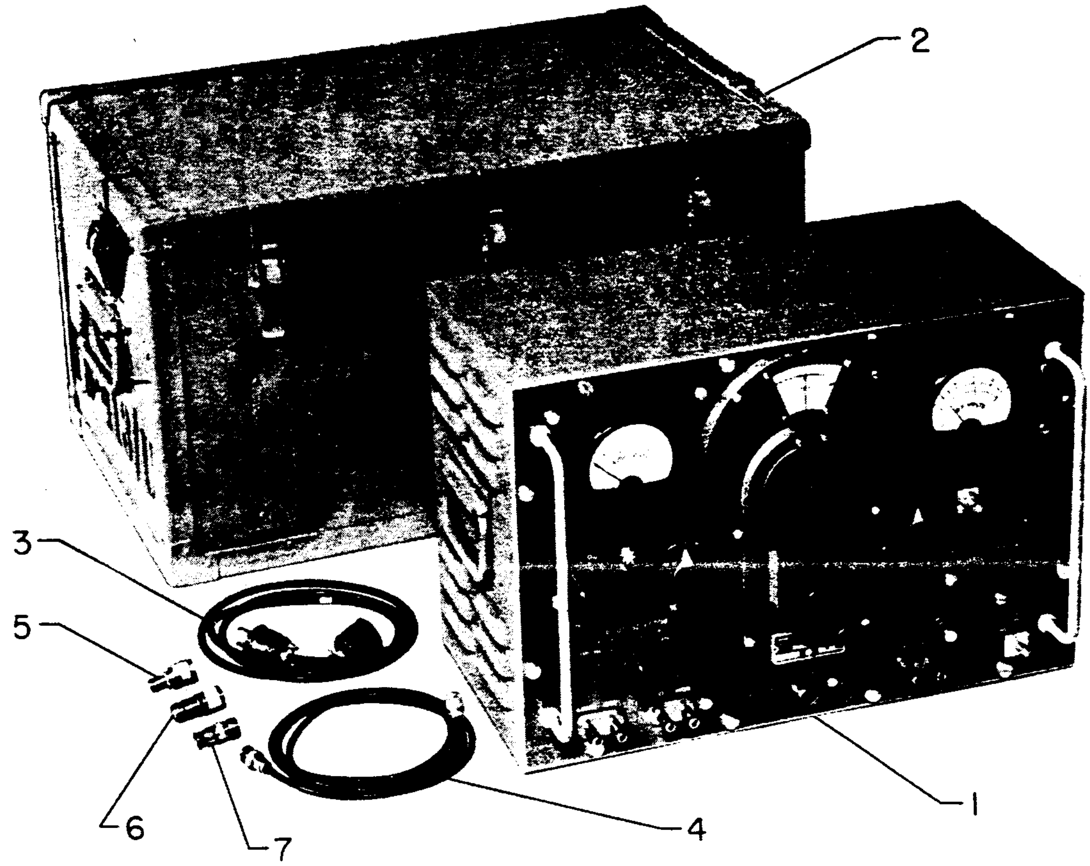
HANDBOOK
MAINTENANCE INSTRUCTIONS

SIGNAL GENERATOR

MODELS TS-413/U, TS-413C/U

PUBLISHED UNDER AUTHORITY OF THE SECRETARY OF THE AIR FORCE

TABLE OF CONTENTS



1 .... SIGNAL GENERATOR TS-413/U
2 .... CASE CY-598/U
3 .... POWER INPUT CORD
4 .... RADIO-FREQUENCY CORD CG-409/U
5 .... ADAPTER UG-201/U
6 .... ADAPTER UG-83/U
7 .... ADAPTER UG-255/U

Figure 1-1. SIGNAL GENERATOR TS-413/U

SECTION I

INTRODUCTION

1-1. SCOPE.

1-2. This handbook contains all the information necessary to enable maintenance specialists to return worn, damaged, or improperly functioning Signal Generators TS-413/U and TS-413A/U to a fully operable condition comparable to that of new equipment.

1-3. MODEL.

1-4. The test set is United States Air Force Model TS-413/U or TS-413A/U as manufactured by Harvey-Wells Electronics, Inc., Southbridge, Massachusetts. All the information in this handbook will cover both models except where explicitly noted.

1-5. COMPONENTS.

1-6. The signal generator consists of the following components:

a. One Signal Generator TS-413/U or TS-413A/U.
b. One Cord CG-409/U.
c. One Cord CX-237/U (TS-413/U only).
d. One Cord CX-337/U (TS-413A/U only).
e. One Adapter UG-83/U.
f. One Adapter UG-201/U.
g. One Adapter UG-255/U.
h. One Case CY-598/U.
i. One calibration chart.

1-7. PURPOSE.

1-8. The signal generator is designed as a standard of output voltages and frequencies. It is used in the test and alignment of radio receivers, transmitters, and other apparatus.

1-9. GENERAL DESCRIPTION.

1-10. The test set is a generator of radio-frequency voltages which can be varied in amplitude continuously from fractions of a microvolt to one volt, and varied in frequency continuously in six overlapping bands from 75 kilocycles to 40 megacycles. The test set's radio-frequency output can be internally amplitude modulated by a self-contained oscillator up to 50 percent at either 400 or 1000 cycles per second, or at any other frequency from 50 to 15,000 cycles per second with an external oscillator. The carrier is amplitude modulated in a separate untuned amplifier-modulator stage to effectively eliminate frequency modulation of the carrier. There are two vacuum-tube voltmeter circuits in the test set to measure the amplitude of the carrier voltage and the percent modulation.

1-11. The carrier frequency is controlled by a turret-type coil assembly with a band selector switch and a tuning capacitor connected to a direct reading dial with a vernier control divided in 100 equal parts to provide a total of 500 divisions per band. Precise calibrations at a number of spot frequencies over most of the test set's range can be obtained from the self-contained one megacycle crystal oscillator.

1-12. TECHNICAL CHARACTERISTICS.

1-13. POWER SUPPLY. The test set requires, for satisfactory operation, a power source supplying 105 to 125 volts at 50 to 1600 cycles per second.

1-14. OPERATING CONTROLS.

1-15. BAND SWITCH KNOB (7, Figure 1-2). The band switch knob is rotated to select any one of the six frequency ranges of the test set. In selecting the proper band, the knob performs the following two functions simultaneously:

a. The knob rotates the turret containing the oscillator coil assembly.

b. The knob rotates the dial shield to show only the proper portion of the calibrated dial.

1-16. RADIO-FREQUENCY TUNING KNOB (1). The radio-frequency tuning knob is connected directly to the variable capacitor C-111 in the oscillator section and is used to vary the frequency over the range indicated on the dial.

1-17. POWER - ON-OFF (2). The POWER - ON-OFF switch is the main power switch and turns the signal generator on or off.

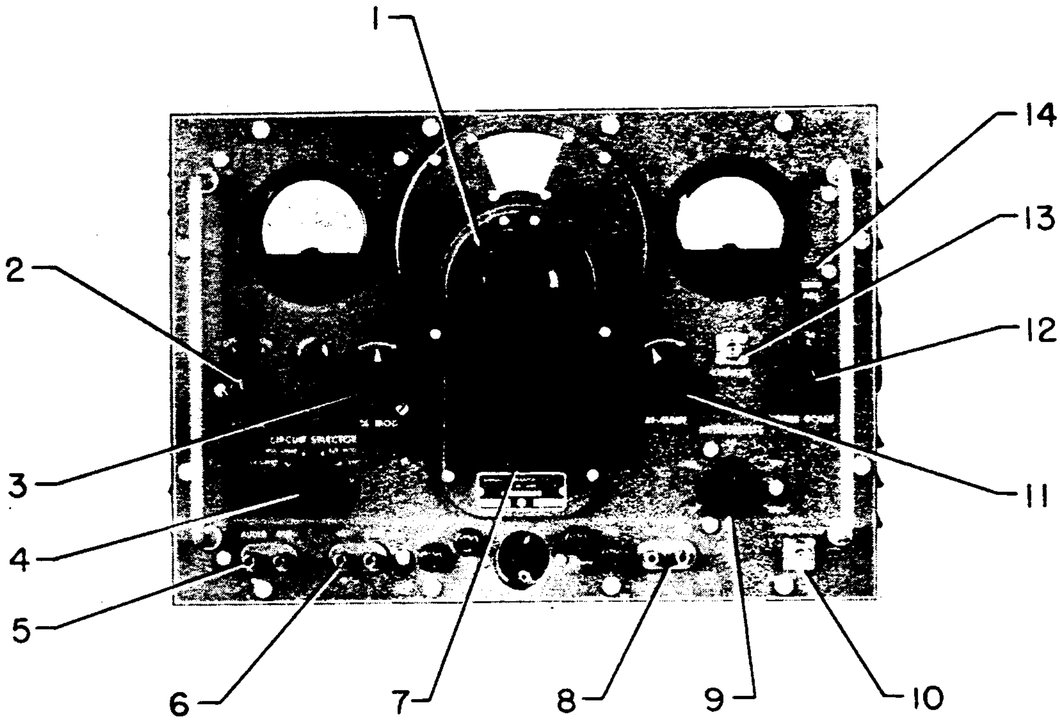
1-18. % MOD (3). The % MOD controls potentiometer R-141 on the schematic and regulates the amount of audio voltage fed to the radio-frequency modulated amplifier. By turning the knob clockwise, the percent modulation is increased; and by turning the knob counterclockwise, the percent modulation is decreased.

1-19. CIRCUIT SELECTOR (4). The CIRCUIT SELECTOR switch is S-103 on the schematic. It is a four-position two-section rotary switch. Its positions are 400 ∿ MOD, 1000 ∿ MOD, EXT MOD, and XTAL.

1-20. When the switch is set to 400 ∿ MOD, the output signal is modulated by a 400 cycle per second sine wave generated in the test set.

1-21. When the switch is set to 1000 ∿ MOD, the output signal is modulated by a 1000 cycle per second sine wave generated in the test set.

1-22. When the switch is set to EXT MOD, the output signal is unmodulated unless an external modulator is used. If an external modulator is used, the test set can be modulated by any frequency from 50 to 15,000 cycles per second.



1 .... RADIO-FREQUENCY TUNING KNOB	8 .... HET OUT
2 .... POWER - ON-OFF	9 .... MICROVOLTS
3 .... % MOD	10....... RF MICROVOLTS
4 .... CIRCUIT SELECTOR	11....... RF GAIN
5 .... AUDIO OUT	12....... METER SCALE
6 .... EXT MOD	13....... 1 VOLT-RF
7 .... BAND SWITCH KNOB	14....... ZERO ADJ.

Figure 1-2. FRONT PANEL

1-23. When the switch is turned to XTAL, power is supplied to the crystal oscillator and the beat difference between crystal harmonics and the test set's frequency can be heard at HET OUT. This position is used to calibrate the set.

1-24. RF GAIN (11). The RF GAIN control is potentiometer R-108 on the schematic and regulates the amplitude of the output signal. By turning the knob clockwise, the amplitude of the output voltage is increased; and by turning the knob counterclockwise, the amplitude of the output voltage is decreased.

1-25. METER SCALE 0.3, 1.0 (12). The METER SCALE switch is a two-position rotary switch S-102 on the schematic. When it is in the 1.0 position, it puts no additional attenuation in output circuit; but when it is in 0.3 position, it attenuates the output voltage by a factor of 3. When in 1.0 position, RF VOLTS are read on 1.0 range; and when it is in 0.3 position, RF VOLTS are read on 0.3 range.

1-26. MICROVOLTS 10, 100, 1K, 10K, 100K (9). The switch labeled MICROVOLTS is the attenuator. This switch controls the open-circuit voltage present at the RF MICROVOLTS output jack. To obtain the actual open-circuit voltage at the RF MICROVOLTS jack, it is necessary to multiply the reading of the radio-frequency voltmeter on the scale indicated by METER SCALE switch, by the setting of the MICROVOLTS switch.

1-27. JACKS.

1-28. AUDIO OUT (5). Any voltage used to modulate the generator is available at the AUDIO OUT terminals. The open-circuit voltage at these terminals can be read on the lower scale of the modulation meter. Either the 400 or the 1000 cycle per second voltage of the audio oscillator is available on proper position of the CIRCUIT SELECTOR switch.

1-29. EXT MOD (6). When the CIRCUIT SELECTOR switch is in the EXT MOD position, the output voltage is not modulated. To modulate the carrier at any frequency from 50 to 15,000 cycles per second, an external generator must be connected across EXT MOD terminals. The external generator need supply only 0.1 watts into 1000 ohms for 30 percent modulation.

1-30. HET OUT (8). When the CIRCUIT SELECTOR switch is in XTAL position, the beat difference between the crystal oscillator and signal generator can be heard at HET OUT. This beat difference is used to calibrate the test set at check points listed in the calibration chart.

1-31. 1 VOLT-RF (13). The voltage at the 1 VOLT-RF output is given directly in volts by reading the RF VOLTS voltmeter on the scale indicated by the METER SCALE switch.

1-32. RF MICROVOLTS (10). The voltage at RF MICROVOLTS jack is given in microvolts when the reading of the RF VOLTS voltmeter on the scale indicated by the METER SCALE switch is multiplied by the reading of attenuator MICROVOLTS switch.

1-33. IMPEDANCE CONSIDERATIONS.

1-34. In using the above-mentioned jacks, consideration should be given to the impedance of the load connected to these jacks. As previously mentioned, the voltages indicated by the radio-frequency voltmeter are open-circuit output voltages; and if the load resistance is low enough to shunt the output resistance appreciably, a voltage correction must be made. Output impedances for the various output voltage ranges are listed in paragraph 2-9. When using the audio output terminals, the above impedance considerations should be kept in mind. The impedance of the audio output terminals is 1000 ohms.

1-35. ACCURACY OF OUTPUT VOLTAGES.

1-36. The accuracy of the indicated radio-frequency output voltages is dependent upon three factors; the radio-frequency voltmeter, the attenuator, and the load at the output jack, which includes the output cable. The radio-frequency voltmeter has an inherent accuracy of ±2 percent of full scale at all frequencies. The attenuator has an accuracy of approximately ±6 percent over the entire frequency range when operating essentially open-circuited or directly into a vacuum-tube voltmeter. When operating into a low impedance load of the order of 50 ohms through a properly terminated cable, the above accuracy can be maintained on all frequencies on all attenuator steps except the 100K position. On the 100K position, the output impedance of the attenuator itself is 50 ohms, and the voltage appearing at the load will be altered.

SECTION II

TABLE OF SPECIFICATIONS

2-1. TUBE COMPLEMENT. The test set contains the following tubes:

TABLE I

TUBE	QUANTITY	JAN TYPE	FUNCTION	LOCATION
V-101	1	9002	Oscillator tube	Oscillator assembly
V-102	1	6AG7	Modulator tube	Amplifier assembly
V-103	1	6AL5W	Dual diode rectifier for radio-frequency indicator	Amplifier assembly
V-104	1	6J6	Dual triode voltage amplifier for radio-frequency indicator	Amplifier assembly
V-105	1	6SA7	Oscillator and detector	Amplifier assembly
V-106	1	5Y3/GT	Rectifier	Power Supply
V-107	1	OA3	Voltage regulator	Power Supply
V-108	1	OD3	Voltage regulator	Power Supply
V-109	1	6SN7W/GT	Audio oscillator	Power Supply
V-110	1	6C4	Cathode follower	Power Supply
V-111	1	6C4	Rectifier for audio indicator	Power Supply

2-2. FUSES. The test sets contain four fuse holders, two fuse holders marked 2A and two marked SPARE. The fuse holders contain two ampere 4AG fuses.

2-3. POWER SUPPLY. The test set requires, for satisfactory operation, a power source supplying 105 to 125 volts at 50 to 1600 cycles per second.

2-4. FREQUENCY RANGE. The frequency range is from 75 kilocycles to 40 megacycles in six ranges as follows:

Band 1	75 kc. to 230 kc.
Band 2	230 kc. to 660 kc.
Band 3	650 kc. to 1.95 mc.
Band 4	1.85 mc. to 5.5 mc.
Band 5	5.4 mc. to 17.5 mc.
Band 6	17 mc. to 40 mc.

2-5. ACCURACY OF CALIBRATION. The accuracy of the test set's output frequency is ±1 percent of scale reading under normal atmospheric conditions. Under field service conditions, the true output frequency will deviate from the indicated frequency by not more than ±5 percent.

2-6. CRYSTAL CALIBRATOR. The crystal calibrator has a fundamental frequency of one megacycle and an accuracy of better than ±0.1 percent. The crystal in the TS-413/U is a type DC-9-AJ, and the crystal in the TS-413A/U is a type CR-18 U.

2-7. RADIO-FREQUENCY OUTPUT VOLTAGE. The radio-frequency output voltage can be obtained at either of two jacks. The range of the low output jack, marked RF MICROVOLTS, is from fractions of one microvolt to 0.1 of a volt; and the range of the high output jack, marked 1 VOLT-RF, is from 0.1 of a volt to one volt.

