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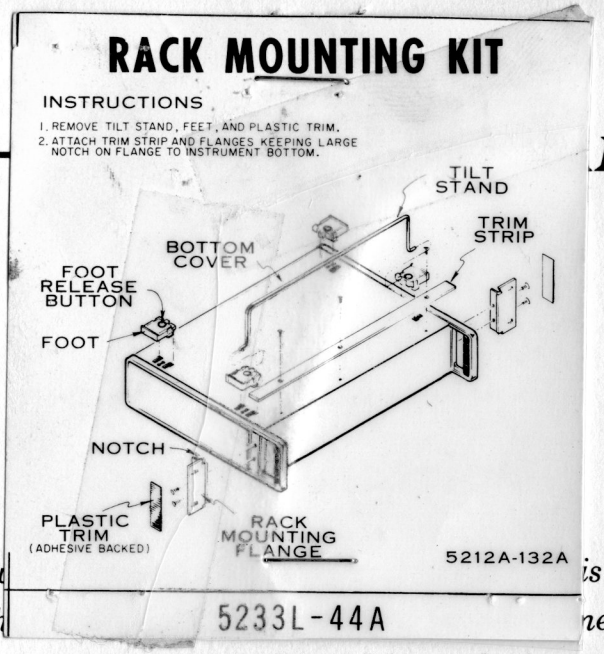
651B
TEST
OSCILLATOR

SERIALS PREFIXED 647-

OPERATING AND SERVICE MANUAL

HEWLETT hp PACKARD

HP 651B



The Heu *is instrument was thorough* *neet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.*

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

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OPERATING AND SERVICE MANUAL

(HP PART NO. 00651-90004)

MODEL 651B
TEST OSCILLATOR

SERIALS PREFIXED: 647-

P. O. Box 301, Loveland, Colorado, 80537 U.S.A.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Figure 1-1. Model 651B Test Oscillator

Table 1-1. Specifications

Frequency Range: 10 Hz to 10 MHz, 6 bands, dial calibration: 1 to 10.

Frequency Response:

Flat within: ±2% 100 Hz to 1 MHz
±3% 10 Hz to 100 Hz
±4% 1 MHz to 10 MHz*

Dial Accuracy: (Including warm-up drift and ±10% line voltage variation).
±2%, 100 Hz to 1 MHz
±3%, 10 Hz to 100 Hz, 1 MHz to 10 MHz

Output: 200 mW (3.16 V) into 50 ohms; 16 mW (3.16 V) into 600 ohms; 6.32 V into open circuit.

Attenuator:

Range: 90 dB in 10 dB steps

Overall Accuracy: ±0.1 dB .3 mV to 3 V range; ±0.2 dB .1 mV range

*This specification applies only at 50 ohm output. The response above 1 MHz at the 600 ohms output is affected by capacitive loads.

Amplitude Control: 20 dB range (nominal).

Output Monitor: Voltmeter monitors level at input of attenuator in volts or dB. Top scale calibrated in volts, bottom scale calibrated in dB.

Accuracy: ±2% at full scale

Flatness: ±1% at full scale, 20 Hz to 4 MHz
±2% at full scale, 10 Hz to 20 Hz, 4 MHz to 10 MHz

Distortion: Less than 1%, 10 Hz to 5 MHz, less than 2% at 10 MHz.

Hum and Noise: Less than 0.05% of maximum rated output.

Temperature Range: 0° to + 50° C.

Power: 115V/230V ±10%, 50 to 1000 Hz, 30 watts.

Dimensions: 5-7/32" high, 16-3/4" wide, 13-1/4" deep (132,6 x 425 x 336 mm).

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The Hewlett-Packard Model 651B Test Oscillator is a wide range capacitance-tuned oscillator covering a frequency range from 10 Hz to 10 MHz. The oscillator has a stable sine-wave output signal that is adjustable from 10 microvolts to 3.16 volts into 50 or 600 ohms. The Model 651B Test Oscillator is shown in Figure 1-1 and the specifications are given in Table 1-1. This manual is written for the standard Model 651B Test Oscillator; refer to paragraph 1-7 for differences between the standard instrument and Options 01 and 02.

1-3. Two output impedances are provided at front panel output connectors. The 600 ohm connector provides an output with an impedance that is compatible with transmission lines and many distribution systems. The 50 ohm connector provides an output where a low-source impedance is desired.

1-4. The Model 651B Test Oscillator output voltage is constantly monitored at the input of the attenuator by an internal voltmeter. The voltmeter has two scales for RMS voltage readings and a dBm scale referenced to 1 milliwatt into 50 ohms. The OUTPUT ATTENUATOR, in conjunction with the AMPLITUDE control, provides a monitored output of desired level when matched into a 50 or 600 ohm load.

1-5. ACCESSORIES.

1-6. Table 1-2 contains a list of the accessories which will increase the usefulness of the Model 651B.

1-7. OPTIONS.

1-8. OPTION 01.

1-9. Option 01 is a standard -hp- Model 651B Test Oscillator that has the dBm scale of the output monitor referenced to 1 milliwatt into 600 ohms. The front panel OUTPUT ATTENUATOR dBm markings have been changed to correspond with the signal level at the 600Ω output connector (-80 to +10 DBM).

1-10. OPTION 02.

1-11. Option 02 is a standard -hp- Model 651B Test Oscillator that has output impedances of 75 ohms and 600 ohms. Also, the output monitor has the dBm scale referenced to 1 milliwatt into 75 ohms.

1-12. INSTRUMENT IDENTIFICATION.

1-13. Hewlett-Packard uses a two-section eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and the Model 651B described in this manual.

1-14. If a letter prefixes the serial number, the instrument was manufactured outside the United States.

Table 1-2. Accessories

-hp- Model 10110A, BNC to Binding Post Adapter: Converts a BNC connector to binding post connectors.	-hp- Model 11005A Line Matching Transformer: Provides fully balanced 600Ω output from single-ended input.
-hp- Model 11004A Line-Matching Transformer: Provides fully balanced 135Ω or 600Ω output from single-ended input.	-hp- Model 11048B Feed-Thru Termination: Precision 50Ω feed-thru termination with male and female BNC connectors.

SECTION II
INSTALLATION

2-1. INSPECTION.

2-2. This instrument was carefully inspected both mechanically and electrically before shipment. It should be physically free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also, check for supplied accessories, and test the electrical performance of the instrument using the procedure outlined in Paragraph 5-5. If there is damage or deficiency, see the warranty on the inside front cover of this manual.

2-3. POWER REQUIREMENTS.

2-4. The Model 651B will operate from either 115 or 230 Vac, 50 - 1000 Hz. The instrument can be easily converted from 115 to 230 volt operation by changing the position of the slide switch located on the rear panel, so that the designation appearing on the switch matches the nominal voltage of the power source. A 0.4 ampere, slow-blow fuse is used for both 115 and 230 volt operation.

2-5. THREE-CONDUCTOR POWER CABLE.

2-6. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. All Hewlett-Packard instruments are equipped with a three-conductor power cable, which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground wire.

2-7. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

2-8. INSTALLATION.

2-9. The Model 651B is fully transistorized; therefore no special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 55°C (131°F).

2-10. RACK/BENCH INSTALLATION.

2-11. The Model 651B is initially shipped as a bench-type instrument (unless ordered specifically as a rack type) with plastic feet and a tilt stand in place. Conversion to a rack-mounted instrument can be accomplished by using the rack mounting kit and instructions furnished with your instrument.

2-12. REPACKAGING FOR SHIPMENT.

2-13. The following is a general guide for repackaging for shipment. If you have any questions, contact your local -hp- Sales and Service Office. (See Appendix B for office locations.)

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument, identifying the owner and indicating the service or repair to be accomplished; include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number, serial number and serial number prefix.

a. Place instrument in original container if available. If original container is not available, a suitable one can be purchased from your nearest -hp- Sales and Service Office.

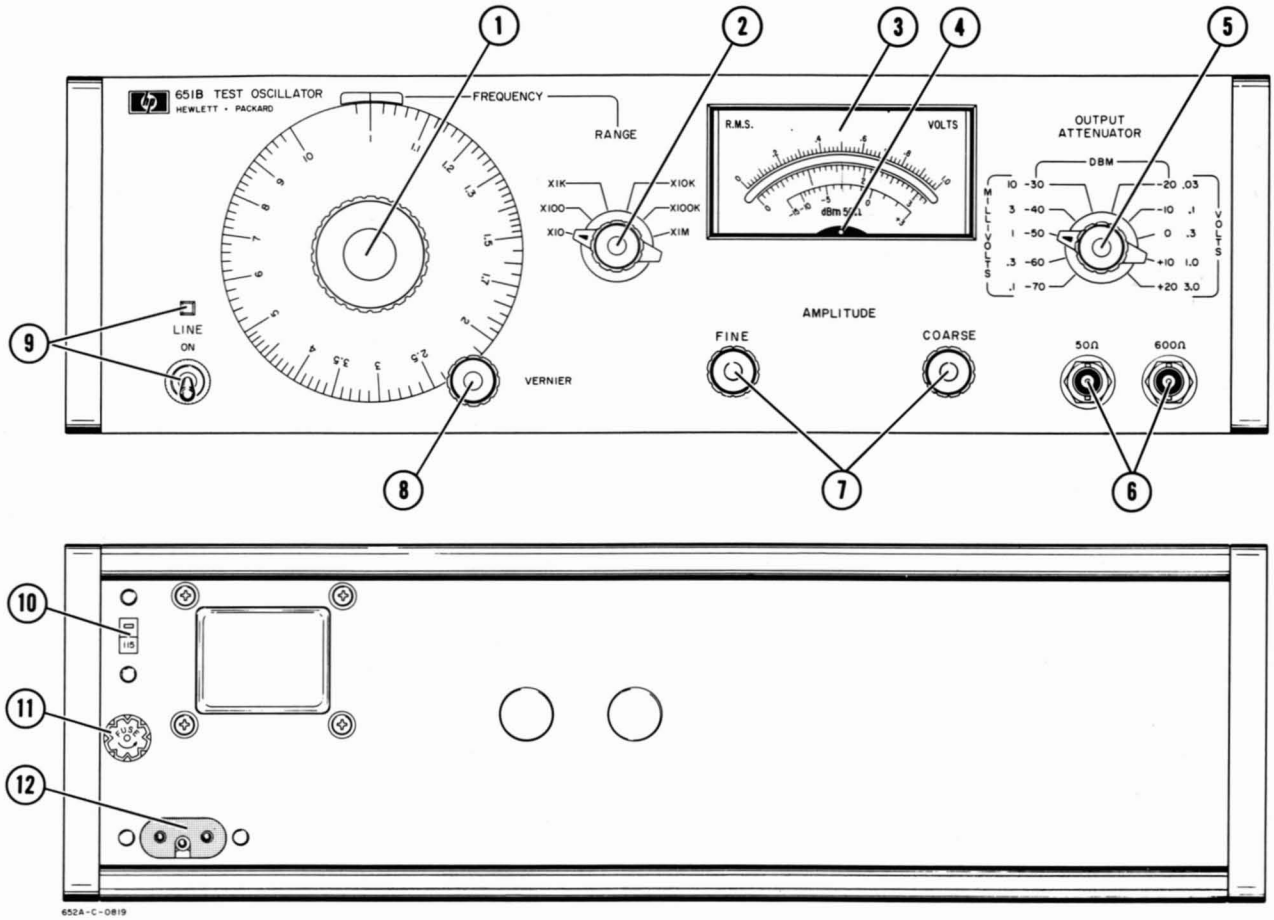
If original container is not used,

b. Wrap instrument in heavy paper or plastic before placing in an inner container.

c. Use plenty of packing material around all sides of instrument and protect panel faces with cardboard strips.

d. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.

e. Mark shipping container with "Delicate Instrument," "Fragile" etc.



(1) FREQUENCY Dial: Varies output frequency within each frequency range. Dial reading multiplied by range setting is the output frequency of the instrument.

(2) FREQUENCY RANGE Switch (S1): Selects one of six frequency ranges, from 10 Hz to 1 MHz.

(3) Output Monitor (M1): Monitors the amplitude of the test oscillator output.

(4) Mechanical Zero Adjust: Allows output monitor to be mechanically zeroed, when instrument is off.

(5) OUTPUT ATTENUATOR: Attenuates test oscillator output in nine steps of 10 dB each.

(6) Output Connectors (J2 and J3): Provides the output signal, at impedance levels of 50Ω and 600Ω. (75Ω and 600Ω on Opt. 02).

(7) AMPLITUDE COARSE and FINE Controls: Controls amplitude of signal applied to OUTPUT ATTENUATOR.

(8) FREQUENCY VERNIER: Provides a fine frequency adjustment for FREQUENCY dial.

(9) LINE ON Switch (S3) and Pilot Lamp: Switch applies primary power to instrument; pilot lamp glows to indicate application of primary power.

(10) 115/230 V Slide Switch (S4): Sets instrument to operate from a primary power source of either 115 Vac or 230 Vac.

(11) FUSE (F1): 0.4 amp fuse protects instrument from overloads.

(12) Primary Power Connector (J1): Connects primary power to test oscillator.

Figure 3-1. Location of Controls and Indicators

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. The Model 651B Test Oscillator generates a stable sine wave output that is available at output impedance levels of 600 ohms and 50 ohms. The frequency of the output is variable from 10 Hz to 10 MHz, and the output power level can be varied from 10 microvolts to 3.16 volts into 600 or 50 ohm loads. The amplitude of the output will be indicated on the output monitor, M1.

3-3. CONTROLS AND INDICATORS.

3-4. Figure 3-1 identifies and describes the function of all the front and rear panel controls, connectors, and indicators on the Model 651B.

3-5. ADJUSTMENT OF MECHANICAL ZERO.

3-6. The output monitor is properly zero-set when the meter pointer rests over the zero mark, and the 651B is in normal operating position at normal operating temperature, and is turned off. Zero-set the output monitor as follows to obtain maximum accuracy and mechanical stability

a. Turn 651B on and allow it to operate for at least 20 minutes, to let the meter movement reach normal operating temperature.

b. Turn 651B off, and allow 30 seconds for all capacitors to discharge.

c. Insert pointed object (such as tip of ballpoint pen) into recess on adjustment wheel, and rotate wheel until meter pointer is exactly over zero.

3-7. OPERATION.

3-8. To operate the 651B Test Oscillator, proceed as follows:

a. Connect primary ac power to 651B (115/230 V, 50 to 1000 Hz), and set slide switch S4 to proper position.

b. Turn LINE ON switch to ON position. Indicator lamp will glow, verifying application of primary power.

c. Set FREQUENCY RANGE switch and FREQUENCY Dial to desired output frequency.

d. Set OUTPUT ATTENUATOR switch to desired voltage range.

e. Connect load to output connector having an impedance which matches impedance of load.

f. Adjust AMPLITUDE controls for desired output voltage, as indicated on output monitor.

g. The output monitor, M1, indicates the rms value of the output voltage, and the power level in dBm for resistive loads of 50 ohms. The output voltage level is obtained by multiplying the monitor scale readings by the monitor scale multiplier which appears on the OUTPUT ATTENUATOR switch. Use the following equation and the impedance correction graph of Figure 3-2 to obtain the Model 651B output power level in dBm, for loads other than those marked on the output connectors.

$$\text{Output Voltage} = \frac{R_L}{R_L + R_S} \times 2V_m$$

Where,

R_L = Load Resistance (Terminating Resistance)

R_S = Source Resistance (Output Impedance of Oscillator

V_m = Model 651B Output Monitor Reading

Problem: A 600 ohm load is placed on the 50 ohm output connector. The Model 651B output monitor indicates an output of 0.9 volts, with the OUTPUT ATTENUATOR set on the 1.0 volt (+10 dBm) range. Find the actual output voltage and power level (in dBm) of the Model 651B.

Solution: The actual output voltage is calculated as follows:

$$\text{Output Voltage} = \frac{600}{600 + 50} \times 2\,(0.9) = 1.66 \text{ volts}$$

The indicated power level would be 17.3 dBm for an output voltage of 1.66 volts on the 3.0 volt (+20 dBm) range. The actual power level is the algebraic sum of the indicated power level and the correction factor obtained from the impedance graph of Figure 3-2. For this example a correction of -10.8 dBm is obtained for a 600 ohm load. The actual power level is +6.5 dBm [17.3 dBm + (-10.8 dBm)] .

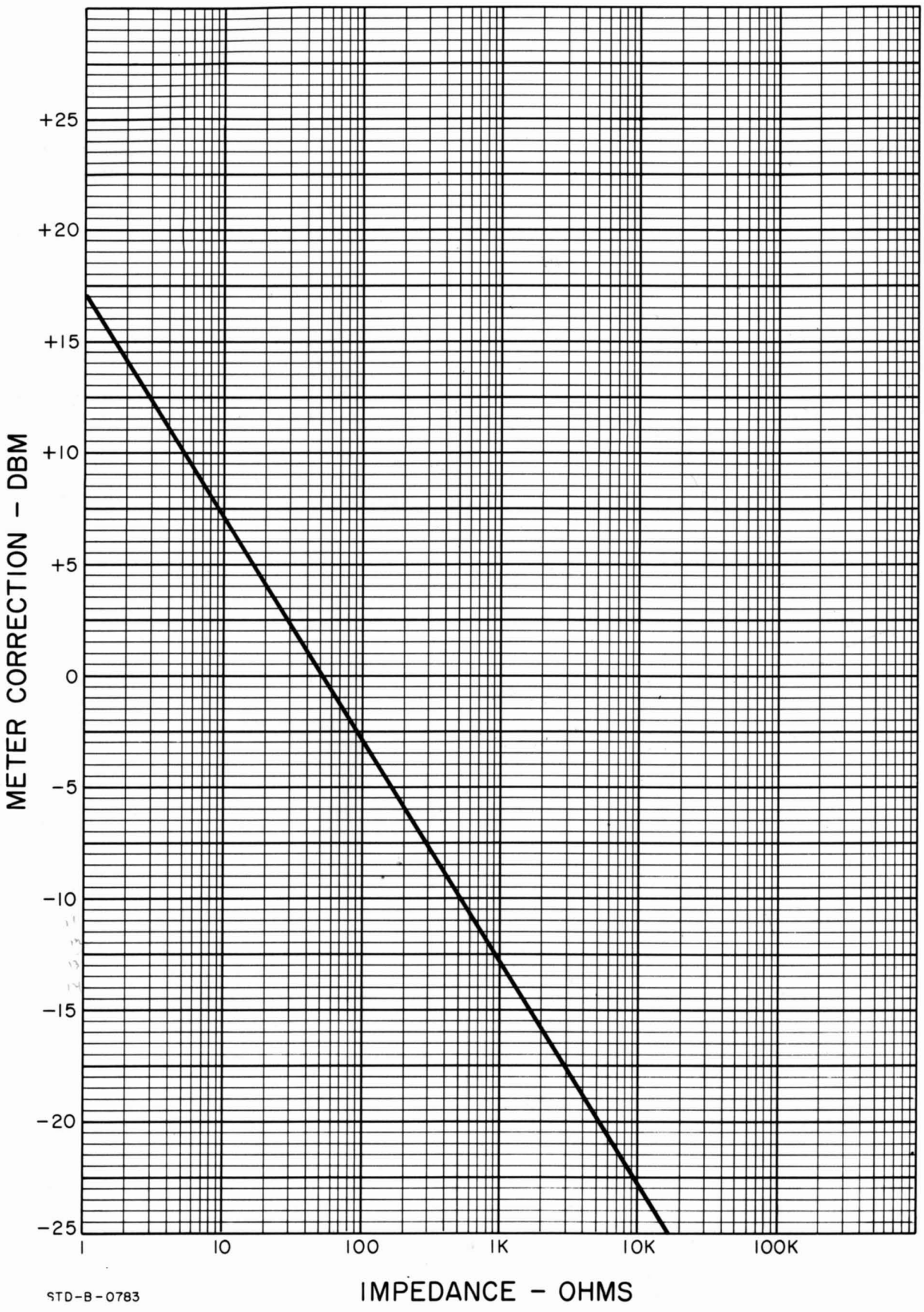


Figure 3-2. Impedance Correction Graph

SECTION IV
THEORY OF OPERATION

4-1. GENERAL DESCRIPTION.

