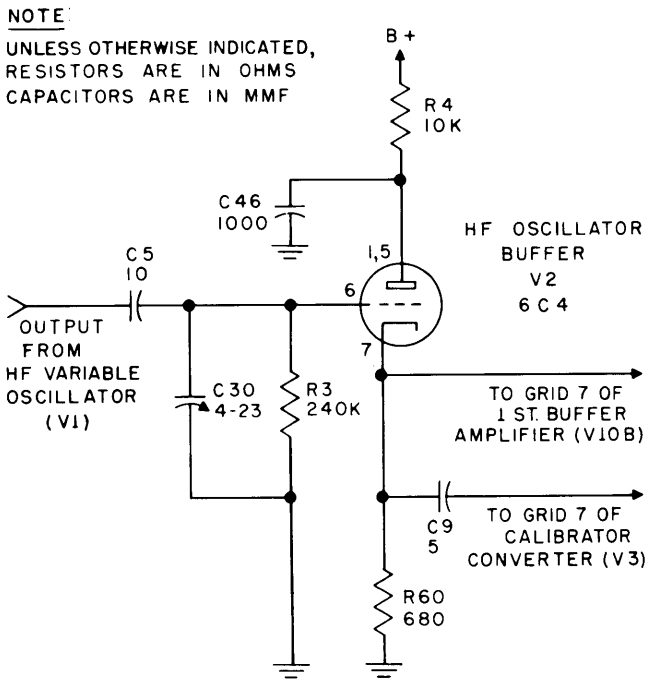
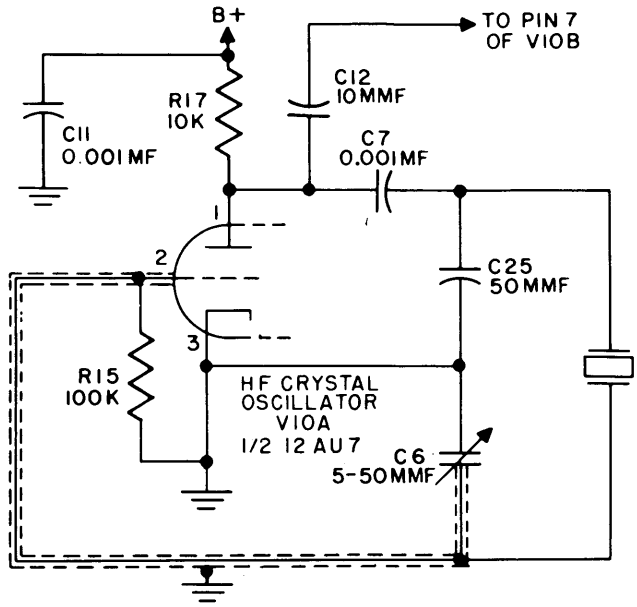


Figure 4–3. Variable HF Oscillator Buffer, Simplified Schematic

4–13. CRYSTAL HF OSCILLATOR. (See figure 4–4.) Throwing the HFO XTAL selector switch S6 to positions 1, 2, or 3 places one of the crystals in the crystal holders XY15, XY16, or XY17, respectively, into the circuit of tube V10A. The bias is supplied by grid leak resistor R15. Variable capacitor C6 provides the grid-to-cathode signal, and is used to vary the crystal oscillator frequency slightly. Capacitor C25 provides feedback to the cathode and capacitor C7 is a d-c blocking condenser between the plate and the crystal. The plate voltage is filtered by resistor R17 and capacitor C11. The output of the oscillator is applied to contacts 1, 2, or 3 of section C of the HFO XTAL selector switch S6.

4–14. 1ST AND 2ND BUFFER AMPLIFIERS. (See figure 4–5.) The signal from either the crystal or the variable oscillator is applied to the grid of buffer



NOTE ALL RESISTANCES IN OHMS UNLESS OTHERWISE SPECIFIED.

Figure 4–4. Crystal HF Oscillator, Simplified Schematic

amplifier V10B through section C of switch S6 and coupling capacitor C12. Bias for the tube is supplied by grid leak resistor R16 and by cathode resistor R59 in parallel with by-pass capacitor C50. Plate voltage for tube V10B is applied from the power supply through HFO (ON-OFF) switch S2, and is filtered by resistor R18 and capacitor C39. The output of tube V10B is applied to the second buffer amplifier V12 through coupling capacitor C61. Bias is supplied for this tube by cathode bias resistor R29 in parallel with by-pass capacitor C62, and by grid leak resistor R63. Resistor R61 is the plate load resistor, resistor R62 is the screen grid voltage dropping resistor, and capacitor C63 is the screen grid by-pass. The output of the 2nd buffer amplifier is applied to the frequency multipliers.

4–15. 1ST, 2ND, AND 3RD FREQUENCY MULTIPLIERS.

4–16. GENERAL. Because the fundamental frequencies of the variable hf and crystal hf oscillators are between 2 and 4 megacycles, it is necessary to use frequency doubler stages (V4, V5, and V11) to provide the 2 to 32-mc frequency range of the unit. Each frequency doubler stage is an amplifier whose output is tuned to twice the input frequency applied to its grid. The operation of these stages depends upon the setting of the frequency range switch as described in paragraphs 4–17 through 4–20.

4–17. 2 TO 4 MEGACYCLES OPERATION. (See figure 4–6.) When FREQUENCY RANGE switch S7 is set to 2–4, the output of the 2nd buffer amplifier is applied to the grid of the 1st frequency multiplier through coupling capacitor C23. Bias for V4 is sup-

plied by cathode resistor R21 in parallel with by-pass capacitor C20 and by grid leak resistor R23. The screen grid voltage from the power supply is applied through resistor R53, HFO OUTPUT potentiometer R25, and resistor R20. Resistor R46 is a screen bleeder resistor. Capacitor C21 is the screen by-pass. Plate voltage is applied from the power supply through the primary winding of inductor L4, and is filtered by resistor R19 and capacitor C22. Capacitor C64 is a d-c blocking capacitor for OUTPUT FREQUENCY capacitor C24A and trimmer capacitor C36 and C24A. The secondary of inductor L4 supplies the 2 to 4-mc signal to the output connectors. The screen of tube V5 is connected to ground through resistor R24 and switch S7C. The screen of tube V11 is not connected. Thus, both tubes become inoperative.

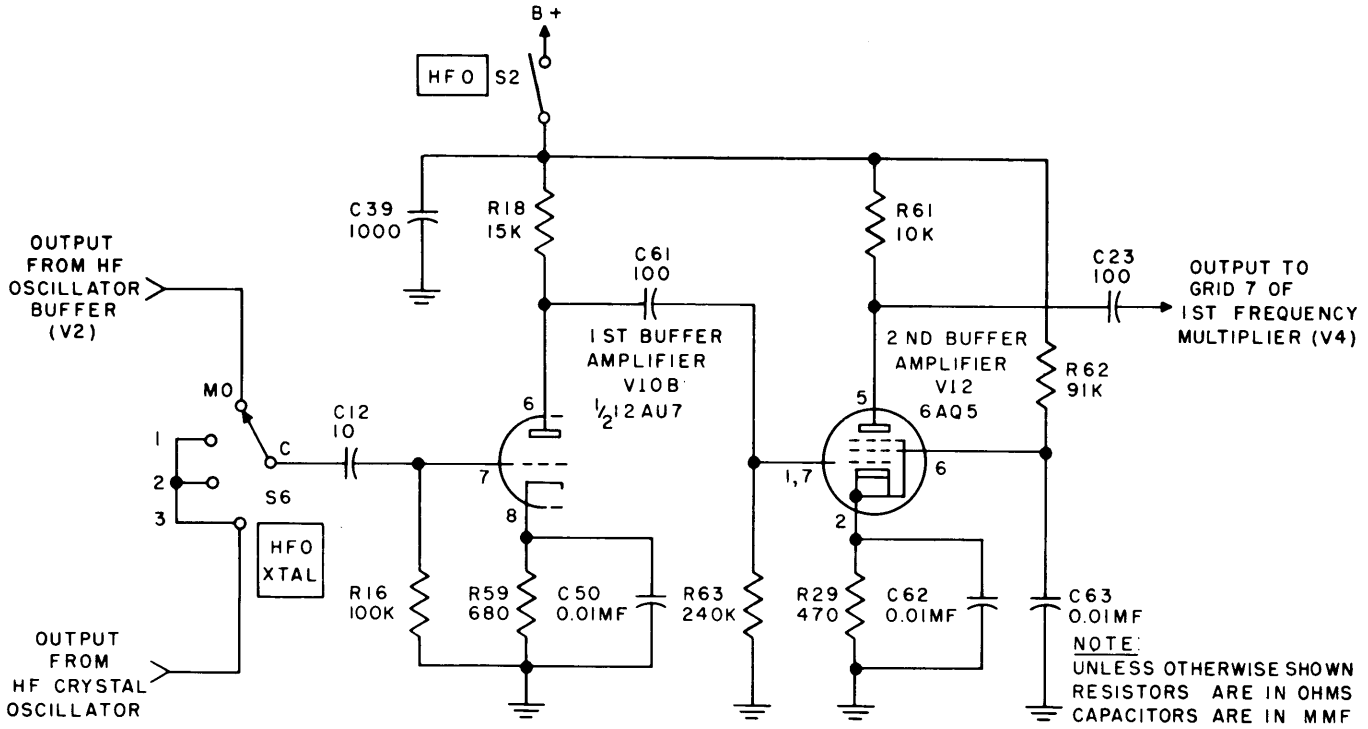


Figure 4-5. 1st and 2nd Buffer Amplifiers, Simplified Schematic

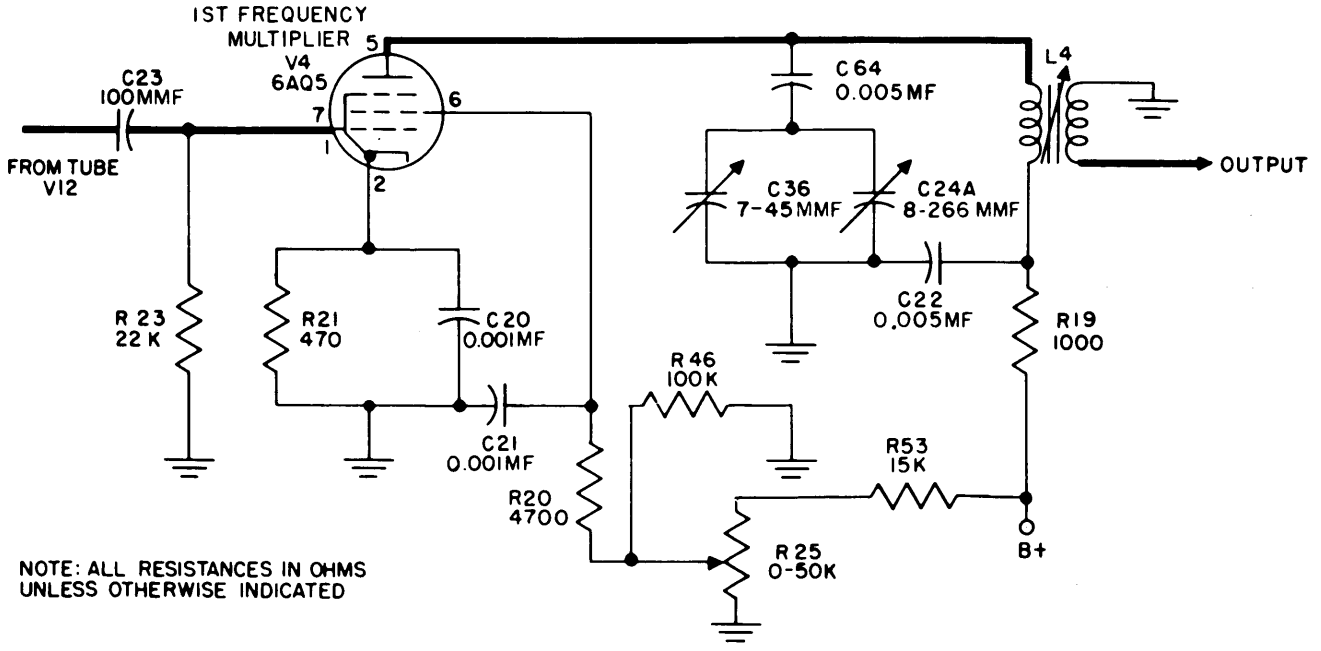


Figure 4-6. Frequ ncy Multipliers, 2 to 4 Mc Operati n

4–18. 4 TO 8 MEGACYCLES OPERATION. (See figure 4–7.) When FREQUENCY RANGE switch S7 is set to 4–8, the cathode, grid and screen connections for tube V4 are the same as in 2 to 4 megacycles operation. The plate voltage from the power supply is fed through the primary of inductor L5. Capacitor