2-8. RADIO-FREQUENCY ACCURACY. The output accuracy will be ±10 percent over range 100 microvolts to one volt, and ±3 microvolts over range zero to 10 microvolts under normal atmospheric conditions.

2-9. OUTPUT IMPEDANCES. The output impedances are approximately those given below:

5 ohms up to .01 volts output
50 ohms from .01 to 0.1 volts output
150 ohms from 0.1 to 0.3 volts output
500 ohms from 0.3 to 1 volt output.

2-10. RADIO-FREQUENCY HARMONIC DISTORTION. The radio-frequency harmonic distortion of the carrier is less than 5 percent of total signal strength.

2-11. RADIO-FREQUENCY LEAKAGE. The radio-frequency leakage measured at 40 mc. and 18 inches from the case is less than 1 microvolt per meter.

2-12. AUDIO-FREQUENCY MODULATION. The following are the specifications for audio-frequency modulation:

a. The signal generator can be modulated internally with a 400 or 1000 cycle per second sine wave. The accuracy of sine wave is ±10 percent of the stated frequency.

b. It can be modulated externally at any frequency from 50 to 15,000 cycles per second with a source capable of delivering a power input of 0.1 watts or 10 volts root mean square into 1000 ohms.

c. The percent modulation can be read up to 50 percent on panel meter, with an accuracy of ±6 percent up to 30 percent amplitude modulation.

2-13. AUDIO-FREQUENCY OUTPUT. There is available at panel binding posts indicated by AUDIO OUT an audio output voltage variable from 0 to 1 volt at either 400 or 1000 cycles per second.

SECTION III

THEORY OF OPERATION

3-1. BLOCK DIAGRAM. (See Figure 3-1.) The radio-frequency voltage is generated in the oscillator section. From the oscillator section, the signal is fed to the modulated radio-frequency amplifier and the crystal oscillator and mixer. Plate voltage is only applied to crystal oscillator and mixer when the CIRCUIT SELECTOR switch is on XTAL.

3-2. The signal is modulated at the untuned modulated radio-frequency amplifier. The modulator has a monitor consisting of a vacuum-tube voltmeter circuit, a cathode follower, a diode detector, and a modulator indicator. This voltmeter circuit is calibrated to read directly the percent modulation of output wave.

3-3. The modulated signal is fed through a resistive attenuator to the output jacks. The monitor of the output signal is a vacuum-tube voltmeter consisting of a dual diode detector, a dual triode amplifier, and a direct-current microammeter, calibrated to indicate the amplitude of the output voltage.

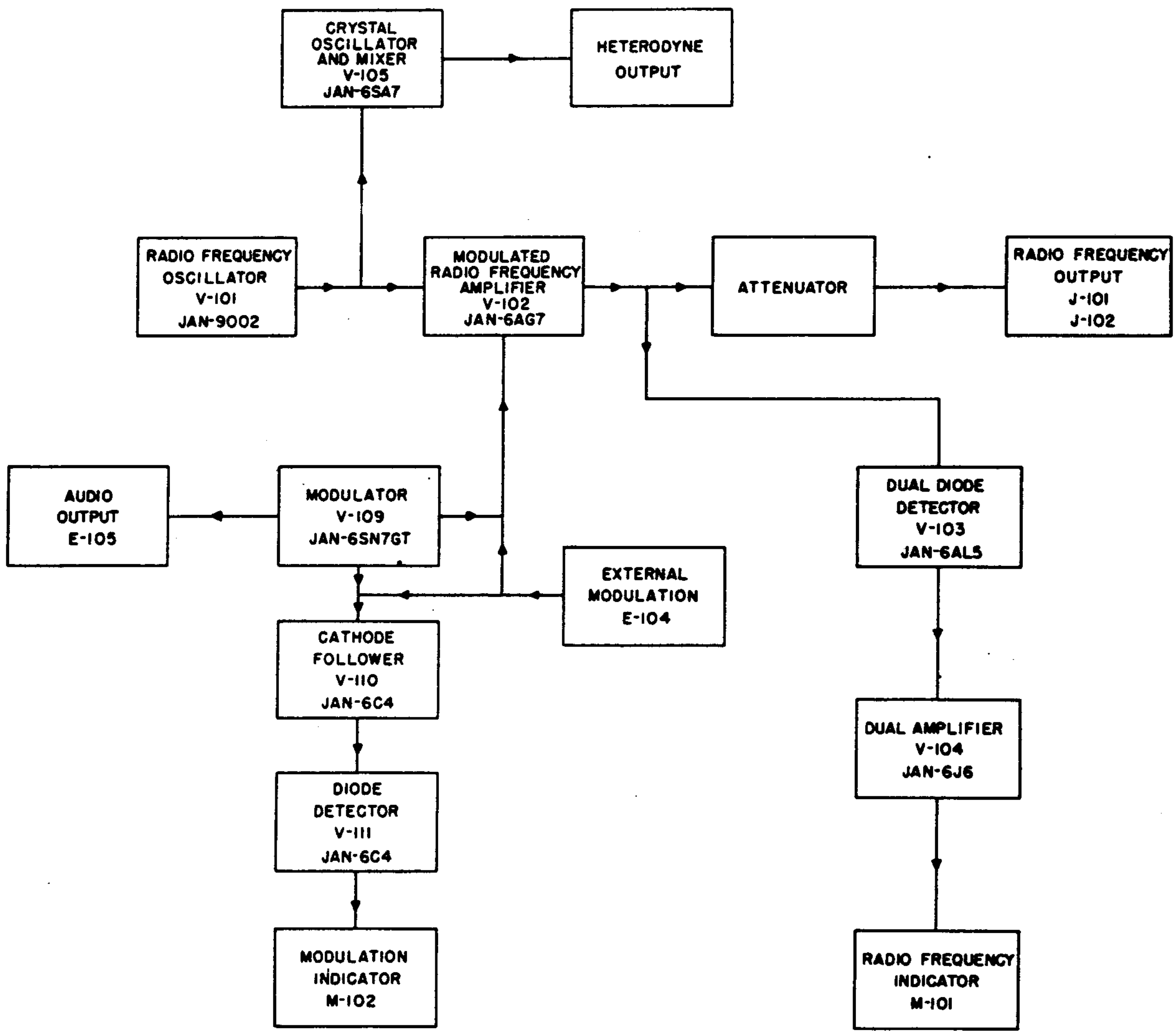


Figure 3-1. BLOCK DIAGRAM

3-4. When the CIRCUIT SELECTOR switch is turned to XTAL, the crystal oscillator and mixer is energized and the crystal oscillator harmonics beat electronically with the radio-frequency signal generated in the oscillator. These two signals are adjusted to zero beat to obtain calibration points for the signal generator.

3-5. GROUND CURRENTS. Strong or excessive ground currents have two highly undesirable effects. First, it makes shielding the signal generator much more difficult or impossible; and secondly, ground currents affect the calibration of radio-frequency meter. With high ground currents or poor shielding, it is nearly impossible to accurately use the signal generator as a standard of low output voltages - that is, at fractions of a microvolt.

3-6. To reduce the effects of ground currents, only one point has been grounded in each of the chassis - the amplifier, the power supply, and the oscillator. There is one exception to this statement; the JAN 6AG7 tube, which has pin one internally connected to shell, is grounded at pin one. In any maintenance work, the repairman must pay careful attention to all grounds. In the overall schematic and sectional schematics, these common grounds are shown as a heavy black line.

3-7. SHIELDING. The amplifier chassis and oscillator section are completely shielded to reduce unwanted radiation. These chassis and shields are silver plated to give the conducting surface a lower surface resistivity. Because the radiation problem is present mainly at the higher frequencies - where skin effect is complete - the silver plated shields act like solid silver with a very low resistance and therefore lower ground currents.

3-8. POWER SUPPLY (See Figure 3-2).

3-9. All the power requirements of the test set are provided by transformer T-101 and its associated rectifier circuits. With plug J-103 connected to a source of a 105 to 125 volts, 50 to 1600 cycles per second, single-phase, alternating current, and with switch S-103 closed, power is applied to the primary of transformer T-101. Fuses F-101 and F-102, commercial two-ampere 4AG type, provide protection against overload or shorts. Filter network C-148, C-149, L-149, and L-148 prevents any stray radio-frequency energy from escaping from the set into the power line and at the same time keeps stray radio-frequency energy from entering the set through the power line.

3-10. The transformer T-101 has four secondary windings. The lowest winding supplies 9.1 volts alternating current for the filament of the oscillator tube V-101. The 9.1 volts is necessary to compensate for the drop in the filter circuit in the filament of the oscillator. The second winding provides 6.3 volts alternating current for the filaments of V-102, V-103, V-104, V-105, V-109, V-110, V-112, and the pilot

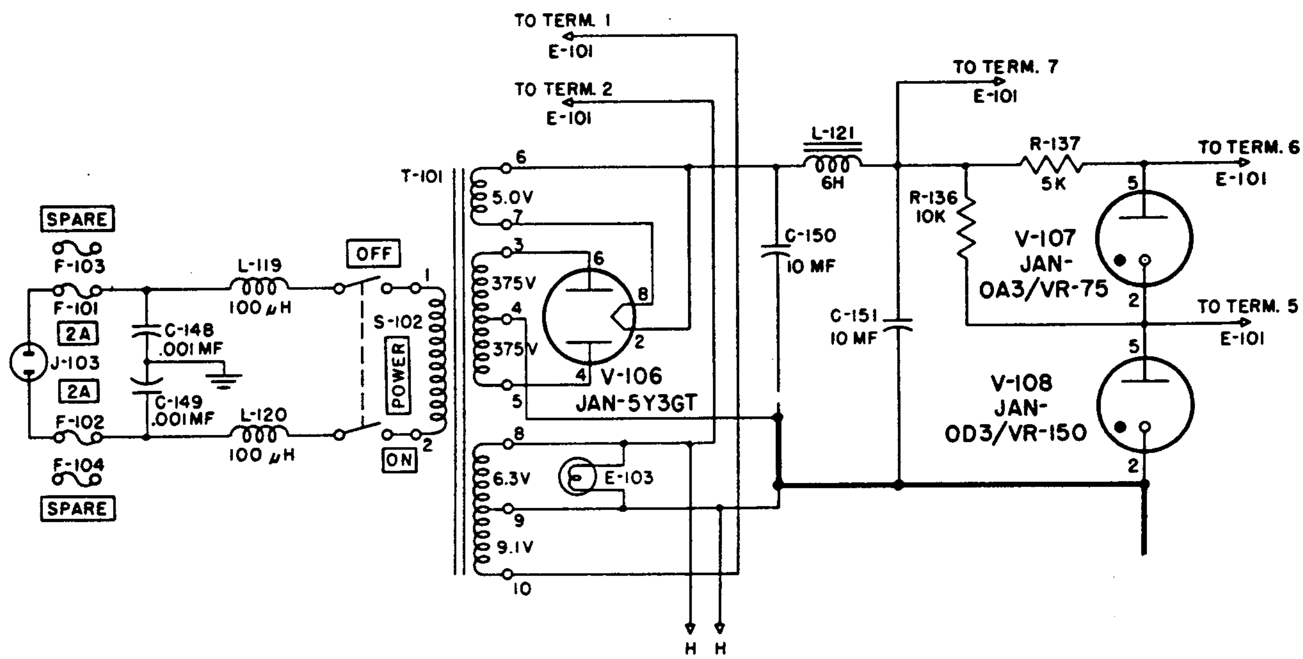


Figure 3-2. POWER SUPPLY DIAGRAM

light I-101. The third winding supplies high voltage for B+. The top winding supplies the 5.0 volts alternating current for the heater of the rectifier tube JAN 5Y3GT (V-106).

3-11. The rectifier tube functions as a full-wave rectifier, and alternating-current voltage is applied to the two plates 180° out of phase by the high voltage (third) secondary winding of T-101. Each plate conducts current only during the half-cycle when its applied voltage is positive. The rectified voltage is applied to the low-pass filter from pin 8 of V-106 (positive) and from the center tap of the high-voltage winding, which is ground. The low-pass filter, consisting of capacitor C-151, C-150 and inductor L-121, smooths out the ripple content of the rectifier output.

3-12. The output of the filter network is +400 volts direct current. Resistors R-136 and R-137 form a combination bleeder and voltage divider network and provide a regulated ±225 volts and +150 volts in conjunction with gaseous regulator tubes JAN types OA3 (V-107) and OD3 (V-108). This regulated voltage provides greater stability for the radio-frequency and audio-frequency oscillators.

3-13. RADIO-FREQUENCY OSCILLATOR (See Figure 3-3). The radio-frequency oscillator is a shunt-fed Hartley oscillator with its plate at radio-frequency ground. The proper feedback voltage to sustain oscillation is obtained from L-101, L-102, L-103, L-104, L-105, or L-106 depending upon the position of the band selector switch between points 1 and 4 at point A. The load voltage is taken off the load coil between points 1 and 2; and since point 1 is grounded and common between tank coil (points 1 and 4 at point A) and the load coil (points 1 and 2), these coils are shown as one continuous coil.

3-14. Bias is obtained for the oscillator by using a grid-leak resistor-capacitor combination of C-112 and R-106, R-101 and C-107, R-102 and C-108, R-103 and C-109, R-104 and C-110, or R-105 and C-111, depending upon the position of the band selector switch. C-111 A & B is the tuning capacitor for the tank coil, and either one section or both sections in parallel are used to tune the tank circuit.

3-15. There are two filter networks incorporated into the oscillator circuit to keep radio-frequency energy from escaping to the power supply. L-109, L-110,