4-2. The Model 651B Test Oscillator includes an oscillator, power amplifier, peak detector, attenuator, and monitor circuit. A block diagram of the instrument is shown in Figure 6-1. The oscillator circuit uses a modified Wein bridge network to generate a stable, distortionless sine wave signal which is applied to the power amplifier circuit. The peak detector circuit provides a degenerative feedback voltage to the oscillator circuit to stabilize the signal applied to the power amplifier. The power amplifier circuit is used to increase the output power available at the 50 ohm and 600 ohm output connectors and to improve the frequency stability of the output signal with changing output loads. The output attenuator provides a means of attenuating the signal at the output connectors in nine steps of 10 dB each. The monitor circuit continuously monitors the signal level at the input to the attenuator. The regulated power supply provides all voltages required by the 651B circuits.

4-3. CIRCUIT DESCRIPTION.

4-4. Refer to Figures 6-2 thru 6-4 for the following discussion.

4-5. OSCILLATOR CIRCUIT.

4-6. The oscillator circuit generates a sinusoidal signal at the frequency selected by the RANGE switch and FREQUENCY Dial located on the front panel. The RC bridge network is a modified Wein bridge circuit, consisting of an RC frequency selective network and a resistive voltage divider network. The Wein bridge in the Model 651B Test Oscillator differs from the conventional Wein bridge circuit in the design of the resistive voltage divider network. The resistor in the conventional Wein bridge is replaced with impedance Z1, which consists of A2CR6 and A2CR7.

4-7. Oscillation at the selected frequency is made possible by the use of both positive and negative feedback. Positive feedback is provided through a frequency sensitive RC network to the differential amplifier A2Q2 and A2Q3; negative feedback is provided to the differential amplifier through a network insensitive to frequency. Only at the selected frequency will the positive feedback exceed the negative feedback voltage to sustain oscillation.

4-8. The RANGE switch, S1, selects combinations of resistors and capacitors (S1R1 through S1R24, and S1C1 through S1C13) to establish the frequency sensitive RC networks for the six frequency ranges of the instrument. The FREQUENCY Dial varies the main frequency tuning elements C1A, C1B, and C1C. The RC components maintain the proper phase relationship of the positive feedback voltage. At frequencies where $X_C = R$, the positive feedback voltage is in phase with the oscillator output voltage (refer to Figure 4-1) and exceeds the negative feedback voltage. At frequencies other than where $X_C = R$, the positive feedback voltage is neither of the right phase nor of sufficient amplitude to maintain oscillations.

4-9. A field effect transistor, A2Q1, is used as the impedance converter because of its extremely high input impedance and low noise characteristics. It provides a high impedance in series with the input impedance of the differential amplifier on the lower four frequency ranges (X10 - X10K). The high impedance added prevents the RC bridge circuit from being loaded by the low input impedance of the differential amplifier, A2Q2 and A2Q3, on the lower frequency ranges. The impedance converter is bypassed on the X100K and X1M ranges due to lower resistor values in the RC bridge.

4-10. The difference between the feedback voltages from the bridge circuit is amplified by differential amplifier A2Q2 and A2Q3, and is applied to the complementary symmetry circuit A2Q5 and A2Q6, through emitter follower A2Q4. A positive feedback voltage from the output of the complementary symmetry circuit is applied between resistors A2R8 and A2R9, in the collector circuit of A2Q2, on the first four frequency ranges. The application of the feedback voltage at this point is used to make the effective resistance of the collector load higher than the input impedance of the emitter follower A2Q4, forcing the collector current into the base of the emitter follower. The increase in the base current results in an increase in the loop gain of the oscillator circuit. The feedback voltage is removed on the X100K and X1M frequency ranges due to the value of resistors A2R8 and A2R9 exceeding the input impedance of the emitter follower at the higher frequencies.

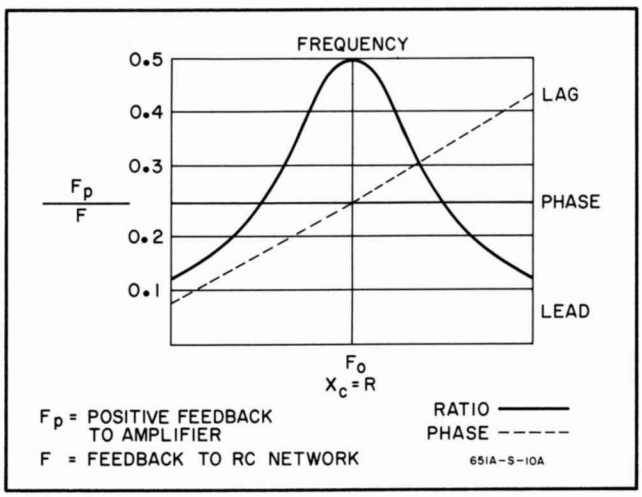


Figure 4-1. RC Network Characteristics

4-11. The complementary symmetry circuit is used to provide power gain and to increase the dynamic voltage range of the oscillator; also, the low output impedance of the complementary symmetry circuit prevents the oscillator output circuit from being loaded by the RC bridge. The complementary symmetry circuit transistors are forward-biased by diodes A2CR2, A2CR3, and A2CR4, and with no signal applied, are conducting slightly to reduce cross-over distortion in the output signal.

4-12. The output of the oscillator circuit drives the power amplifier with a constant voltage set by the AMPLITUDE COARSE and FINE controls, R2 and R3. The voltage level applied to the power amplifier is held constant by the action of the peak detector circuit.

4-13. PEAK DETECTOR.

4-14. Refer to Figure 4-2 for a simplified schematic of the peak detector circuit.

4-15. Feedback from the peak detector provides a bias voltage, proportional to the oscillator circuit output, to control the dynamic resistance of diodes A2CR6 and A2CR7. The peak detector A2Q7, conducts only on the positive peaks of the oscillator output signal. When the positive peaks of the oscillator output exceed a set level, the peak detector conducts, breaking down the reference diode A2CR5. The breakdown of the reference diode causes a reduction in the forward bias on the RC bridge voltage divider, A2CR6 and A2CR7. The decrease in forward bias causes the diodes to conduct less, increasing the dynamic resistance, and thus increasing the impedance Z1. The increase in impedance Z1 increases the amount of negative feedback voltage to the differential amplifier, A2Q2 and A2Q3, which results in a reduction of the oscillator output signal. The reduction in signal level compensates for the initial increase in the oscillator output.

4-16. A2R17 may be adjusted to compensate for differences in the operating characteristics of diodes A2CR6 and A2CR7, minimizing distortion in the negative feedback, thus minimizing distortion in the oscillator output. Diodes A2CR8 and A2CR9 compensate for reverse current leakage in A2Q7, due to increases in temperature.

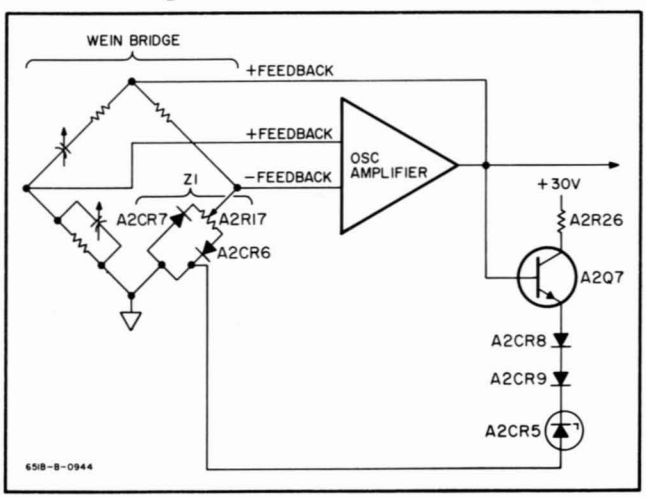


Figure 4-2. Peak Detector Circuit

4-17. POWER AMPLIFIER.

4-18. The power amplifier circuit increases the power gain of the signal received from the oscillator circuit. The operation of the differential amplifier A2Q8 and A2Q9, emitter follower A2Q10, and complementary symmetry circuit A2Q11 and A2Q12 is similar to the corresponding stages in the oscillator circuit. The negative feedback voltage from the output of the complementary symmetry circuit is applied to the differential amplifier at a fixed level to stabilize the power amplifier output signal. The power amplifier output is continuously monitored by the monitor circuit before the signal is applied to the output attenuator circuit.

4-19. MONITOR CIRCUIT.

4-20. The monitor circuit monitors the signal level applied to the output attenuator circuit and provides a signal to the output monitor M1, which indicates the amplitude of the output in RMS volts and dBm. The amplifier A1Q9 serves both as an impedance converter between the monitor circuit and the power amplifier output circuit, and as a current source to provide full-scale monitor indications. The high input impedance of A1Q9 prevents the power amplifier from being loaded with the low impedance of the output monitor, M1. The emitter follower, A1Q8, provides a positive feedback voltage which is applied between resistors A1R18 and A1R19, in the collector lead of amplifier A1Q8. The application of the feedback voltage at this point is used to increase the effective resistance of the collector circuit, which results in the amplifier A1Q9 appearing as a high impedance current source to the monitor. Diode A1CR10 provides a small amount of forward bias to rectifier diodes A1CR8 and A1CR9, which keeps the diodes out of the non-linear region, thus increasing monitor accuracy at one-tenth full-scale readings. The 10 MHz adjustment, A1C15, compensates for small variations in circuit capacitance so the monitor will have a flat frequency response. The monitor calibration resistor, A1R23, provides an additional calibration adjustment which is made at 400 Hz.

4-21. OUTPUT ATTENUATOR.

4-22. The output attenuator provides a means of attenuating the signal level applied to the 50 ohm and 600 ohm output connectors. The OUTPUT ATTENUATOR switch, S2, selects a combination of four resistor networks to produce the desired level of signal attenuation. Each step provides an attenuation of 10 dB. The AMPLITUDE controls, R2 and R3, vary the level of attenuation in increments between each 10 dB step selected by the OUTPUT ATTENUATOR switch.

4-23. Output impedances other than the standard 50 and 600 ohms can be obtained by changing the value of resistor S2R13. The value of the resistor replacing S2R13 is added to the 50 ohm oscillator output impedance to obtain the new output impedance level at the 600 ohm connector.

4-24. REGULATED POWER SUPPLY.

4-25. The regulated power supply provides all voltages required by the test oscillator circuits. The power supply consists of a +30 volt series regulated supply and a -25 volt series regulated supply which is referenced to the +30 volt circuit.

4-26. The +30 volt regulated supply is of the conventional series regulator type. The emitter follower A1Q2 is used to increase the loop gain of the circuit, thus improving voltage regulation. The +30 volt adjustment, A1R4, sets the +30 volt and -25 volt supply output level.

4-27. The -25 volt regulated supply is of the conventional series regulator type and operates the same as the +30 volt supply. A current limiter, A1Q7, has been added to limit the load current to a set value. When the load current exceeds the set value, the current limiter conducts, causing the series regulator A1Q4 to reduce the output voltage level until the load causing an excessive current is removed. Diodes A1CR6 and A1CR7 protect the control transistor A1Q6, against short circuits between the two voltage supplies, or short circuits in the output of the -25 volt supply.

Table 5-1. REQUIRED TEST EQUIPMENT

Instrument Type	Required Characteristics	Recommended Model
Oscilloscope	Passband: 10 Hz to 10 MHz Sensitivity: 50 mV/cm Input Impedance: 1 megohm	-hp- Model 175A Oscilloscope
Electronic Counter	Range: 10 Hz to 10 MHz Accuracy: ± 5 counts	-hp- Model 5244L Electronic Counter
RMS Voltmeter	Frequency Range: 10 Hz to 10 MHz Voltage Range: 1 mV to 6.32 V Accuracy: ±1%	-hp- Model 3400A RMS Voltmeter (with known error)
Distortion Analyzer	Distortion Sensitivity: > 42 dB	-hp- Model 331A
DC Null Voltmeter	Range: 10 μV to 30 V Accuracy: ±2% of full scale	-hp- Model 419A
AC Differential Voltmeter	Range: 3 V to 4 V Accuracy: ±0.1%	-hp- Model 741A AC-DC Differential Voltmeter/DC Standard
Attenuator	Attenuation Range: 90 dB in 10 dB steps Frequency Range: 10 Hz to 10 MHz	-hp- Model 355D VHF Attenuator (with known error)
Amplifier	Gain: 40 dB Frequency Range: 10 Hz to 10 MHz	-hp- Model 461A Amplifier
Thermal Converter	Input: 3 V RMS Output: 7 mV dc Accuracy: ±0.2% Frequency Range: 10 Hz to 10 MHz	-hp- Model 11049A Thermal Converter
0 to 10 mV Reference Supply	See Figure 5-3 for schematic a. Resistor: fxd, 6500Ω ±1% b. Resistor: var, 500Ω ±5% c. Resistor: var, 50Ω ±5% d. Battery: 1.34 V	 a. -hp- Part No. 0811-0392 b. -hp- Part No. 2100-0324 c. -hp- Part No. 2100-1481 d. Mallory RM-42R
Terminating Resistance	a. Feedthrough, 50Ω b. Feedthrough, 600Ω	a. -hp- Model 11048B b. -hp- Model 11047A
Adapter	BNC to Binding Post	-hp- Model 10111A Adapter

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains maintenance and service information for the -hp- Model 651B Test Oscillator. Included are Performance Checks, Alignment and Calibration Procedures, and Troubleshooting Procedures.

5-3. REQUIRED TEST EQUIPMENT.

5-4. The equipment needed to properly maintain the Model 651B is listed in Table 5-1. The table lists the type of equipment to be used, the specification requirements, and the recommended commercially available test equipment. If the equipment listed in Table 5-1 is not available, any instrument that satisfies the given specifications may be used.

5-5. PERFORMANCE CHECKS.

5-6. The performance checks are in-cabinet checks that insure that the Model 651B Test Oscillator is operating within specifications. These checks may be used for incoming inspection, periodic maintenance, and for specification checks after a repair. Use the performance checks to verify instrument performance before making internal adjustments or repairs.

5-7. DIAL ACCURACY CHECK.

a. Connect 651B 50Ω output terminal to dc input terminal of electronic counter as shown in Figure 5-1.

b. Set 651B controls as follows:

FREQUENCY RANGE X10
FREQUENCY Dial 1
OUTPUT ATTENUATOR. . . 3.0 V
AMPLITUDE. . . . . Adjust for monitor indication of 3.0 V

c. Set electronic counter to read period average; counter should indicate 100 ±3 ms.

d. Set 651B FREQUENCY dial to 5; electronic counter should indicate 20 ±0.6 ms.

e. Set 651B FREQUENCY dial to 10; electronic counter should indicate 10 ±0.3 ms.

f. Set 651B FREQUENCY RANGE to X100 and set FREQUENCY dial to 1; electronic counter should indicate 10 ±0.2 ms.

g. Set 651B FREQUENCY dial to 5; electronic counter should indicate 2 ±0.04 ms.

h. Set 651B FREQUENCY dial to 10; electronic counter should indicate 1 ±0.02 ms.

i. Set electronic counter to read frequency. Set 651B to each frequency listed in Table 5-2. If electronic counter indication for each frequency is not within the listed tolerance, perform the frequency dial calibration, Paragraph 5-21.

Table 5-2. Dial Accuracy Check

Frequency (Hz)	Electronic Counter Indication (Hz)
1K	1000 ±20
5K	5000 ±100
10K	10K ±0.2K
50K	50K ±1K
100K	100K ±2K
500K	500K ±10K
1M	1M ±30K
5M	5M ±150K
10M	10M ±300K

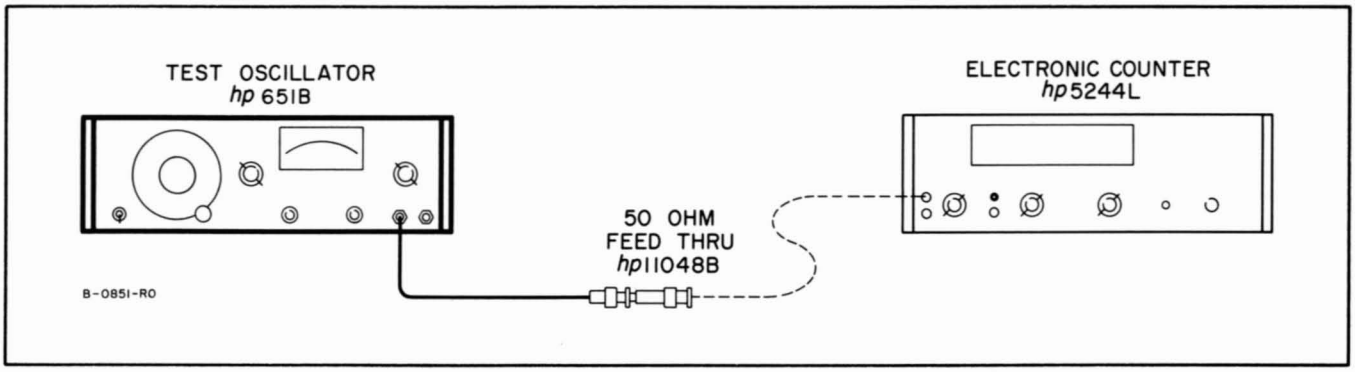


Figure 5-1. Dial Accuracy Check

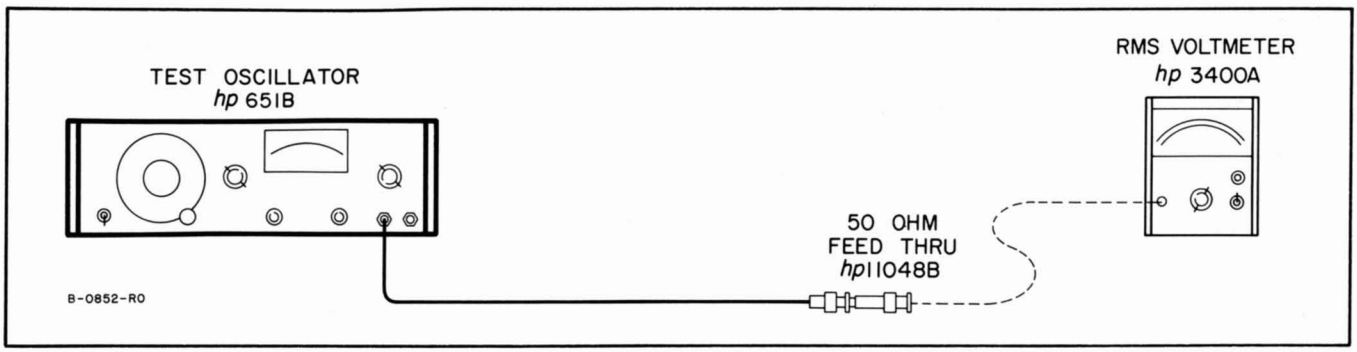


Figure 5-2. Output Monitor, Voltage Check

5-8. OUTPUT MONITOR CHECK.

a. Connect an RMS voltmeter to 50Ω output terminal of 651B as shown in Figure 5-2. Use an RMS voltmeter with known error.

b. Set 651B controls as follows:

FREQUENCY RANGE X100
FREQUENCY Dial. 4
OUTPUT ATTENUATOR . . 3.0 V

c. Adjust 651B amplitude controls for a 3.0 V indication on output monitor. RMS voltmeter should indicate 3.0 V ±2%. If RMS voltmeter indication is not within this tolerance, perform the monitor calibration, Paragraph 5-31. If desired, the monitor may be checked with 651B connected directly to RMS voltmeter (effectively on open circuit). In this case, RMS voltmeter indication should be 6 V ±2%.

NOTE

When amplitude controls are turned fully CCW, the 651B monitor will typically be offset one division up-scale. This is a normal indication, and does not require a monitor calibration.

5-9. OUTPUT VOLTAGE CHECK.

a. Connect RMS voltmeter to 50Ω output terminal of 651B as shown in Figure 5-2.

b. Set 651B controls as follows:

FREQUENCY RANGE X1K
FREQUENCY Dial 10
OUTPUT ATTENUATOR . . 3.0 V

c. Adjust 651B AMPLITUDE controls for a 3.0 V indication on RMS voltmeter.

d. Turn AMPLITUDE controls fully CCW; RMS voltmeter indication should be reduced to 0.3 V or less (20 dB down).

e. Turn AMPLITUDE controls on 651B fully CW; RMS voltmeter should indicate 3.16 V or greater.

f. Disconnect RMS voltmeter from 50Ω output terminal of 651B and connect to 600Ω output terminal. Replace 50Ω load with 600Ω load (-hp- Model 11047A).

g. Repeat steps c through e of this paragraph.