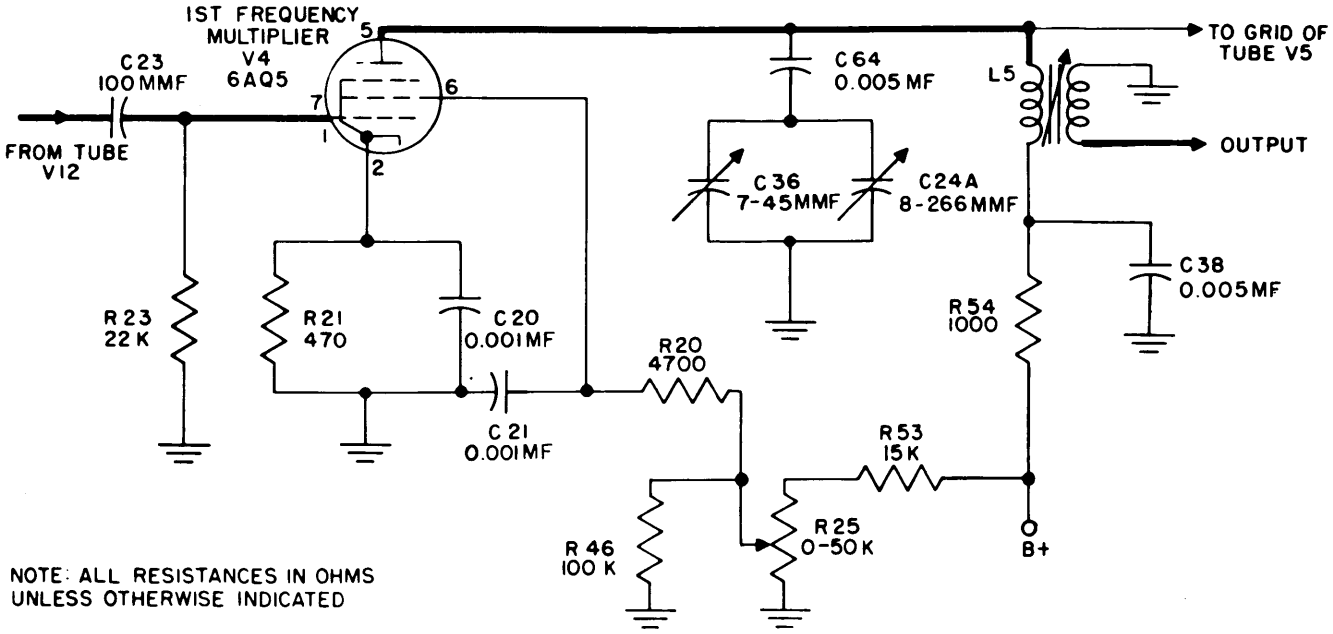


Figure 4–7. Frequency Multipliers, 4 to 8 Mc Operation

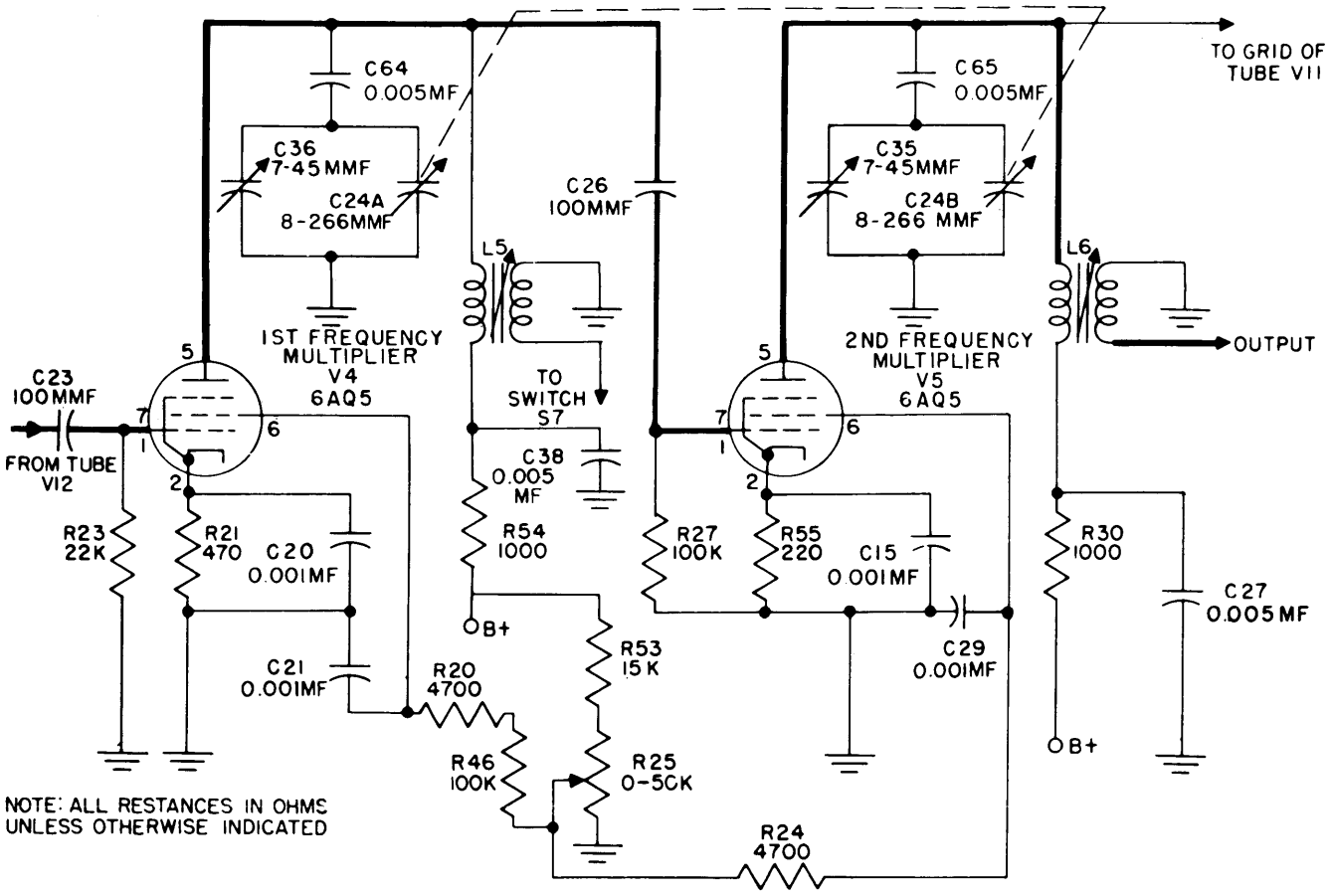
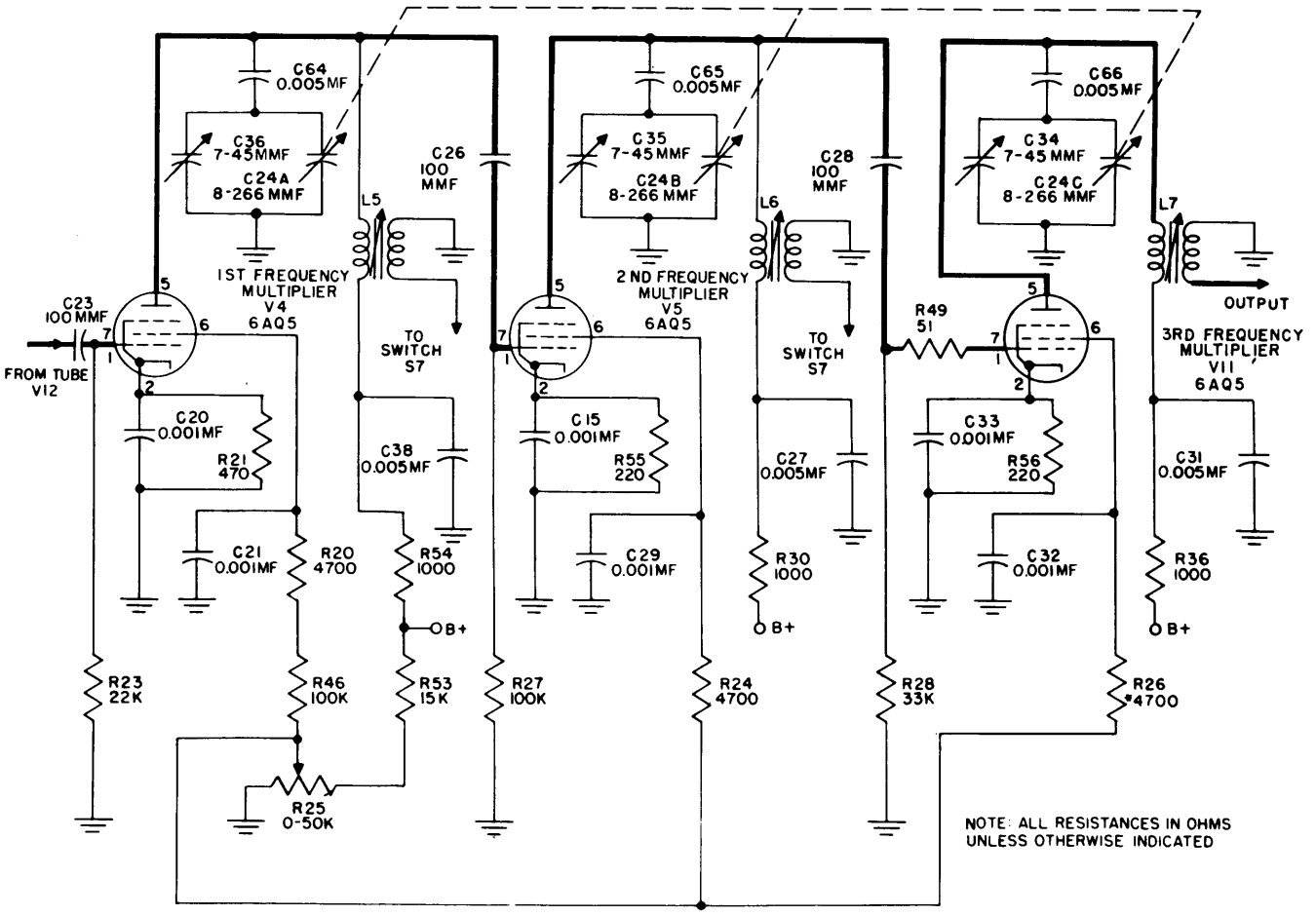


Figure 4–8. Frequency Multipli rs, 8 to 16 Mc Operation

C64 is a d-c blocking capacitor. The tuned circuit, consisting of inductor L5, main tuning capacitor C24A, and trimmer capacitor C36, is tuned to twice the frequency of the signal applied to the grid of tube V4. The secondary of inductor L5 applies to the 4 to 8 mc r-f voltage to the HFO output jacks. Tubes V5 and V11 are inoperative.

4-19. 8 TO 16 MEGACYCLES OPERATION. (See figure 4-8.) When FREQUENCY RANGE switch S7 is set to 8-16, the grid, cathode, and plate connections of tube V4 are the same as in 4 to 8 megacycles operation. The screen grid voltage is applied through resistors R53, R25, R46, and R20. The 4 to 8 mc plate signal of tube V4 is applied to the grid of tube V5 through coupling capacitor C26. Bias for tube V5 is provided by capacitor C26 in conjunction with R27, whose long time constant produces a clamping action, and by cathode resistor R55 in parallel with capacitor C15. Screen voltage is applied through resistors R24, R25, and R53, and is filtered by capacitor C29. Capacitor C65 provides a d-c block to main tuning capacitor C24B and trimmer capacitor C35. Plate voltage, decoupled by resistor R30 and capacitor C27, is applied from the primary of inductor L6. The resonant plate circuit, consisting of capacitors C24B, C35, and the primary of inductor L6, is tuned to twice the frequency supplied to the grid of tube V5. The doubled frequency is applied to the output frequency connectors from the secondary of inductor L6, and is also applied to the grid of tube V11. Tube V11 is inoperative because the screen grid is disconnected.

4-20. 16 TO 32 MEGACYCLES OPERATION. (See figure 4-9.) When FREQUENCY RANGE switch S7 is set to 16-32, the connections to tubes V4 and V5 are the same as in 8-16 megacycles operation. The output from the plate of tube V5 is applied to the grid of tube V11 through coupling capacitor C28. Bias for tube V11 is supplied by capacitor C28 in conjunction with R28, and by cathode resistor R56 in parallel with capacitor C33. Resistor R49 acts as a parasitic suppressor. Screen voltage is applied through resistors R26, R25, and R53 and is filtered by capacitor C32. Capacitor C66 blocks the plate voltage from main tuning capacitor C24 and trimmer C34. Plate voltage is filtered by resistor R36 and capacitor C31. The tuned plate circuit, consisting of capacitors C34 and C24C and the primary of inductor L7, is tuned to twice the frequency of the signal applied to the grid of V11. The doubled frequency is applied to the output connectors from inductor L7 secondary.