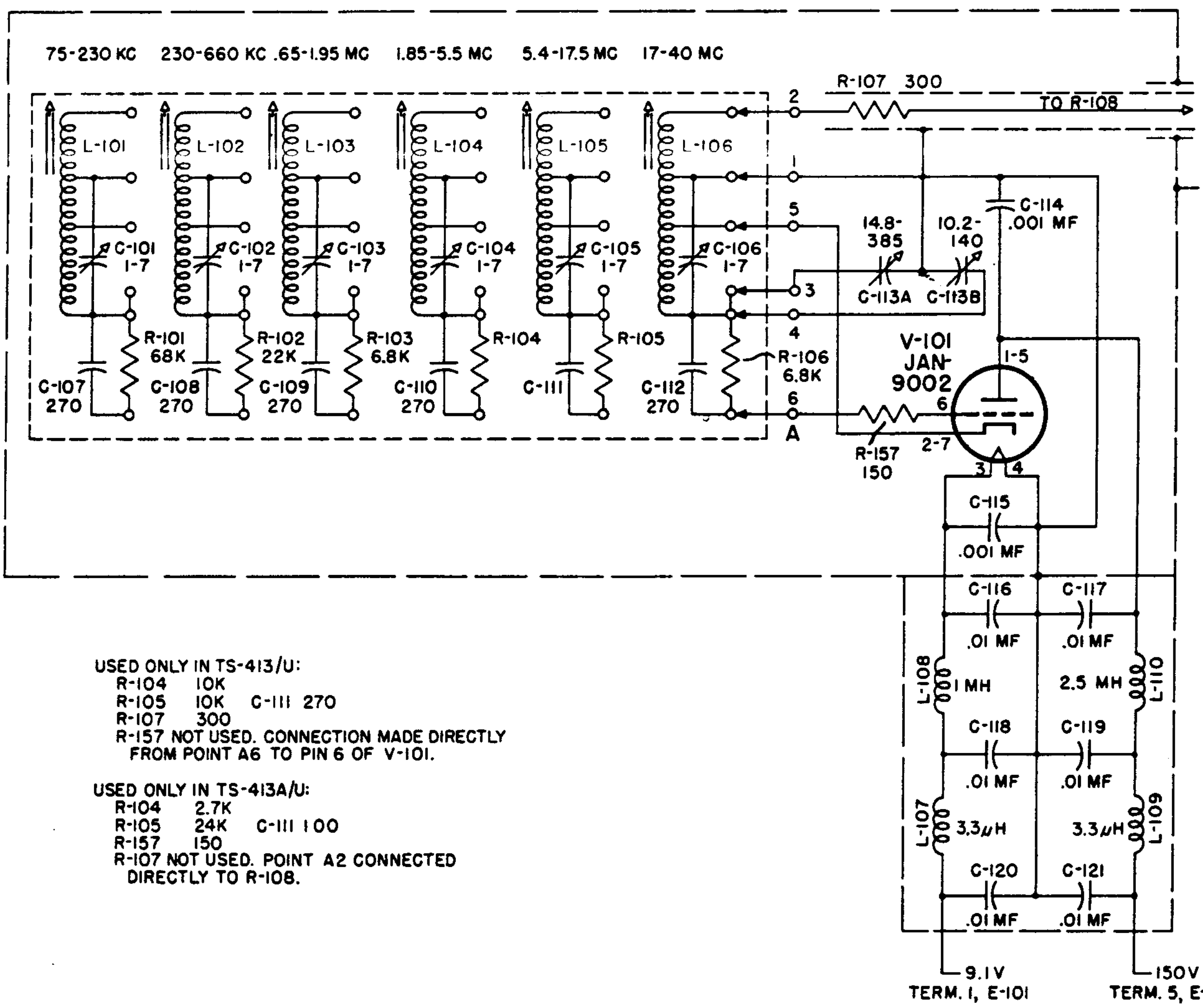


Figure 3-3. RADIO-FREQUENCY OSCILLATOR DIAGRAM

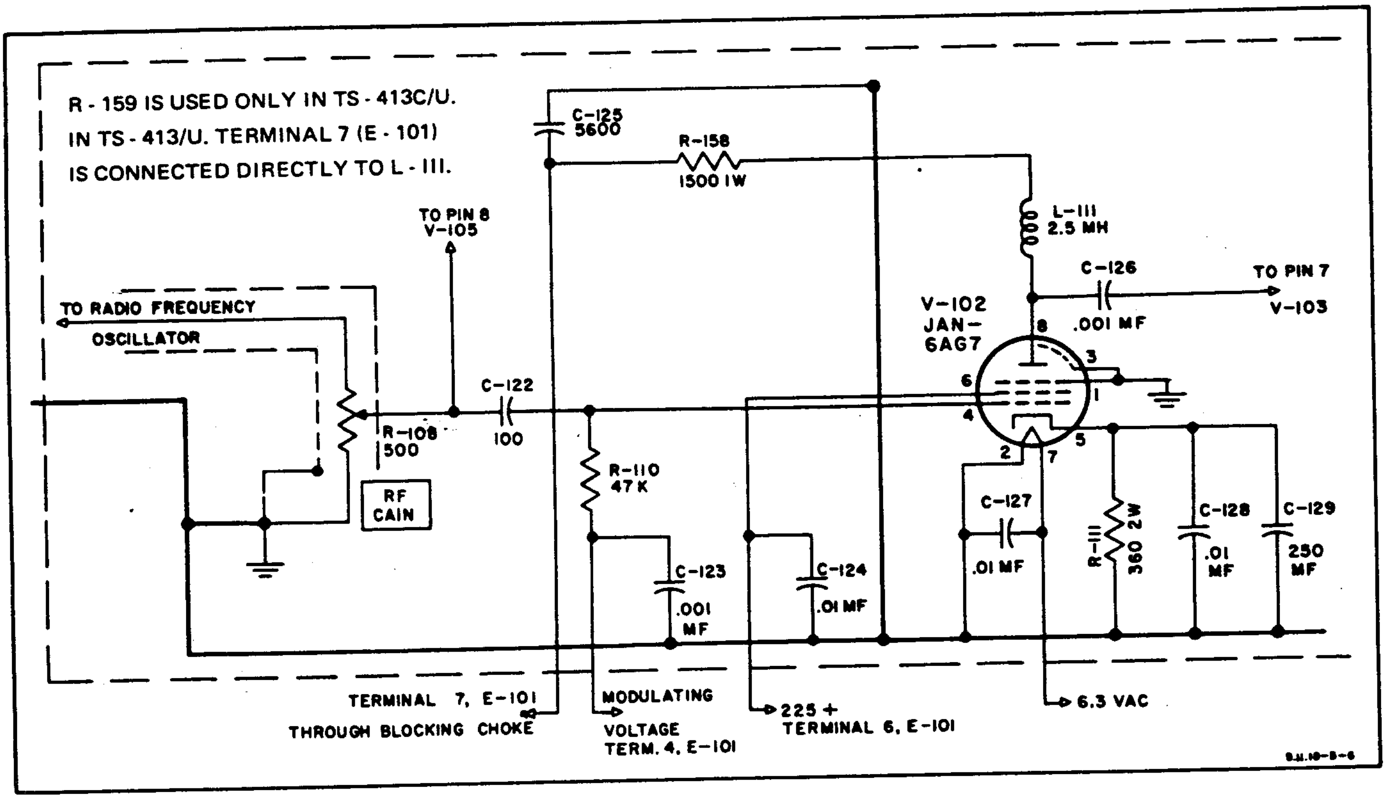


Figure 3-4. MODULATED RADIO-FREQUENCY AMPLIFIER DIAGRAM

C-117, C-119, and C-121 form a filter for the plate supply voltage; and L-107, L-108, C-115, C-116, C-118, and C-120 form a filter network for the filament voltage. Because of the large drop in filament chokes L-107 and L-121, the filament winding for the oscillator delivers approximately 9.1 volts alternating current to enable the drop across the tube to be the required 6.3 volts alternating current.

3-16. C-101, C-102, C-103, C-104, C-105, or C-106 is the trimmer capacitor used to recalibrate the oscillator per paragraph 6-6 with its corresponding variable inductor.

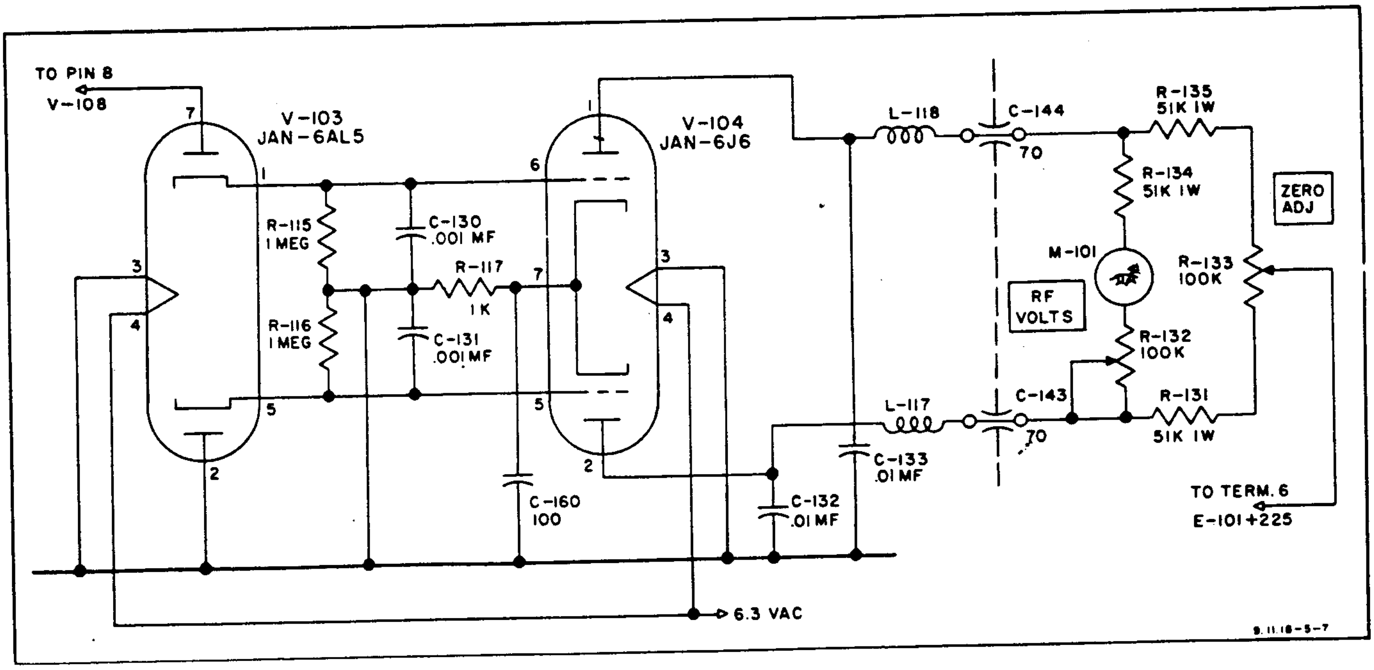


Figure 3-5. RADIO-FREQUENCY INDICATOR DIAGRAM

3-17. MODULATED RADIO-FREQUENCY AMPLIFIER (See Figure 3-4). Tube V-102 is untuned grid-modulated radio-frequency amplifier. The signal generated in the oscillator is fed to grid, pin 4, through potentiometer R-108. The modulating voltage is fed from audio oscillator through pin 4 of E-101, the blocking network, resistor R-110, and across capacitor C-123 to the grid pin 4 of V-102. The modulating voltage varies the grid bias at an audio frequency which amplitude modulates the radio-frequency voltage on the plate, pin 8, of V-102. The cathode resistor R-111, which supplies bias for the grid, is bypassed by both C-128 and C-129. Capacitor C-129, a 250 microfarad capacitor, is used to bypass the low frequency audio modulating voltages; but its internal inductance is too high to bypass the radio-frequency signals. Therefore, C-128, a .01 microfarad capacitor, is connected across C-129 to bypass the radio-frequency signals. R-111 supplies the necessary cathode bias for V-102 to operate as either a modulated or unmodulated radio-frequency amplifier. L-111 is an inductive plate load for V-102. R-158 is used in the TS-413A/U to flatten the amplifier's gain characteristics.

3-18. RADIO-FREQUENCY INDICATOR (See Figure 3-5). The radio-frequency indicator is a vacuum-tube voltmeter circuit consisting of a dual diode (V-103) feeding into a dual triode (V-104) with a direct-current microammeter as the indicator. One side of the diode is fed from the radio-frequency modulated amplifier, and the other side is referenced at ground. The grounded side is used to supply a reference voltage. The rectified voltage is fed through the parallel balanced circuits R-115 and C-130, and R-116 and C-131 to grids, pin 5 and 6, of V-104. Each plate, pin 1 and pin 2, of V-104, is brought to one side of M-102, the direct-current indicating meter, in series with either R-132 or R-134. R-132 is variable to compensate for variation in circuit constants. R-131, R-135, and R-133 form a voltage divider circuit to zero the radio-frequency indicator meter. The direct-current microammeter is calibrated to indicate the root mean square or effective value of the radio-frequency voltage. C-160 is used to eliminate parasitic oscillations in the radio-frequency indicator.

3-19. CRYSTAL OSCILLATOR AND DETECTOR (See Figure 3-6). Tube V-105 is a mixer and crystal oscillator used to beat the crystal frequency of its harmonics against the generated signal for calibration pur-

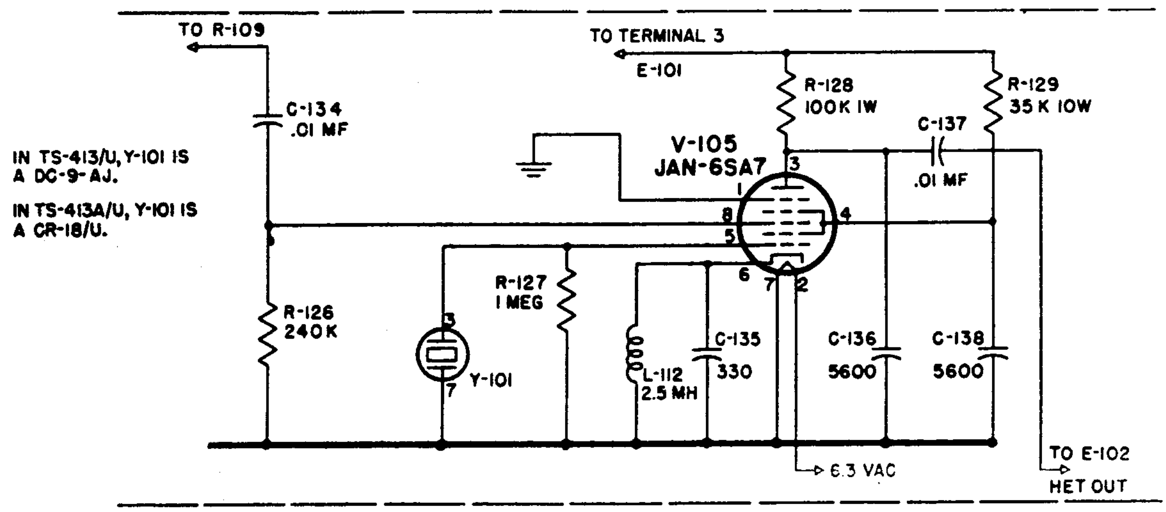


Figure 3-6. CRYSTAL OSCILLATOR AND DETECTOR DIAGRAM

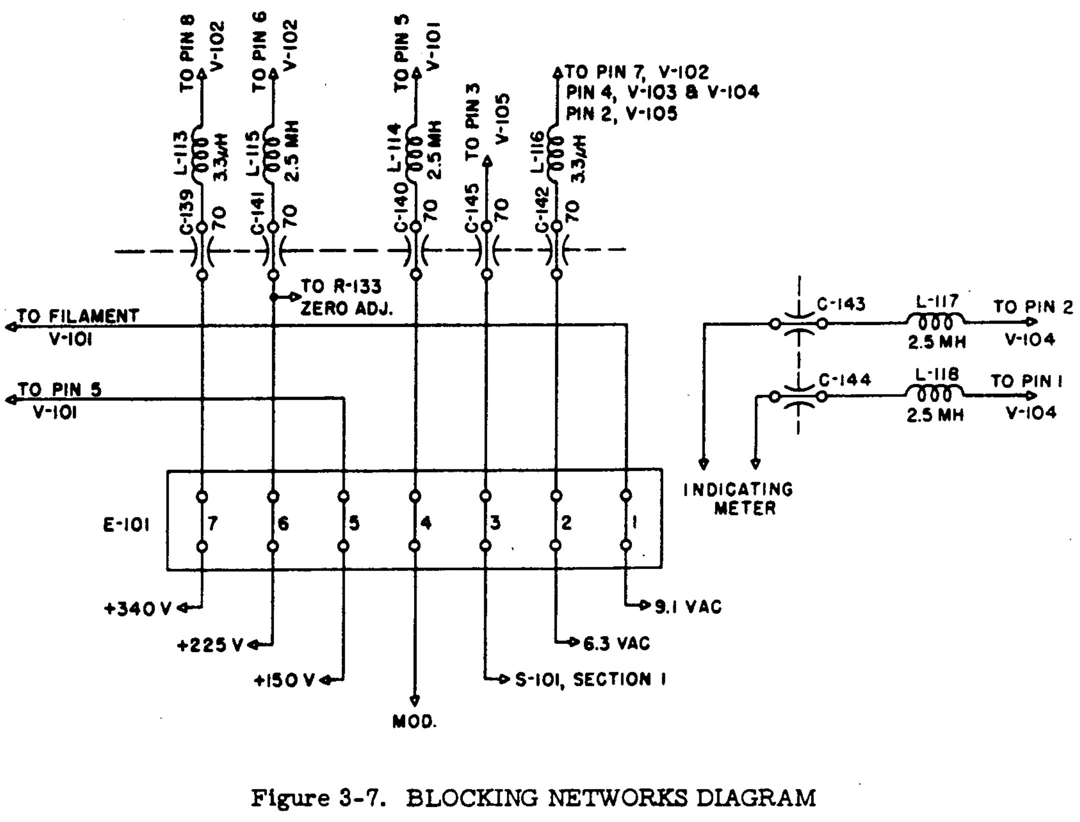


Figure 3-7. BLOCKING NETWORKS DIAGRAM

poses. Its frequency of oscillation is determined by Y-101, a one megacycle crystal, connected to pin 5 and ground of V-105. In parallel with the crystal is a grid-leak resistor R-127 to provide bias for the oscillator. Since the oscillator must deliver up to the fortieth harmonic, the plate, pin 4, is untuned. L-112 and C-135 form a tuned circuit in cathode of oscillator which is resonant at a lower frequency than first harmonic frequency of the crystal. The signal from modulated radio-frequency amplifier is fed to pin 8 (across capacitor C-135 and through R-126). R-128 and R-129 are plate dropping resistors for B+, and C-137, C-138, C-136 are blocking capacitors. Electronic mixing takes place in V-105, and the beat frequency is heard at HET OUT through R-130 and C-146.

3-20. BLOCKING NETWORKS (See Figure 3-7). All interconnections between the four preceding components, the radio-frequency oscillator, the modulated radio-frequency amplifier, the radio-frequency indicator, and the crystal oscillator and detector, and the remaining components of the signal generator are made through the blocking network consisting of the radio-frequency chokes, feed-through capacitors and terminal strip E-101 shown in the referenced figure. This network effectively prevents the radio-frequency energy from escaping from these sections to the remainder of the test set.