5-10. OUTPUT IMPEDANCE CHECK.

a. Connect 50Ω output of 651B directly to RMS voltmeter.

b. Set 651B controls as follows:

FREQUENCY RANGE X1K
FREQUENCY Dial. 1
OUTPUT ATTENUATOR . . 3.0 V

c. Adjust 651B amplitude controls for a 6.0 V indication on RMS voltmeter.

d. Insert a 50Ω feedthrough load between 651B and RMS voltmeter. RMS voltmeter indication should drop to 3.0 V ±0.15 V, verifying a 50Ω output impedance.

e. Remove the 50Ω feedthrough load, and disconnect the cable to the 50Ω output of the 651B.

f. Connect 600Ω output of 651B directly to RMS voltmeter.

g. Adjust 651B AMPLITUDE controls for a 6.0V indication on RMS voltmeter.

h. Insert a 600Ω load between 651B and RMS voltmeter. RMS voltmeter indication should drop to 3.0 V ±0.15 V.

5-11. MONITOR FLATNESS CHECK.

a. Connect nullmeter, thermal converter, and reference supply to 651B as shown in Figure 5-3, setting 651B and reference supply outputs to minimum before connecting.

CAUTION

DO NOT EXCEED RATED INPUT OF THERMAL CONVERTER. ANY OVERLOAD OR HIGH VOLTAGE TRANSIENT MAY DESTROY THERMOELEMENT.

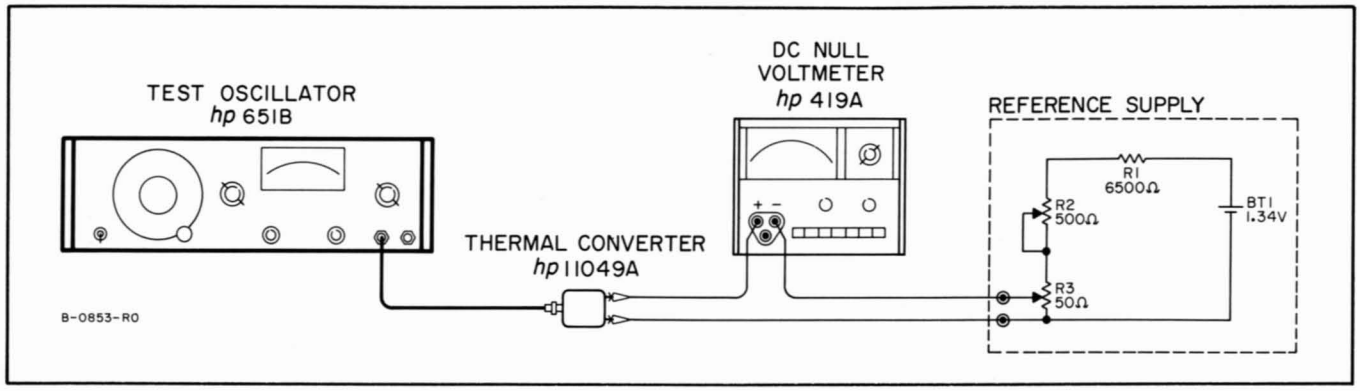


Figure 5-3. Monitor Flatness Check

b. Set 651B controls as follows:

FREQUENCY RANGE X1K
FREQUENCY Dial 10
OUTPUT ATTENUATOR . . 3.0 V

c. Adjust 651B AMPLITUDE controls for a monitor indication of 3.0 V.

d. Adjust reference supply for a null indication. Do not readjust reference supply once null is obtained.

e. Set 651B to each frequency setting in Table 5-3, and adjust AMPLITUDE controls so that a null indication is obtained for each frequency setting. If the 651B monitor indication is not within the tolerances listed in the table, perform the monitor calibration; Paragraph 5-31.

Table 5-3. Monitor Flatness Check

Frequency (Hz)	Monitor Indication	
	Min.	Max.
10	2.94	3.06
20	2.94	3.06
100	2.97	3.03
400	2.97	3.03
5K	2.97	3.03
50K	2.97	3.03
500K	2.97	3.03
1M	2.97	3.03
4M	2.97	3.03
10M	2.94	3.06

5-12. FREQUENCY RESPONSE CHECK.

a. Perform steps a and b of Paragraph 5-11, setting FREQUENCY dial to 1.

b. Adjust 651B AMPLITUDE controls for a null meter indication of 7.0 mV.

c. Adjust reference supply for a null indication. Do not readjust reference supply once null is obtained.

d. Sweep FREQUENCY dial slowly from 1 to 10. If the null meter indication exceeds the tolerances listed in Table 5-4, perform the calibrations and adjustments in Paragraphs 5-22 through 5-25.

e. Repeat steps b through d for each frequency range listed in Table 5-4.

Table 5-4. Frequency Response Check

Frequency Range	Null Meter Indication	
	Min.	Max.
X10	-420 μV	+420 μV
X100	-280 μV	+280 μV
X1K	-280 μV	+280 μV
X10K	-280 μV	+280 μV
X100K	-280 μV	+280 μV
X1M	-560 μV	+560 μV

5-13. DISTORTION CHECK.

a. Connect a distortion analyzer to the 651B as shown in Figure 5-4.

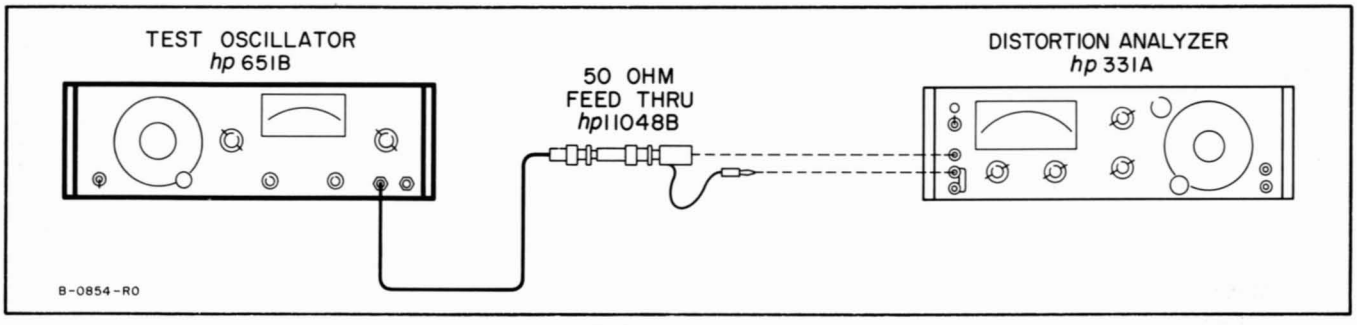


Figure 5-4. Distortion Check

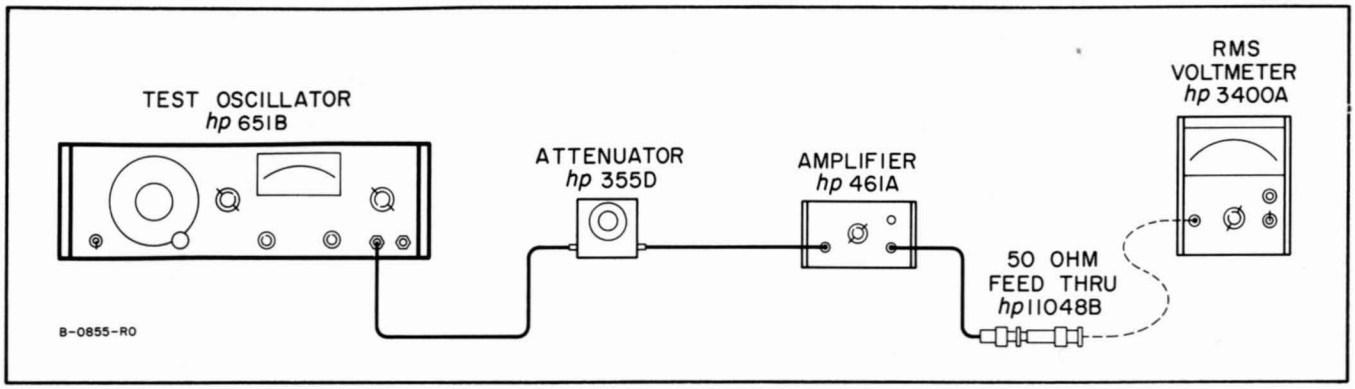


Figure 5-5. Attenuation Check

b. Set 651B controls as follows:

FREQUENCY RANGE X1K
FREQUENCY Dial 1
OUTPUT ATTENUATOR . . 3.0 V
AMPLITUDE. . . . . Adjust for monitor indication of 3.0 V

c. Distortion level as indicated on distortion analyzer, should be less than 1%.

d. Set 651B to each frequency listed in Table 5-3 (except the top three frequency settings, because the frequency limit of the distortion analyzer is 600 kHz) and observe distortion analyzer indication; distortion level should be less than 1% for each frequency. If distortion level is not less than 1%, perform the minimum distortion adjustment, Paragraph 5-30.

5-14. ATTENUATION CHECK.

a. Connect external attenuator, amplifier, and RMS voltmeter to 651B, as shown in Figure 5-5. Use an attenuator with known error.

NOTE

Float the amplifier and RMS voltmeter by using a three-prong to two prong adapter on the ac power cord of both instruments.

b. Set 651B controls as follows:

FREQUENCY RANGE X1K
FREQUENCY Dial 1
OUTPUT ATTENUATOR . . 3.0 V (+20 dB)

c. Set attenuator switch to 90 dB position.

d. Set amplifier gain switch to 40 dB position.

e. Adjust 651B AMPLITUDE controls for an indication of 9 mV on RMS voltmeter.

f. Check attenuator on each range by decreasing attenuation on external attenuator as attenuation is increased on 651B. RMS voltmeter indication should be 9 mV ±1% for .3 mV through 3.0 V ranges (-60 dB to +20 dB); for .1 mV range (-70 dB), RMS voltmeter indication should be 9 mV ±2%.

g. Repeat steps c through f of this paragraph with the 651B set to 100 kHz, 1 MHz, 5 MHz, and 10 MHz.

5-15. ADJUSTMENT AND CALIBRATION PROCEDURE.

5-16. The following is a complete adjustment and calibration procedure for the Model 651B. The adjustments should be performed only if it has been determined by the Performance Checks that the 651B is not within specifications. Figure 5-7 shows the location of all the internal adjustments.

5-17. COVER REMOVAL.

5-18. To remove the top or bottom cover remove the two retaining screws from the sides of the cover, slide the cover about 1/2 inch to the rear, and lift it off. To replace the cover, reverse the removal procedure.

5-19. To remove a side cover, remove the two retaining screws in the cover, and lift it off.

5-20. POWER SUPPLY VOLTAGE ADJUSTMENT.

a. Connect a dc voltmeter to power supply positive output, connector point 1. (Refer to Figure 6-3).

b. Adjust A1R4 for an indication of +30 V on the dc voltmeter.

c. Connect dc voltmeter to power supply negative output, connector point 2; dc voltmeter should indicate -25 V ±0.75 V. If the negative supply output is not within tolerance, change value of resistor A1R13* to obtain specified output. Decrease value of A1R13* to increase negative supply voltage; increase value of A1R13* to decrease negative supply voltage.

5-21. FREQUENCY DIAL CALIBRATION.

a. Remove oscillator circuit shield by removing six retaining screws.

CAUTION

THE 651B CONTAINS VERY HIGH IMPEDANCE, HIGH FREQUENCY CIRCUITS. CONTAMINATION OF THE SWITCHES, CIRCUIT BOARDS OR TUNING CAPACITOR WILL CAUSE HIGH IMPEDANCE LEAKAGE PATHS AND SUBSEQUENT DETERIORATION OF THE PERFORMANCE OF THE INSTRUMENT. AVOID TOUCHING ANY OF THESE CIRCUITS WITH THE BARE FINGERS, AS SKIN OILS ARE EXTREMELY CONTAMINATING. IF HANDLING IS NECESSARY, WEAR CLEAN COTTON OR RUBBER GLOVES. DO NOT USE A PENCIL TO TRACE CIRCUITS IN THE INSTRUMENT. GRAPHITE PENCIL LEAD IS AN EXTREMELY GOOD CONDUCTOR AND AN ACCIDENTLY INTRODUCED PATH OF THIS TYPE IS SOMETIMES DIFFICULT TO LOCATE. TO AVOID SURFACE CONTAMINATION OF A PRINTED CIRCUIT OR SWITCH, CLEAN WITH A WEAK SOLUTION OF WARM WATER AND MILD DETERGENT AFTER REPAIR. RINSE THOROUGHLY WITH CLEAN WATER AND ALLOW IT TO DRY COMPLETELY BEFORE OPERATING. DO NOT USE ALCOHOL OR ANY OTHER CLEANING SOLUTION EXCEPT DETERGENT AND WATER. DO NOT APPLY ANY COMMERCIAL MOISTURE SEALING SPRAY TO THE BOARDS; APPLICATION OF THESE AGENTS MAY CAUSE LEAKAGE PATHS.

b. Set 651B controls as follows:

FREQUENCY RANGE X1K
FREQUENCY Dial . . . . . Fully CW
OUTPUT ATTENUATOR . . 3.0 V
AMPLITUDE Controls . . . Fully CW

c. Connect 651B to distortion analyzer as shown in Figure 5-4.

d. Adjust A2R17 for minimum distortion. Distortion should be less than 1% (42 dB down).

NOTE

This adjustment is a preliminary adjustment for the FREQUENCY Dial calibration.

e. Connect RMS voltmeter to A2TP1; RMS voltmeter indication should be 110 mV ±10 mV (gain control voltage). If gain control voltage is not within this limit, change value of A2R16* to obtain specified voltage. Increase value of A2R16* to decrease the gain control voltage; decrease value of A2R16* to increase the gain control voltage.

f. Attach a test to A2TP2, and isolate the test lead with a 1K resistor, as shown in Figure 5-6. Connect test lead so that test point voltage may be monitored with oscillator shield and bottom cover in place. Do not replace oscillator shield and bottom cover at this time.

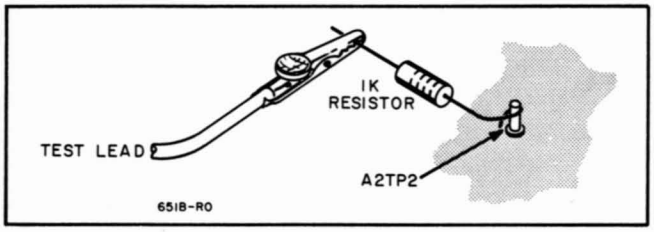


Figure 5-6. A2TP2 Test Lead Connection

g. Connect test lead to a dc voltmeter.

h. Replace oscillator circuit shield and bottom cover of instrument, leaving test lead connected to dc voltmeter. Record A2TP2 voltage.

NOTE

This voltage is directly related to the gain control voltage at A2TP1, and is used as a reference in the following calibration procedures.

i. Connect 651B to electronic counter as shown in Figure 5-1.

j. Turn 651B FREQUENCY Dial to fully CCW position.

k. Adjust S1C2 and S1C7 alternately until 651B output frequency is 10.2 kHz (as indicated on electronic counter) and voltage at A2TP2 is same as recorded in step h.

l. Turn FREQUENCY Dial to fully CW position. 651B output frequency should be 970 Hz (as indicated on electronic counter). If 651B is not within 965 to 970 Hz, loosen tuner coupler (MP2, Figure 7-1), and slip tuner until specified frequency is obtained.

m. Set 651B output frequency to 1 kHz (as indicated on electronic counter).

NOTE

If number 1 on FREQUENCY Dial is not lined up with mark on dial indicator, remove FREQUENCY Dial knob and loosen four dial retaining screws. Slip FREQUENCY Dial until number 1 lines up with mark on dial indicator. Tighten retaining screws and replace knob.

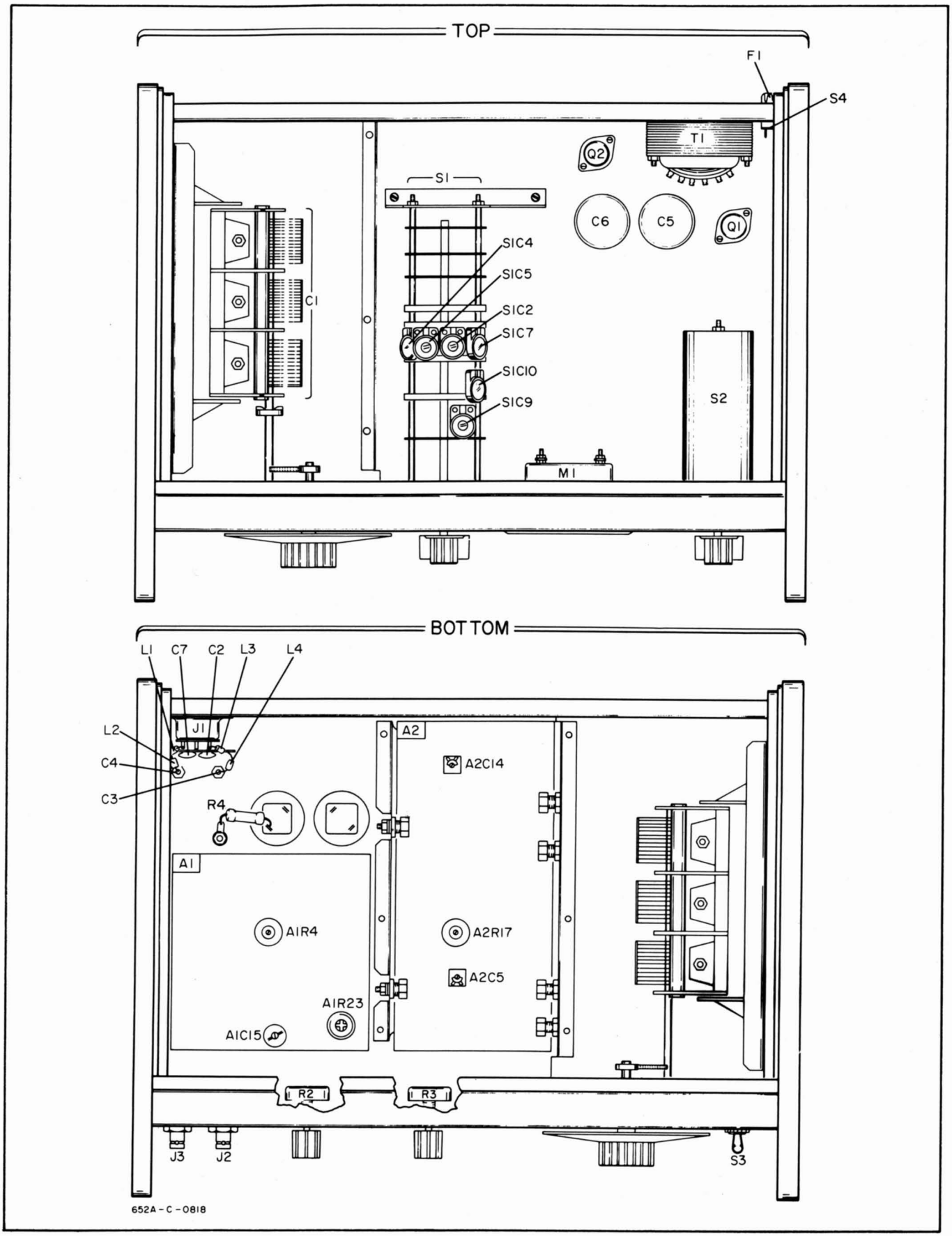


Figure 5-7. Location of Internal Adjustments

CAUTION

THE ADJUSTMENTS IN PARAGRAPHS 5-22 THROUGH 5-25 ARE HIGHLY CRITICAL AND WILL HAVE TO BE PERFORMED ONLY IN RARE CASES. THE VALUES OF THE RANGE SWITCH RESISTORS WERE BRIDGED AT THE FACTORY FOR OPTIMUM PERFORMANCE, AND THEORETICALLY SHOULD NEVER HAVE TO BE CHANGED. DOUBLE-CHECK THE INSTRUMENT PERFORMANCE BEFORE CHANGING THE VALUES OF ANY OF THE RANGE SWITCH RESISTORS.