Figur 4-9. Fr quency Multipli rs, 16 to 32 Mc Operati n

4–21. BEAT FREQUENCY OSCILLATOR AND BUFFER AMPLIFIER. (See figure 4–10.) One of two crystals is placed into the beat-frequency oscillator circuit by switch S8. Plate voltage is applied through BFO (ON-OFF) switch S3 and plate load resistor R37. The plate voltage is filtered by resistor R40 and capacitor C53. Capacitor C55 provides a low impedance cathode return path for a portion of the r-f signal. Bias is developed across grid leak resistor R35 and capacitor C37. The bfo output signal is applied from plate 1 of V9A to grid 7 of buffer amplifier V9B through coupling capacitor C52. The buffer offers a high impedance to the oscillator, thus preventing unstable oscillator operation due to varying loads. Self-bias is provided by resistor R38. Plate voltage is filtered by resistor R39 and capacitor C51.

4–22. CALIBRATING CONVERTER. (See figure 4–11.) The 100-kilocycle crystal oscillator is used to calibrate the variable oscillator frequency. The calibrator provides 20 main check points spaced 100 kilocycles apart, and 20 sub-check points located halfway between the main check points. The main check points have an audible range of approximately 20 dial divisions on either side of zero beat, while the sub-check points have approximately seven to eight dial divisions on either side of zero beat. All other beat points are of lower amplitude, and have an audible range of fewer dial divisions. Crystal Y1 is connected between the first, or oscillator grid, and the fourth grid of tube V3, which is the oscillator anode. Capacitor C17 provides feedback to the cathodes. Capacitors C16 and C49 provide the grid excitation. Bias for the oscillator is provided by grid leak resistor R8 and by cathode resistor R7 in parallel with capacitor C18. The output of the variable oscillator buffer stage V2 is applied to the third grid of tube V3 through coupling capacitor C9. The crystal calibration frequency and the variable oscillator frequency are mixed in tube V3 to produce a different beat signal. Bias for the variable oscillator signal is provided by capacitor C10 in conjunction with resistor R6, and by cathode resistor R7 in parallel with the by-pass capacitor C18. Tube V3 plate voltage is filtered by resistor R50 and capacitors C13 and C40. The plate load is resistor R48. The output of tube V3 is applied to calibrator amplifier V6.

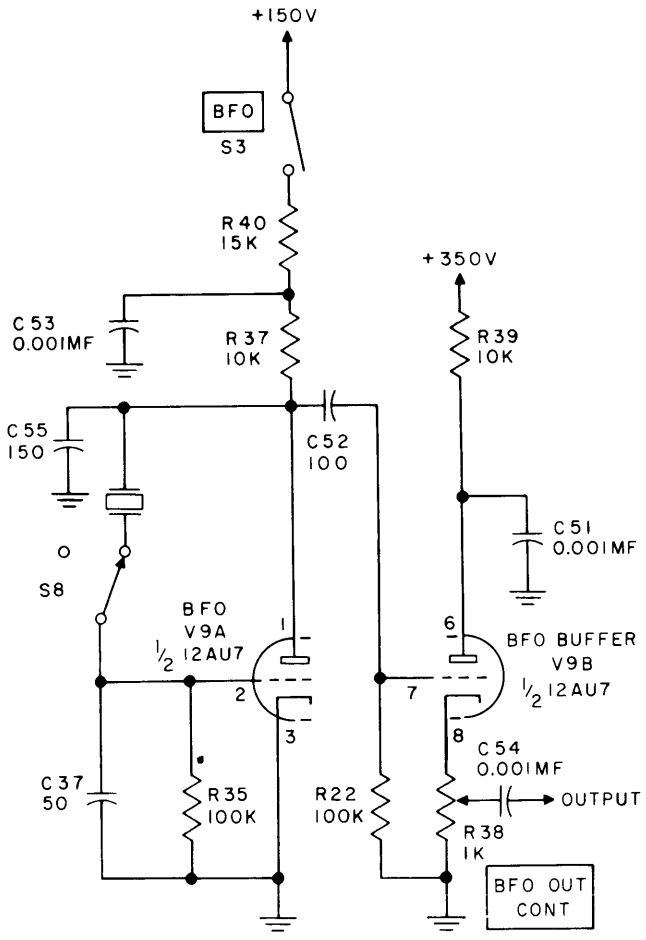


Figure 4–10. Beat Fr quency Oscillat r, Simplified Sch matic

4–23. POWER SUPPLY. (See figure 4–12.) The external a-c power is applied through jacks J1 and J12, plugs P1 and P12, fuse F1, and POWER switch S1 to the primary of transformer T1. Terminals 7 and 8 of T1 supply filament voltage for all the tubes, and voltage for pilot light I1, which is in series with R41. Resistor R41 limits the current in lamp I1 to lengthen its life and reduce glare. Secondary winding terminals 9 and 11 are connected across the plate of full-wave rectifier tube V8, and terminals 5 and 6 are connected across the filament of the tube. The rectified voltage output of tube V8 is filtered by capacitors C44, C45, and C47, and choke L1. For stable voltage from the power supply, voltage regulator tube V7 is provided. The series current limiter is resistor R47. Plate and screen voltages to the various oscillators are supplied from this regulated voltage. Plate and screen voltage to the other stages is supplied from the unregulated 350-volt output through fuse F2.

4–24. METERING CIRCUIT. (See figure 4–13.) METER SELECTOR switch S5 is used to connect meter M1 into various circuits. Table 4–2 gives the meter readings at each setting of the switch S5. Because the HFO and BFO signal outputs are rf, it is necessary to rectify and filter them so that they can be read directly on the d-c meter. The HFO output is applied to crystal rectifier CR1 through coupling capacitor C8. The meter is shunted by resistor R31. The rectified output of the crystal is filtered by capacitor C43 and then applied to the meter. The BFO output is applied through coupling capacitor C10 to crystal rectifier CR2 and shunt resistor R32. The rectified output of crystal CR2 is filtered by capacitor C48 and then applied to the meter.

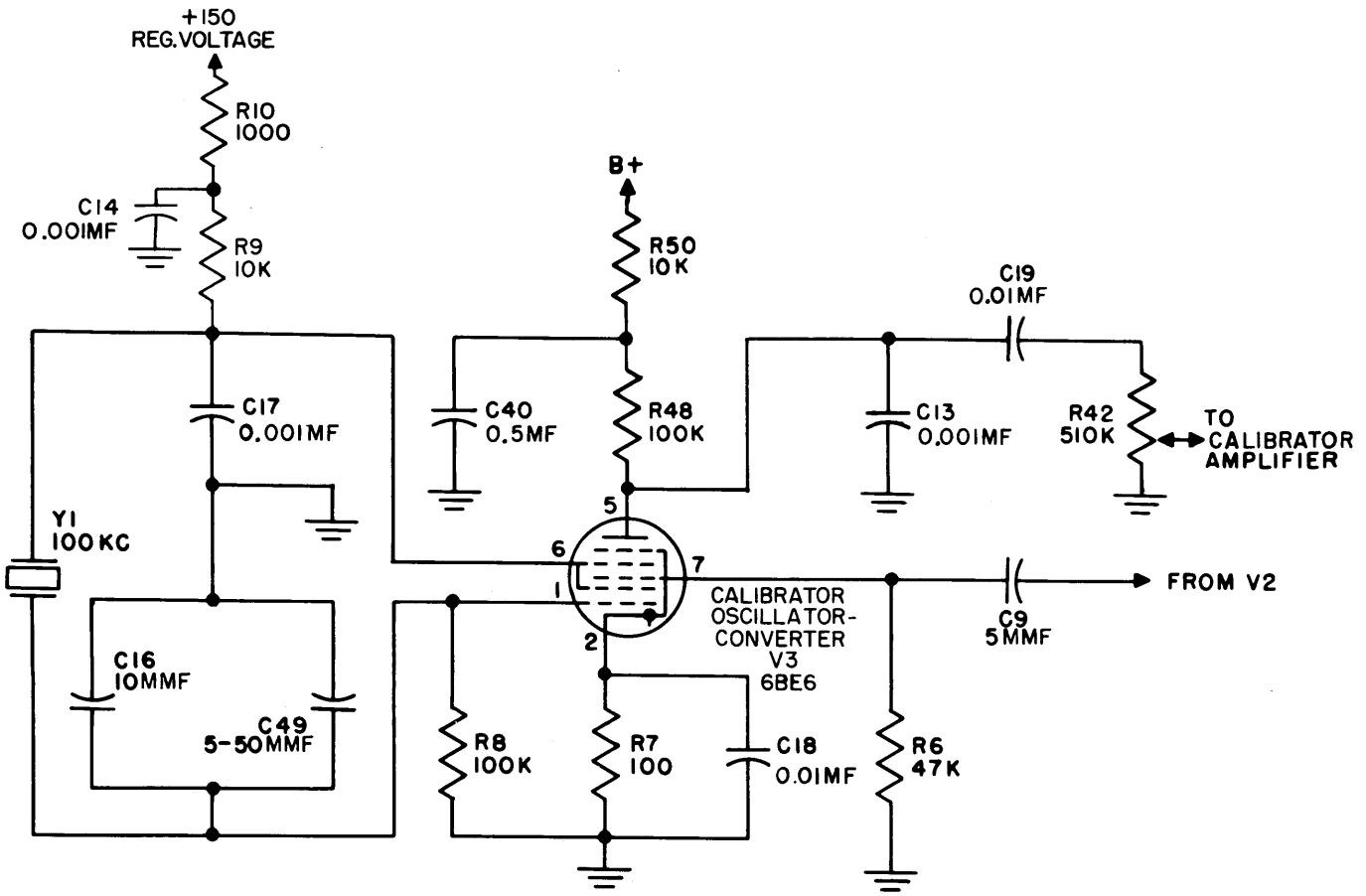
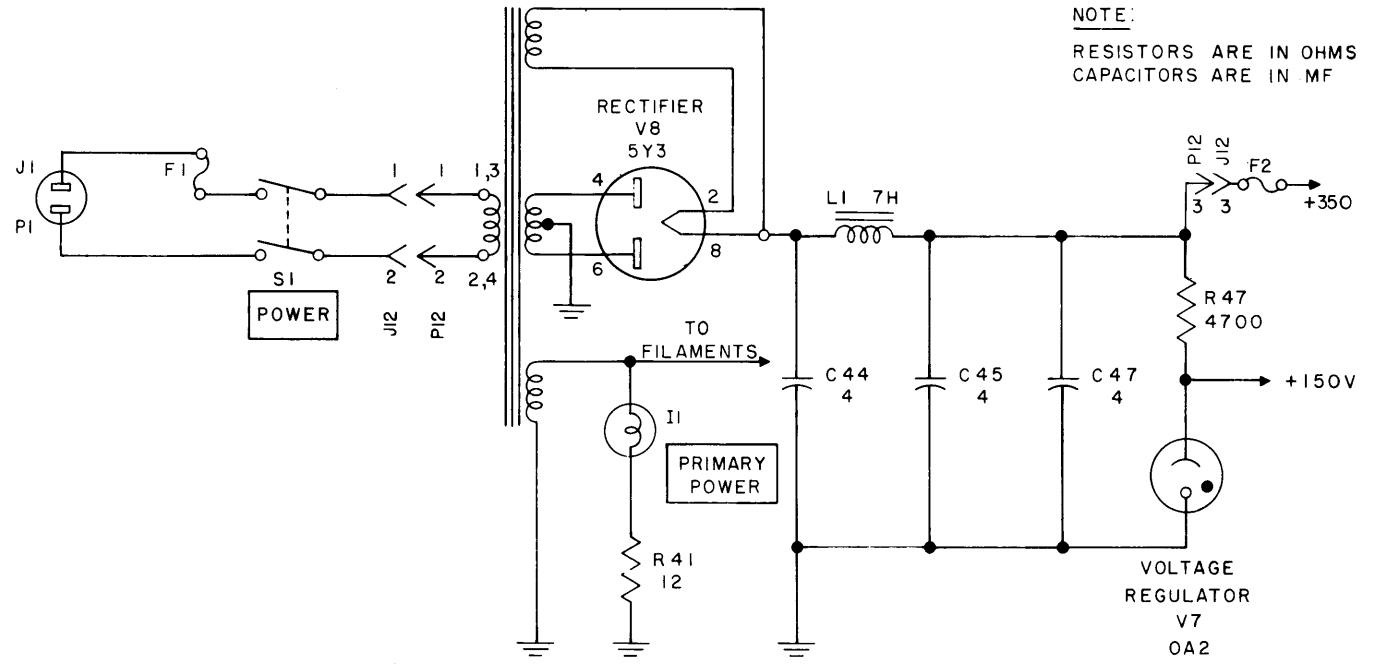


Figure 4-11. Calibrating Converter, Simplified Schematic



Figur 4-12. Power Supply, Simplied Schematic

TABLE 4–2

METER READINGS FOR VARIOUS POSITIONS OF SWITCH S5

Position of Switches	Meter Reading
HFO	Plate current of variable oscillator tube V1.
BFO	Plate current of beat frequency oscillator tube V9A.
HF OUT	Rectified high frequency output signal current.
BF OUT	Rectifier beat frequency output signal current.