3-21. AUDIO OSCILLATOR (See Figure 3-8). The audio oscillator is a resistance-capacitance tuned oscillator capable of generating either 400 or 1000 cycles per second sine wave. The frequency of oscillation is dependent upon the ratio of resistive-capacitive network (R-139, C-154, and C-152) which feeds the signal back to pin 1 and resistive-capacitive network (R-138, C-153, and C-155) from pin 1 to ground. By changing the position of S-103 (the CIRCUIT SELECTOR switch), capacitors C-152 and C-153 can be either removed or put into the oscillator circuit, changing its frequency from 400 to 1000 cycles per second. With R-139, C-154, and C-152 in the feedback circuit and C-153, C-115, and R-138 in grid circuit, the oscillator's fundamental frequency is 400 cycles per second. With C-152 and C-153 out of the circuit, the oscillator's frequency is 1000 cycles per second. R-141 and R-140 are plate dropping resistors, and R-142 and R-143 are cathode bias resistors and part of voltage developed across R-143 is used to feed the cathode follower in the next stage (see Figure 3-9). Neither cathode resistor is bypassed by a capacitor thereby introducing negative feedback for a more stable audio oscillator. R-142 is adjustable to vary the bias on pin 1. The correct adjustment of R-142 is a compromise between voltage output and the distortion of the audio output wave determined by use of an oscilloscope. The CIRCUIT SELECTOR (S-103) in EXT MOD and XTAL position opens the cathode, pin 6, and allows either an external audio oscillator or the crystal calibrator to be used.

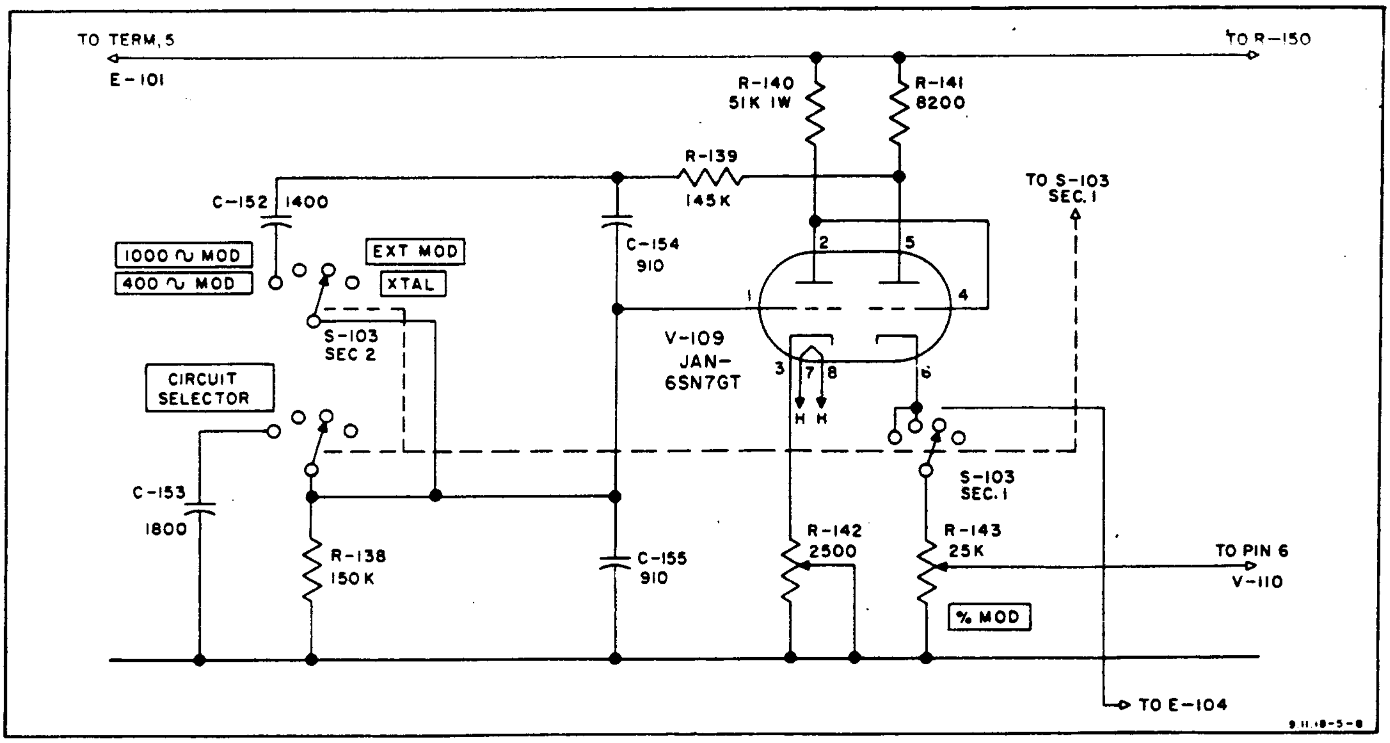


Figure 3-8. AUDIO OSCILLATOR DIAGRAM

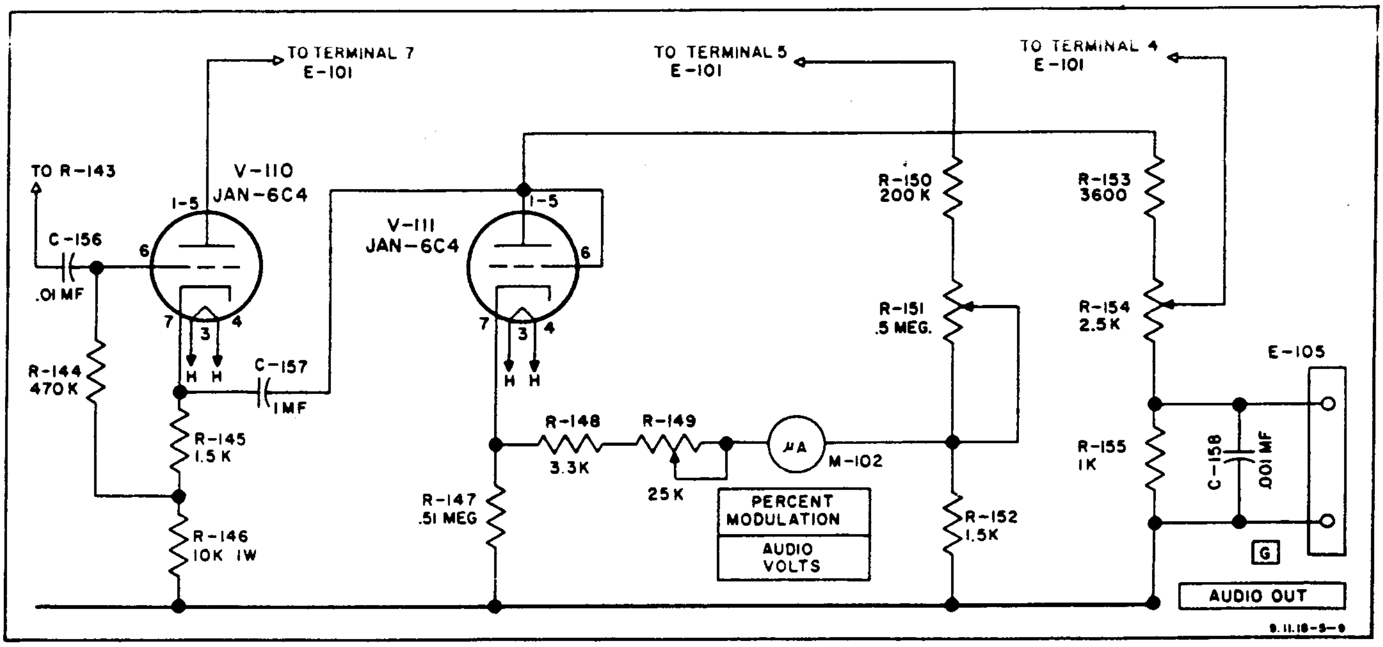


Figure 3-9. AUDIO-FREQUENCY INDICATOR DIAGRAM

3-22. AUDIO-FREQUENCY INDICATOR (See Figure 3-9). The signal from either the audio oscillator or the external modulator (depending upon the external position of S-103) is fed to grid, pin 6, of V-111, which is a cathode follower. Since the value necessary for a proper load resistor will supply too much feedback to the grid of V-111, the arrangement for bias uses the split resistors (R-145 and R-146) in the form shown. With this arrangement it is possible to obtain both the correct bias and the correct load resistor, since only the voltage developed across R-145 supplies bias to the grid. V-111 is connected as a diode and is used as a slide-back positive-peak vacuum-tube voltmeter with direct-current indicating meter M-102. R-150, R-151, and R-152 are used as a voltage divider circuit to bias the meter. R-148, R-149, the resistance of M-102, and R-152 parallel R-147 to form the load resistance of the diode. R-151 and R-149 can be adjusted to compensate for circuit variance as explained in paragraph 6-8. R-153, R-154, and R-155 provide a voltage divider for the audio-modulating voltage. The modulating voltage is taken off R-154, a variable used to adjust the percent modulation; and the audio output is taken off the parallel combination of R-155 and C-158.

3-23. ATTENUATOR (See Figure 3-10). The attenuator consists of resistors R-119, R-118, R-120, R-121, R-122, R-123, R-124, and R-125. It is used to reduce a known voltage in controllable amounts. It is, in theory, an accurate voltage divider. S-102 controls an additional voltage divider to attenuate the output by an additional factor of 3. This voltage divider consists of R-112, R-113, and R-114 and is switched by switch S-102.

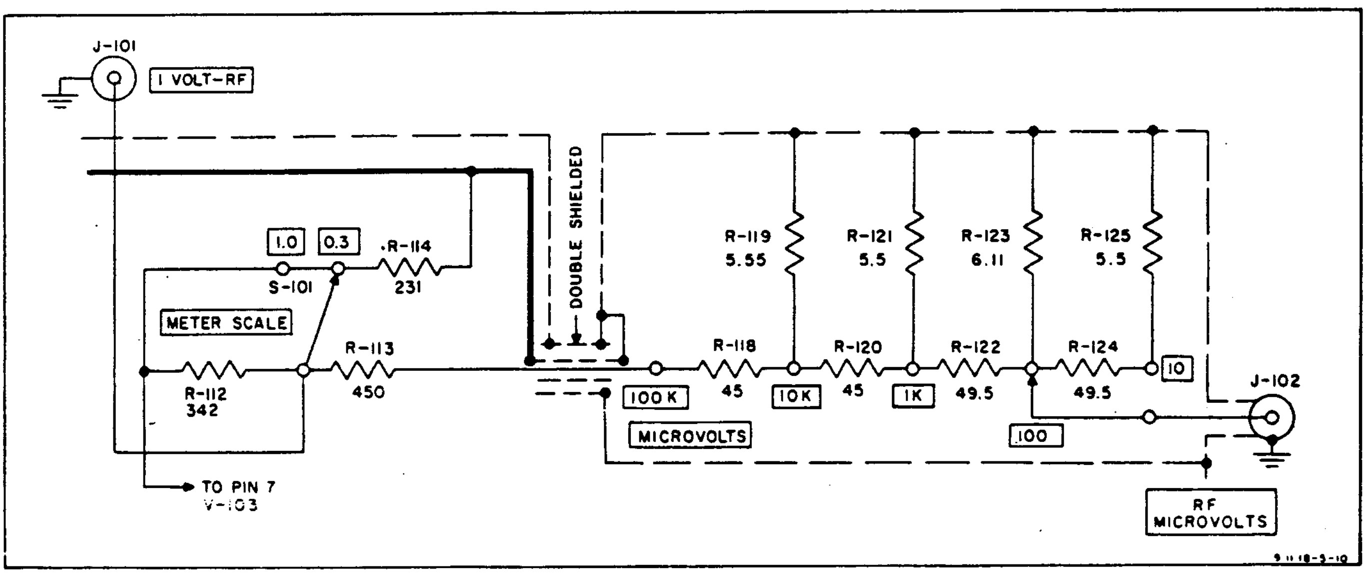


Figure 3-10. ATTENUATOR DIAGRAM

3-24. NORMAL SEQUENCE OF OPERATIONS.

CAUTION

Before the power is connected, the operator should connect the signal generator's instrument case to ground to avoid the possibility of shock.

3-25. WARM UP. With Cord CX-237/U, connect the test set to a power source meeting the requirements of paragraph 1-13. Turn POWER ON-OFF switch to ON. The pilot light should light. Check RF GAIN and % MOD controls and adjust if either PERCENT MODULATION or RF VOLTS meter is over full scale. Allow set to warm up for twenty minutes.

3-26. The following is a normal sequence of operations in using the test set. This sequence can be varied for different uses and by different operators.

a. Warm up set as described in paragraph 3-25.

b. Turn band selector switch to desired band.

c. Turn radio-frequency tuning knob to desired frequency.

d. Turn CIRCUIT SELECTOR switch to position for proper modulation or calibration.

(1) If turned to position 3, EXT MOD, an external modulator must be connected to terminal marked EXT MOD.

(2) If turned to XTAL, proceed as described in paragraph 6-10.

e. Adjust % MOD control for desired modulation. Reading on PERCENT MODULATION meter indicates actual percentage modulation of the carrier.

f. The adjustment of RF GAIN, METER SCALE switch, and MICROVOLTS control is dependent upon voltage desired at either 1 VOLT-RF or RF MICROVOLTS jacks. The following is a typical but not the only sequence which can be followed:

(1) Turn METER SCALE switch to 1.0.

(2) Adjust RF GAIN for full scale deflection.

(3) Voltage at 1 VOLT-RF jack is one volt. Voltage at 1 VOLT-RF is always the actual voltage read on the proper scale as indicated by METER SCALE switch.

(4) The microvolts output at the RF MICROVOLTS jack is the product of the reading of the radio-frequency voltmeter on the scale indicated by the METER SCALE switch and the setting of the MICROVOLTS control.

g. Connect desired jack to equipment to be tested with cord CG-409/U and/or adapters UG-83/U, UG-201/U, or UG-255/U.

CAUTION

The output of the attenuator should never be connected to an alternating-current voltage source. If it is necessary to connect the output to a direct-current source, a .5 microfarad capacitor should be connected in series with connecting line.

3-27. STOP TEST SET.

3-28. Turn POWER ON-OFF switch to OFF.

3-29. STORE TEST SET.

3-30. Replace test set in carrying case CY-598/U for storage or when not in use.

SECTION IV

TEST EQUIPMENT AND SPECIAL TOOLS

4-1. There are no special test equipment or tools required for overhaul of the signal generator.

SECTION V

TROUBLE SHOOTING, REPAIR AND OVERHAUL

NOTE

Whenever trouble shooting any part of this test set, reference should continuously be made to the Wiring Diagrams in Section VII. Before making use of any of the voltage or resistance readings, the repairman should thoroughly study paragraphs 7-1 through 7-3 for the proper interpretation of the readings.

WARNING

Before removing the signal generator from its case, be sure that the power cord has been disconnected.

5-1. SECTIONALIZING TROUBLE.

5-2. In trouble shooting the signal generator TS-413/U, the first thing to do is to determine that component assembly which is defective by means of the following trouble shooting table:

TABLE II

SYMPTOM	PROBABLE CAUSE	REMEDY
All controls in correct position but unit does not operate.	Power ON-OFF switch off.	Turn switch to ON.
	Fuse blown.	Replace fuse.
	Replaced fuse blown. Power supply defective.	See paragraph 5-3.
	Power cord defective.	Repair or replace power cord.
	Incorrect power source.	Check main line power with paragraph 1-13.
	No power in main line.	Connect to good power source.
	Defective power supply.	See paragraph 5-3.
Low audio output.	Meter calibration off.	See paragraph 6-8.
	Bias adjusted incorrect.	See paragraph 6-10.
	Defective oscillator tube V-109, JAN-6SN7GT.	Replace tube. See paragraph 6-10.
No audio output, radio-frequency voltmeter reads.	CIRCUIT SELECTOR switch on XTAL or EXT MOD.	Turn CIRCUIT SELECTOR switch to 400 ∿ MOD or 1000 ∿ MOD.
	% MOD turned fully counter-clockwise.	Turn % MOD control fully clockwise.
	Defective V-109, JAN-6SN7GT.	Replace V-109 and recalibrate according to paragraph 6-10.
	Defective V-110, JAN-6C4.	Replace V-110 and recalibrate according to paragraph 6-8.
	Defective V-111, JAN-6C4.	Replace V-111 and recalibrate according to paragraph 6-8.
No audio output reading when CIRCUIT SELECTOR switch on 1000 ∿ MOD or 400 ∿ MOD. Audio output normal when CIRCUIT SELECTOR switch turned on EXT MOD and external modulating source connected. Radio-frequency voltmeter reads normally.	Audio oscillator defective.	See paragraph 5-23.
No audio output reading when CIRCUIT SELECTOR switch on 1000 ∿ MOD or 400 ∿ MOD. No audio output when CIRCUIT	Audio voltmeter circuit defective.	See paragraph 5-25.