5-22. X100, X1K, AND X10K RANGE FREQUENCY CALIBRATION.

a. Connect 651B to electronic counter as shown in Figure 5-1, with dc voltmeter monitoring voltage at A2TP2.

b. Check frequency tracking of FREQUENCY Dial at 1, 5, 8, and 10 on X100, X1K, and X10K ranges while monitoring voltage at A2TP2. Voltage at A2TP2 should remain relatively constant from the 1 to 10 position of the FREQUENCY Dial.

c. If frequency ranges are off on the 1 position of the FREQUENCY Dial, change value of RANGE switch resistors associated with respective range (refer to Table 5-5). Change value of both resistors on each range at same time to keep voltage at A2TP2 same on all ranges (within ±0.02 V from voltage recorded in Paragraph 5-21, step h).

Table 5-5
Frequency Range Switch Padding Resistors

Frequency Range	Padding Resistors
X10	S1R1* and S1R14*
X100	S1R3* and S1R16*
X1K	S1R5* and S1R18*
X10K	S1R7* and S1R20*
X100K	S1R9* and S1R22*
X1M	S1R11* and S1R24*

5-23. X10 RANGE FREQUENCY CALIBRATION.

a. Connect 651B to electronic counter as shown in Figure 5-1, with dc voltmeter monitoring voltage at A2TP2.

b. Set 651B FREQUENCY RANGE to X10 and set FREQUENCY Dial to 10; electronic counter should indicate 100 ±3 Hz. Set FREQUENCY Dial to 1; electronic counter should indicate 10 ±0.3 Hz.

c. If either of above frequencies is not within tolerance, change value of resistors S1R1* and S1R14* simultaneously to bring frequency within tolerance. A2TP2 voltage must remain same as that recorded in Paragraph 5-21, step h (within ±0.02 V).

NOTE

It may be necessary to split difference in frequency between ends of dial.

d. Set FREQUENCY Dial to 2, 5, and 8, while monitoring electronic counter. Dial must be accurate within ±3%, if not, repeat steps b and c until FREQUENCY Dial is accurate within ±3% over its entire range.

5-24. X1M RANGE FREQUENCY CALIBRATION.

NOTE

The following adjustments are critical. Final voltage and frequency readings must be made with all instrument covers in place.

a. Connect 651B to electronic counter as shown in Figure 5-1, with dc voltmeter monitoring voltage at A2TP2.

b. Set 651B FREQUENCY RANGE to X1M, and set FREQUENCY Dial to 10. Adjust S1C5 and S1C10 with tuning wand until electronic counter indicates 10.15 MHz (1.5% high), and voltage at A2TP2 is same as in Paragraph 5-21 step h (±0.02 V).

NOTE

To accomplish step b, remove top cover from 651B, make adjustments and replace cover. Check FREQUENCY Dial accuracy and voltage at A2TP2.

c. If 651B will not oscillate (no reading on output monitor) or S1C5 and S1C10 do not have enough range to complete step b, set FREQUENCY Dial to 5, remove bottom cover, and adjust A2C5 with tuning wand until 651B oscillates and electronic counter indicates 5 MHz. Then repeat step b.

NOTE

Replace bottom cover to check 651B frequency, after adjusting A2C5.

d. Set FREQUENCY Dial fully CCW, and adjust S1C10 until voltage at A2TP2 is same as in Paragraph 5-21, step h (±0.02 V). Set FREQUENCY Dial to 1, and check electronic counter indication; frequency should be 1 MHz ±3%.

e. If either 651B frequency or A2TP2 voltage does not adjust according to steps c and d, change values of resistors S1R11* and S1R24* simultaneously until both frequency and voltage are within specifications.

f. Set FREQUENCY Dial to 5 and adjust A2C5 until electronic counter indicates 4.975 to 4.950 MHz (0.5% to 1.9% low).

g. Recheck 651B frequency with FREQUENCY Dial set to 10. If necessary, readjust S1C5 and S1C10 for frequency of 10.15 MHz (1.5% high).

5-25. X100K RANGE FREQUENCY CALIBRATION.

NOTE

The following adjustments are critical. Final voltage and frequency readings must be made with all instrument covers in place.

a. Connect 651B to electronic counter as shown in Figure 5-1, with dc voltmeter monitoring voltage at A2TP2.

b. Set 651B FREQUENCY RANGE to X100K and set FREQUENCY Dial to 10. Adjust S1C4 and S1C9 with tuning wand until electronic counter indicates 1 MHz and A2TP2 voltage is same as in Paragraph 5-21, step h (±0.02 V).

c. Set 651B FREQUENCY Dial to 1. Electronic counter should indicate 100 kHz, ±2 kHz, and voltage at A2TP2 should be same as in Paragraph 5-21, step h (±0.02 V).

d. If 651B frequency or voltage at A2TP2 is not within specified limits of step c, change values of resistors S1R9* and S1R22* simultaneously to bring both readings within specifications.

e. Set 651B FREQUENCY Dial to 10, and recheck frequency. If necessary, repeat step b.

5-26. 10 MHz FLATNESS ADJUSTMENT.

a. Connect nullmeter, thermal converter, and reference supply to 651B as shown in Figure 5-3, setting 651B and reference supply outputs to minimum before connecting.

CAUTION

DO NOT EXCEED RATED INPUT OF THERMAL CONVERTER. ANY OVERLOAD OR HIGH VOLTAGE TRANSIENT MAY DESTROY THERMOELEMENT.

b. Set 651B controls as follows:

FREQUENCY RANGE X1K
FREQUENCY Dial 10
OUTPUT ATTENUATOR . . 3.0 V

c. Adjust AMPLITUDE controls for a 3.0 V indication on output monitor. Do not readjust AMPLITUDE controls.

d. Adjust reference supply for a null indication. Do not readjust reference supply once null is obtained.

e. Set 651B FREQUENCY RANGE to X1M.

f. Sweep FREQUENCY Dial slowly from 1 to 10. Null meter deviation from null should not exceed ± 0.54 mV.

NOTE

The percent of change in the 651B output, as read on the null meter, is doubled due to the thermal converter being a square law device.

g. Adjust A2C14 to reduce any output peaking which may be present. If necessary, change the value of A2C24* slightly.

5-27. OUTPUT ADJUSTMENT.

5-28. WAVEFORM ADJUSTMENT.

a. Connect a 50Ω load to the 651B 50Ω output terminal, and connect the output to an oscilloscope.

b. Set OUTPUT ATTENUATOR to 3.0 V, and turn AMPLITUDE controls fully CW.

c. Check 651B output, with and without load, on all frequencies. If spurious oscillations occur, change value of A2C21* until spurious oscillations are eliminated.

5-29. AMPLITUDE ADJUSTMENT.

a. Connect 651B to RMS voltmeter, as shown in Figure 5-2.

b. Set 651B controls as follows:

FREQUENCY RANGE X10
FREQUENCY Dial 1
OUTPUT ATTENUATOR . . 3.0 V
AMPLITUDE . . . . . Fully CW

c. RMS voltmeter should indicate at least 3.16 V. If maximum output is less than 3.16 V, slightly increase value of A2R24. *

5-30. MINIMUM DISTORTION ADJUSTMENT.

a. Connect 651B to distortion analyzer as shown in Figure 5-4.

b. Set 651B controls as follows:

FREQUENCY RANGE X1K
FREQUENCY Dial. 1
OUTPUT ATTENUATOR . . 3.0 V
AMPLITUDE. . . . . Fully CW

c. Adjust A2R17 for minimum distortion as indicated on distortion analyzer. Distortion should be less than 1% (40 dB down).

NOTE

Distortion will be typically 50 dB down.

5-31. OUTPUT MONITOR CALIBRATION.

NOTE

The following adjustments are critical. Final voltage readings must be made with all instrument covers in place.

a. Connect 651B to RMS voltmeter as shown in Figure 5-2.

b. Set 651B controls as follows:

FREQUENCY RANGE X100
FREQUENCY Dial. 1
OUTPUT ATTENUATOR . . 3.0 V

c. Set AMPLITUDE controls for a 3.0 V indication on RMS voltmeter.

d. Adjust A1R23 for a 3.0 V indication on 651B monitor. If A1R23 does not have sufficient range to properly calibrate monitor, change value of A1R22* slightly. Decrease A1R22* to decrease monitor indication; increase A1R22* to increase monitor indication.

e. Set 651B FREQUENCY RANGE to X1M, and set FREQUENCY Dial to 10.

f. Set AMPLITUDE controls for a 3.0 V indication on RMS voltmeter.

NOTE

Allow for known error of RMS voltmeter at 10 MHz.

g. Adjust A1C15 with tuning wand for a 3.0 V indication on 651B monitor.

5-32. TROUBLESHOOTING PROCEDURE.

5-33. This section contains information and procedures designed to aid in the process of isolating malfunctions. Troubleshooting should be undertaken only after it has been determined that the malfunction cannot be corrected by performing the adjustment and calibration procedures.

5-34. When a malfunction occurs, remove power from the 651B, and visually inspect for loose or broken wires, connectors, or components. Also, an investigation should be made to ensure that the trouble is not the result of conditions external to the instrument.

5-35. The Troubleshooting Tree in Figure 5-8 illustrates a systematic method of elimination used to locate a faulty circuit or component. The tree does not include specific troubles and problems; it presents a list of key points to be checked for normal circuit indications or conditions, which can be used to eliminate the properly operating circuits from the troubleshooting path. The checks outlined in the troubleshooting tree were not devised to measure all circuit parameters, but to localize the malfunction. Therefore, additional checks and measurements will probably be required to completely isolate the faulty component.

5-36. To use the troubleshooting tree, decide if (1) is true or false, and proceed to the next step along the pertinent branch of the tree. In some cases, there are two or more branches for a given indication, meaning that either one or all the branches could lead to the malfunction. Additional information for use with the troubleshooting tree is given in Paragraph 5-37. Refer to the block diagram in Figure 6-1, and the schematics of Figures 6-2 and 6-3, when using the troubleshooting tree.

5-37. TROUBLESHOOTING INFORMATION.

5-38. This section provides additional information for each particular step of the troubleshooting tree.

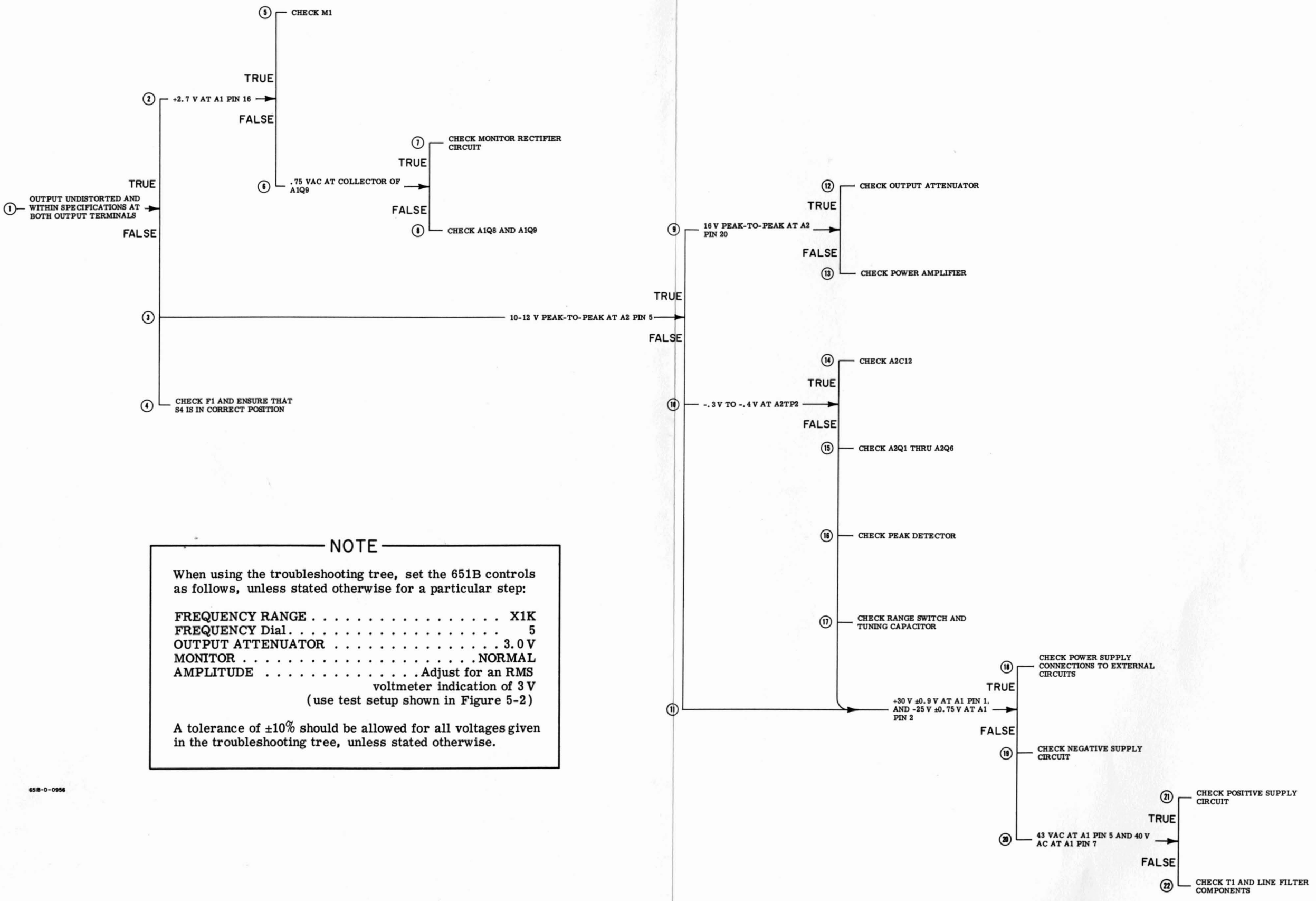
(1) Check the output at both output connectors, and ensure that it is undistorted and within specifications, over the entire frequency range of the instrument.

(2) When the 651B output voltage is 3, the normal dc voltage applied at A1 pin 16 is approximately +2.7 V. The voltage at A1 pin 17 should be about .14 V less than that at A1 pin 16; is not, M1 is probably faulty.

(3) If the oscillator circuit is operating properly, the signal at A2 pin 5 will be a sine wave of 10 V to 12 V peak-to-peak. This voltage should remain constant, regardless of the amplitude or frequency setting of the instrument.

(4) Check fuse F1 if there is no output and the line indicator lamp does not light; also ensure that the 115/230 V switch, S4, is in the correct position.

(5) Disconnect M1 from the circuit, and apply a current of 1.5 mA, to check for full scale deflection. Decrease the current, and the pointer deflection of M1 should decrease proportionally.



NOTE

When using the troubleshooting tree, set the 651B controls as follows, unless stated otherwise for a particular step:

FREQUENCY RANGE X1K
FREQUENCY Dial 5
OUTPUT ATTENUATOR . . . . . 3.0 V
MONITOR . . . . . NORMAL
AMPLITUDE . . . . . Adjust for an RMS voltmeter indication of 3 V (use test setup shown in Figure 5-2)

A tolerance of ±10% should be allowed for all voltages given in the troubleshooting tree, unless stated otherwise.

651B-D-0956

Figure 5-8. Troubleshooting Tree 01810-1

(6) When the 651B output voltage is 3, the ac signal applied to the rectifier from the collector of A1Q9 is approximately .75 Vac.

(7) Check the rectifier diodes A1CR8 through A1CR10, and capacitors A1C12 and A1C13. Also check A1C11 and A1CR11.

(8) Check the dc voltages on A1Q8 and A1Q9 at the points listed below; also check A1C11 and A1CR10.

Emitter A1Q8 . . . . . +1.8 V
Collector A1Q9 . . . . +2.5 V
Base A1Q9. . . . . -9.8 V
Emitter A1Q9 . . . . .-10.5 V

(9) The normal signal at A2 pin 20 will be a sine wave of about 16 V peak-to-peak, when the 651B output is 3 V.

(10) A2TP2 should have a dc voltage from -.3 to -.4 V. If the voltage is positive, C1 is probably shorted, or the peak detector is bad. If the voltage is negative, but out of tolerance, check A2Q1 through A2Q6.

(11) If there is no positive or negative output from the power supply, isolate it from external circuits by disconnecting A2 pins 1, 2, 6 and 7. If the power supply outputs return to normal, the malfunction is in one of the external circuits, causing it to load the power supply.

(12) Check S2R1 through S2R12 if there is no output at either the 50 ohm or 600 ohm connector. Check S2R13 if the output is missing only at the 600 ohm connector.

(13) Check A2Q8 through A2Q12, and A2C19. If A2C19 becomes shorted, A2Q11 and A2Q12 will be destroyed.

(14) If the oscillator circuit is functioning normally, but no signal is present at A2 pin 5, coupling capacitor A2C12 is probably bad.

(15) If the instrument is malfunctioning on all frequency ranges, check A2Q2 through A2Q6, and A2CR1 through A2CR4. (A2Q5 and A2Q6 should be replaced as a pair, if either goes bad.) If the instrument malfunctions only on the lower four ranges, A2Q1 is probably bad.

(16) Check A2Q7, A2CR5, A2CR8 and A2CR9. If these components are good, check A2CR6 and A2CR7.

(17) If the 651B output is within specifications on some frequency ranges, but is not on others, check the S1 components for the inoperative ranges. If the output is unstable or distorted through portions of all frequency ranges, check tuning capacitor C1.

(18) Check the power supply connections to external circuits, and check the resistors in series with the connections (A2R13, A2R26, A2R37, and A2R44).

(19) If only the negative half of the power supply output is bad, check Q2, A1Q5, A1Q6, A1CR3, and A1CR4.

(20) If both the positive and negative power supply outputs are bad, check for 43 V ac at A1 pin 5, and 40 V ac at A1 pin 7. If these voltages are not correct, the malfunction is probably either T1 or one of the line filter components.

(21) The negative power supply output is referenced to the positive supply; consequently, if both outputs are incorrect, the malfunction is probably in the positive supply. Check the components in the positive supply - Q1, A1Q2, A1Q3, A1CR1 and A1CR2.

(22) Check T1 and the line filter components, L1 through L4, C2, C3, C4, and C7.

5-39. SERVICING ETCHED CIRCUIT BOARDS.

5-40. The Model 651B contains two plated-through, double-sided, etched circuit boards. When working on these boards, observe the following rules to prevent damage to the circuit board or components:

a. Use a low-heat (25 to 50 watts) soldering iron with a small tip.

b. To remove a component, clip a heat sink (long nose pliers, commercial heat sink tweezers, etc.) on the component lead as close to the component as possible. Place the soldering iron directly on the component lead, and pull up on the lead. If a component is obviously damaged or faulty, clip the leads close to the component, and remove the leads from the board.

CAUTION

EXCESSIVE OR PROLONGED HEAT CAN LIFT THE CIRCUIT FOIL FROM THE BOARD OR CAUSE DAMAGE TO COMPONENTS.

c. Clean the component lead holes by heating the solder in the hole, quickly removing the soldering iron, and inserting a pointed, nonmetallic object such as a toothpick.

d. To mount a new component, shape the leads and insert them in the holes. Clip a heat sink on the component, heat with the soldering iron, and add solder as necessary to obtain a good electrical connection.

5-41. SERVICING ROTARY SWITCHES.

5-42. The Model 651B contains two rotary type switches: FREQUENCY RANGE and OUTPUT ATTENUATOR. When working on these switches, observe the following rules:

a. Use a low heat (25 to 50 watts) soldering iron with a small tip.

b. When replacing components, attempt to dress them as nearly to their original alignment as possible.

c. Clean excessive flux from the connection and adjoining area.

d. After cleaning the switch, apply a light coat of lubriplate to the switch detent balls. DO NOT apply lubricant to switch contacts or allow lubricant to contaminate components.

5-43. SERVICING TUNER ASSEMBLY.

5-44. When replacing the tuning capacitor, C1, make certain that the tuner coupler and the frequency dial shaft are aligned to prevent binding of the FREQUENCY Dial or VERNIER control. If necessary, remove the frequency dial knob, frequency dial, and loosen the tuner drive assembly (casting and spur gears) retaining screws; then align tuner coupler and frequency dial shaft. Tighten retaining screws after tuner coupler and dial shaft are aligned.

SECTION VI
CIRCUIT DIAGRAMS

6-1. INTRODUCTION.