4–25. TEMPERATURE CONTROL SYSTEM. (See figure 4–14.) A three-section oven is provided to control the temperature of the variable hf oscillator, the buffer, and the calibrating oscillator-converter. Power is applied to the inner and middle oven heaters from the POWER switch S1. The outer oven contains insulation only and uses no power. When the temperature of the middle oven goes below 60° C. (140° F.), thermostat M2 is open-circuited and relay K1 is energized. Pilot light I2, in series with resistor R52, middle oven heater resistors R11, R12, R13, and R14, and inner oven resistors R5, R57, R65, and R66 are connected into the circuit. Resistors R58 and R64 are added to drop the voltage to the inner oven resistors when operating from a 220-volt source.

4–26. When the temperature of the middle oven goes above 60° C. (140° F.), main thermostat M2 closes. This shorts out relay K1, causing it to be de-energized. No current flows through the heater elements or the OVEN HEATER pilot light I2. Thermostat S9 is provided to prevent overheating if thermostat M2 or relay K1 fails to function. Thermostat S9 opens the circuit at a slightly higher temperature than thermostat M2.

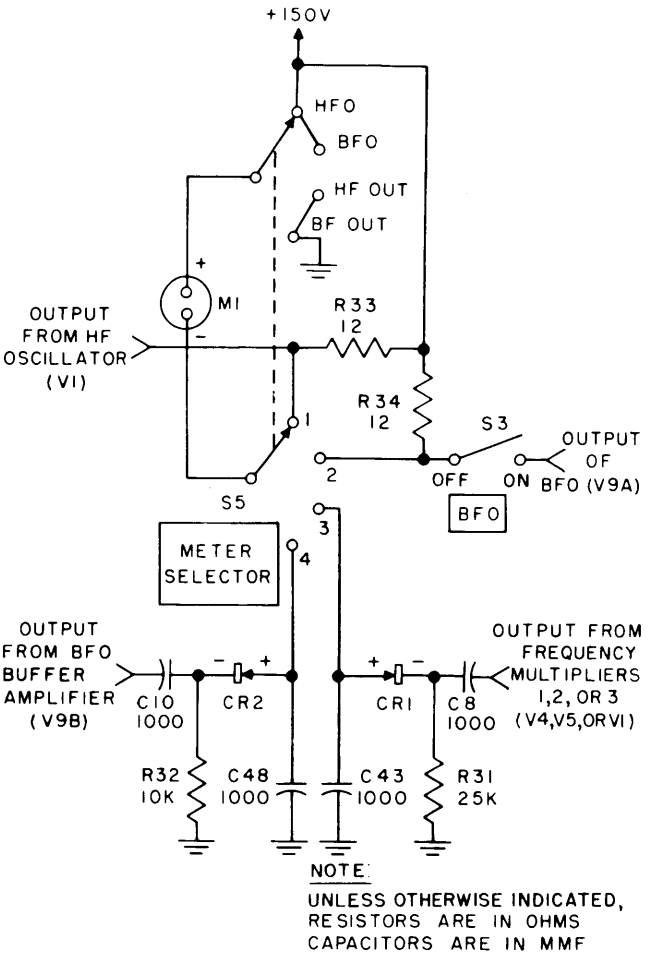


Figure 4–13. Metering Circuit, Simplified Schematic

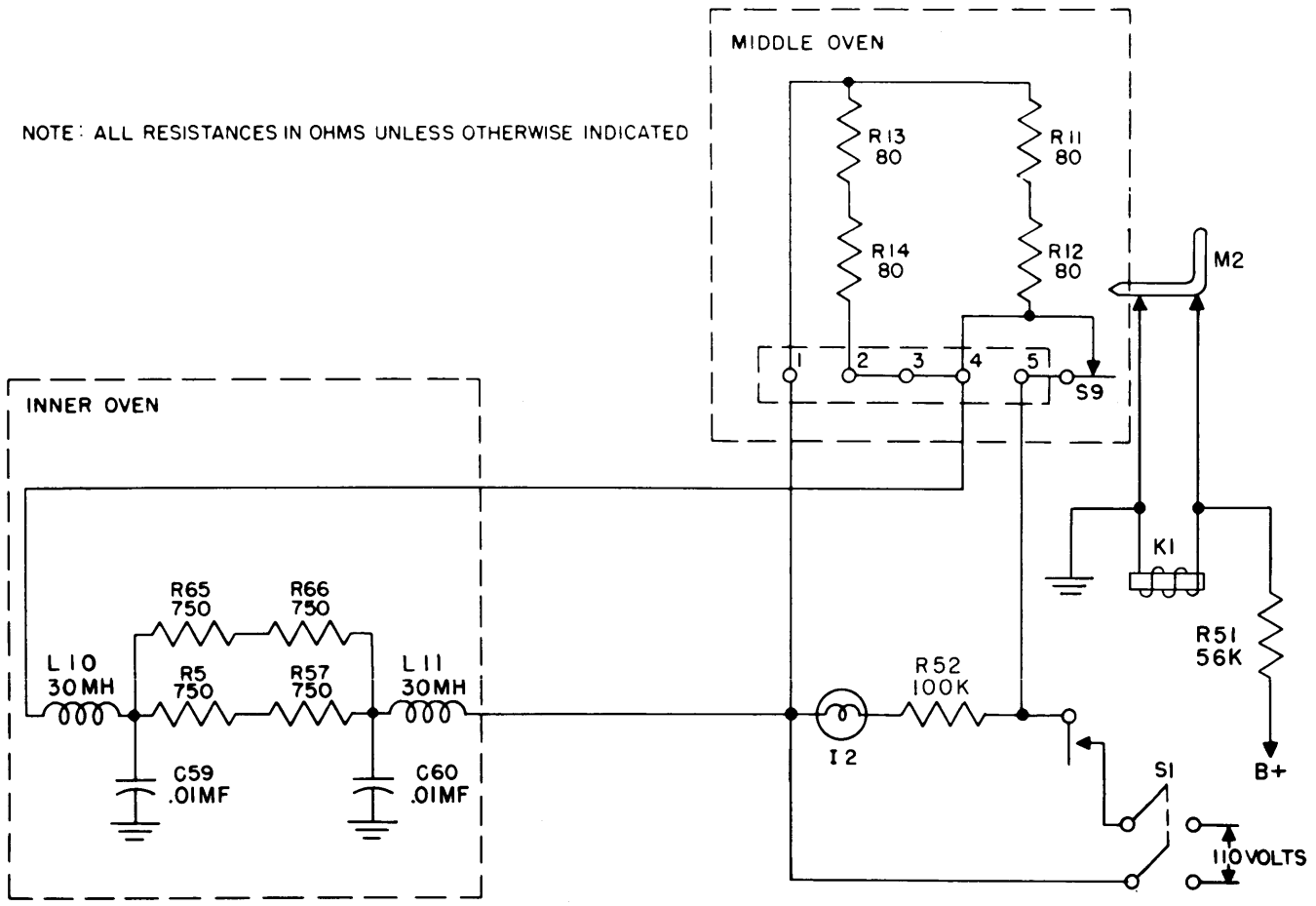


Figure 4–14. Temperature Control System, Simplified Schematic

SECTION V
ORGANIZATIONAL AND OPERATIONAL MAINTENANCE

5–1. MINIMUM PERFORMANCE STANDARDS.

5–2. The variable master oscillator minimum performance standards are contained in Table 5–1. If the requirements, as outlined, are not met, refer to paragraph 5–3.

5–3. SYSTEM TROUBLE ANALYSIS.

5–4. To determine whether or not the variable master oscillator is the defective component of an inoperative system, perform the minimum performance standards described in Table 5–1. To locate trouble, perform the procedures listed in Table 5–2.

5–5. REMOVAL OF ASSEMBLIES.

5–6. In order to gain access to the relay, thermostat, or other items mounted between the outer oven and the front panel (see figure 5–1), it is necessary to separate the oven assembly from the main chassis. To do this, follow the procedure below:

a. Rotate the DIAL UNITS control until a reading between 0000.0 and 0010.0 is obtained.

b. Loosen the coupler set-screw closest to the oven on the shaft located between the wall of the oven and the counter bevel gear (see figure 5–2). Use the special Allen wrench provided.

c. Rotate the DIAL UNITS control until the other set-screw, located approximately 90° from the first, appears. Lock the DIAL UNITS control with the dial lock and only then loosen the other set-screw.

CAUTION

After the second screw is loosened, neither the DIAL UNITS control nor the variable capacitor's flexible shaft must be moved. If they are, refer to paragraph 6–11.

d. Disconnect oven connectors P3 and P4 (see figure 5–3) located at the rear of the oven.

e. Disconnect oven connector (see figure 5–2) located between the oven assembly and the front panel.

TABLE 5–1
MINIMUM PERFORMANCE STANDARDS

Step	Procedure	Remarks
1.	Place the variable master oscillator in operation by throwing the POWER and HFO switches to ON and the HFO XTAL switch to MO.	
2.	Connect an r-f millammeter (with 75-ohm load resistor) to any one of the HFO output jacks.	
3.	Set the DIAL UNITS control arbitrarily to any number.	
4.	Set the FREQUENCY RANGE switch, in turn, to each of its positions and note the reading on the r-f milliammeter.	In the 2 to 4 mc range, the meter reading should be at least 160 ma and at least 80 ma on all other ranges (with the HFO OUTPUT control fully clockwise and the OUTPUT FREQUENCY dial turned to resonance, as indicated by maximum output).