SYMPTOM	PROBABLE CAUSE	REMEDY
SELECTOR switch turned on EXT MOD and external modulating source connected. Radio-frequency voltmeter reads normally.		
Low radio-frequency output.	Bad oscillator tube. Poor contacts.	Replace V-101, JAN-9002. See paragraph 6-2. Check band switch and rotate for better contact.
No radio-frequency voltmeter reading. Audio voltmeter reads correctly.	RF GAIN turned off. Oscillator coils not making good contact. Radio-frequency indicator calibrated wrong. Radio-frequency coil defective.	Turn RF GAIN control clockwise. Move band change knob for better contact. See paragraph 6-6. Change frequency range. See paragraph 5-11.
No radio-frequency voltmeter reading. Output at 1 VOLT RF jack.	Radio-frequency voltmeter circuit defective.	See paragraph 5-19.
No radio-frequency voltmeter reading. A 50 milliampere direct-current meter inserted at pin 5 E-101 reads 5 to 20 milliamperes.	Radio-frequency amplifier defective.	See paragraph 5-17.
No radio-frequency voltmeter reading. A 50 milliampere direct-current meter inserted at pin 5 does not read.	Radio-frequency oscillator defective.	See paragraph 5-11.
Output at 1 VOLT RF but no output at RF MICROVOLTS.	Attenuator defective.	See paragraph 5-27.
Radio-frequency voltmeter reads, no heterodyne output.	CIRCUIT SELECTOR switch not on XTAL. Frequency not a harmonic of crystal. Earphones defective. Crystal oscillator tube V-105, JAN-6SA7 defective. Crystal Y-101, DC-9-AJ or CR-18/U, defective. Circuit defective.	Turn CIRCUIT SELECTOR switch to XTAL. Check crystal check charts for proper points. Replace with good earphones. Replace with good tube. Replace with DC-9-AJ or CR-18/U known to be good. See paragraph 5-19.
No modulation of radio-frequency carrier, audio and radio-frequency voltmeter normal.	Modulation control R-154 not in proper adjustment. Circuit defective.	See paragraph 6-8. See paragraph 5-17.
Radio-frequency indicator does not zero.	ZERO ADJ wrong. Tube V-103, JAN-6AL5W, defective. Tube V-104, JAN-6J6, defective. Radio-frequency indicator circuit defective.	Readjust ZERO ADJ on front panel. Replace with good tube. Replace with good tube. See paragraph 5-19.
Audio-frequency voltmeter does not zero.	Zero adjust wrong. Tube V-110, JAN-6C4, defective. Tube V-111, JAN-6C4, defective. Audio voltmeter circuit defective.	See paragraph 6-8. Replace and see paragraph 6-8. Replace and see paragraph 6-8. See paragraph 5-25.

5-3. POWER SUPPLY. Refer to paragraph 3-8.

5-4. Trouble in the power supply can originate from two sources. A component of the power supply itself may be defective, or a short or partial short in any other subassembly might cause excessive current drain in the power supply and burn out a component of the power supply. Whenever replacing defective power supply components, it is necessary to test the other subassemblies for shorts.

5-5. The chart in paragraphs 5-6 and 5-7 can be used to determine defective components in all subassemblies as well as the secondary of the power supply. To use this chart, remove all wires connected by solder lugs to E-101 and make the resistance checks between the points shown.

5-6. Resistance check on E-101 with interconnecting harness removed is shown in Table III. (See Figure 5-1).

TABLE III

Resistance between following points on E-101	Resistance Ohms	Defective component if resistance not normal
1 and 2	41	Defective secondary of transformer T-101 between pins 8 - 10 or defective wiring to pins 8 and 10. See paragraph 5-9 for disassembly of power supply.
5 and 6	15,000	Short or open circuit in R-137 or R-138. See paragraph 5-9 for disassembly of power supply.
7 and Ground	Meter should read instantly about 50,000 and increase to between 300,000 to 400,000.	Defective electrolytic capacitors C-150 and C-151.

5-7. Resistance checks on interconnecting harness are shown in Table IV.

TABLE IV

Resistance between following points on cable connecting to E-101	Resistance Ohms	Defective component if resistance not normal
1 and Ground	25 Ohms	Defective filament block network, C-115, C-116, C-118, or C-120 short circuited. See paragraph 5-12.
2 and Ground When checking the resistance between pin 2 and ground, remove tubes V-102, V-103, V-104, and V-105.	Infinite	Short circuit in filament wiring. Continuity check each filament circuit with practical wiring diagram, Section VII.
3 and Ground	Infinite	Detector crystal oscillator and detector capacitor C-137, C-145, C-138, or C-136 shorted. See paragraph 5-21.
4 and Ground	Infinite	Shorted capacitor C-123 or C-122.
5 and Ground	Infinite	Defective plate blocking network in the radio-frequency oscillator C-121, C-119, C-117, or C-114 short circuited. See paragraph 5-12.
6 and Ground	Infinite	Defective radio-frequency amplifier or radio-frequency indicator circuit C-141, C-124, C-143 or C-132 short circuited. See paragraphs 5-17 and 5-18.
7 and Ground	Infinite	Defective radio-frequency amplifier circuit C-139 or C-125 short circuited. See paragraph 5-17.

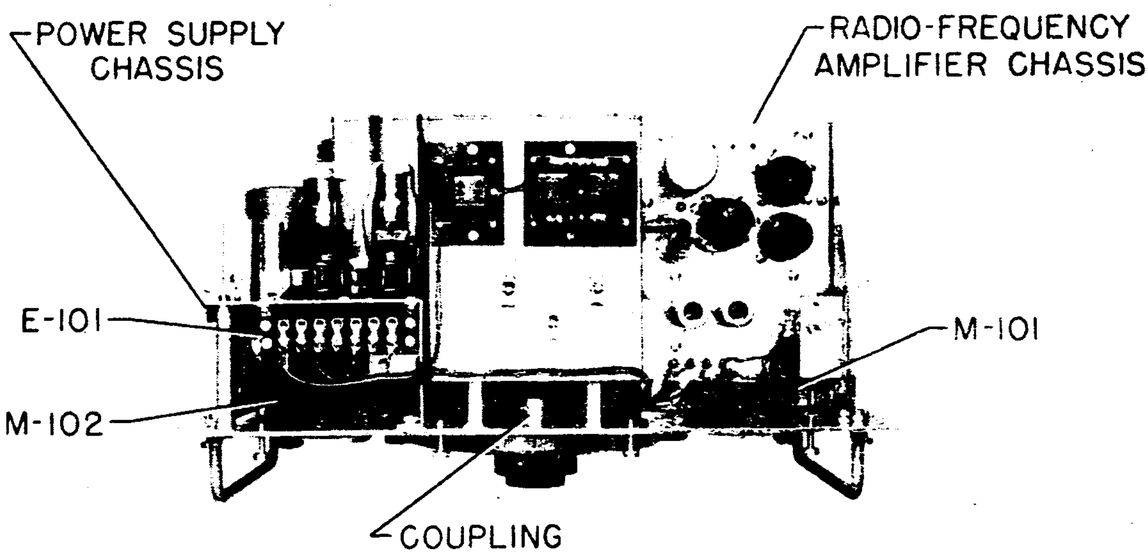


Figure 5-1. TOP VIEW

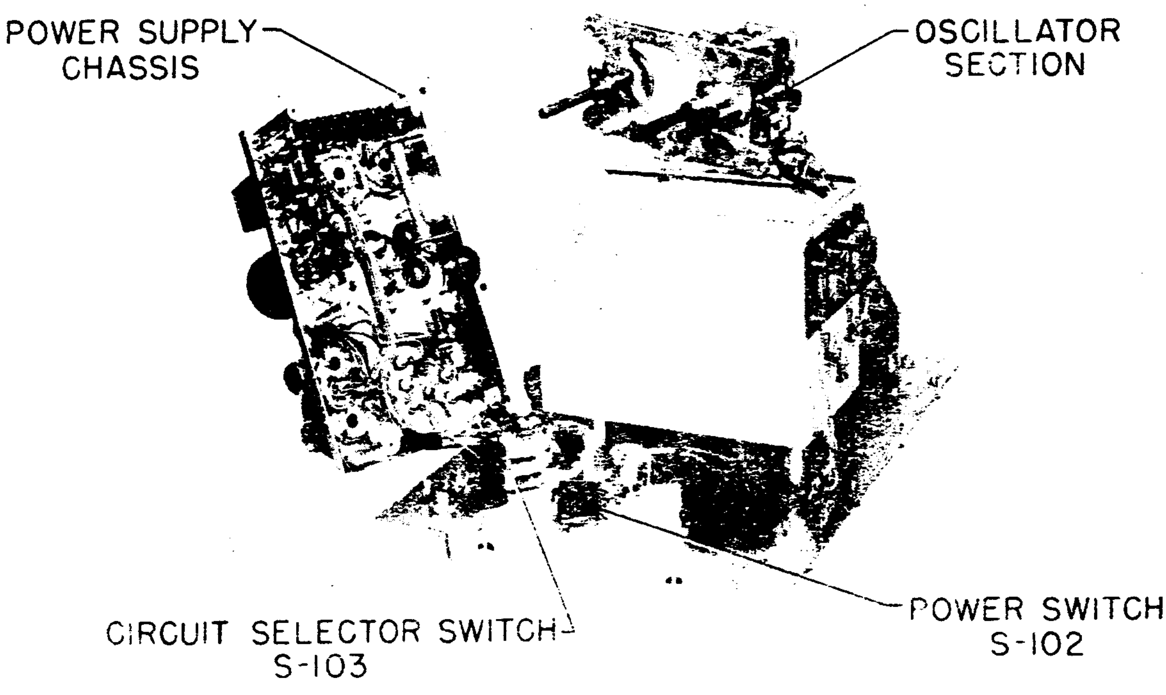


Figure 5-2. DISASSEMBLED VIEW

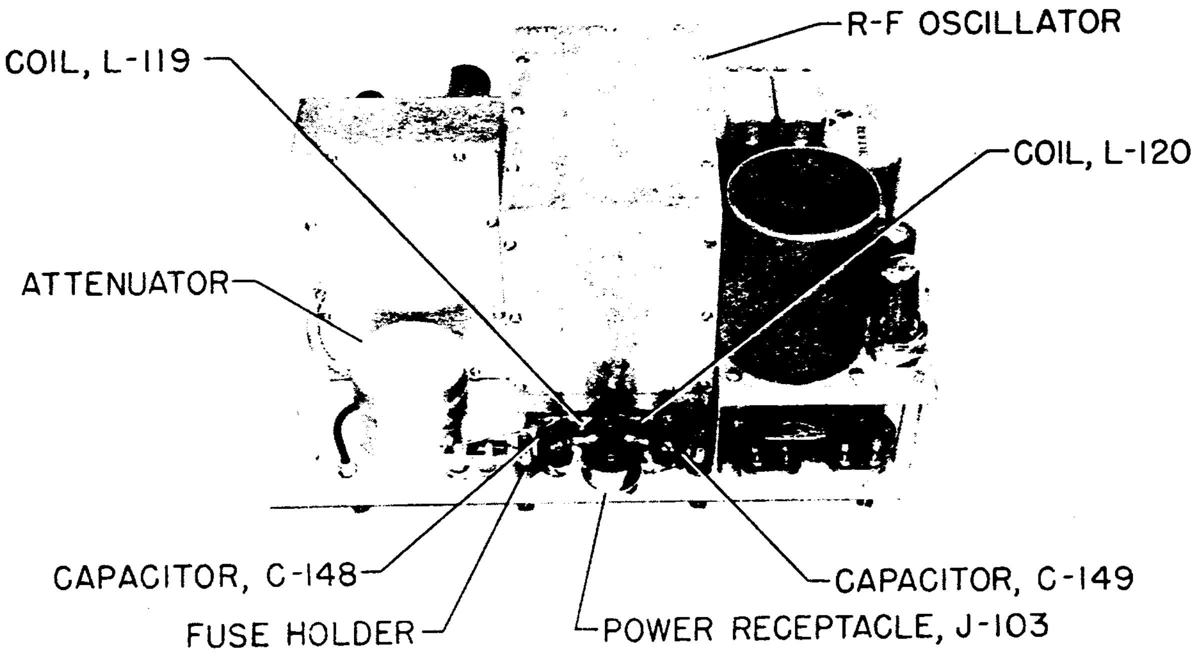


Figure 5-3. TOP REAR VIEW

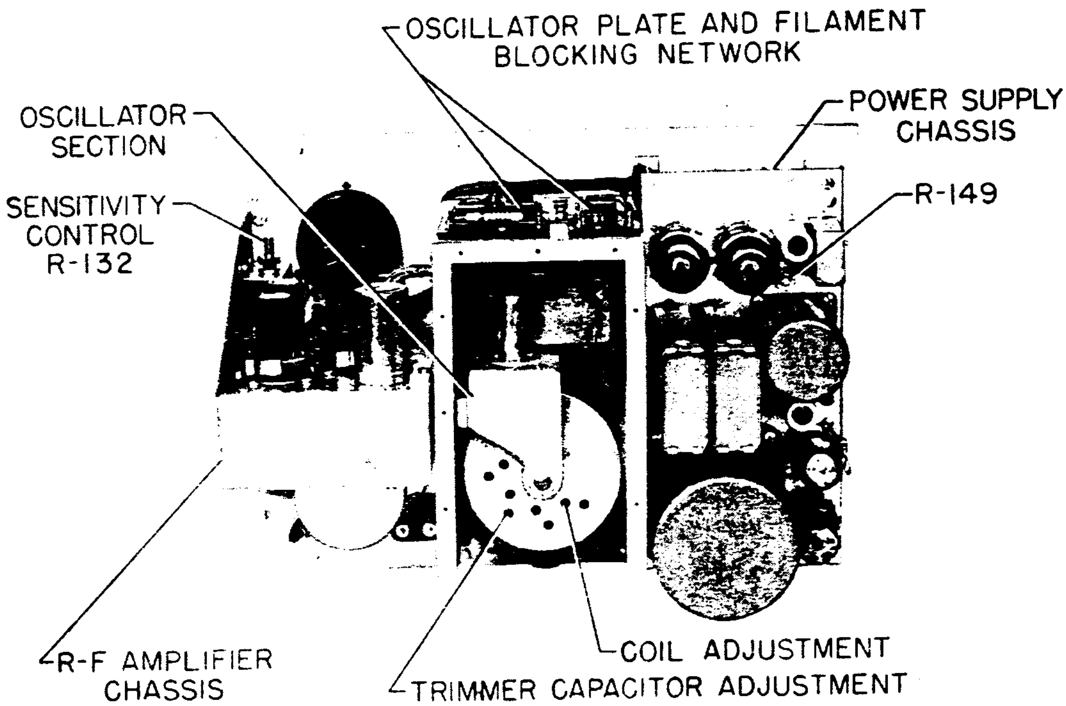


Figure 5-4. REAR VIEW

5-8. In addition to the above resistance checks, the resistances and voltages at all the tubes (V-105, V-106, and V-107), and transformer terminals are given in the diagrams of Section VII.

5-9. DISASSEMBLY OF POWER SUPPLY. Remove the six screws holding the power supply to the front panel and rest complete set on handle with E-101 facing mechanic. Complete power supply chassis can now be lifted and placed on bench resting on transformer with complete underneath of chassis available for work (see Figure 5-2).

5-10. After replacing any damaged components, the tubes V-106, V-107, and V-108 should be tested. The primary of power supply can be tested by checking continuity between the male blades of plug J-103. It should read approximately 5 ohms. If reading is not correct, check fuses, filter coils, by-pass capacitor, and power receptacle located under oscillator chassis as shown in Figure 5-3.

5-11. RADIO-FREQUENCY OSCILLATOR. See paragraph 3-13.

5-12. The radio-frequency oscillator is contained within shield compartment shown in Figure 5-4. To repair the radio-frequency oscillator, it is necessary to remove the shield cover and shield over oscillator's filament and plate filter networks.

5-13. If the oscillator is not oscillating, test the tube V-101. Secondly, replace the turret (see Figure 5-4) with one known to be good. Thirdly, check the voltages at pins 1 and 5 of E-101 and they should be 9.1 volts alternating current, and 150 volts direct current. If these are all correct, refer to Section VII and continuity check the oscillator circuit.

5-14. REMOVAL OF THE OSCILLATOR FROM ITS SHIELD. To remove the oscillator section from its shield to replace a defective part, or clean tuning capacitor, the entire casting, parts attached to the casting, and variable capacitor should be removed as one piece as follows: (see Figure 5-2.)

a. Remove indicator for vernier.
b. Remove vernier knob by loosening two set screws in the knob.
c. Remove band switch knob by loosening two set screws.
d. Remove dial cover assembly by removing six screws holding it to the front panel.
e. Loosen two set screws on gear on band switch.
f. Remove the chain, two gears, and dial shutter assembly from the shafts by loosening Allen screws.
g. Loosen two set screws on coupling between oscillator shield and back of front panel, connecting to dial. (see Figure 5-1.)
h. Remove dial.
i. Remove four screws holding casting to bakelite posts supported on oscillator shield.
j. Cut lacing cord holding cable to terminal.
k. Complete oscillator section may now be lifted out without disconnecting any cables.