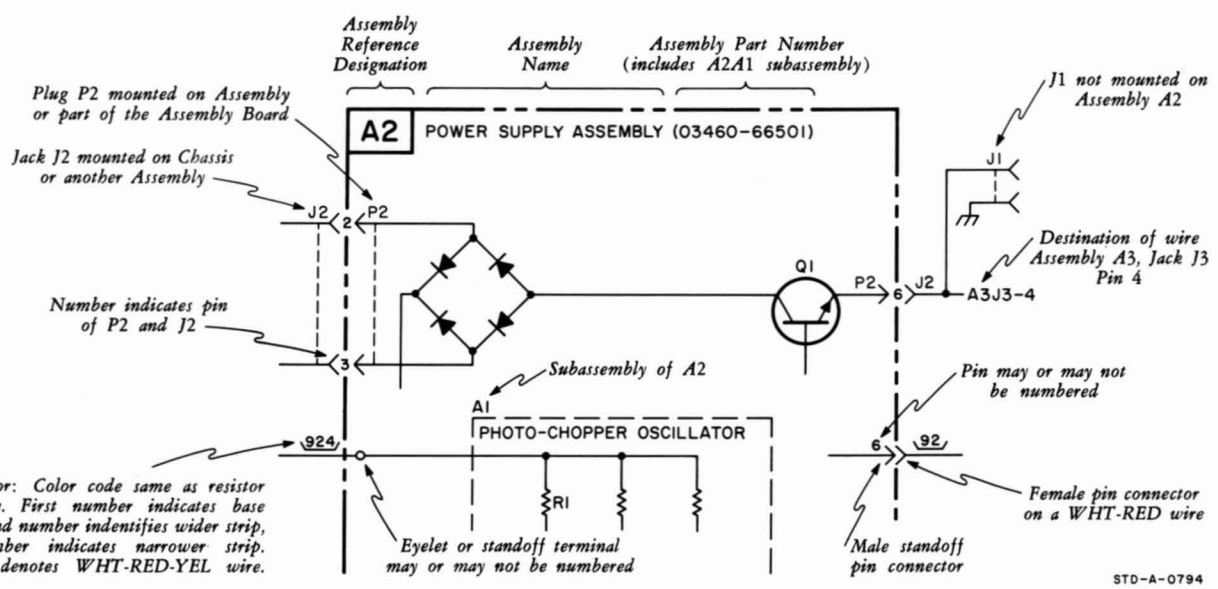
6-2. This section contains the circuit diagrams necessary for operation and maintenance of the Model 651B. Figure 6-1 is a block diagram which shows the overall relationship between the basic circuits of the instrument. Figures 6-2 and 6-3 contain the detailed schematic diagrams as well as component location drawings of each printed circuit board and the two rotary switches.

6-3. An explanation of terms and symbols used as reference designators is given below.

REFERENCE DESIGNATIONS

PARTIAL REFERENCE DESIGNATIONS ARE SHOWN: PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.

ASSEMBLY	SUBASSEMBLY	COMPONENT	COMPLETE DESIGNATION
A2	NONE	Q1	A2Q1
A2	A1	R1	A2A1R1
NONE	NONE	J1	J1



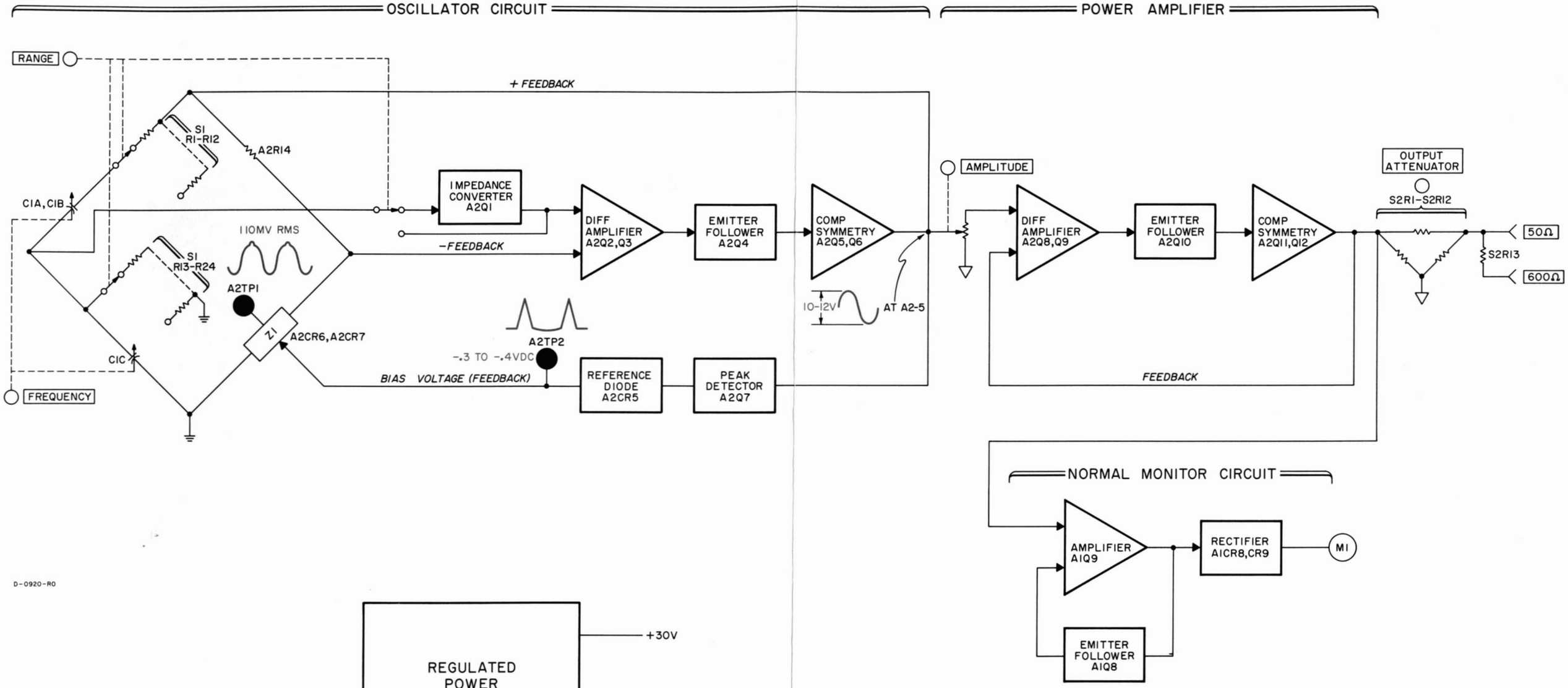


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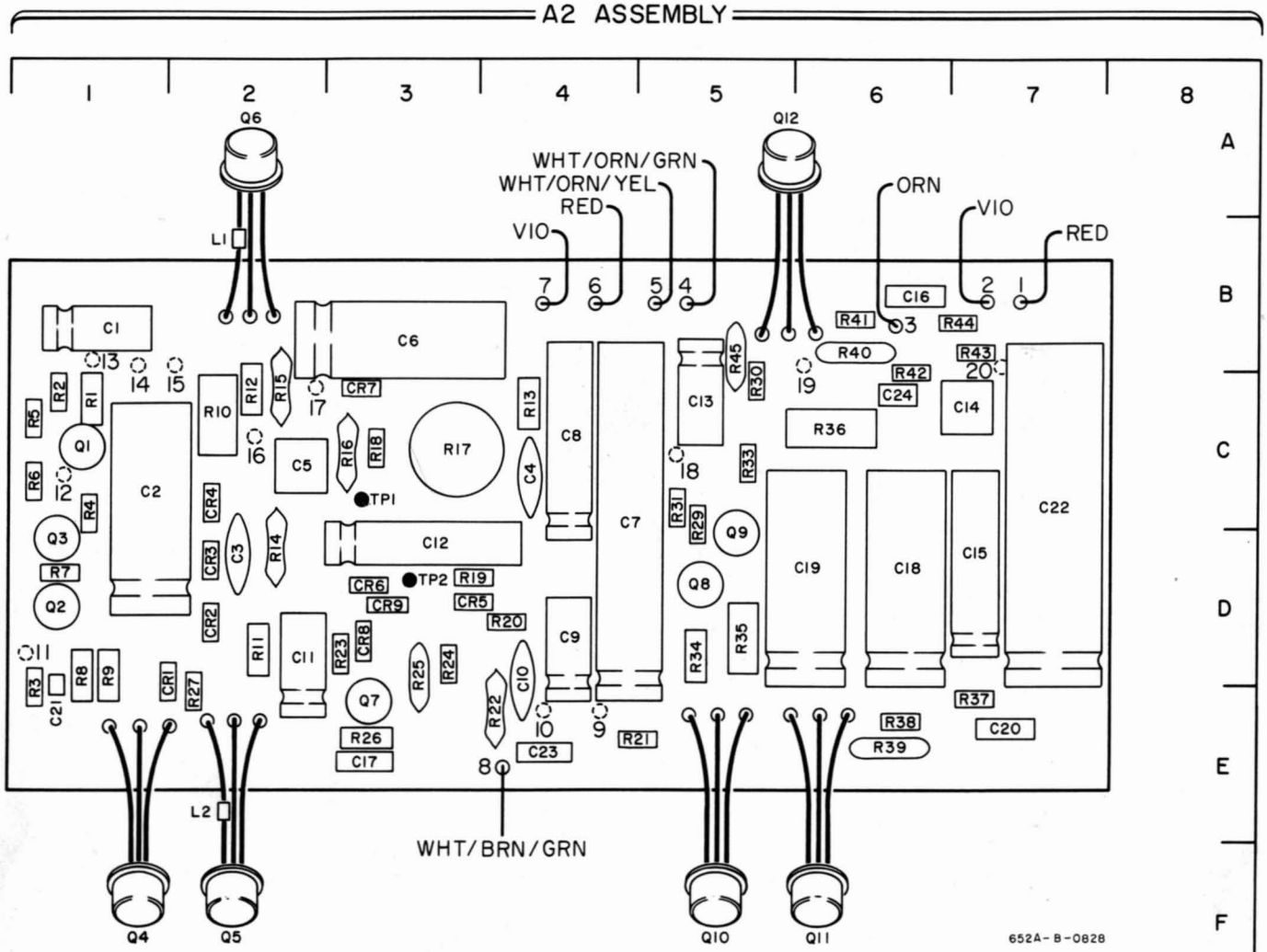
Figure 6-1. Block Diagram



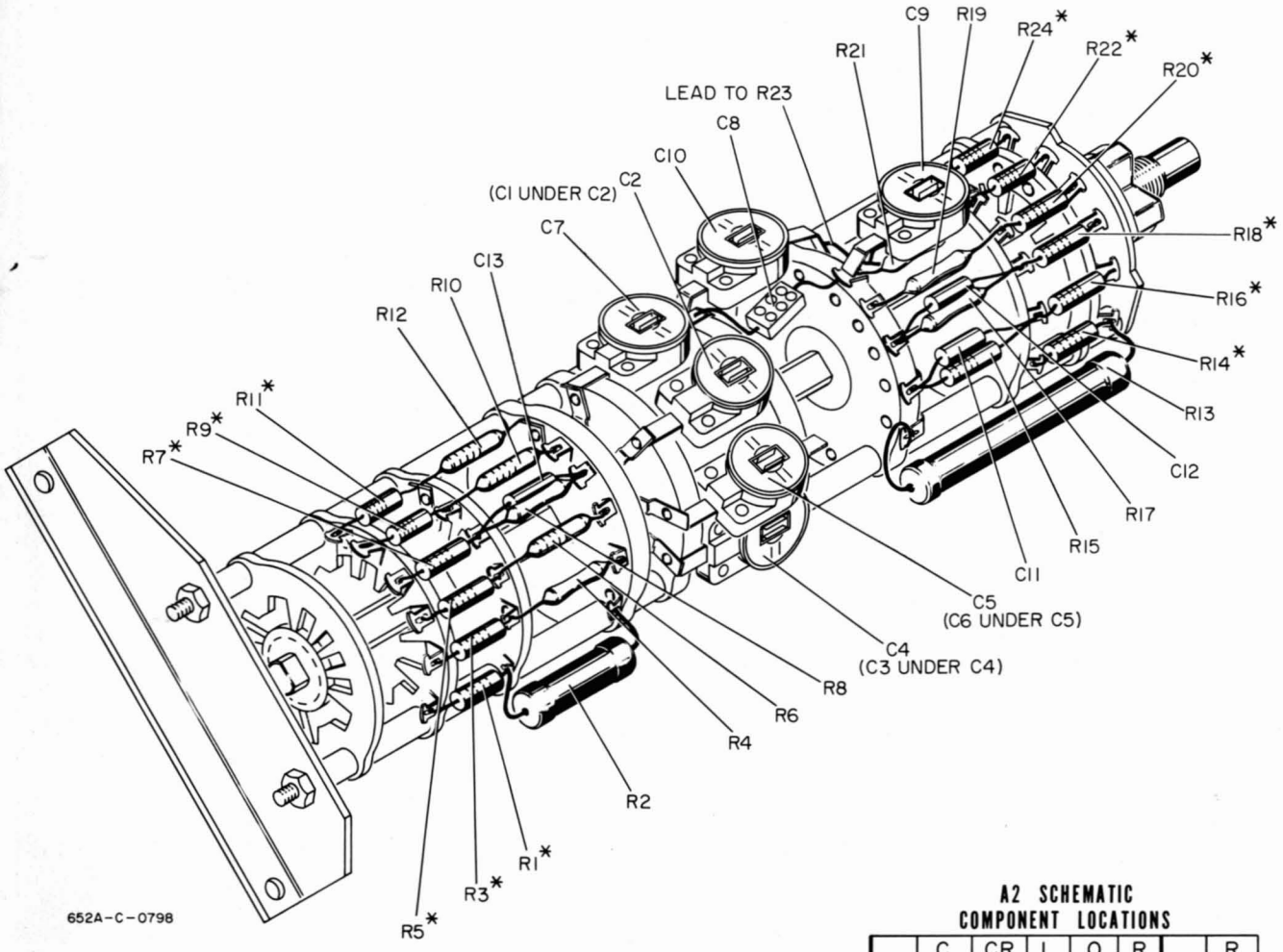
A2 ASSEMBLY COMPONENT LOCATIONS

	C	CR	L	Q	R		R
1	B1	D2	B2	C1	C1	25	D3
2	C1	D2	E2	D1	C1	26	E3
3	D2	D2		D1	E1	27	E2
4	C4	C2		F1	C1	28	---
5	C2	D3		F2	C1	29	C5
6	B3	D3		A2	C1	30	C5
7	C4	C3		E3	D1	31	C5
8	C4	D3		D5	D1	32	---
9	D4	D3		D5	D1	33	C5
10	D4			F5	C2	34	D5
11	D2			F6	D2	35	D5
12	D3			A5	C2	36	C6
13	C5				C4	37	E7
14	C7				D2	38	E6
15	D7				C2	39	E6
16	B6				C3	40	B6
17	E3				C3	41	B6
18	D6				C3	42	B6
19	D6				D3	43	B7
20	E7				D4	44	B7
21	E1				E5	45	B5
22	C7				E4		
23	E4				D3		
24	C6				D3		

A2 ASSEMBLY WIRE COLORS (BOTTOM)

PIN NO.	WIRE COLOR
9	WHITE
10	BLACK
11	WHT/ORN
12	BLACK
13	ORANGE
14	WHT/YEL
15	RED
16	WHT/YEL
17	BLACK
18	WHT/BLK
19	BLUE
20	

p/o Figure 6-2. Oscillator Circuit



NOTES

1. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN. PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.
2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED.

   RESISTANCE IN OHMS

   CAPACITANCE IN MICROFARADS
3. ———— – – ———— DENOTES ASSEMBLY.
4. ——————— DENOTES MAIN SIGNAL PATH.
5. – – – – – – – – DENOTES FEEDBACK PATH.
6. ▭ DENOTES FRONT PANEL MARKING.
7. DENOTES SCREWDRIVER ADJUST.
8. ◯ DENOTES FRONT PANEL CONTROL.
9. ⏚ DENOTES CHASSIS GROUND.
10. ▽ DENOTES CIRCUIT GROUND.
11. * AVERAGE VALUE SHOWN, OPTIMUM VALUE SELECTED AT FACTORY.
12. ⊘ DENOTES GROUND CONNECTION MADE WITH ASSEMBLY MOUNTING SCREWS IN PLACE.
13. DENOTES SHIELDING BEAD.

A2 SCHEMATIC COMPONENT LOCATIONS

	C	CR	L	Q	R		R
1	H14	E15	G16	F12	F11	25	D17
2	D13	F15	E16	F14	G12	26	C18
3	F16	F15		G14	J15	27	D16
4	J16	G15		E15	G14	28	---
5	F 8	G18		F16	H14	29	F20
6	F 7	H 8		G16	H14	30	H19
7	J 8	H 7		F18	F14	31	C20
8	J 9	F18		F20	D14	32	---
9	J 7	F18		G20	D14	33	G20
10	J 8			E21	H15	34	D20
11	G17			F22	F16	35	F21
12	C16			G22	G16	36	H21
13	C17				J12	37	C23
14	J22				D 7	38	F22
15	J23				E 7	39	F23
16	H19				F 7	40	G23
17	D19				G 7	41	G23
18	G22				G 7	42	G23
19	F22				H10	43	J23
20	D23				H 8	44	H23
21	D14				J 8	45	H22
22	F23				H17		
23	J17				G17		
24	G23				E17		

A2 OSCILLATOR CIRCUIT (00652-66501)

S1 RANGE

A (F)(R) B (F)(R) C (F)(R) D (F)(R) E (F)(R) F (F)(R) G (F)(R) H (F)(R)