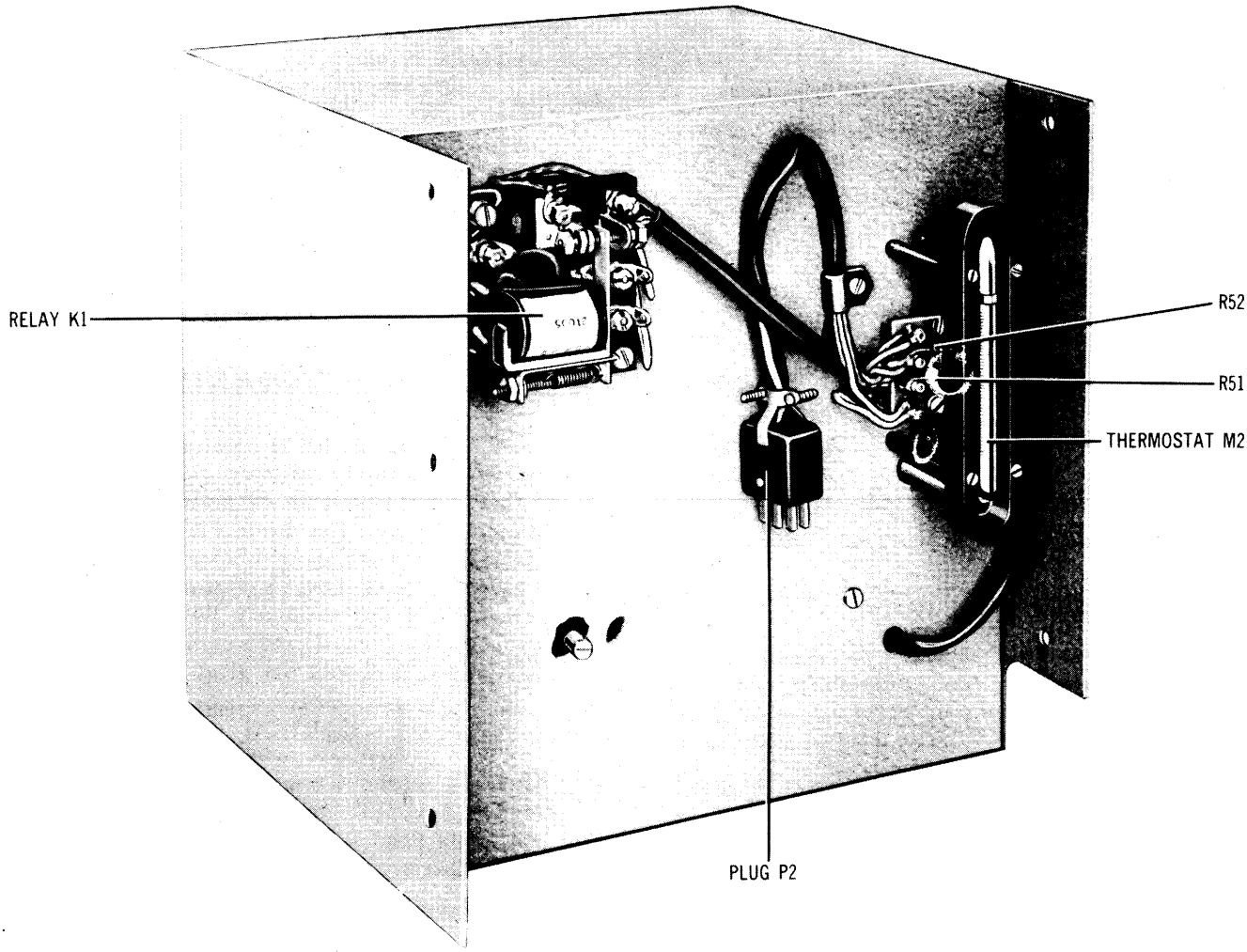


Figure 5–1. Outer Oven, Fr nt Vi w

TABLE 5-2

SYSTEM TROUBLE ANALYSIS

Step	Test Equipment Control Position	Equipment Control Positions	Normal Indications	Possible Causes of Abnormal Indicati ns
1.		POWER switch ON.	PRIMARY POWER and OVEN HEAT lamps light.	If the vacuum tube filaments light, check the pilot lamps. If the tube filaments do not light, check: fuses, line cord, S1, T1, and J1.
2.	R-f milliammeter connected to HFO output jack.	HFO switch ON. HFO XTAL switch to MO. FREQUENCY RANGE switch to 2-4. HFO OUTPUT control fully clockwise, OUTPUT FREQUENCY dial tuned to resonance.	Reading of at least 160 ma on the r-f milliammeter.	Check V1, V2, V3, V7, V8, V10, V12, V4 (and associated components), J5, J7, J8, S6, and S7. Check metering circuit.
3.	Same as step 2.	Same as step 2. FREQUENCY RANGE switch to 4-8.	Reading of at least 80 ma on the r-f milliammeter.	Same as step 2.
4.	Same as step 2.	Same as step 2. FREQUENCY RANGE switch to 8-16.	Same as step 3.	Check V5 and associated component S7.
5.	Same as step 2.	Same as step 2. FREQUENCY RANGE switch to 16-32.	Same as step 3.	Check V11 and associated component S7.
6.	Same as step 2.	HFO XTAL switch to 1. FREQUENCY RANGE switch to 2-4.	Same as step 2.	Check V10A and associated component S6. Crystal in socket XY17.
7.	Same as step 2.	HFO XTAL switch to 2 and 3, in turn.	Same as step 3.	Check S6 and crystal sockets XY16 and XY15.
8.	R-f milliammeter connected to BFO output jack.	BFO switch to ON.	R-f ma meter reading should be approximately 2.5 ma.	Check: V9, associated components, J9, J10, J11.
9.	Connect headset to CAL. OUTPUT jack.	Turn CAL. OUTPUT knob on and vary DIAL UNITS control until a zero beat is obtained.		Check V3, V6 and associated components.

f. Remove the five screws fastening the electronic chassis bottom cover plate.

g. Remove the two screws (accessible from the bottom right side of the electronic chassis) that secure the chassis to the spacer.

h. Remove the two screws securing the left side of the oven assembly to the electronic chassis (the lower screw is accessible through a hole in the right side plate of the electronic chassis).

i. Remove the three screws securing the oven assembly to the front panel angle.

j. Gently draw out the entire oven assembly, taking care not to move the variable capacitor extension shaft.

5-7. DISASSEMBLY.

5-8. Follow this procedure (see figures 5-4 and 5-5).

a. Remove the oven as described in paragraph 5-6.

b. Remove the screws fastening the oven rear cover.

c. Remove the oven rear cover and two layers of Celotex insulation.

d. Remove the oven mounting screws near the edges of the nickel-plated middle oven cover. Gently draw out the entire inner oven taking care not to move the variable capacitor shaft. If the shaft is moved, refer to paragraph 6-11 for alignment instructions.

e. Remove the four screws at the top of the inner

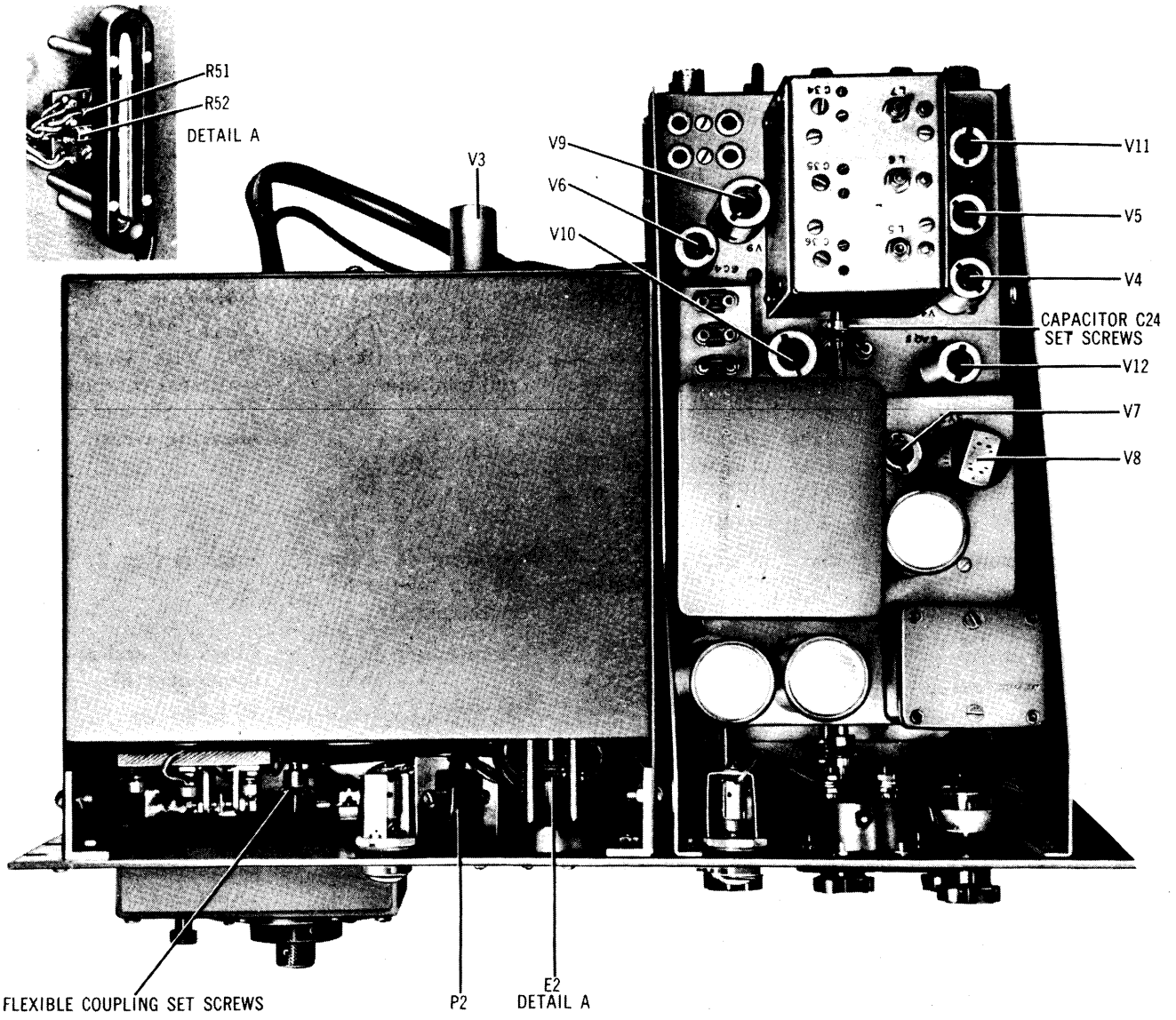


Figure 5–2. Variable Master Oscillator, Top View

oven and the four screws at the bottom.

f. Remove the inner oven shield.

g. Unsolder the leads from the middle oven to the terminal board on the front of the outer oven. Tag each lead.

h. Gently draw the middle oven out of the outer oven housing.

i. Remove the three screws on the top and three screws on the bottom of the tuning assembly shield.

j. Remove the two screws, nuts, and washers on the left side of the inductor assembly (figure 5–5). Pull out the spacer that separates the brackets.

k. Remove the two binding-head screws that secure the right side of the inductor assembly to the bracket below it.

l. Unsolder the leads that come through the grommets. Tag each lead.

m. Gently pull the inductor assembly forward.

n. Remove the three bottom screws that secure the tuning capacitor.

o. Gently pull the capacitor forward as far as the soldered leads will permit.

p. Unsolder and tag the connecting leads.

q. Remove any other parts, as required.

5–9. MINOR REPAIR AND ADJUSTMENT.

5–10. TUBE REPLACEMENT. Nine tubes, V4 through V12, are mounted on the electronic chassis (see figure 5–2). These tubes are accessible from the top of the chassis and may be replaced as required. Three tubes, VI, V2, and V3, are mounted on the mechanical chassis (see figure 5–3). Do not replace V1 unless it is definitely suspected of being defective or erratic. If V1 is replaced, the oscillator calibration