5-15. ASSEMBLY

a. Replace oscillator section in oscillator shield.
b. Lace cable to terminal.
c. Replace four screws holding casting to bakelite posts supported on oscillator shield.
d. Replace dial.
e. Tighten two set screws on coupling between oscillator shield and back of front panel, connecting to dial. (see Figure 5-1.)
f. Replace the chain, two gears, and dial shutter assembly on shaft and tighten Allen screws.
g. Tighten two set screws on gear on band switch.
h. Replace dial cover assembly and secure with six screws to front panel.
i. Replace band switch knob and tighten two set screws in the knob.
j. Replace vernier knob and tighten two set screws in the knob.
k. Replace indicator for vernier.

5-16. RADIO-FREQUENCY AMPLIFIER CHASSIS. The radio-frequency amplifier, crystal oscillator and detector, METER SCALE switch network, dual diode, and dual triode amplifier for the radio-frequency meter are all enclosed in one shield chassis (see Figure 5-3). The bottom plate of this shielded chassis is removable. After removing all the screws holding this plate and removing the plate, the chassis is accessible and open for testing. The location of electrical components mounted on R-C boards are shown in Figures 5-5, 5-6, 5-7, 5-8, and 5-9.

NOTE

Do not remove screws holding the top plate to the chassis.

NOTE

If leads are shorter or made longer, or parts interchanged, there is a possibility of setting up parasitic oscillations in any of the circuits in the amplifier chassis.

5-17. MODULATED RADIO-FREQUENCY AMPLIFIER. See paragraph 3-17.

5-18. Perform trouble shooting on the radio-frequency amplifier as follows:

a. Check tube JAN-6AG7 (V-102).
b. Check resistances, referring to Table VIII.
c. Check voltages, referring to Table IX.

5-19. RADIO-FREQUENCY VOLTMETER CIRCUIT. See paragraph 3-18.

5-20. Perform trouble shooting on the radio-frequency voltmeter circuit as follows:

a. Check tube JAN-6AL5 (V-103) or replace with one known to be good.
b. Check tube JAN-6J6 (V-104) or replace with one known to be good.
c. Check continuity of meter, M-101, with ohmmeter by placing 200,000 ohm resistor in series with meter, M-101, and using high resistance scale of meter. The meter should read approximately one-quarter of full scale.
d. Check resistances, referring to Table VIII
e. Check voltages, referring to Table IX.

5-21. CRYSTAL OSCILLATOR AND DETECTOR. Full technical information on the crystal oscillator and detector will be found in paragraph 3-19.

5-22. Perform trouble shooting as follows:
a. Check tube JAN-6SA7 (V-105) or replace with one known to be good.
b. Check crystal DC-9-AJ or CR-18/U or replace with one known to be good.
c. Check resistances, referring to Table VIII.
d. Check voltages, referring to Table IX.

5-23. AUDIO OSCILLATOR. See paragraph 3-21.

5-24. Perform trouble shooting as follows:
a. Check tube JAN-6SN7GT (V-109) or replace with a tube known to be good.
b. Check resistances, referring to Table VIII.
c. Check voltages, referring to Table IX.
d. Check CIRCUIT SELECTOR switch for proper mechanical operation.
e. When replacing any parts, recheck audio-oscillator calibration as described in paragraph 6-12.

5-25. AUDIO VOLTMETER CIRCUIT. See paragraph 3-23.

5-26. Perform trouble shooting as follows:
a. Check tubes JAN-6C4 (V-110 and V-111) or replace with tubes known to be good.
b. Check resistances, referring to Table VIII.
c. Check voltages, referring to Table IX.
d. Check meter M-102, as explained in paragraph 5-20, part c.
e. When replacing any defective parts, recheck audio voltmeter calibration, as described in paragraph 6-10.

5-27. ATTENUATOR

5-28. The attenuator consists of a housing containing precision one-percent resistors. The METER SCALE switch is considered a part of the attenuator for test purposes. By measuring the resistance given in the table below, accurate check of both attenuator and METER SCALE switch is possible.

TABLE V

MICROVOLTS POSITION	RESISTANCE AT RF MICROVOLTS TO GROUND
100K	50
10K	5
1K	4.5
100	5
10	5

Figure 5-5. RADIO-FREQUENCY AMPLIFIER CHASSIS

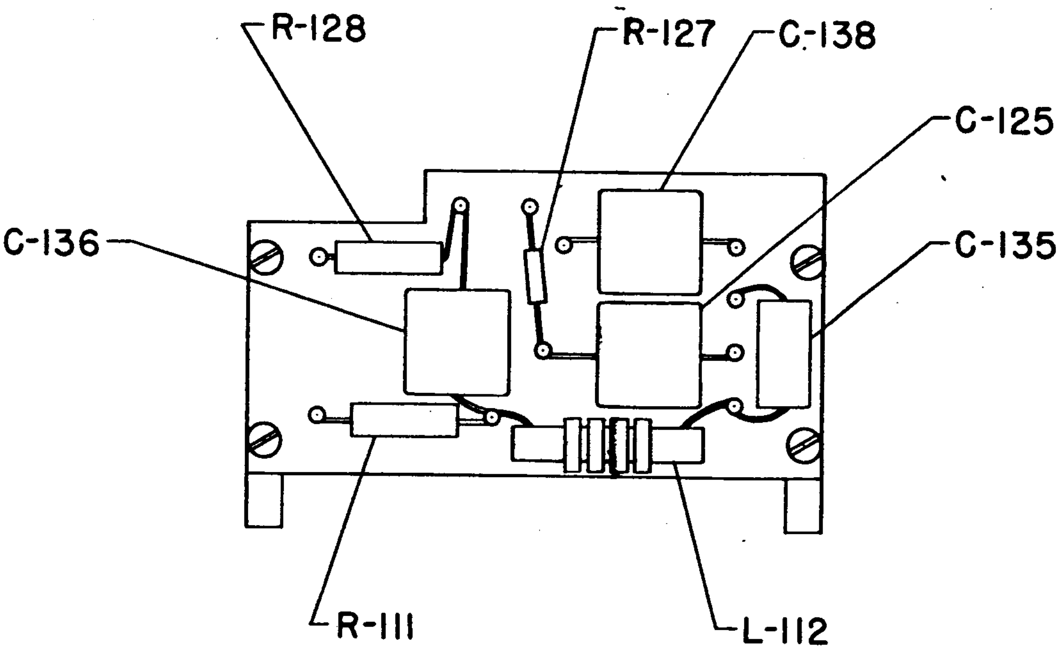


Figure 5-6. R-C BOARD NO. 1

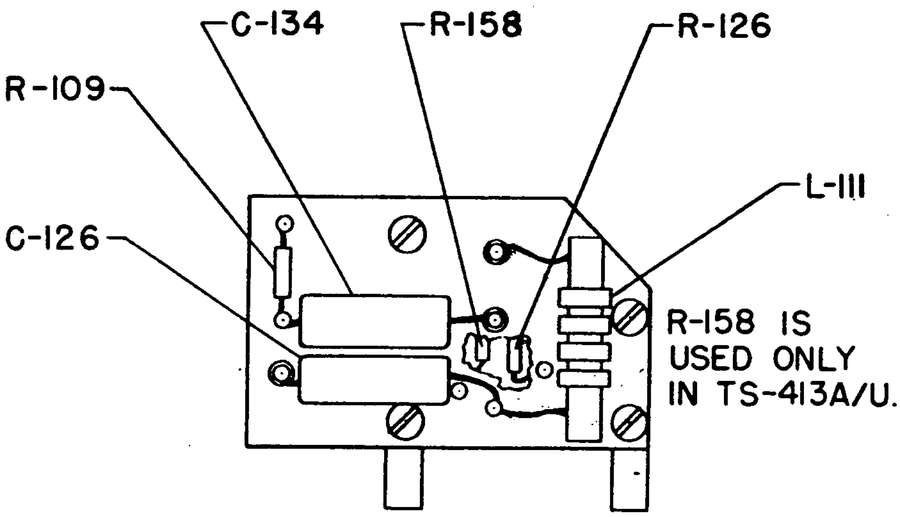


Figure 5-7. R-C BOARD NO. 2

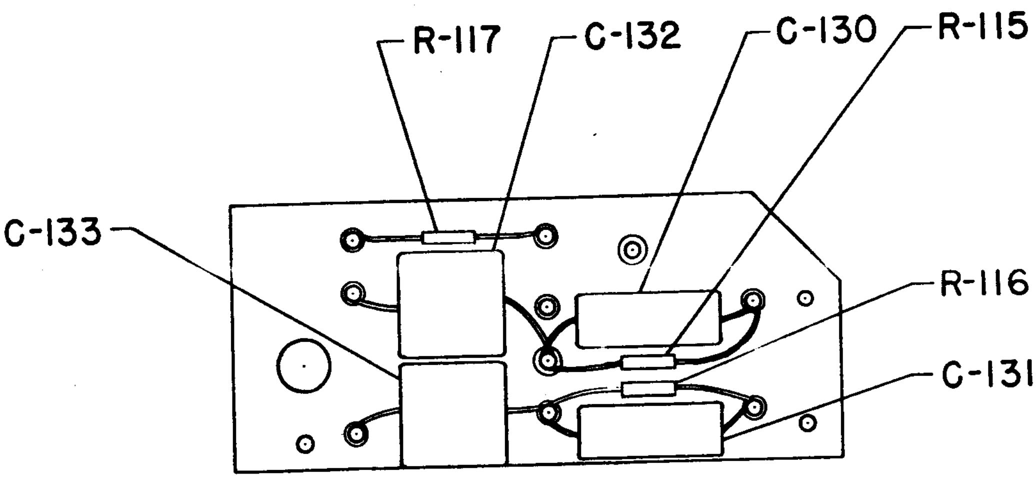


Figure 5-8. R-C BOARD NO. 3

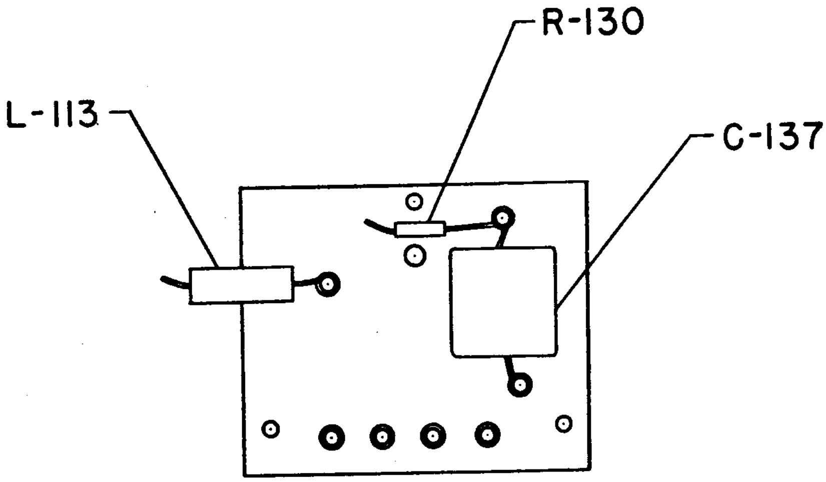


Figure 5-9. R-C BOARD NO. 4

SECTION VI

CALIBRATION

6-1. CALIBRATION.

6-2. GENERAL. This equipment will be inspected at intervals of 90 days to determine the accuracy of the calibration. When tube V103 or V104 is replaced recalibrate the RF VOLTS meter; V110 or V111 is replaced recalibrate the percent modulation and modulation meter; V109 is replaced recalibrate the audio oscillator.

6-3. TEST EQUIPMENT REQUIRED. The following test equipment or its equivalent is required for calibration of the TS-413/U and TS-413A/U Signal Generators.

a. Electronic Multimeter, type ME-6A/U.
b. Oscilloscope type AN/USM-24C.
c. Frequency Counter, type AN/USM-26.

6-4. PRELIMINARY ELECTRICAL TEST. (See paragraph 1-13.)

6-5. CALIBRATION PROCEDURES.

WARNING

High voltages are present in this set. Disconnect power supply before removing set from protective case.

6-6. OSCILLATOR OUTPUT FREQUENCY CALIBRATION. Accuracy within ± 1 percent is required for the oscillator frequency output.

a. Remove signal generator TS-413/U or TS-413A/U from protective case.

b. Connect output of signal generator TS-413/U or TS-413A/U to input of frequency counter.

c. Energize signal generator under test.

d. Turn band switch knob (7, Figure 1-2) to correct frequency range. (Refer to Table VI.)

e. Turn rf tuning knob (1, Figure 1-2) to readings indicated under LOW FREQUENCY SETTING in Table VI and, check with frequency counter.

f. If frequency shown on counter is not within ± 1% of dial setting on signal generator, adjust slug-tuned coil (see figure 5-4) until frequency on counter is within ± 1% of dial setting.

g. Repeat steps s. and f. using HIGH FREQUENCY SETTING of Table VI.

h. Adjust trimmer capacitor (see Figure 5-4) so that frequencies of both sets are the same.

6-7. RF VOLTS METER CALIBRATION.

a. Connect electronic multimeter to 1 VOLT-RF jack (13, Figure 1-2). Leads should be as short as possible to avoid error.

b. Set the signal generator to any frequency between 75 kc and 1 mc.

c. Turn RF GAIN control (11, Figure 1-2) fully counterclockwise.

d. Turn ZERO ADJ (14, Figure 1-2) until RF VOLTS meter indicates zero.

e. Turn METER SCALE switch (12, Figure 1-2) to 1.0 position.

f. Advance RF GAIN control until electronic multimeter indicates 1 volt.

g. If RF VOLTS meter on the signal generator does not indicate 1 volt, adjust sensitivity control R-132 (see Figure 5-4) until 1 volt is indicated.

6-8. MODULATION METER CALIBRATION.

a. Remove signal generator TS-413/U or TS-413A/U from protective case.

b. Energize the signal generator.

c. Turn % MOD control (3, Figure 1-2) fully counterclockwise.

TABLE VI

BAND	LOW FREQUENCY SETTING		HIGH FREQUENCY SETTING	
	Setting	Actual Frequency	Setting	Actual Frequency
75 kc. to 230 kc.	80	80 kc.	220	220 kc.
230 kc. to 660 kc.	240	240 kc.	650	650 kc.
650 kc. to 1.95 mc.	.70	.70 mc.	1.9	1.9 mc.
1.85 kc. to 5.5 mc.	1.9	1.9 mc.	5.5	5.5 mc.
5.4 mc. to 17.5 mc.	5.5	5.5 mc.	17.0	17.0 mc.
17 mc. to 40 mc.	17.0	17.0 mc.	40.0	40.0 mc.

d. Adjust modulation adjustment R-151 (see Figure 6-2) until modulation meter reads zero.

e. Connect electronic multimeter to AUDIO OUT jack (5, Figure 1-2).

f. Turn CIRCUIT SELECTOR switch (4, Figure 1-2) to 400Ω MOD or 1000Ω MOD position.

g. Advance % MOD control until modulation meter indicates 0.8 volt.

h. If electronic multimeter does not indicate the same as the modulation meter, adjust sensitivity control R-149 (see Figure 5-4) until 0.8 volt is indicated.

i. Repeat steps c. and d.

6-9. PERCENT MODULATION CALIBRATION.

a. Connect AUDIO OUT jack on signal generator to horizontal amplifier terminals of oscilloscope.

b. Connect 1 BOLT-RF or RF MICROVOLTS jack on signal generator to vertical amplifier terminals of oscilloscope.

c. Turn % MOD control to 30 percent.

d. Energize the signal generator and oscilloscope.

e. Measure vertical edges of the trapezoidal waveform on oscilloscope. (See Figure 6-1.)

f. Determine the percent of modulation by using percent modulation formula:

$$\text{Percent modulation} = \frac{B-A}{B+A} \times 100$$

A = length of short vertical edge
B = length of longer vertical edge

g. If percent modulation is not within ± 6 percent, adjust R-154 (see Figure 6-1) until desired percentage is obtained.

6-10. AUDIO OSCILLATOR CALIBRATION.

a. Connect AUDIO OUT jack to horizontal amplifier terminals of oscilloscope.

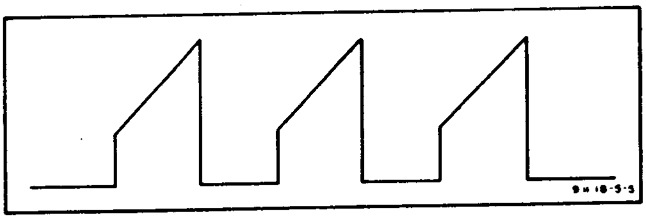


Figure 6-1. TRAPEZODIAL WAVEFORMS.

b. Connect 1 VOLT-RF MICROVOLTS jack to vertical terminals of oscilloscope.

c. Energize the signal generator and oscilloscope.

d. Turn % MOD control from minimum to maximum observing waveshape and output voltage.

e. If a good compromise between adequate output voltage on modulation meter and waveshape is not observed, adjust R-142 until good compromise is obtained.

f. Recalibrate modulation meter as described in paragraph 6-8, if necessary.