RANGE SID(R): X10, X100, X1K, X10K, X100K, XIM

SECOND APPEARANCE

AMPLITUDE ○ R2A 500

10-12V

+30V

C12 500

C13 100

R26 10

R31 82K

+FEEDBACK

-FEEDBACK

C2 200

R14 2K

R9 1K

R8 1K

*C21 4.7PF

C17 1.8

R27 2.7

R25 11.75K

R24* 1K

R34 2K

Q4

CR1 7V

L2*

Q2

Q5

Q7

Q8

CR2

CR3

CR4

C3 0.1

R11 13

R12 13

Q6

C11 200

CR8

CR9

CR5 7V

R7* 20

R4 1K

Q3

R6 91

L1*

R23 47

R33 1500

Q9

R29* 150

R30 39K

C16 1.8

C1 100

R5 1200

R10 820

R28 30.1

C4 0.1

R22 2K

C23 1.8

R1 1K

Q1

R2 6200

R19 20K

R13 10

R3 43K

TP2

SEE NOTE 12

-.3 TO -.4VDC

R28 100 (AMPLITUDE) VERNIER

R15 1500

C6 1000

*R16 261

C5 1.7-14.1PF 10MHz ADJUST

TP1

DISTORTION ADJUST

R17 100

R18* 100

CR7

CR6

R20 2.7

C7 2000

C9 20

R21 10K

C10 0.1

C8 300

-25V

SIC7 5-20PF 10KHz ADJUST

RANGE SIE(R): X10, X100, X1K, X10K, X100K, XIM

RANGE P/O SIC(R): X10, X100, X1K, X10K, X100K, XIM

RANGE SIG(F): X10, X100, X1K, X10K, X100K, XIM

RANGE SIF(R): X10, X100, X1K, X10K, X100K, XIM

*SIR1 560K, SIR3 39K, SIR5 3900, SIR7 430, SIR9 13, SIR11 20

SIR2 12M, SIR4 1.23M, SIR6 123K, SIR8 12.3K, SIC13 2PF, SIR10 1210, SIR12 100

10KHz ADJUST, 1MHz ADJUST, 10MHz ADJUST

SIC1 75PF, SIC2 5-20PF, SIC3 47PF, SIC4 7-45PF, SIC5 5-20PF, SIC6 12PF

C1A 14-617PF, C1B 14-617PF, C1C 14-617PF

FREQUENCY

RANGE SIC(F): X10, X100, X1K, X10K, X100K, XIM

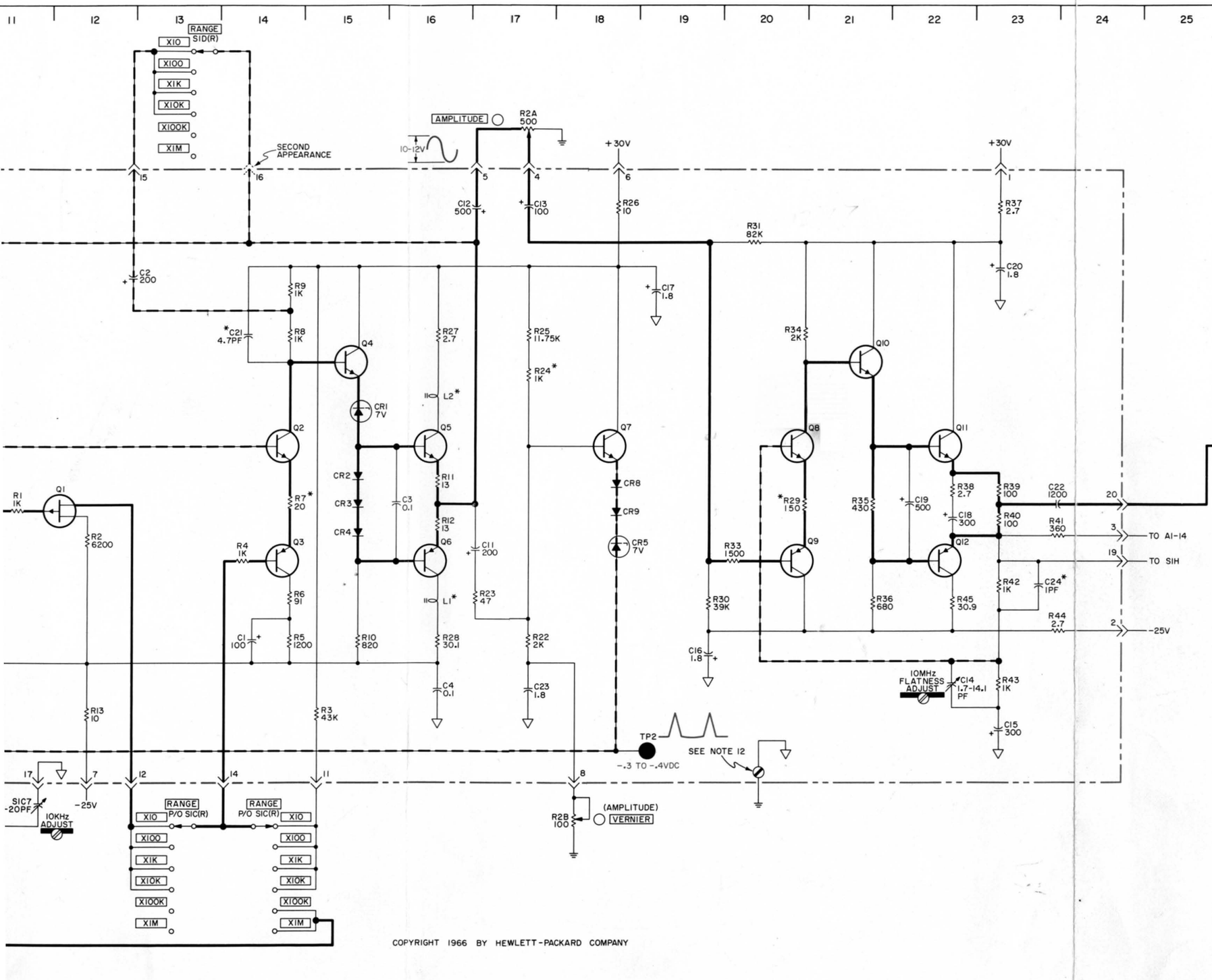
SIR13 24.5M, SIR15 2.45M, SIR17 245K, SIR19 24.5K, SIR21 2510, SIR23 225

*SIR14 1.8M, *SIR16 120K, *SIR18 12K, *SIR20 1100, *SIR22 110, *SIR24 30

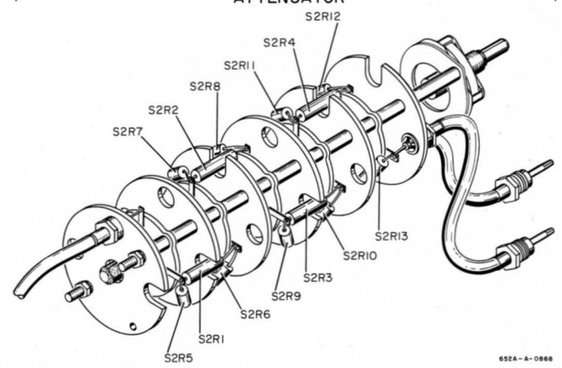
10MHz ADJUST, SIC10 1.5-7PF

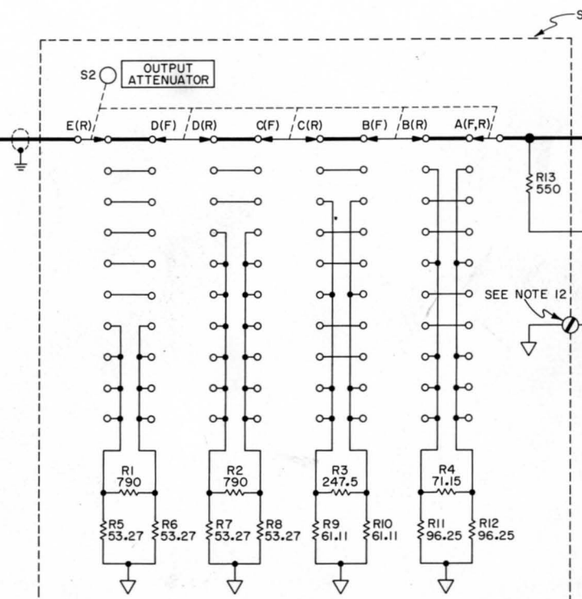
SIC11 0.68PF, SIC12 1.0PF, SIC9 1.5-7PF (1MHz ADJUST), SIC8 5PF

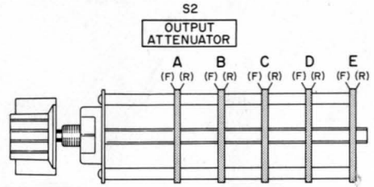
652A-J-0886



S2 OUTPUT ATTENUATOR







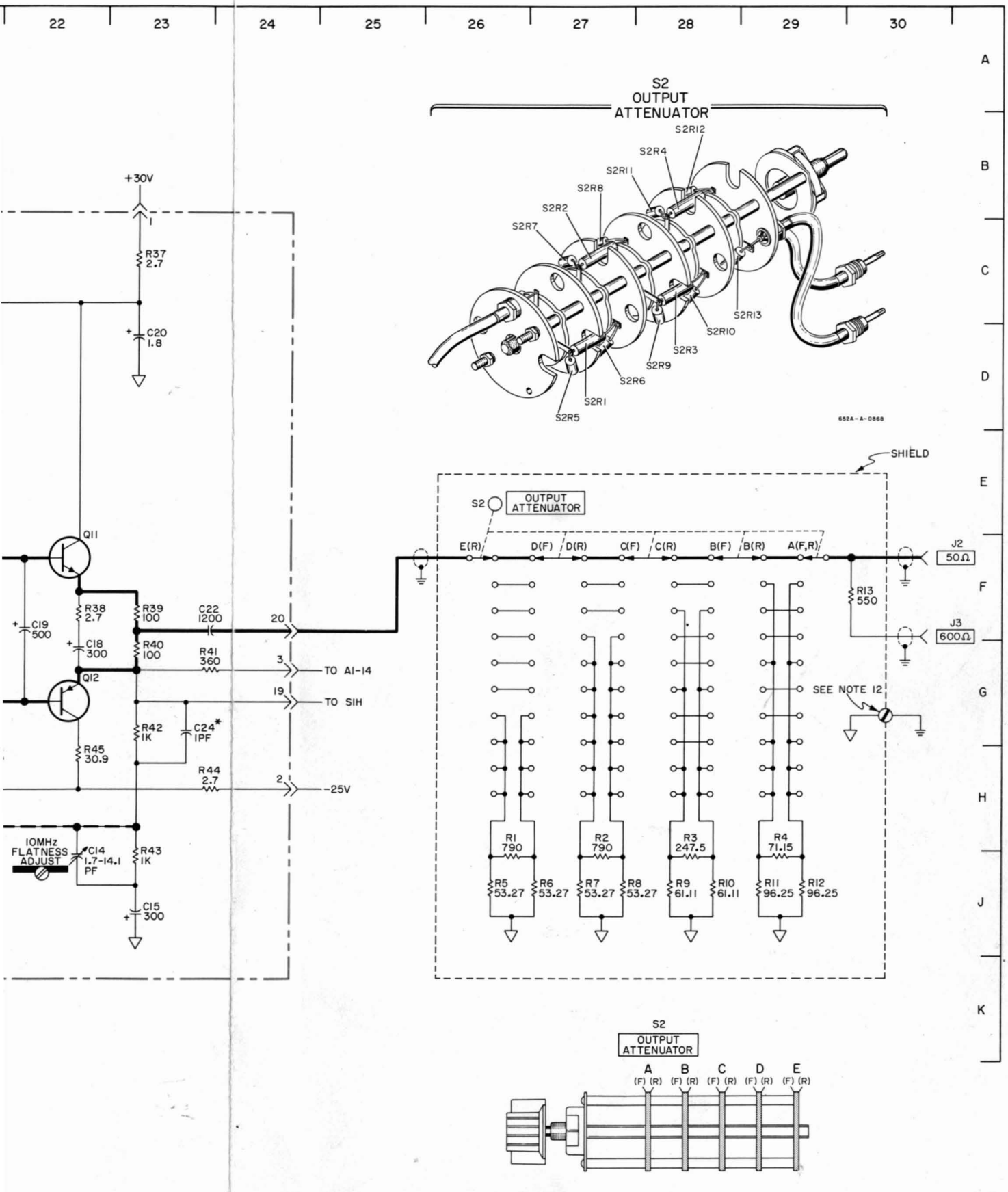
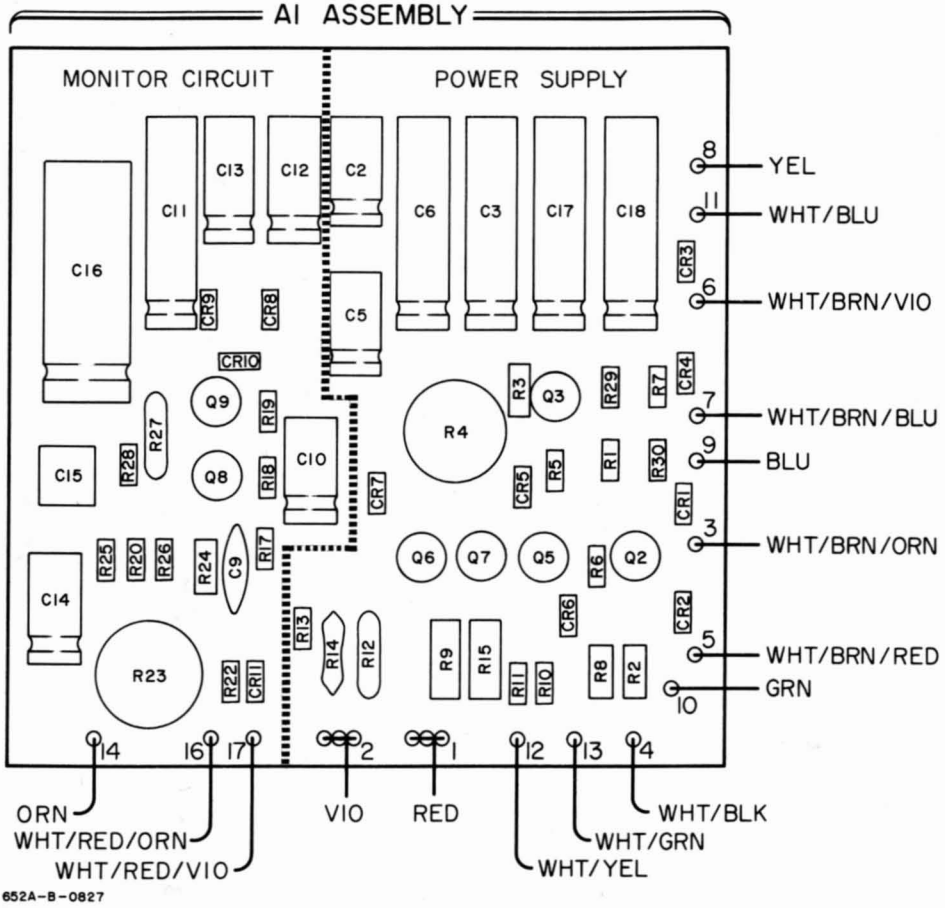


Figure 6-2. Oscillator Circuit



NOTES

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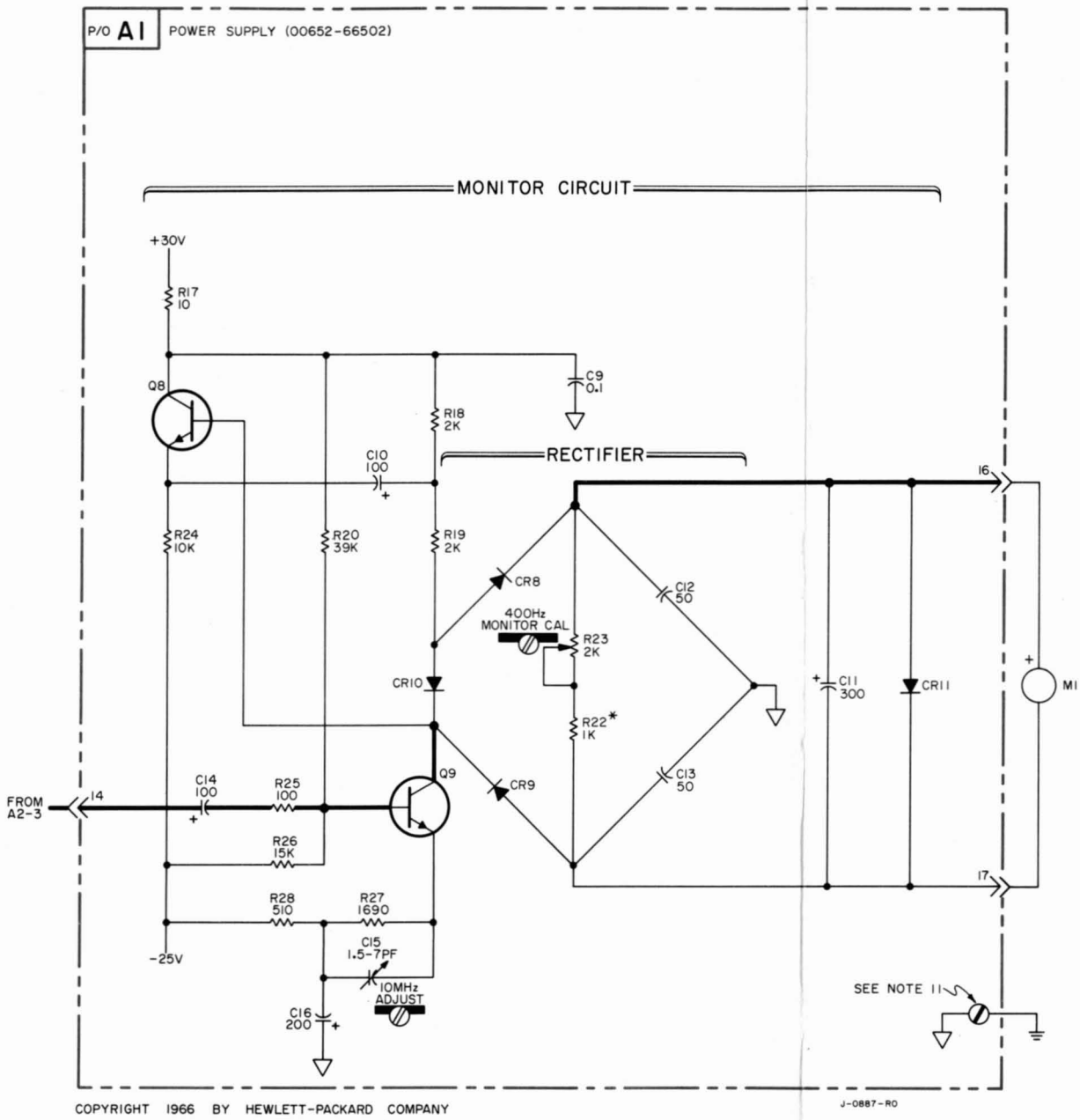
2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED.
   RESISTANCE IN OHMS
   CAPACITANCE IN MICROFARADS
3. ——— – – ——— DENOTES ASSEMBLY.
4. ▭ DENOTES FRONT PANEL MARKING.
5. ⬚ DENOTES REAR PANEL MARKING.
6. DENOTES SCREWDRIVER ADJUST.
7. DENOTES COMPONENTS NOT MOUNTED ON ASSEMBLY.
8. ⏚ DENOTES CHASSIS GROUND.
9. ▽ DENOTES CIRCUIT GROUND.
10. ⊘ DENOTES GROUND CONNECTION MADE WITH ASSEMBLY MOUNTING SCREWS IN PLACE.



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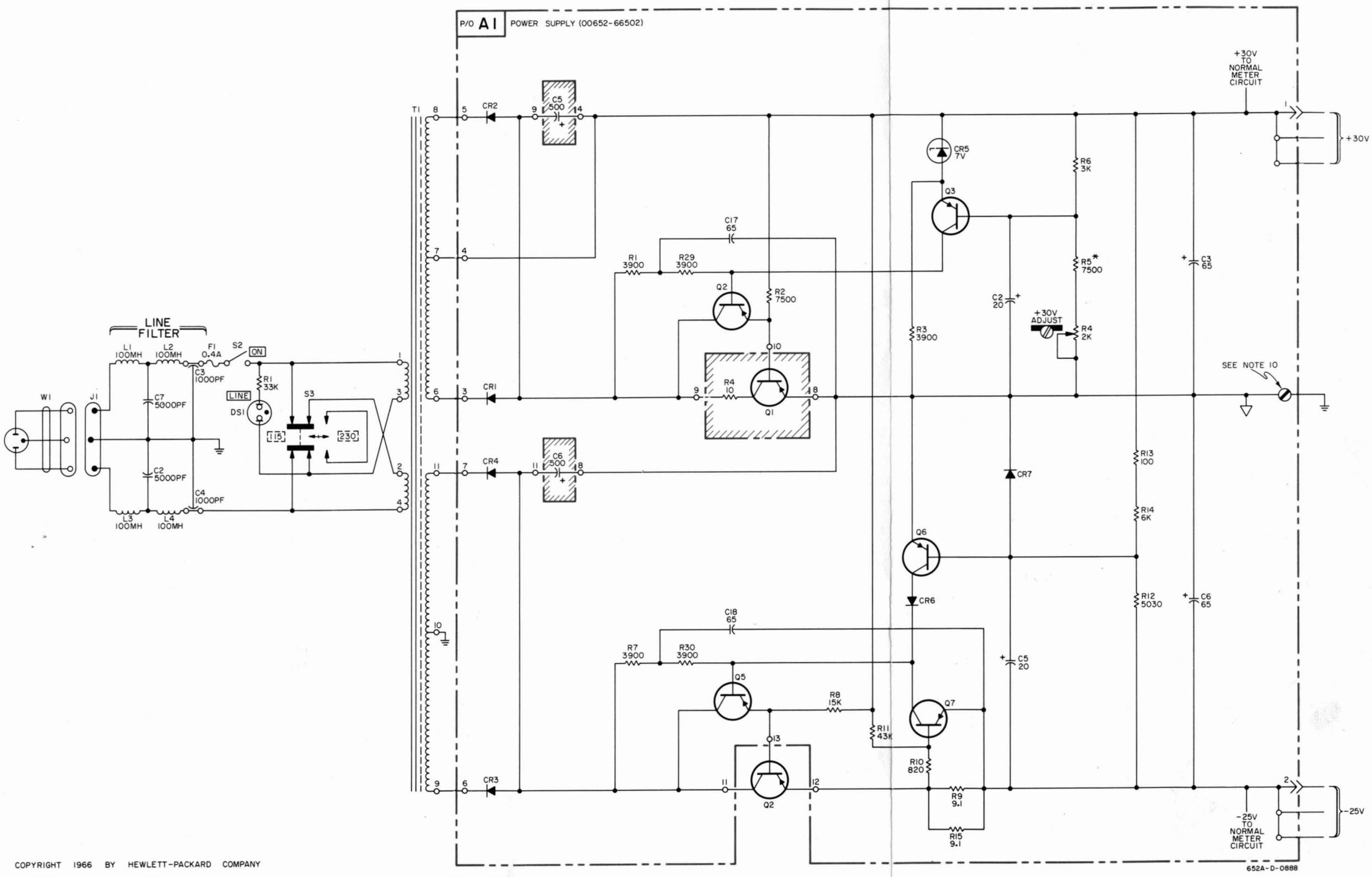


Figure 6-3. Monitor Circuit and Power Supply

SECTION VII
REPLACEABLE PARTS

7-1. INTRODUCTION.