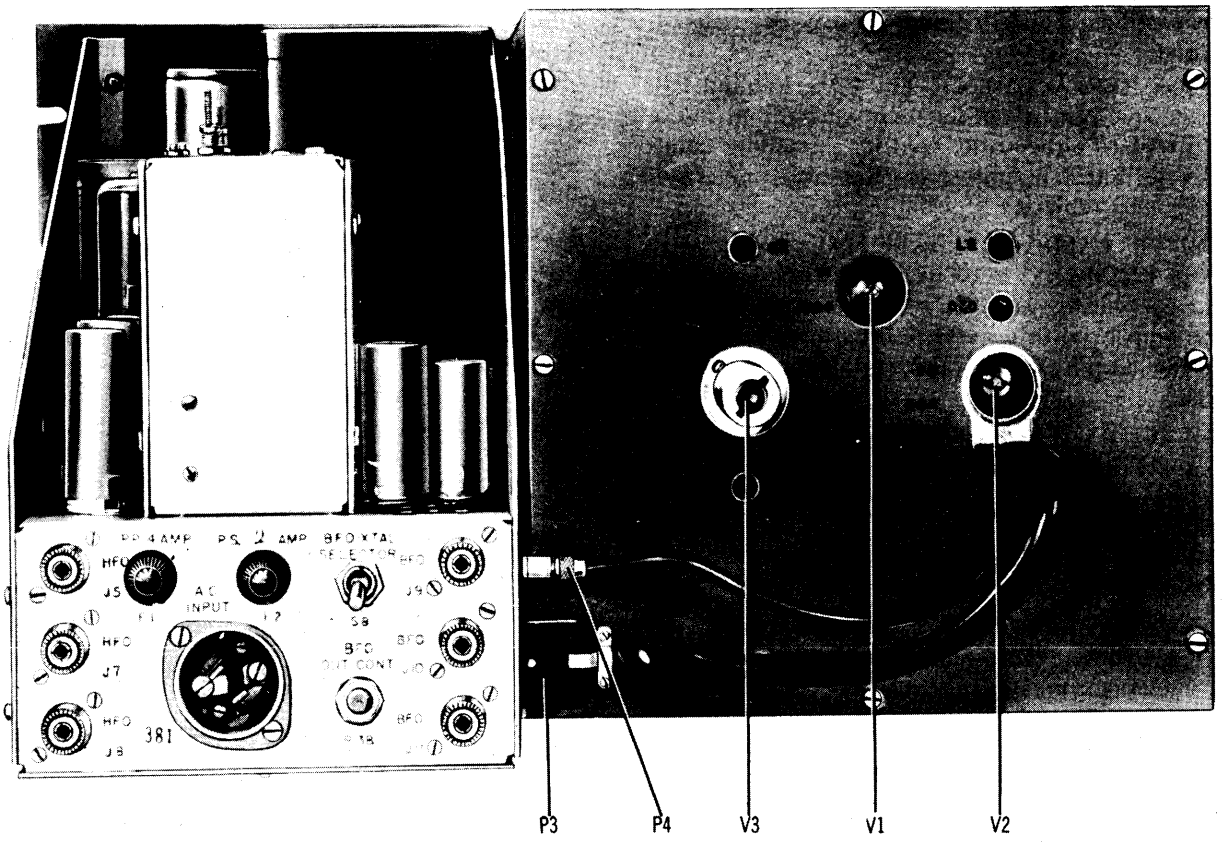


Figure 5-3. Variable Master Oscillator, Rear View

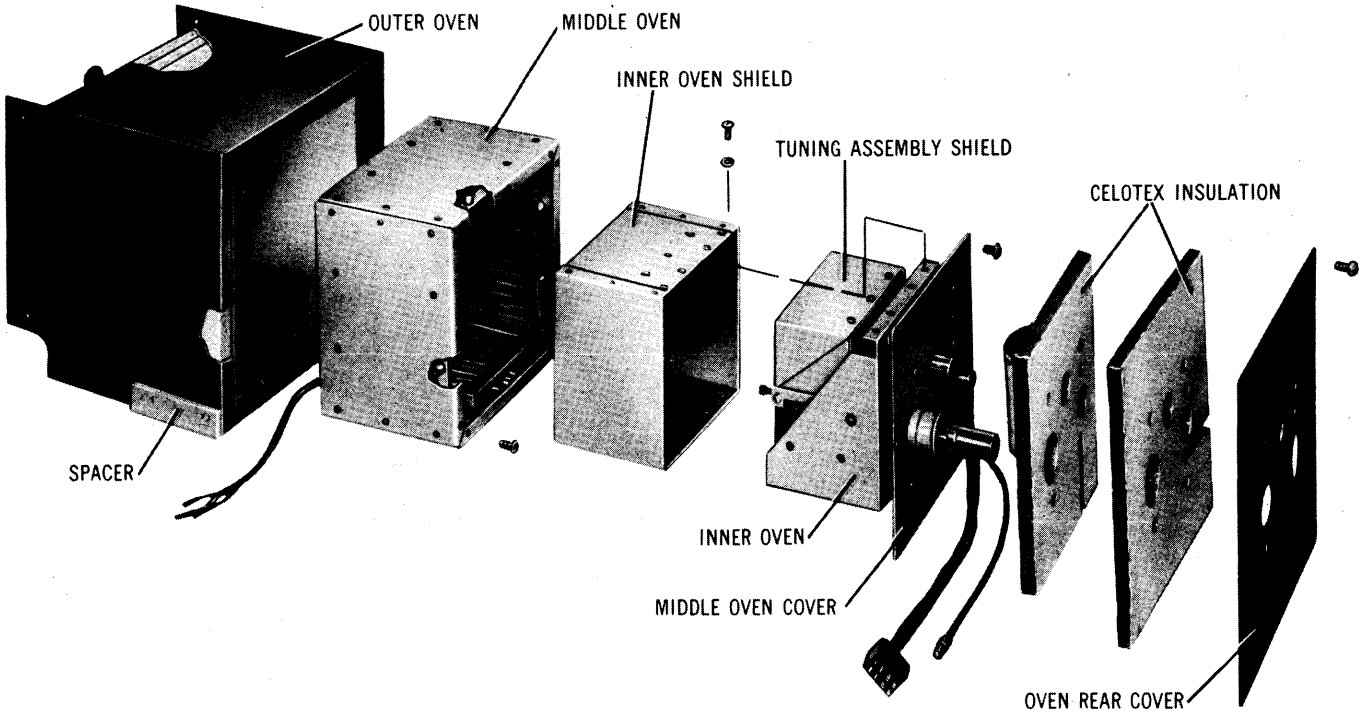


Figure 5-4. Oven Assembly, Exploded View

must be checked and, if necessary, adjusted as described in paragraph 8–4 in the Handbook of Overhaul Instructions. Tubes V2 and V3 may be replaced, as required.

5–11. FUSE REPLACEMENT. The P.P. (F1) and P.S. (F2) fuses are located on the rear apron (see figure 1–3). To replace either fuse, turn its fuseholder counterclockwise until it unscrews. Remove fuse from fuseholder and replace.

5–12. PILOT LAMP REPLACEMENT. To replace either the PRIMARY POWER or OVEN HEATER pilot lamps (see figure 1–2), remove the glass jewel. Remove lamp by turning and pulling simultaneously. Replace the lamp by gently pushing down and turning clockwise.

5–13. MERCURY THERMOSTAT REPLACEMENT. To replace a defective mercury thermostat (see figure 5–1), remove the outer oven assembly as described in paragraph 5–6. Remove the thermostat from its holder by unsoldering the two leads from the terminal board, and pulling thermostat out of its holder.

5–14. METER REPLACEMENT. To replace the meter, loosen the two screws fastening the spade lug leads to the meter terminals and remove the four nuts fastening the meter to the front panel. Carefully remove the meter.

5–15. OVEN HEATER REPLACEMENT. To gain access to the oven heater elements follow the oven disassembly procedure contained in paragraph 5–8. Replace any of the four oven heater elements, as required.

5–16. LUBRICATION.

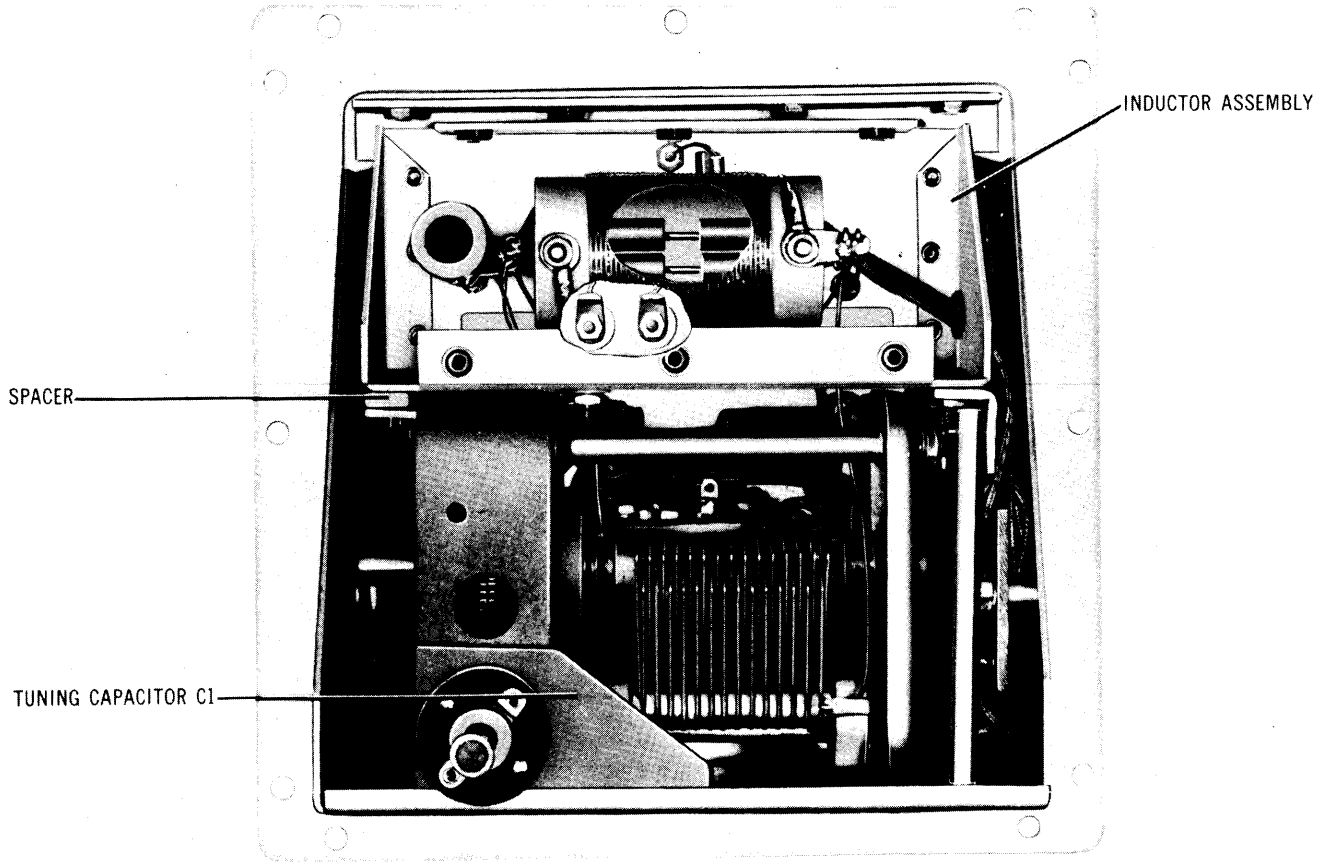
5–17. Lubrication is not required for any of the variable master oscillator parts.

5–18. INSPECTION SCHEDULE.

5–19. Refer to Table 5–3 for the variable master oscillator inspection schedule.

TABLE 5–3
INSPECTION SCHEDULE

Inspection	Time
Exterior and front panel free of chips, corrosion, loose or missing screws, frayed cabling.	monthly
Interior wiring and other parts for defects such as loose connection, crystallized solder joints, corrosion, fungus growth.	semi-annually
Tubes for satisfactory performance.	3,000 hrs.



Figur 5–5. Inn r Ov n, Fr nt View

SECTION VI
FIELD AND FASRON MAINTENANCE

6-1. MINIMUM PERFORMANCE STANDARDS.

6-2. The minimum performance standards for the variable master oscillator are outlined in Table 5-1. If the requirements as outlined in that table are not met, or if the master oscillator is inoperative, refer to paragraph 6-3 for system trouble analysis.

6-3. SYSTEM TROUBLE ANALYSIS.

6-4. Use the System Trouble Analysis Table 5-2 to locate the defective stage or group of stages. Refer to figure 6-1 for tube socket voltage and resistance readings.

6-5. DISASSEMBLY.

6-6. The disassembly of the equipment is described in paragraph 5-8 of Section V. No additional instructions are necessary.

6-7. REASSEMBLY.

6-8. Reassemble all disassembled items by reversing their individual disassembly procedures. If the tuning assembly has to be aligned before reassembly, refer to paragraph 6-11.

6-9. ALIGNMENT AND ADJUSTMENT.

6-10. After any repairs are made, the variable master oscillator must be aged and recalibrated. The aging procedure is described in 6-13. The calibration procedure is described in paragraph 6-14. If the relative positions of the tuning capacitor and the DIAL UNITS gear train have been disturbed, realign them as described in paragraph 6-11.

6-11. ALIGNMENT OF THE DIAL UNITS CONTROL.

6-12. Follow this procedure:

a. Adjust the tuning capacitor C1 (see figure 5-5) so that the tips of the rotor plates are 1/16 of an inch above the tips of the stator plates.

b. Rotate the DIAL UNITS control until a reading of 0000.0 is obtained. Lock the DIAL UNITS control.

c. Insert the oscillator tuning assembly into the oven and replace the middle oven rear mounting screws.

d. Tighten the flexible coupling screws (see figure 5-2) accessible at the bottom of the oscillator, between the front of the outer oven and the front panel. Use the special Allen wrench provided (see figure 2-1).

e. Loosen the dial lock, rotate the DIAL UNITS control until the other set screw becomes accessible, and then tighten it.

f. Replace the rear insulation, cover plate, and connectors.

6-13. AGING PROCEDURE.

a. Throw the POWER switch to ON. After ten minutes the mercury column in the OVEN HEAT thermostat should read approximately 60° C. If the OVEN HEAT lamp does not light and extinguish as the thermal control system cycles on and off, check I2, J2, P2, K1, M2, and the components in the middle oven.

b. After four hours of operation, throw the POWER switch to OFF.

c. Wait four hours, then repeat steps a and b.

d. Wait four hours, then repeat step c.

e. Throw the POWER switch to ON. Allow the oscillator to heat for 18 hours. After this time the oscillator can be considered as having been aged, and oscillator drift will be at a minimum. Do not throw the POWER switch OFF.

6-14. CALIBRATION.

6-15. GENERAL. The variable master oscillator is equipped with a 100-kc crystal oscillator that is used to check the oscillator fundamental frequencies (2 to 4 mc). The operation of the 100-kc oscillator is such that 20 main check points, spaced 100 kc apart (i.e., at 2.0 mc, 2.1 mc, etc.), are provided. Sub-check points, located approximately mid-way between the main check points, are also provided. The main check points are readily identifiable by the loudness of the beat note on either side of the zero beat, and by the fact that the audible beat range extends for approximately 20 dial divisions either side of zero beat. The sub-check points are not as loud as the adjoining main check points, and their beat range extends for approximately eight dial divisions either side of zero beat. This is in contrast to other non-usable beat notes, which are correspondingly less loud, and which have very limited tuning ranges.

6-16. CALIBRATION PROCEDURE.

a. Turn POWER switch to ON.

b. Wait at least four hours for the oven temperature to stabilize.

c. Turn the HFO switch to ON.

d. Set the HFO XTAL switch to MO.