6-11. FINAL CALIBRATION.

a. Connect high impedence earphones to HET OUT (8, figure 1-2).

b. With chart furnished with signal generator TS-413/U or TS-413A/U check accuracy by beating radio frequency output against crystal output at each point 1 to 40 mc on rf tuning dial.

Note

If readings are not consistent, correct or replace chart.

6-12. (Deleted)

6-13. (Deleted)

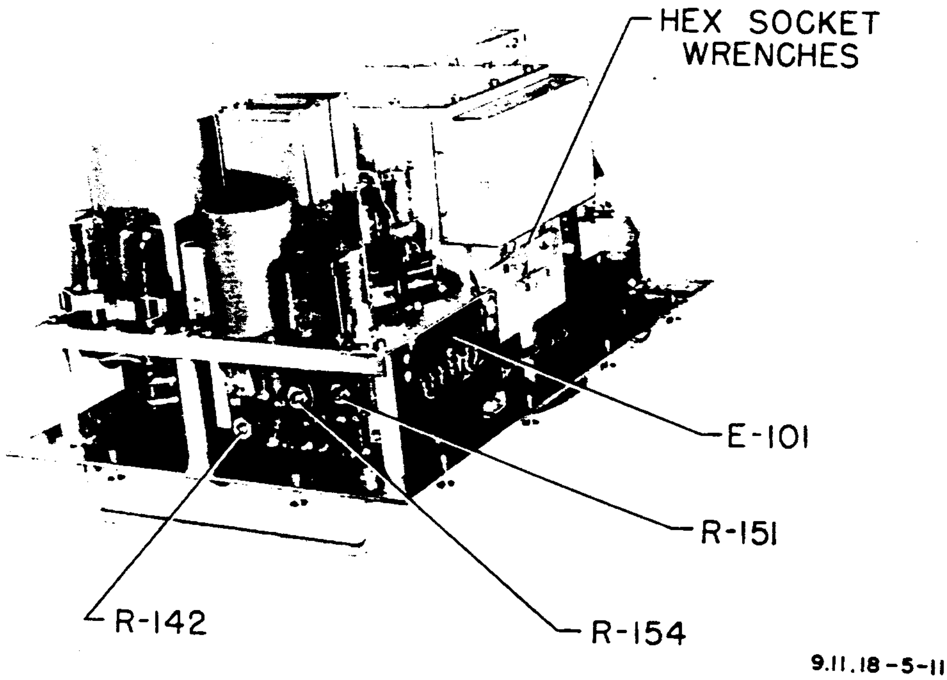


Figure 6-2. SIDE VIEW

SECTION VII

WIRING DIAGRAMS

7-1. GENERAL. All voltmeter readings given in this section were measured with a 20,000 ohms-per-volt voltmeter, unless otherwise specified. In taking voltmeter readings, it is important to remember the following simple rules:

a. Voltmeter resistance must be at least ten times as large as the resistance of the circuit across which the voltage is measured. If the voltmeter resistance is nearly equal to the circuit resistance, the voltmeter will indicate a voltage lower than the actual voltage from the circuit.

b. The resistance of a voltmeter on any range can be calculated by this simple rule. Resistance of the voltmeter equals ohms-per-volt multiplied by the full range of volts. For example, the resistance of a 20,000 ohms-per-volt meter on the 100 volt range is 2,000,000 ohms (resistance equals 20,000 ohms-per-volt times 100 volts or 2,000,000 ohms).

c. To minimize voltmeter loading in high-resistance circuits, use the highest voltmeter range. Although only a small deflection will be obtained, the electrical accuracy of the voltage measurement will be increased. The decreased loading of the voltmeter will more than compensate for the visual inaccuracy which results from reading only a small deflection on the voltmeter scale.

d. Extremely heavy loading is indicated when the deflection of the pointer on the meter (not the voltage reading) is nearly the same for different ranges. Negligible loading is indicated when the voltage reading (not the deflection) for different ranges agree.

e. When taking voltage readings at points where radio-frequency energy is present, insert a radio-frequency choke of about 2.5 millihenries in the hot lead of the voltmeter.

f. When checking cathode voltages, remember that a reading can be obtained when the cathode resistor is actually open because the resistance of the meter may act as a cathode resistor. Thus, the cathode voltage may be approximately normal only as long as the voltmeter is connected between the cathode and ground. Before measuring a cathode voltage, first make a resistance check with the power off to determine whether the cathode resistor is normal.

g. All alternating-current voltages unless otherwise noted are made with a 1000 ohms-per-volt voltmeter.

h. All power is turned off when making resistance measurements and the tubes removed from the sockets for filament checks.

i. Resistance readings across the two electrolytic filter capacitors in the power supply are shown as 0-300K. For a normal indication, the ohmmeter reading will increase slowly from 0 to 300K as the electrolytic capacitor charges.

7-2. OSCILLATOR SECTION. Because of the impractibility of taking voltage reading for the radio-frequency oscillator, (V-101), the reading at the terminal of that socket has been left blank. Voltage checks can be made at E-101 or the plate and filament blocking networks as a check for the oscillator. When making resistance measurements in the oscillator section, the oscillator turret is removed.

7-3. All voltage and resistance measurements are taken with the controls adjusted as follows: % MOD and RF GAIN turned fully counterclockwise, CIRCUIT SELECTOR switch in 400 ∿ MOD position, METER SCALE in 1.0 position, and MICROVOLTS in 100K position, except when noted differently in Tables VII, VIII, and IX.

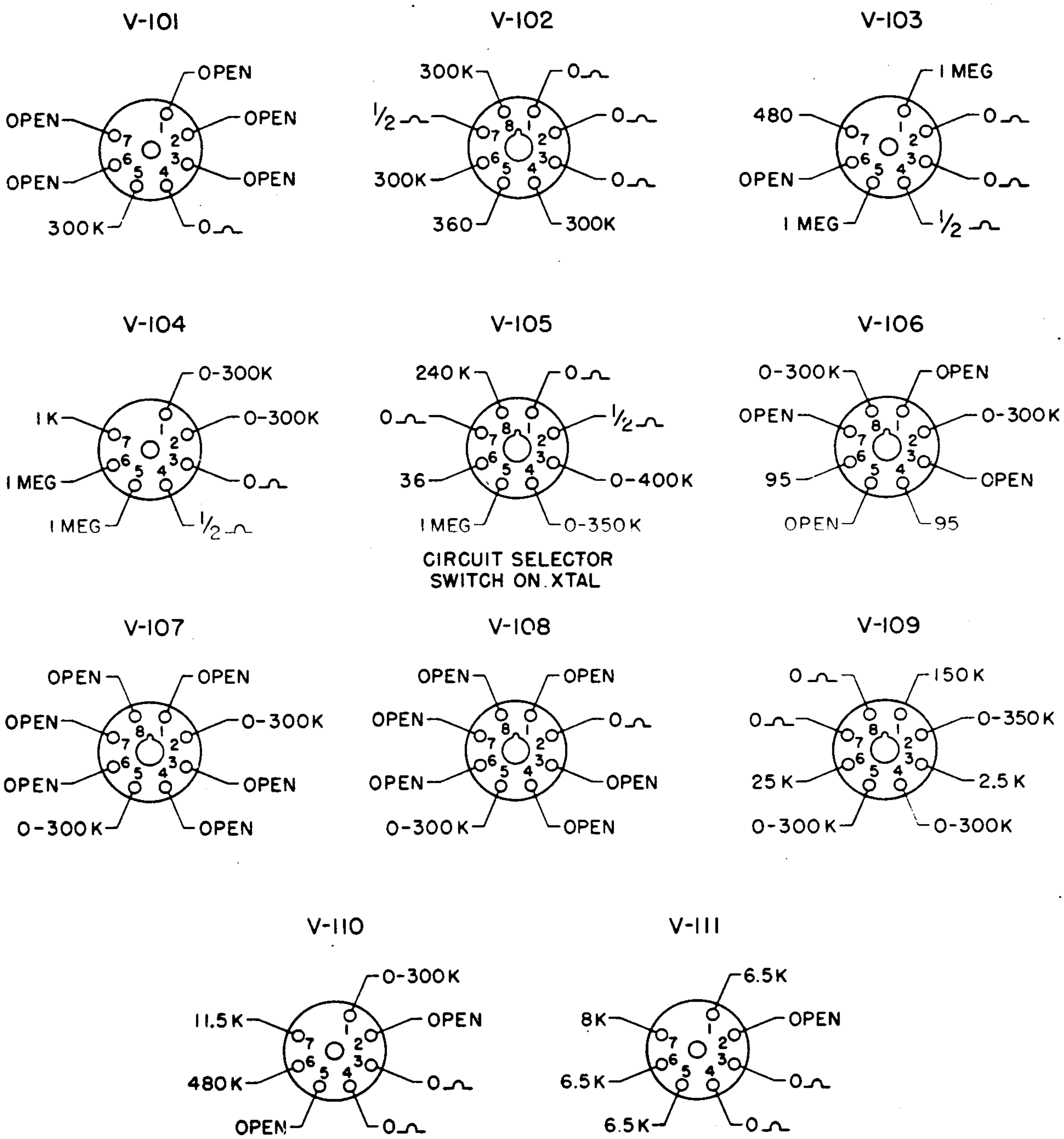
TABLE VII

VOLTAGES ON E-101

TERMINALS	1	2	3	4	5	6	7
VOLTAGES	9.1	6.3	0	MOD SIG	150	225	395
VOLTAGES CIRCUIT SELECTOR switch on XTAL	9.1	6.3	420	0	150	225	390

TABLE VIII

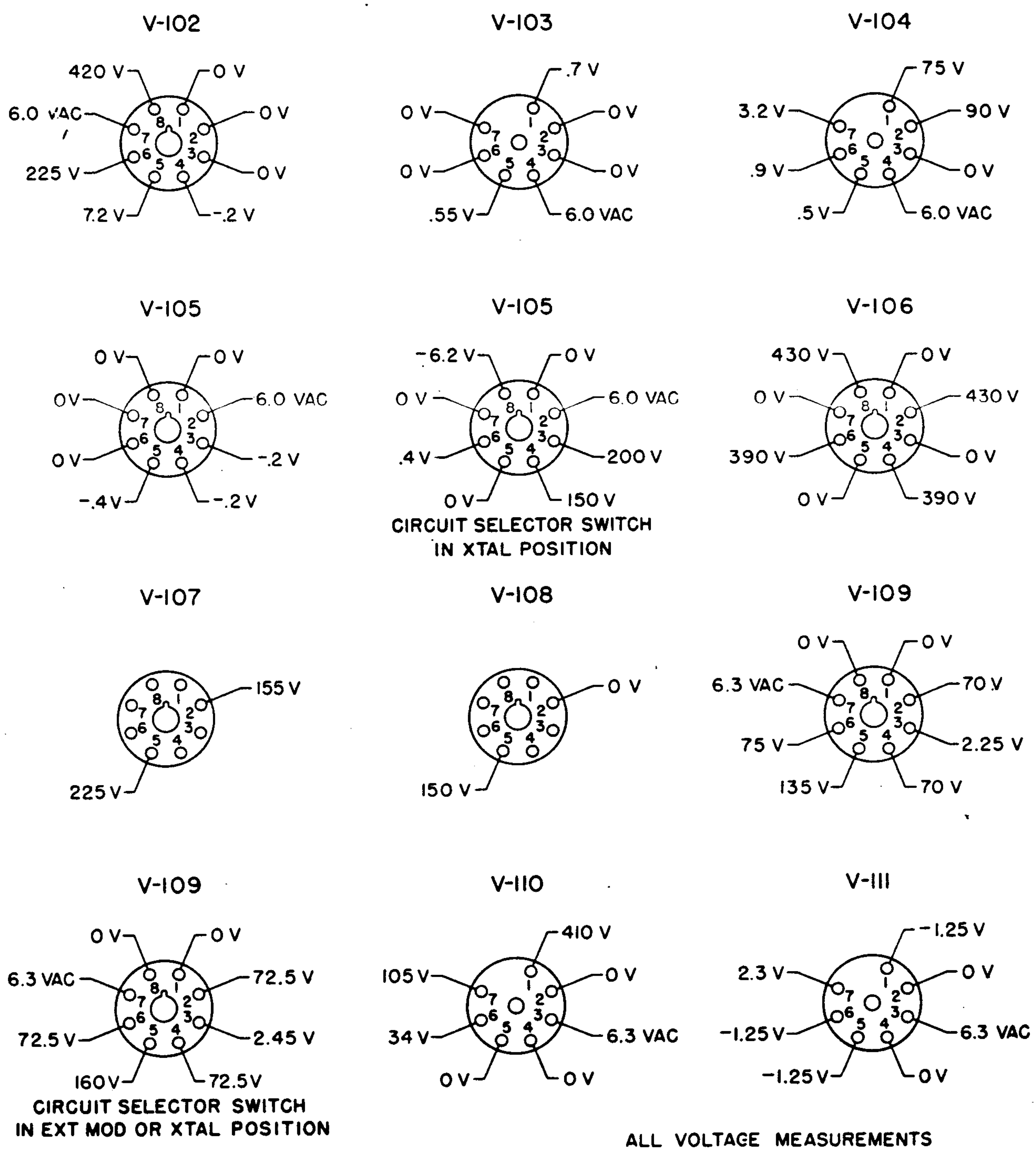
RESISTANCE MEASUREMENTS



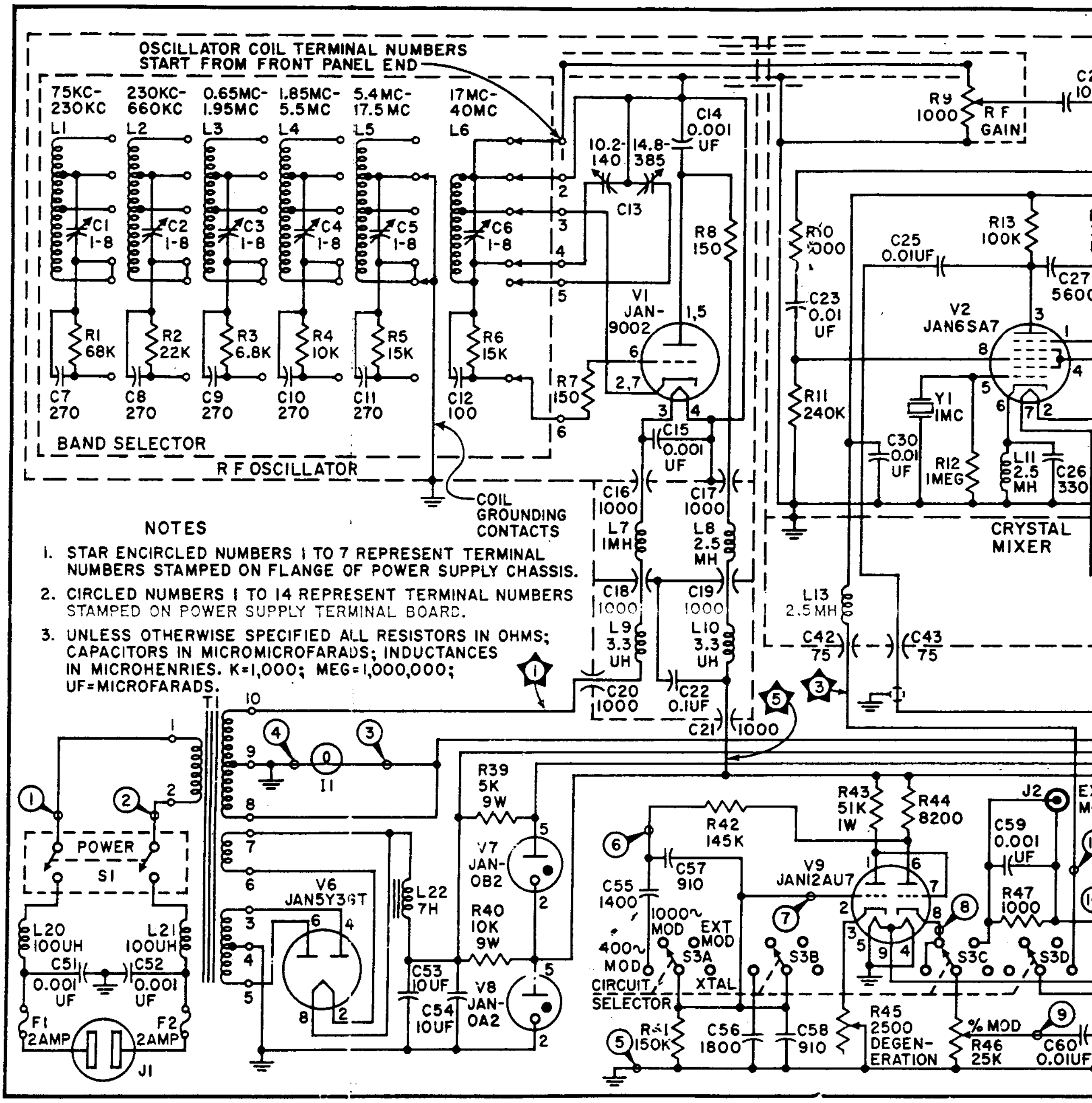
ALL RESISTANCE MEASUREMENTS
TAKEN TO CHASSIS GROUND.