7-2. This section contains information for ordering replacement parts. Table 7-1 lists parts in alphameric order of their reference designators and indicates the description, -hp- part number of each part, together with any applicable notes, and provides the following:

a. Total quantity used in the instrument (TQ column). The total quantity of a part is given the first time the part number appears.

b. Description of the part. (See list of abbreviations below.)

c. Typical manufacturer of the part in a five-digit code. (See Appendix A for list of manufacturers.)

d. Manufacturer's part number.

7-3. Miscellaneous parts are listed at the end of Table 7-1.

7-4. ORDERING INFORMATION.

7-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office. (See Appendix B for list of office locations.) Identify parts by their Hewlett-Packard part numbers. Include instrument model and serial numbers.

7-6. NON-LISTED PARTS.

7-7. To obtain a part that is not listed, include:

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. Function and location of the part.

DESIGNATORS

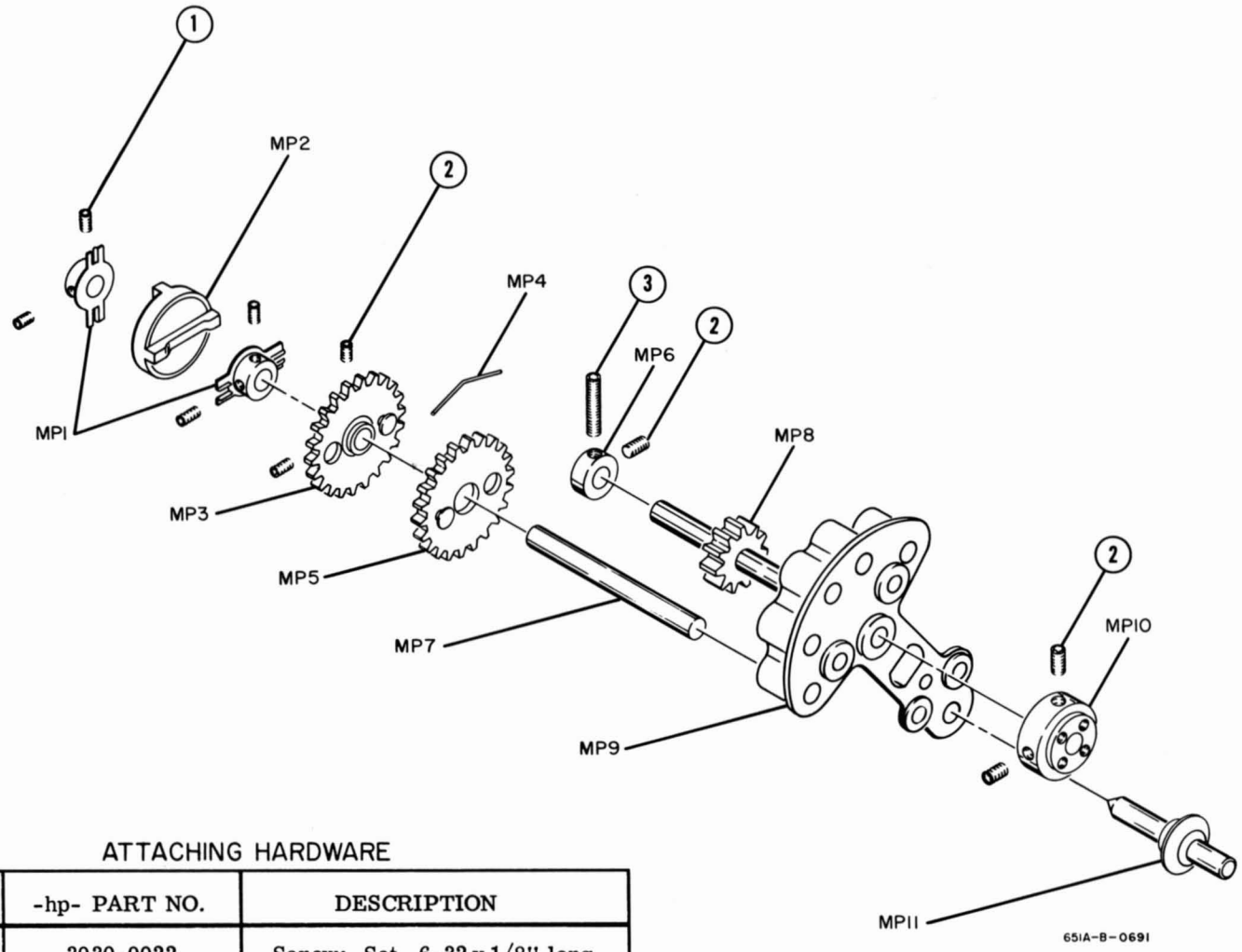
A	= assembly	F	= fuse	P	= plug	V	= vacuum tube, neon bulb, photocell etc.
B	= motor	FL	= filter	Q	= transistor		
BT	= battery	HR	= heater	QCR	= transistor-diode	W	= cable
C	= capacitor	J	= jack	R	= resistor	X	= socket
CR	= diode	K	= relay	RT	= thermistor	XDS	= lampholder
DL	= delay line	L	= inductor	S	= switch	XF	= fuseholder
DS	= lamp	M	= meter	T	= transformer		
E	= misc electronic part	MP	= mechanical part	TC	= thermocouple	Z	= network

ABBREVIATIONS

Ag	= silver	ID	= inside diameter	ns	= nanosecond (s) = 10^{-9}	SPDT	= single-pole double-throw
Al	= aluminum	impg	= impregnated	nsr	= not separately replaceable	SPST	= single-pole single-throw
amp	= ampere (s)	incd	= incandescent				
Au	= gold	ins	= insulation (ed)			Ta	= tantalum
				obd	= order by description	TiO_2	= titanium dioxide
C	= capacitor	K	= kilohm (s) = 10^{+3}	OD	= outside diameter		
cer	= ceramic	Kc	= kiloycycle (s) = 10^{+3}			tog	= toggle
coef	= coefficient			p	= peak	tol	= tolerance
com	= common	L	= inductor	pc	= printed circuit	trim	= trimmer
comp	= composition	lin	= linear taper	pf	= picofarad (s) = 10^{-12}	TSTR	= transistor
conn	= connection	log	= logarithmic taper	piv	= peak inverse voltage		
cps	= cycles per second			p/o	= part of	v	= volt (s)
		m	= milli = 10^{-3}	pos	= position (s)	vacw	= alternating current working volt (s)
dep	= deposited	ma	= milliampere (s) = 10^{-3}	poly	= polystyrene		
DPDT	= double-pole double-throw	Mc	= megacycle (s) = 10^{+6}	pot	= potentiometer	var	= variable
		meg	= megohm (s) = 10^{+6}	p-p	= peak-to-peak	vdcw	= direct current working volt (s)
DPST	= double-pole single-throw	met flm	= metal film	prec	= precision (temperature coefficient, long term stability, and/or tolerance)		
		mfr	= manufacturer			w	= watt (s)
elect	= electrolytic	mtg	= mounting			w/	= with
encap	= encapsulated	μ	= micro = 10^{-6}			wiv	= reverse working voltage
		my	= Mylar ®	R	= resistor	w/o	= without
f	= farad (s)			Rh	= rhodium	ww	= wirewound
FET	= field effect transistor	na	= nanoampere (s) = 10^{-9}	rms	= root-mean-square		
fxd	= fixed	NC	= normally closed	rot	= rotary	*	= optimum value selected at factory, average value shown (part may be omitted)
GaAs	= gallium arsenide	Ne	= neon				
Gc	= gigacycle (s) = 10^{+9}	NO	= normally open	Se	= selenium	**	= no standard type number assigned (selected or special type)
gd	= guard (ed)	NPO	= negative positive zero (zero temperature coefficient)	sect	= section (s)		
Ge	= germanium			Si	= silicon		
grd	= ground (ed)			sl	= slide		
h	= henry (ies)						
Hg	= mercury						

® Dupont de Nemours

REV D



ATTACHING HARDWARE

ITEM	-hp- PART NO.	DESCRIPTION
(1)	3030-0022	Screw: Set, 6-32 x 1/8" long
(2)	3030-0001	Screw: Set, 8-32 x 3/16" long
(3)	3030-0004	Screw: Set, 8-32 x 1" long

Figure 7-1. Frequency Tuning Assembly

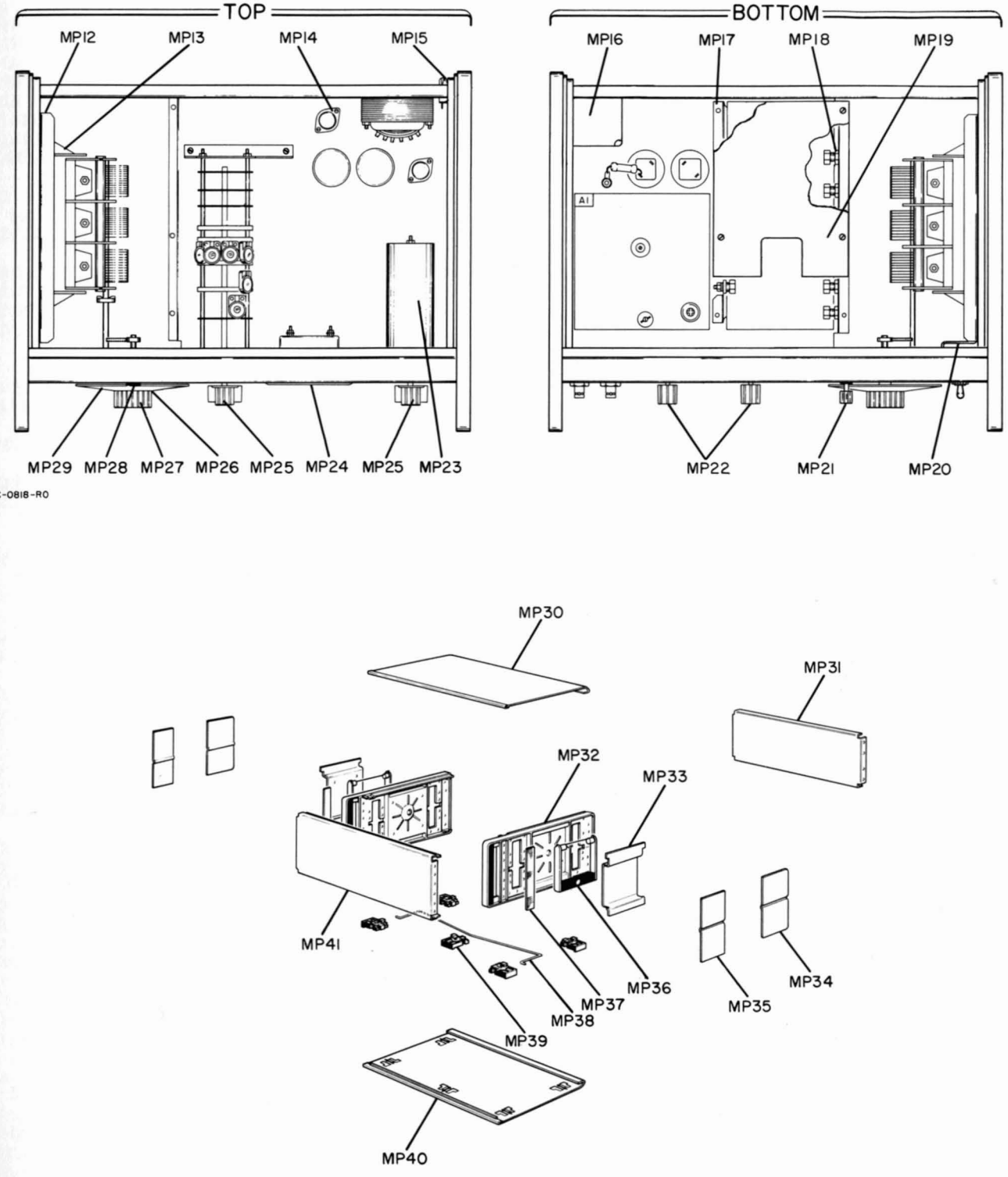


Figure 7-2. Chassis Mechanical Parts

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A1	00652-66502		1	Pc board: power supply	28480	00652-66502
A1C1				Not assigned		
A1C2	0180-0045		2	C: fxd Al elect 20 μF +75% -10% 25 vdcw	56289	30D206G025 DB2-DSM
A1C3	0180-0149		4	C: fxd Al elect 65 μF +100% -10% 60 vdcw	56289	(Type 30D) D36978
A1C4				Not assigned		
A1C5	0180-0045			C: fxd Al elect 20 μF +75% -10% 25 vdcw	56289	30D206G025 DB2-DSM
A1C6	0180-0149			C: fxd Al elect 65 μF +100% -10% 60 vdcw	56289	(Type 30D) D36978
A1C7, A1C8				Not assigned		
A1C9	0150-0084		4	C: fxd cer 0.1 μF +80% -20% 50 vdcw	56289	33C41 obd
A1C10	0180-0061		3	C: fxd Al elect 100 μF +75% -10% 15 vdcw	56289	30D107G015DC2-DSM
A1C11	0180-0062		3	C: fxd Al elect 300 μF +75% -10% 6 vdcw	56289	30D307G006DF2-DSM
A1C12, A1C13	0180-0058		2	C: fxd Al elect 50 μF +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
A1C14	0180-0061			C: fxd Al elect 100 μF +75% -10% 15 vdcw	56289	30D107G015DC2-DSM
A1C15	0121-0127		3	C: var air 1.7 to 14.1 pF	74970	189-505-5
A1C16	0180-0284		2	C: fxd Al elect 200 μF +75% -10% 30 vdcw	56289	D38559
A1C17, A1C18	0180-0149			C: fxd Al elect 65 μF +100% -10% 60 vdcw	56289	(Type 30D) D36978
A1CR1 thru A1CR4	1901-0026		4	Diode: Si 200 piv	04713	SR 1358-8 obd
A1CR5	1902-0045		1	Diode: breakdown 7.32 V ±2% 400 mW glass	07263	obd
A1CR6, A1CR7	1901-0025		10	Diode: Si 100 mA at +1 V 100 piv 12 pF	03877	SG 917 obd
A1CR8, A1CR9	1901-0027		2	Diode: Si 1N4392 1 pF 10 wiv 0.5 ns	73293	obd
A1CR10, A1CR11	1901-0025			Diode: Si 100 mA at +1 V 100 piv 12 pF	03877	SG 817 obd
A1Q1				Not assigned		
A1Q2	1850-0107		2	TSTR: Ge PNP 2N398A	04713	2N398A
A1Q3	1853-0036		3	TSTR: Si PNP 2N3906	04713	2N3906
A1Q4				Not assigned		
A1Q5	1850-0107			TSTR: Ge PNP 2N398A	04713	2N398A
A1Q6, A1Q7	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906
A1Q8	1854-0218		2	TSTR: Si NPN 2N3393	24446	2N3393
A1Q9	1854-0042		3	TSTR: Si NPN SM1570	04713	SM1570
A1R1	0683-3925		4	R: fxd comp 3900Ω ±5% 1/4 W	01121	CB3925
A1R2	0686-7525		1	R: fxd comp 7500Ω ±5% 1/2 W	01121	EB7525
A1R3	0687-3921		1	R: fxd comp 3900Ω ±10% 1/2 W	01121	EB3921
A1R4	2100-0090		1	R: var comp lin 200Ω ±30% 0.15 W	71450	UPM-70RE (-hp-) obd
A1R5*	0683-7525		1	R: fxd comp 7500Ω ±5% 1/4 W	01121	CB7525
A1R6	0683-3025		1	R: fxd comp 3000Ω ±5% 1/4 W	01121	CB3025
A1R7	0683-3925			R: fxd comp 3900Ω ±5% 1/4 W	01121	CB3925
A1R8	0687-1531		1	R: fxd comp 15 KΩ ±10% 1/2 W	01121	EB1531
A1R9	0689-0915		2	R: fxd comp carbon 9100Ω ±5% 1 W	01121	GB91G5
A1R10	0683-8215		1	R: fxd comp 820Ω ±5% 1/4 W	01121	CB8215
A1R11	0683-4335		2	R: fxd comp 43 KΩ ±5% 1/4 W	01121	CB4335
A1R12	0757-0039		1	R: fxd met flm 5030Ω ±1% 1/2 W	75042	CEC T-O obd
A1R13*	0683-3915		2	R: fxd comp 390Ω ±5% 1/4 W	01121	CB3915
A1R14	0757-1013		1	R: fxd met flm 6000Ω ±1% 1/2 W	75042	CEC T-O obd
A1R15	0689-0915			R: fxd comp carbon 9100Ω ±5% 1 W	01121	GB91G5
A1R16				Not assigned		
A1R17	0684-1001		1	R: fxd comp 10Ω ±10% 1/4 W	01121	CB1001
A1R18, A1R19	0683-2025		3	R: fxd comp 2000Ω ±5% 1/4 W	01121	CB2025
A1R20	0683-3935		2	R: fxd comp 39 KΩ ±5% 1/4 W	01121	CB3935
A1R21				Not assigned		

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A1R22*	0683-1025		4	R: fxd comp 1000Ω ±5% 1/4 W	01121	CB1025
A1R23	2100-0282		1	R: var ww 2000Ω ±20% 1-1/2 W	11236	110 obd
A1R24	0687-1031		1	R: fxd comp 10 KΩ ±10% 1/2 W	01121	EB1031 obd
A1R25	0684-1011		2	R: fxd comp 100Ω ±10% 1/4 W	01121	CB1011
A1R26	0683-1535		1	R: fxd comp 15 KΩ ±5% 1/4 W	01121	CB1535
A1R27	0698-0026		1	R: fxd met flm 1690Ω ±1% 1/2 W	19701	MF7C T-O obd
A1R28	0683-5115		1	R: fxd comp 510Ω ±5% 1/4 W	01121	CB5115
A1R29, A1R30	0683-3925			R: fxd comp 3900Ω ±5% 1/4 W	01121	CB3925
A2	00652-66501		1	Pc board: oscillator amplifier	28480	00652-66501
A2C1	0180-0061			C: fxd Al elect 100 μF +75% -10% 15 vdcw	56289	30D107G015DC2-DSM
A2C2	0180-0284			C: fxd Al elect 200 μF +75% -10% 30 vdcw	56289	D38559
A2C3, A2C4	0150-0084			C: fxd cer 0.1 μF +80% -20% 50 vdcw	56289	33C41 obd
A2C5	0121-0127			C: var air 1.7 to 14.1 pF	74970	189-505-5
A2C6	0180-0305		1	C: fxd Al elect 1000 μF +100% -10% 2.5 vdcw	56289	34D108H2R5FJ4
A2C7	0180-0112		1	C: fxd Al elect 2000 μF 1 vdcw	56289	D33239
A2C8	0180-0062			C: fxd Al elect 300 μF +75% -10% 6 vdcw	56289	30D307G006DF2-DSM
A2C9	0180-0076		1	C: fxd elect 20 μF 25 vdcw	56289	40D206G025DC6-DST
A2C10	0150-0084			C: fxd cer 0.1 μF +80% -20% 50 vdcw	56289	33C41 obd
A2C11	0180-0060		1	C: fxd Al elect 200 μF +75% -10% 3 vdcw	56289	30D207G003CC2-DSM
A2C12	0180-0063		1	C: fxd Al elect 500 μF +75% -10% 3 vdcw	56289	30D507G003DF2-DSM
A2C13	0180-0039		1	C: fxd Al elect 100 μF +75% -10% 12 vdcw	56289	30D107G012CC2-DSM
A2C14	0121-0127			C: var air 1.7 to 14.1 pF	74970	189-505-5
A2C15	0180-0062			C: fxd Al elect 300 μF +75% -10% 6 vdcw	56289	30D307G006DF2-DSM
A2C16, A2C17	0180-0101		4	C: fxd Ta 1.8 μF ±10% 35 vdcw	56289	150D185X9035B2
A2C18	0180-0306		1	C: fxd Al elect 300 μF +100% -10% 15 vdcw	56289	34D307H015FJ4
A2C19	0180-0307		1	C: fxd Al elect 500 μF +100% -10% 15 vdcw	56289	34D507H015FJ4
A2C20	0180-0101			C: fxd Ta 1.8 μF ±10% 35 vdcw	56289	150D185X9035B2
A2C21*	0150-0042		1	C: fxd TiO_2 4.7 pF ±5% 500 vdcw	78488	Type GA obd
A2C22	0180-1756		1	C: fxd Al elect 1200 μF +100% -10%	56289	Type 34D Special obd
A2C23	0180-0101			C: fxd Ta 1.8 μF ±10% 35 vdcw	56289	150D185X9035B2
A2C24*	0150-0022		1	C: fxd TiO_2 3.3 pF ±10% 500 vdcw	78488	Type GA obd
A2CR1	1902-0046		1	Diode: breakdown 7.15 V ±10% 400 mW	04713	10939-139 obd
A2CR2 thru A2CR4	1901-0025			Diode: Si 100 mA at +1 V 100 piv 12 pF	03877	SG-817
A2CR5	1901-0778		1	Diode: breakdown 7.87 V ±2%	07910	obd
A2CR6, A2CR7	1910-0016		3	Diode: Ge 60 wiv	03877	S3185G obd
A2CR8, A2CR9	1901-0040		2	Diode: Si	03877	SG-5050
A2L1*, A2L2*	9170-0016		1	Bead: shielding	02114	56-590-65/3B
A2Q1	1855-0004		1	TSTR: P FET channel	17856	U112 obd
A2Q2	1854-0042			TSTR: Si NPN SM1570	04713	SM1570
A2Q3	1853-0046		1	TSTR: Si PNP 2N3250	04713	2N3250
A2Q4, A2Q5	1854-0053		4	TSTR: Si NPN 2N2218	04713	2N2218
A2Q6	1853-0012		2	TSTR: Si PNP 2N2904A	04713	2N2904A
A2Q7	1854-0218			TSTR: Si NPN 2N3393	24446	2N3393
A2Q8	1854-0042			TSTR: Si NPN SM1570	04713	SM1570
A2Q9	1853-0007		1	TSTR: Si PNP 2N3251	04713	2N3251
A2Q10, A2Q11	1854-0053			TSTR: Si NPN 2N2218	04713	2N2218