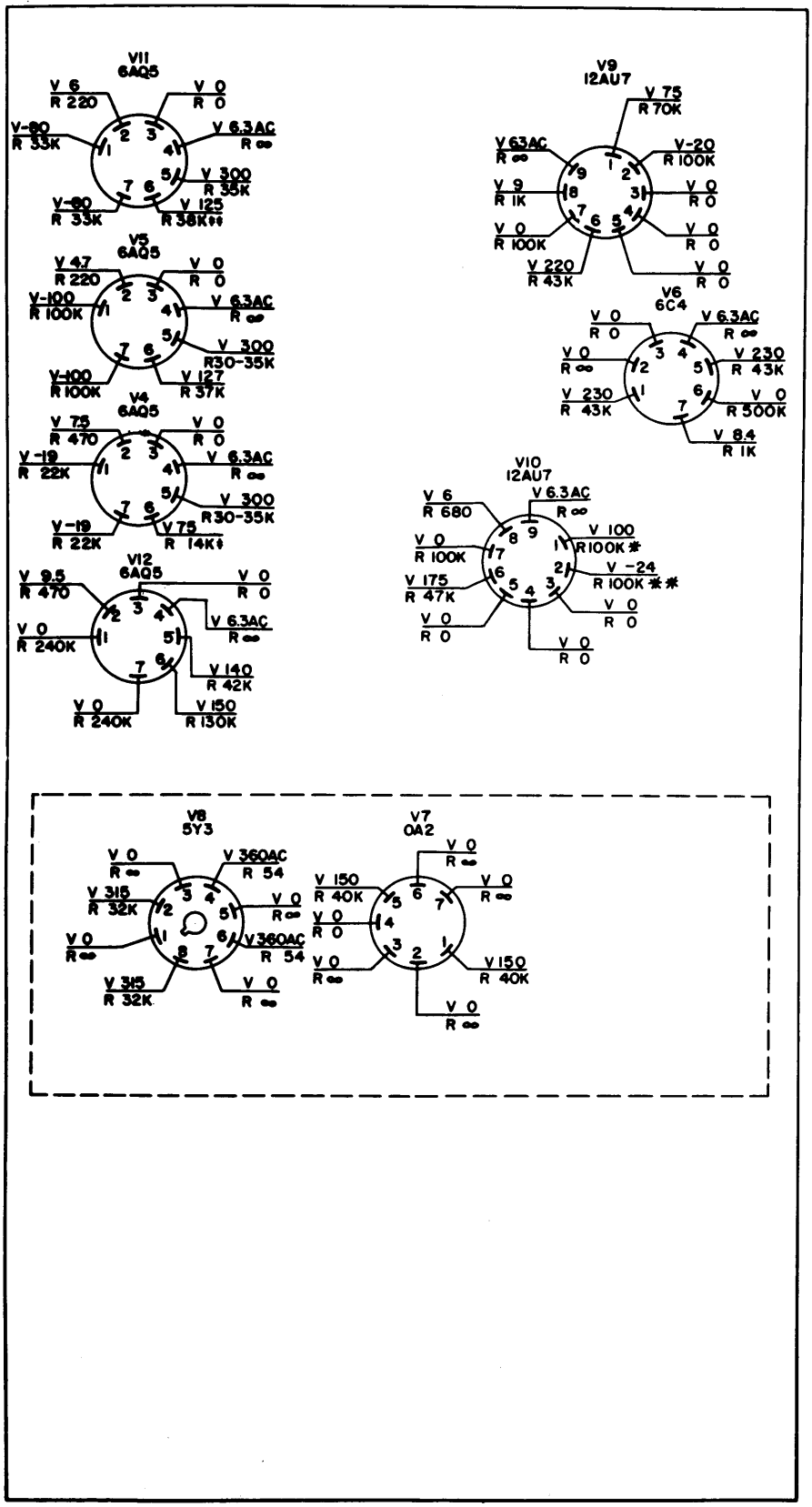
e. Set the FREQUENCY RANGE switch to 2-4.

f. Turn the CAL. OUTPUT control fully clockwise.

g. Connect a pair of headphones to the CAL. OUTPUT jack.

h. Vary the DIAL UNITS knob until a reading of 00 is obtained in the DIAL HUNDREDS window and a reading of 00.0 is obtained on the DIAL UNITS vernier dial.

i. Adjust L2, accessible through a slot in the rear



CONTROL SETTINGS

CONTROL	SETTING
DIAL UNITS	0000.0
HFO	ON
BFO	ON
HFO-XTAL	1, 2 OR 3
OUTPUT FREQUENCY	2MC
FREQUENCY RANGE	16-32MC
HF OUTPUT	MAXIMUM
CAL OUTPUT	MAXIMUM

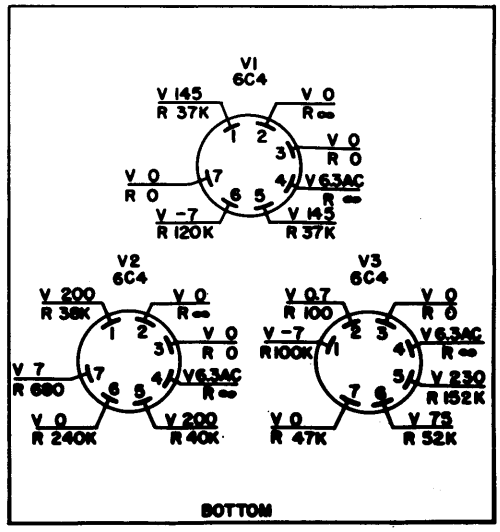
*WITH HFO XTAL SWITCH AT MO, VOLTAGE IS ZERO, RESISTANCE IS INFINITE

**WITH HFO XTAL SWITCH AT MO, VOLTAGE AND RESISTANCE ARE ZERO

‡ WITH FREQUENCY RANGE SWITCH AT "2-4" OR "4-8", AND HF OUTPUT AT MAXIMUM, RESISTANCE IS 30K. WITH FREQUENCY SELECTOR SWITCH AT "8-16" OR "16-32", AND HF OUTPUT AT MINIMUM, RESISTANCE IS 105 K. WITH FREQUENCY RANGE SWITCH AT "2-4" OR "4-8," AND HF OUTPUT SWITCH AT MINIMUM, RESISTANCE IS 4.7 K.

‡‡ WITH HF OUTPUT AT MINIMUM AND FREQUENCY SELECTOR SWITCH AT "16-32" RESISTANCE IS 4.7K. WITH FREQUENCY SELECTOR SWITCH AT "2-4", "4-8", OR "8-16", RESISTANCE IS INFINITE.

NOTE: ALL VOLTAGE AND RESISTANCE READINGS TAKEN WITH A 20,000 OHM/VOLT METER



Figur 6–1. Tube Sock t Voltage and R sistanc M asur ments

of the oven assembly, until a zero beat is obtained.

j. Vary the DIAL UNITS knob until a reading of 47 is obtained on the DIAL HUNDREDS window, and a reading of 00.0 is obtained on the DIAL UNITS vernier dial.

Note

Approach ail settings from a clockwise direction to reduce the error due to mechanical backlash.

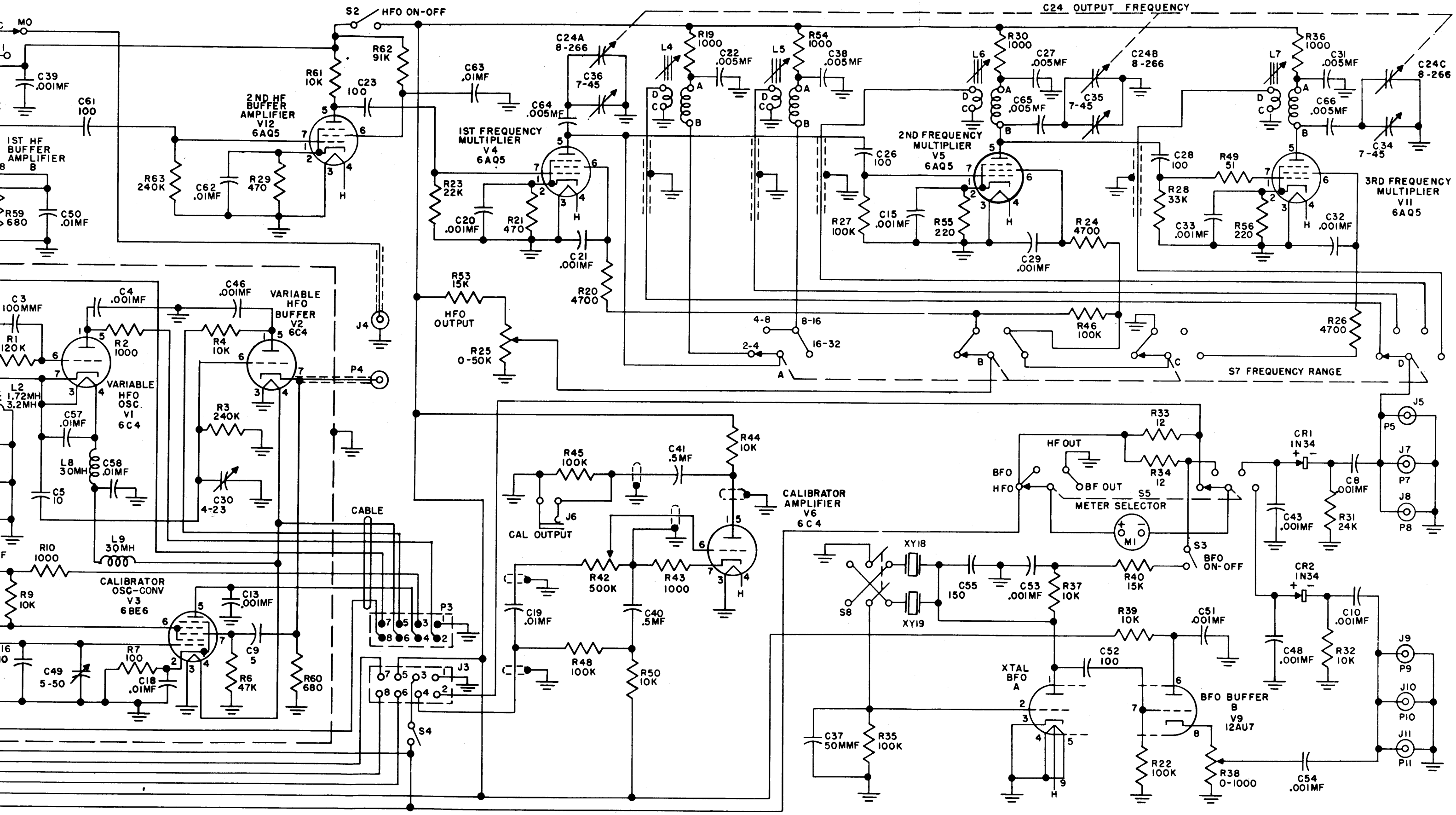
k. Adjust C2, accessible through a slot in the rear of the oven assembly, until a zero beat is obtained.

l. Repeat steps h through k until both ends of the band are aligned.