TABLE IX

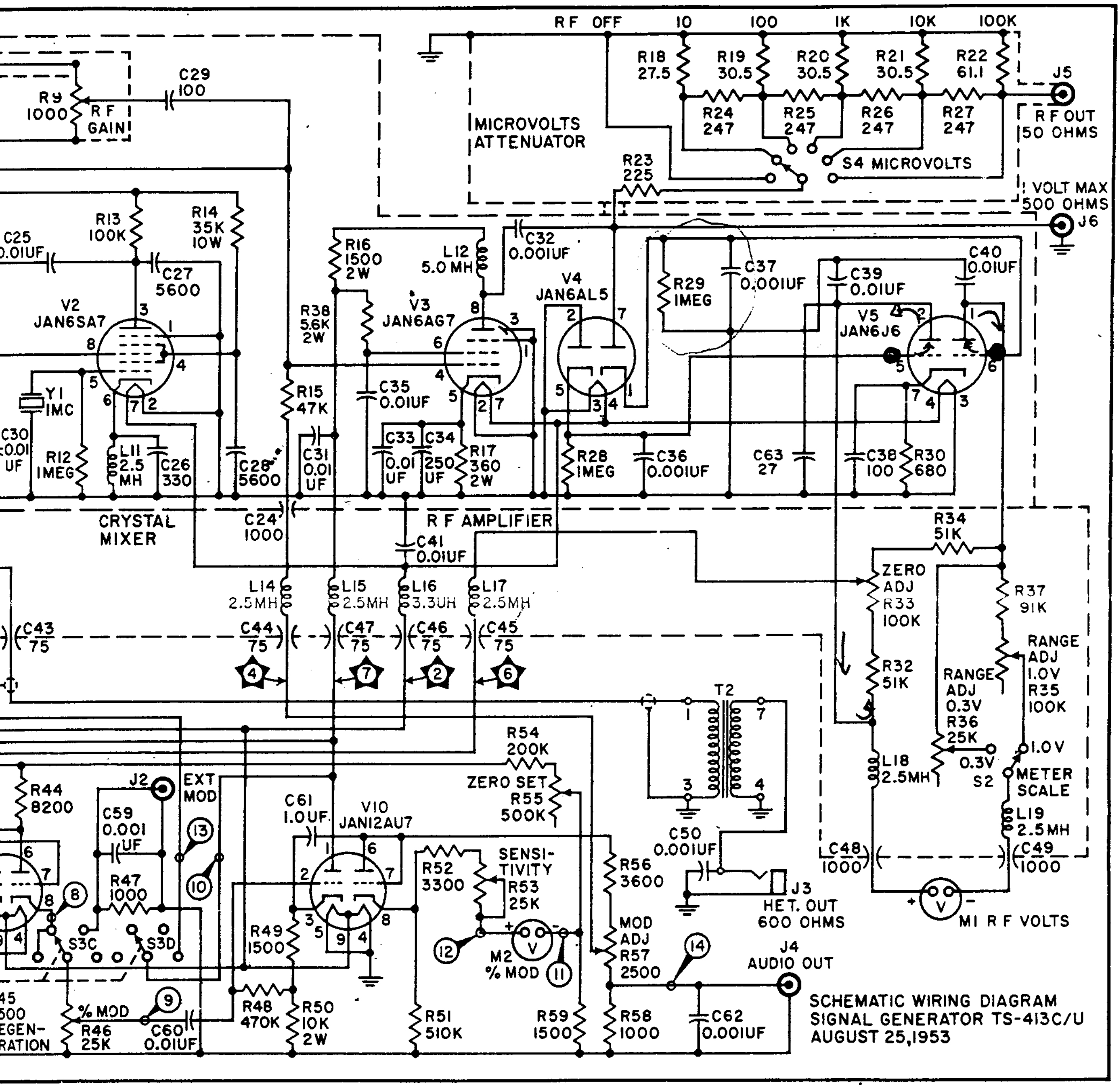
VOLTAGE MEASUREMENTS



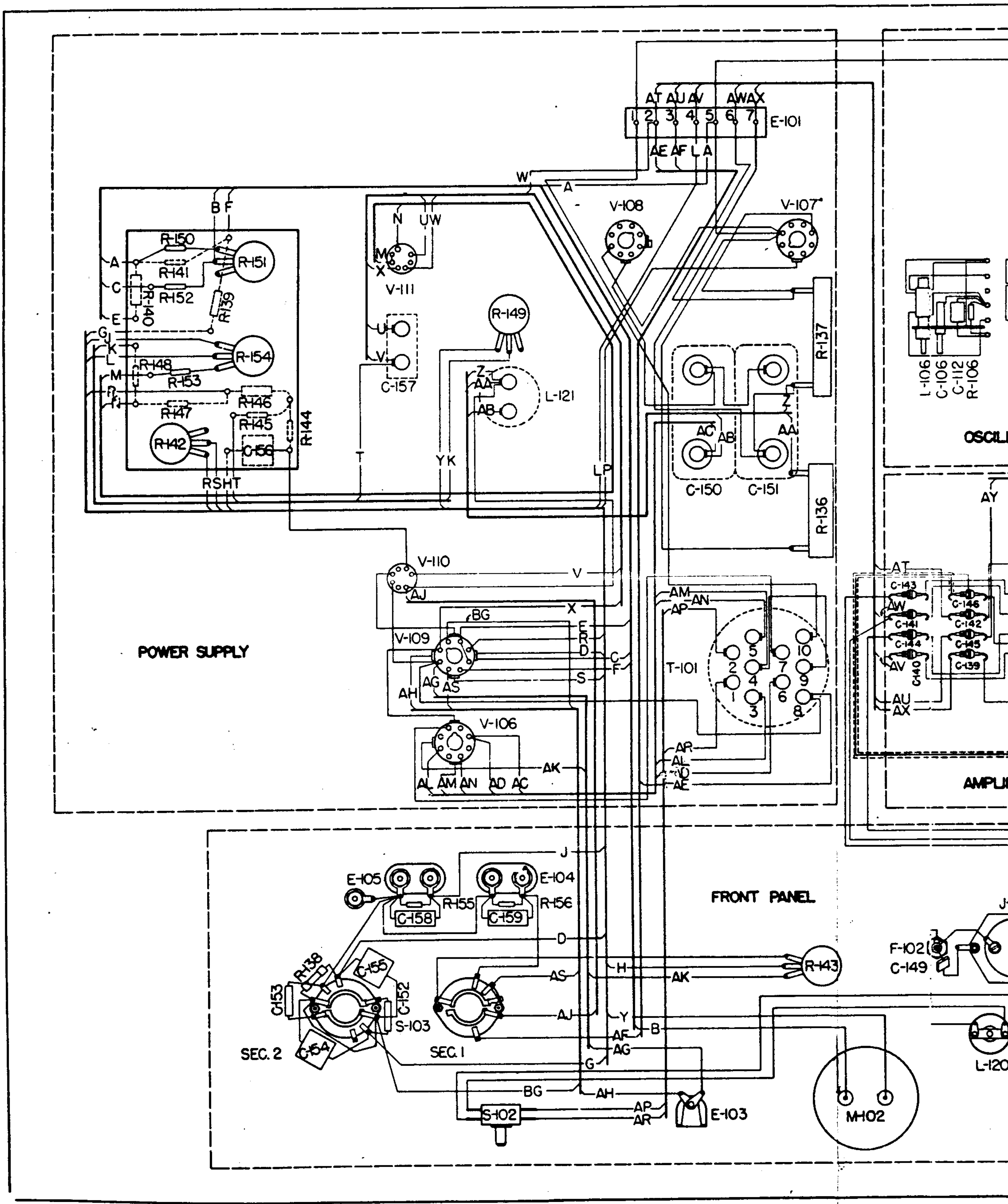
ALL VOLTAGE MEASUREMENTS
TAKEN TO CHASSIS GROUND.

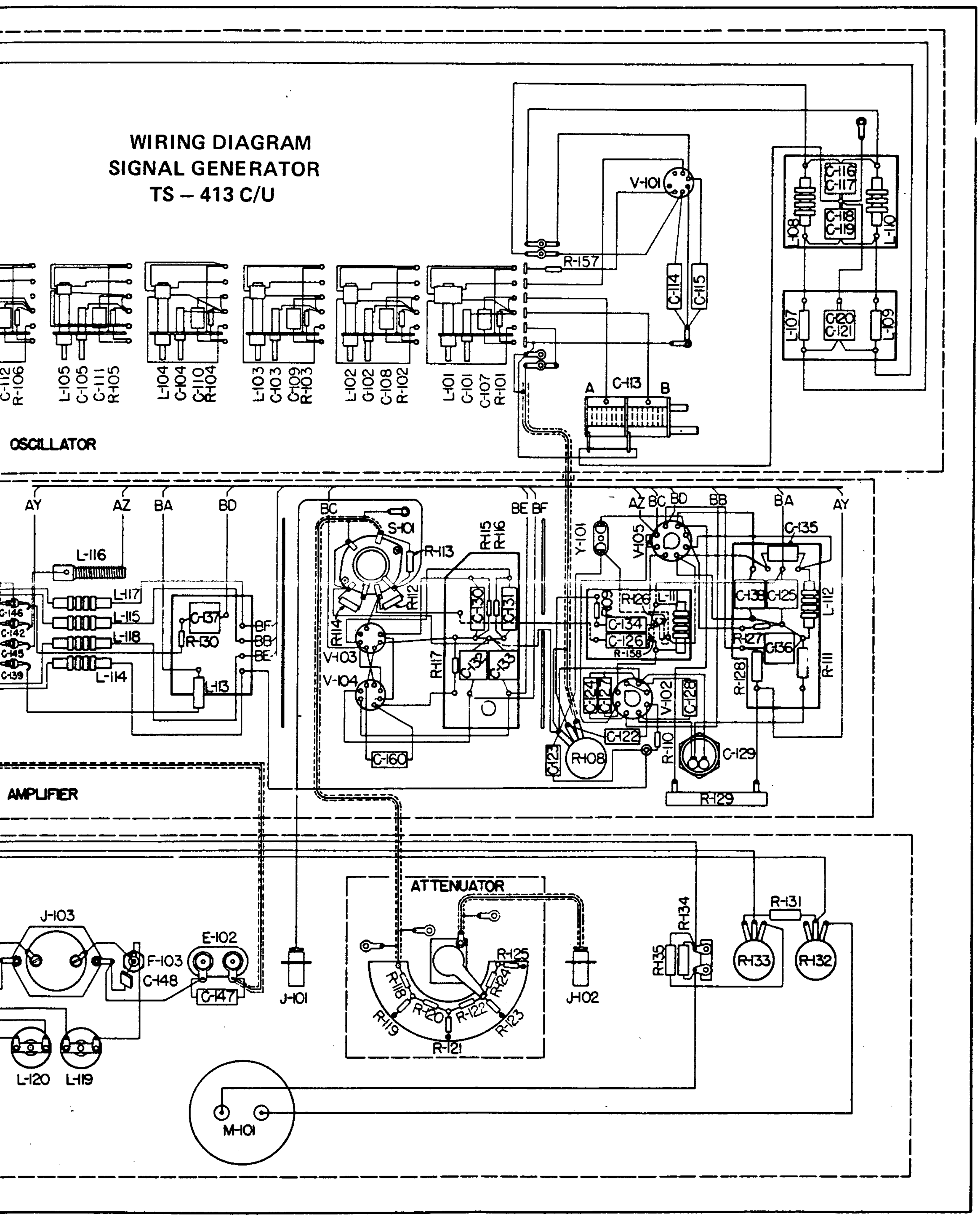


OSCILLATOR COIL TERMINAL NUMBERS START FROM FRONT PANEL END
75KC-230KC
230KC-660KC
0.65MC-1.95MC
1.85MC-5.5MC
5.4MC-17.5MC
17MC-40MC
L1 L2 L3 L4 L5 L6
C1 1-8
C2 1-8
C3 1-8
C4 1-8
C5 1-8
C6 1-8
R1 68K
R2 22K
R3 6.8K
R4 10K
R5 15K
R6 15K
C7 270
C8 270
C9 270
C10 270
C11 270
C12 100
BAND SELECTOR
R F OSCILLATOR
COIL GROUNDING CONTACTS
10.2-140
14.8-385
C13
C14 0.001 UF
R8 150
V1 JAN-9002
R7 150
C15 0.001 UF
C16 1000
C17 1000
L7 1MH
L8 2.5 MH
C18 1000
C19 1000
L9 3.3 UH
L10 3.3 UH
C20 1000
C22 0.1UF
C21 1000
R9 1000
R F GAIN
R10 1000
R13 100K
C25 0.01UF
C27 5600
C23 0.01 UF
V2 JAN6SA7
R11 240K
Y1 1MC
C30 0.01 UF
R12 1MEG
L11 2.5 MH
C26 330
CRYSTAL MIXER
L13 2.5MH
C42 75
C43 75
NOTES
1. STAR ENCIRCLED NUMBERS 1 TO 7 REPRESENT TERMINAL NUMBERS STAMPED ON FLANGE OF POWER SUPPLY CHASSIS.
2. CIRCLED NUMBERS 1 TO 14 REPRESENT TERMINAL NUMBERS STAMPED ON POWER SUPPLY TERMINAL BOARD.
3. UNLESS OTHERWISE SPECIFIED ALL RESISTORS IN OHMS; CAPACITORS IN MICROMICROFARADS; INDUCTANCES IN MICROHENRIES. K=1,000; MEG=1,000,000; UF=MICROFARADS.
T1
I1
POWER
S1
L20 100UH
L21 100UH
C51 0.001 UF
C52 0.001 UF
F1 2AMP
F2 2AMP
J1
V6 JAN5Y3GT
L22 7H
C53 10UF
C54 10UF
R39 5K 9W
V7 JAN-OB2
R40 10K 9W
V8 JAN-OA2
R42 145K
C57 910
C55 1400
1000~ MOD
EXT MOD
400~ MOD
S3A
S3B
XTAL
MOD CIRCUIT SELECTOR
R41 150K
C56 1800
C58 910
R43 51K 1W
R44 8200
V9 JAN12AU7
R45 2500 DEGEN-ERATION
S3C
S3D
J2
C59 0.001 UF
R47 1000
% MOD
R46 25K
C60 0.01UF



SCHEMATIC WIRING DIAGRAM
SIGNAL GENERATOR TS-413C/U
AUGUST 25,1953


POWER SUPPLY
FRONT PANEL
OSCIL
AMPLI
E-101
V-108
V-107
V-111
V-110
V-109
V-106
R-149
L-121
C-157
R-137
R-136
C-150
C-151
T-101
R-150
R-141
R-152
R-140
R-139
R-151
R-154
R-148
R-153
R-147
R-146
R-145
R-144
R-142
C-156
L-106
C-106
C-112
R-106
E-105
E-104
C-158
R-155
C-159
R-156
R-143
R-138
C-155
C153
C-152
S-103
C-154
SEC. 2
SEC. 1
S-102
E-103
M-102
F-102
C-149
L-120
C-143
C-146
C-141
C-142
C-144
C-145
C140
C-139


WIRING DIAGRAM
SIGNAL GENERATOR
TS – 413 C/U
OSCILLATOR
AMPLIFIER
ATTENUATOR
V-101
R-157
C-114
C-115
C-113
A
B
L-108
L-110
L-107
L-109
C-116
C-117
C-118
C-119
C-120
C-121
C-112
R-106
L-105
C-105
C-111
R-105
L-104
C-104
C-110
R-104
L-103
C-103
C-109
R-103
L-102
C-102
C-108
R-102
L-101
C-101
C-107
R-101
AY
AZ
BA
BD
BC
BE
BF
BB
L-116
L-117
L-115
L-118
L-114
L-113
C-137
R-130
C-146
C-142
C-145
C-139
S-101
R-113
R-115
R-116
R-112
R-114
V-103
V-104
C-130
C-131
R-117
C-132
C-133
C-160
Y-101
V-105
C-135
R-126
L-111
C-134
C-126
R-158
C-138
C-125
L-112
R-127
C-136
R-128
R-111
C-124
C-127
V-102
C-128
C-122
C-123
R-108
R-110
C-129
R-129
J-103
F-103
C-148
E-102
C-147
J-101
J-102
R-125
R-124
R-118
R-120
R-122
R-119
R-121
R-123
R-134
R-135
R-131
R-133
R-132
L-120
L-119
M-101