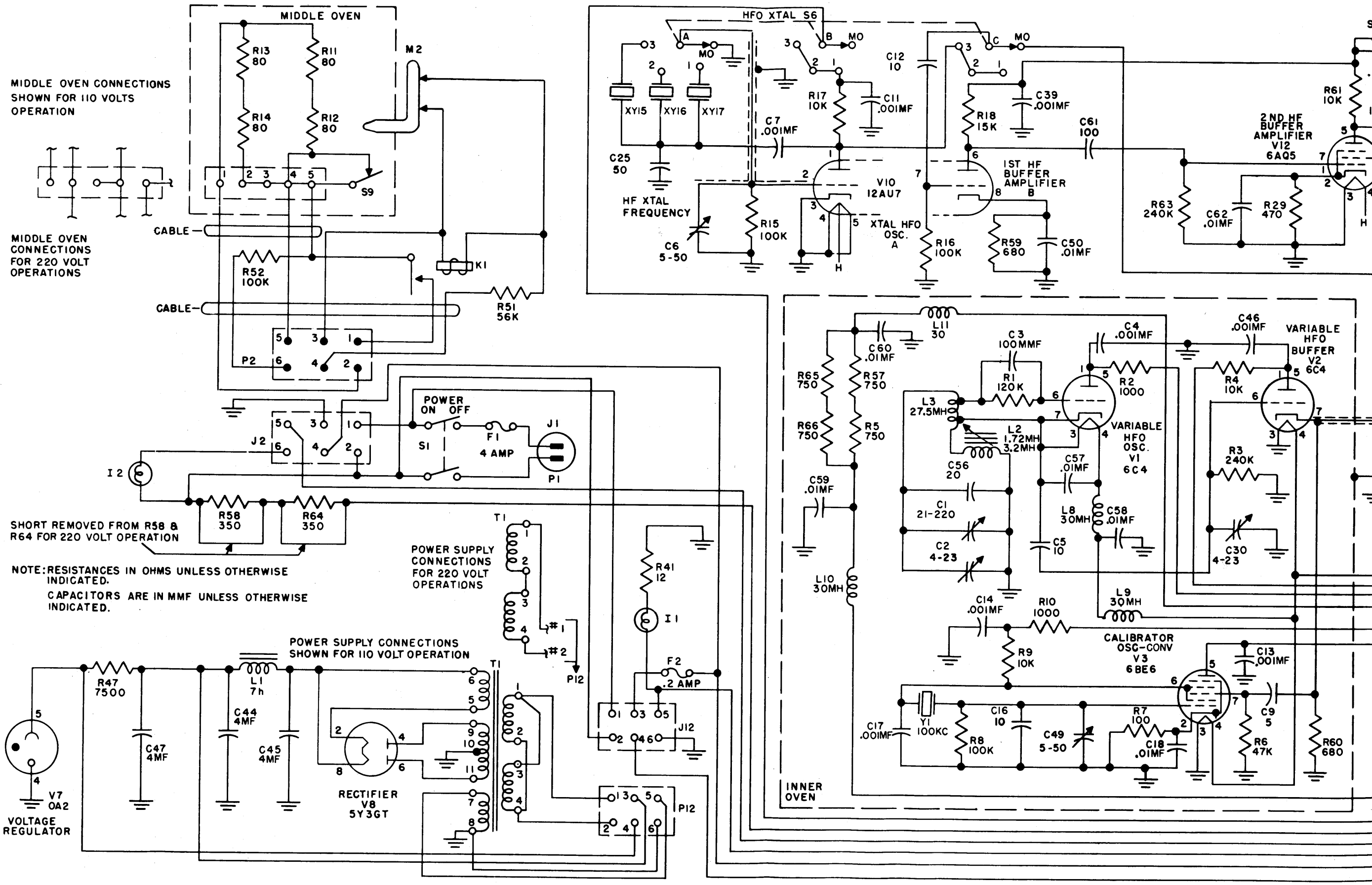
6–17. OVERHAUL SCHEDULE.

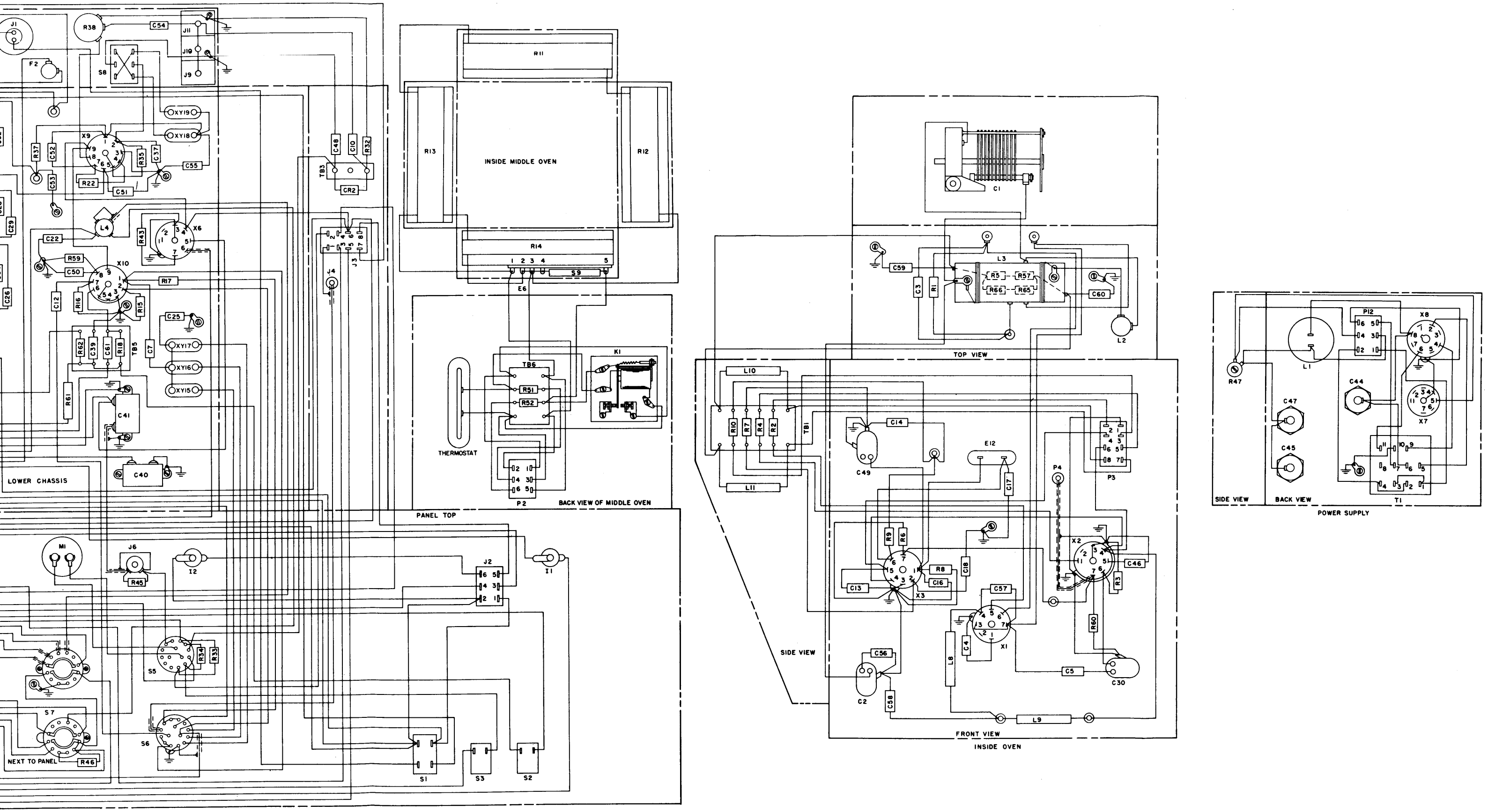
6–18. The variable master oscillator should be overhauled every three years.

SECTION VII
DIAGRAMS

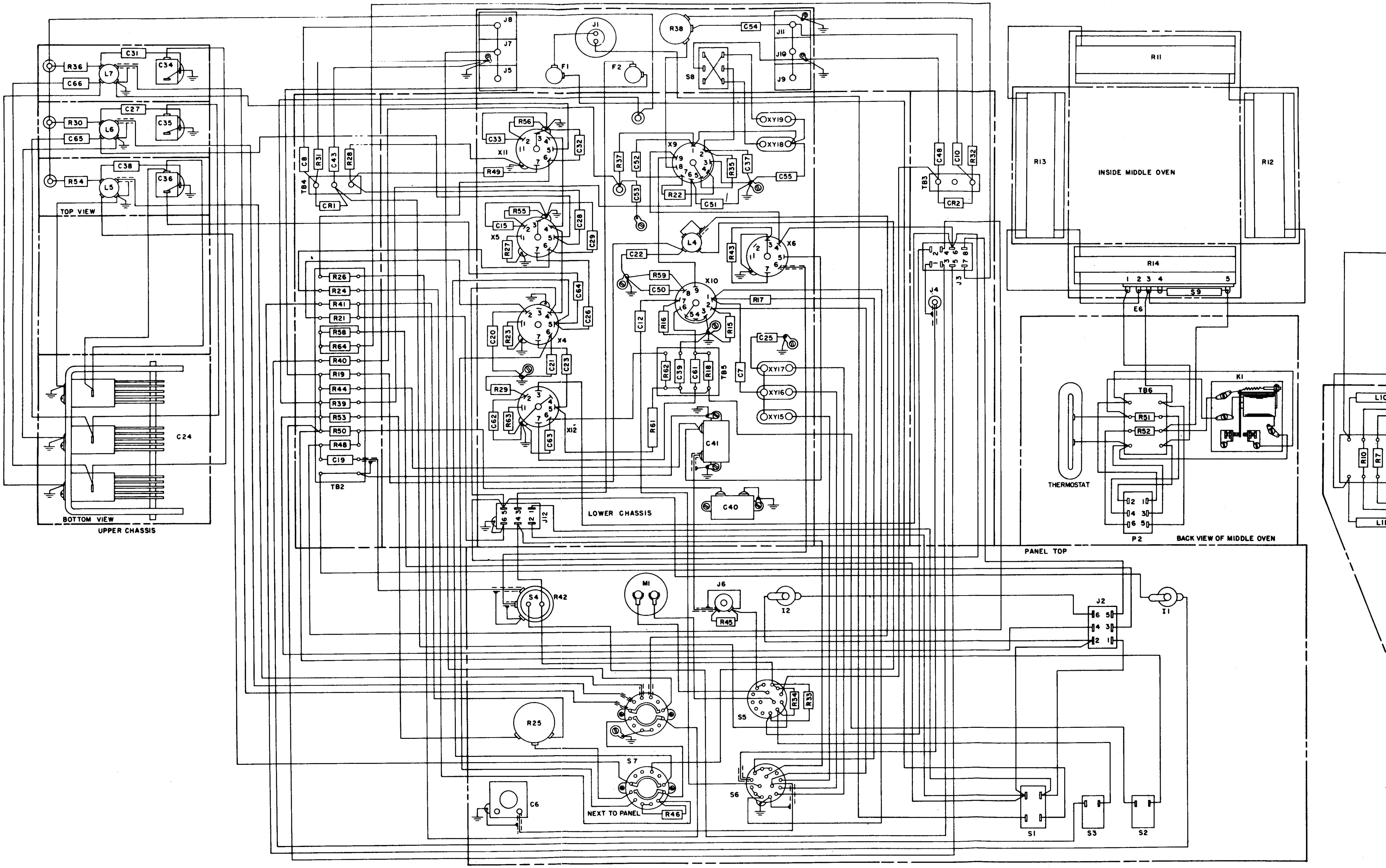


Figur 7–1. Variabl Mast r Oscillator, Schematic Diagram


MIDDLE OVEN
M2
R13 80
R11 80
R14 80
R12 80
S9
MIDDLE OVEN CONNECTIONS SHOWN FOR 110 VOLTS OPERATION
MIDDLE OVEN CONNECTIONS FOR 220 VOLT OPERATIONS
CABLE
CABLE
R52 100K
K1
R51 56K
P2
POWER ON OFF
S1
F1 4 AMP
J1
P1
J2
I2
R58 350
R64 350
SHORT REMOVED FROM R58 & R64 FOR 220 VOLT OPERATION
NOTE: RESISTANCES IN OHMS UNLESS OTHERWISE INDICATED.
CAPACITORS ARE IN MMF UNLESS OTHERWISE INDICATED.
POWER SUPPLY CONNECTIONS FOR 220 VOLT OPERATIONS
T1
R41 12
I1
F2 .2 AMP
J12
P12
POWER SUPPLY CONNECTIONS SHOWN FOR 110 VOLT OPERATION
R47 7500
L1 7h
C44 4MF
C45 4MF
C47 4MF
RECTIFIER V8 5Y3GT
V7 0A2
VOLTAGE REGULATOR
HFO XTAL S6
XY15
XY16
XY17
C25 50
HF XTAL FREQUENCY
C6 5-50
C7 .001MF
R17 10K
C11 .001MF
R15 100K
V10 12AU7
XTAL HFO OSC. A
C12 10
R18 15K
C39 .001MF
C61 100
IST HF BUFFER AMPLIFIER B
R16 100K
R59 680
C50 .01MF
2ND HF BUFFER AMPLIFIER V12 6AQ5
R61 10K
R63 240K
C62 .01MF
R29 470
L11 30
C60 .01MF
R65 750
R57 750
R66 750
R5 750
C59 .01MF
L10 30MH
C3 100MMF
R1 120K
L3 27.5MH
L2 1.72MH 3.2MH
C56 20
C1 21-220
C2 4-23
C4 .001MF
R2 1000
VARIABLE HFO OSC. V1 6C4
C57 .01MF
L8 30MH
C58 .01MF
C5 10
C46 .001MF
VARIABLE HFO BUFFER V2 6C4
R4 10K
R3 240K
C30 4-23
L9 30MH
C14 .001MF
R10 1000
R9 10K
CALIBRATOR OSC-CONV V3 6BE6
C13 .001MF
C9 5
R6 47K
R60 680
C17 .001MF
Y1 100KC
R8 100K
C16 10
C49 5-50
R7 100
C18 .01MF
INNER OVEN



Figur 7-2. Variable Mast r Oscillat r, Wiring Diagram


TOP VIEW
BOTTOM VIEW
UPPER CHASSIS
LOWER CHASSIS
INSIDE MIDDLE OVEN
THERMOSTAT
BACK VIEW OF MIDDLE OVEN
PANEL TOP
NEXT TO PANEL