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.	
A2Q12	1853-0012			TSTR: Si PNP 2N2904A	04713	2N2904A	
A2R1	0687-1021		1	R: fxd comp 1000Ω ±10% 1/2 W	01121	EB1021	
A2R2	0683-6225		1	R: fxd comp 6200Ω ±5% 1/4 W	01121	CB6225	
A2R3	0683-4335			R: fxd comp 43 KΩ ±5% 1/4 W	01121	CB4335	
A2R4	0683-1025			R: fxd comp 1000Ω ±5% 1/4 W	01121	CB1025	
A2R5	0684-1221		1	R: fxd comp 1200Ω ±10% 1/4 W	01121	CB1221	
A2R6	0683-9105		1	R: fxd comp 91Ω ±5% 1/4 W	01121	CB9105	
A2R7*	0683-2005		1	R: fxd comp 20Ω ±5% 1/4 W	01121	CB2005	
A2R8, A2R9	0686-1025		2	R: fxd comp 1000Ω ±5% 1/2 W	01121	EB1025	
A2R10	0693-8211		1	R: fxd comp carbon 820Ω ±10% 2 W	01121	HB8211	
A2R11, A2R12	0686-1305		3	R: fxd comp 13Ω ±5% 1/2 W	01121	EB1305	
A2R13	0687-1001		2	R: fxd comp 10Ω ±10% 1/2 W	01121	EB1001	
A2R14	0757-0739		2	R: fxd met flm 2000Ω ±1% 1/4 W	19701	MF6C T-O	obd
A2R15	0757-0736		1	R: fxd met flm 1500Ω ±1% 1/4 W	19701	MF6C T-O	obd
A2R16*	0757-1090		1	R: fxd met flm 261Ω ±1% 1/2 W	75042	CEC T-O	obd
A2R17	2100-0108		1	R: var comp lin 100Ω ±30% 0.15 W	71450	UPM-65CV	obd
A2R18*	0684-1011			R: fxd comp 100Ω ±10% 1/4 W	01121	CB1011	
A2R19	0683-2035		1	R: fxd comp 20 KΩ ±5% 1/4 W	01121	CB2035	
A2R20	0683-0275		5	R: fxd comp 2.7Ω ±5% 1/4 W	01121	CB27G5	
A2R21	0684-1031		4	R: fxd comp 10 KΩ ±10% 1/4 W	01121	CB1031	
A2R22	0757-0739			R: fxd met flm 2000Ω ±1% 1/4 W	19701	MF6C T-O	obd
A2R23	0683-4705		1	R: fxd comp 47Ω ±5% 1/4 W	01121	CB4705	
A2R24*	0683-1025			R: fxd comp 1000Ω ±5% 1/4 W	01121	CB1025	
A2R25	0757-0757		2	R: fxd met flm 15 KΩ ±1% 1/4 W	19701	MF6C T-O	obd
A2R26	0687-1001			R: fxd comp 10Ω ±10% 1/2 W	01121	EB1001	
A2R27	0683-0275			R: fxd comp 2.7Ω ±5% 1/4 W	01121	CB27G5	
A2R28	0757-0500			R: fxd comp 30.1Ω ±1% 1/4 W	19701	MF6C T-O	obd
A2R29*	0684-1511		1	R: fxd comp 150Ω ±10% 1/4 W	01121	CB1511	
A2R30	0683-3935			R: fxd comp 39 KΩ ±5% 1/4 W	01121	CB3935	
A2R31	0683-8235		1	R: fxd comp 82 KΩ ±5% 1/4 W	01121	CB8235	
A2R32				Not assigned			
A2R33	0684-1521		2	R: fxd comp 1500Ω ±10% 1/4 W	01121	CB1521	
A2R34	0686-2025		1	R: fxd comp 2000Ω ±5% 1/2 W	01121	EB2025	
A2R35	0689-4315		1	R: fxd comp carbon 430Ω ±5% 1 W	01121	GB4315	
A2R36	0693-6811		1	R: fxd comp carbon 680Ω ±10% 2 W	01121	HB6811	
A2R37, A2R38	0683-0275			R: fxd comp 2.7Ω ±5% 1/4 W	01121	CB27G5	
A2R39, A2R40	0757-1012		2	R: fxd met flm 100Ω ±0.25% 1/2 W	75042	CEC T-O	obd
A2R41	0683-3615		1	R: fxd comp 360Ω ±5% 1/4 W	01121	CB3615	
A2R42, A2R43	0683-1025			R: fxd comp 1000Ω ±5% 1/4 W	01121	CB1025	
A2R44	0683-0275			R: fxd comp 2.7Ω ±5% 1/4 W	01121	CB27G5	
A2R45	0757-0500		1	R: fxd met flm 30.1Ω ±1% 1/4 W	75042	CEB T-O	obd
C1A thru C1C	0121-0018		1	C: var air 3-sect 14.75 pF to 617.75 pF	28480	0121-0018	
C2	0150-0014		2	C: fxd cer 0.005 μF 500 vdcw	04222	D1-4	obd
C3, C4	0150-0005		2	C: fxd cer 1000 pF ±20% 500 vdcw	04222	Type CFS-1	obd
C5, C6	0180-0047		2	C: fxd Al elect 500 μF 75 vdcw	56289	D32443	obd
C7	0150-0014			C: fxd cer 0.005 μF 500 vdcw	04222	D1-4	obd
DS1	2140-0015		1	Lamp: neon T-2 bulb NE2H	24446	obd	
	5040-0234		1	Pilot light: jewel	28480	5040-0234	
	5040-0235		1	Pilot light: base	28480	5040-0235	
F1	2110-0019		1	Fuse: 0.4 A slow-blow 125 V	75915	313.400	obd
L1 thru L4	9140-0029		4	Coil: radio frequency 100 μH	99848	3100-15-101	

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
M1 (Std. inst. only)	1120-0924		1	Meter	55026	1332 obd
M1 (Opt. 01 only)	1120-0925		1	Meter	55026	1332 obd
M1 (Opt. 02 only)	1120-0926		1	Meter	55026	1332 obd
MP1	1500-0002		2	Yoke: flexible coupler	76487	Single yoke portion of 39006 coupler
MP2	5040-0212		1	Insulator: flexible coupling	28480	5040-0212
MP3	5060-0021		1	Gear assembly	28480	5060-0021
MP4	5000-0637		1	Spring: thrust	28480	5000-0637
MP5	5060-0020		1	Gear assembly	28480	5060-0020
MP6	5020-0233		1	Collar	28480	5020-0233
MP7	5020-0348		1	Shaft	28480	5020-0348
MP8	5020-0641		1	Shaft: spur gear	28480	5020-0641
MP9	5020-0639		1	Casting: Capacitor drive assembly	28480	5020-0639
MP10	5020-0630		1	Hub: dial	28480	5020-0630
MP11	5040-0607		1	Disc assembly: vernier drive	28480	5040-0607
MP12	00651-00102		1	Plate: capacitor	28480	00651-00102
MP13	5040-0631		2	Bracket: capacitor mount	28480	5040-0631
MP14	1200-0043		2	Insulator: TSTR mounting	000LB	293011 obd
MP15	1400-0084		1	Holder: fuse extractor post type for single 3 AG cartridge fuse	75915	342014 obd
MP16	00651-05503		1	Shield: filter	28480	00651-05503
MP17	00652-05506		1	Shield: separates board	28480	00652-05506
MP18	1205-0008		6	Body: heat sink	13103	1101-24-2
MP19	00652-04101		1	Plate: cover over A2 board	28480	00652-04101
MP20	00651-05501		1	Shield: power over switch	28480	00651-05501
MP21	0370-0025		1	Knob: round black vernier	28480	0370-0025
MP22	0370-0026		2	Knob: round black	28480	0370-0026
MP23	00651-05504		1	Shield: outer cover	28480	00651-05504
MP24	5040-0685		1	Bezel: meter window	28480	5040-0685
MP25	0370-0112		2	Knob: bar skirted black	28480	0370-0112
MP26	61B-40D-4		1	Plate: frequency dial	28480	61B-40D-4
MP27	0370-0160		1	Knob: round black dial	28480	0370-0160
MP28	5040-0642		1	Indicator: dial	28480	5040-0642
MP29	00651-04001		1	Dial	28480	00651-04401
MP30	5060-0739		1	Cover assembly: top 11" long	28480	5060-0739
Attaching Hardware:	2370-0013		2	Screw: machine	73076	obd
	0510-0075		2	Nut: sheet metal	78553	C11351-632-24B
MP31	00651-00202		1	Panel: rear	28480	00651-00202
MP32	5060-0731		2	Frame assembly: 5 x 11 full module	28480	5060-0731
MP33	5060-0766		2	Retainer: handle 5" high	28480	5060-0766
Attaching Hardware:	2515-0017		2	Screw: machine	77250	obd
MP34	5000-0732		2	Cover: side rear 5 x 11 full module	28480	5000-0732
Attaching Hardware:	2370-0016		2	Screw: machine	80120	obd
MP35	5000-0733		2	Cover: side front 5 x 11 full module	28480	5000-0733
Attaching Hardware:	2370-0016		2	Screw: machine	80120	obd
MP36	5060-0222		2	Handle assembly: 5" high side	28480	5060-0222
MP37	5000-0051		2	Cabinet trim	28480	5000-0051
MP38	1490-0030		1	Stand: tilt stainless steel rod	91260	obd
MP39	5060-0767		5	Foot assembly: full module	28480	5060-0767
MP40	5060-0751		1	Cover assembly: bottom 11" long	28480	5060-0751
Attaching Hardware:	2370-0013		2	Screw: machine	73076	obd
	0510-0075		2	Nut: sheet metal	78553	C11351-632-24B

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
MP41 (Std. inst. only)	00651-00205		1	Panel: front	28480	00651-00205
MP41 (Opt. 01 only)	00651-00206		1	Panel: front	28480	00651-00206
MP41 (Opt. 02 only)	00651-00207		1	Panel: front	28480	00651-00207
Q1, Q2	1850-0098		2	TSTR: Ge PNP*	28480	1850-0098
R1	0684-3331		1	R: fxd comp 33 KΩ ±10% 1/4 W	01121	CB3331
R2	2100-0732		1	R: var lin comp 500Ω 2-1/4 W	01121	Type J obd
R3	2100-0079		1	R: var lin comp 240Ω ±10% 2-1/4 W	01121	Type J obd
R4	0766-0029		1	R: fxd met oxide 10Ω ±2% 3 W	07115	LPI-3 obd
S1	00651-61901		1	Switch assembly: range	28480	00651-61901
S1C1	0140-0040		1	C: fxd mica 75 pF ±5%	04062	RCM 15E 750J
S1C2	0130-0006		3	C: var cer 5 to 20 pF	72982	503 000 B2PO28R
S1C3	0140-0032		1	C: fxd mica 47 pF ±10%	04062	RCM 15F 470K
S1C4	0130-0001		1	C: var cer 7 to 45 pF	72982	503-000-D2PO-33R
S1C5	0130-0006			C: var cer 5 to 20 pF	72982	503 000 B2PO28R
S1C6	0160-0987		1	C: fxd mica 12 pF ±5%	04062	RDM15C120J5S
S1C7	0130-0006			C: var cer 5 to 20 pF	72982	503 000 B2PO28R
S1C8	0140-0001		1	C: fxd mica 5 pF ±20%	04062	RCM15C050M
S1C9, S1C10	0130-0003		2	C: var cer 1.5 to 7 pF	72982	503-000 COPO-10R
S1C11	0150-0046		1	C: fxd 0.68 pF ±5% 500 vdcw	78488	Type GA obd
S1C12	0150-0029		1	C: fxd 1 pF ±10% 500 vdcw	78488	Type GA obd
S1C13	0150-0031		1	C: fxd 2 pF ±5% 500 vdcw	78488	Type GA obd
S1R1*	0686-5645		1	R: fxd comp 560 KΩ ±5% 1/2 W	01121	EB5645
S1R2	0730-0145		1	R: fxd carbon flm 12 MΩ ±1% 1 W	91637	DC-1 obd
S1R3*	0686-3935		1	R: fxd comp 39 KΩ ±5% 1/2 W	01121	EB3935
S1R4	0757-0983		1	R: fxd met flm 1.23 MΩ ±1% 1/2 W	75042	CEC T-O obd
S1R5*	0686-3925		1	R: fxd comp 3900Ω ±5% 1/2 W	01121	EB3925
S1R6	0757-0981		1	R: fxd met flm 123 KΩ ±1% 1/2 W	75042	CEC T-O obd
S1R7*	0686-4315		1	R: fxd comp 430Ω ±5% 1/2 W	01121	EB4315
S1R8	0757-0042		1	R: fxd met flm 12.3 KΩ ±1% 1/2 W	75042	CEC T-O obd
S1R9*	0686-1305			R: fxd comp 13Ω ±5% 1/2 W	01121	EB1305
S1R10	0757-0821		1	R: fxd met flm 1210Ω ±1% 1/2 W	75042	CEC T-O obd
S1R11*	0686-2005		1	R: fxd comp 20Ω ±5% 1/2 W	01121	EB2005
S1R12	0757-0198		1	R: fxd met flm 100Ω ±1% 1/2 W	19701	MF7C T-O obd
S1R13	0733-0006		1	R: fxd carbon flm 24.5 MΩ ±1% 2 W	91637	DC-2 obd
S1R14	0686-1855		1	R: fxd comp 1.8 MΩ ±5% 1/2 W	01121	EB1855
S1R15	0757-1017		1	R: fxd met flm 2.45 MΩ ±1% 1/2 W	75042	CEC T-O obd
S1R16*	0686-1245		1	R: fxd comp 120 KΩ ±5% 1/2 W	01121	EB1245
S1R17	0757-0982		1	R: fxd met flm 245 KΩ ±1% 1/2 W	75042	CEC T-O obd
S1R18*	0686-1235		1	R: fxd comp 12 KΩ ±5% 1/2 W	01121	EB1235
S1R19	0757-1014		1	R: fxd met flm 24.5 KΩ ±1% 1/2 W	75042	CEC T-O obd
S1R20*	0686-1125		1	R: fxd comp 1100Ω ±5% 1/2 W	01121	EB1125
S1R21	0757-0038		1	R: fxd met flm 2510Ω ±1% 1/2 W	75042	CEC T-O obd
S1R22*	0686-1115		1	R: fxd comp 110Ω ±5% 1/2 W	01121	EB1115
S1R23	0757-0980		1	R: fxd met flm 225Ω ±1% 1/2 W	75042	CEC T-O obd
S1R24*	0686-3005		1	R: fxd comp 30Ω ±5% 1/2 W	01121	EB3005
S2 (Std. inst. and Opt. 01 only)	00651-63401		1	Attenuator Assembly for standard instrument and Opt. 01 only, includes R1 through R13.	28480	00651-63401
S2 (Opt. 02 only)	00651-63402			Attenuator Assembly for Opt. 02 only, includes R1 through R14.	28480	00651-63402
S2R1, S2R2	0757-1009		2	R: fxd met flm 790Ω ±0.25% 1/2 W	75042	CEC T-O obd
S2R3	0757-1008		1	R: fxd met flm 247.5Ω ±0.25% 1/2 W	75042	CEC T-O obd

Table 7-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
S2R4	0757-1006		1	R: fxd met flm 71.15Ω ±0.25% 1/2 W	75042	CEC T-O obd
S2R5 thru S2R8	0757-1004		1	R: fxd met flm 53.27Ω ±0.25% 1/2 W	75042	CEC T-O obd
S2R9, S2R10	0757-1005		2	R: fxd met flm 61.11Ω ±0.25% 1/2 W	75042	CEC T-O obd
S2R11, S2R12	0757-1007		2	R: fxd met flm 96.25Ω ±0.25% 1/2 W	75042	CEC T-O obd
S2R13	0757-1016		1	R: fxd met flm 550Ω ±0.25% 1/2 W	75042	CEC T-O obd
S2R14 (Opt. 02 only)	0757-1025		1	R: fxd prec met flm 25.0Ω ±1% 1/4 W	19701	MF6CT-O obd
S3	3101-0036		1	Switch: toggle power SPST	88140	8928K61
S4	3101-0033		1	Switch: slide DPDT 115/230 V	79727	G:-326 obd
T1	9100-0294		1	Transformer	28480	9100-0294
W1	00651-61603		1	Cable: main	28480	00651-61603
W2	00651-61604		1	Cable: power	28480	00651-61604
W3	00651-61602		1	Cable assembly: attenuator input	28480	00651-61602
W4, W5	00651-61601		2	Cable assembly: attenuator output	28480	00651-61601
				MISCELLANEOUS		
	8120-0078		1	Cord: power 7.5 feet	70903	KH-4147 obd
	00651-90004		1	Manual: operating and service	28480	00651-90004

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N. Y.
00334	Humidail Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N. J.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04354	Precision Paper Tube Co.	Chicago, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc., Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04777	Automatic Electric Sales Corp.	Northlake, Ill.
04796	Sequoia Wire & Cable Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P. M. Motor Company	Chicago 44, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metropolitan Telecommunications Corp., Metro Cap. Division	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	The Bassick Co.	Bridgeport, Conn.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06475	Western Devices, Inc.	Inglewood, Calif.
06540	Amatom Electronic Hardware Co. Inc.	New Rochelle, N. Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06751	U. S. Semcor Division of Nuclear Corp. of America	Phoenix, Arizona
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N. Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	The Birtcher Corp.	Los Angeles, Calif.
07700	Technical Wire Products	Springfield, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert, Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada.
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co., Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S., Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Atohm Electronics	Sun Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
09664	The Bristol Co.	Waterbury, Conn.
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronic, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N. J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
13103	Thermalloy	Dallas, Texas
13396	Telefunken (G.M.B.H.)	Hannover, Germany
13835	Midland Mfg. Co.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co. Inc.	Brooklyn, N.Y.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15909	The Daven Co.	Livingston, N.J.
16037	Spruce Pine Mica Co.	Spruce Pine, N. C.
16352	Computer Diode Corp.	Lodi, N. J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokomo, Ind.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
18486	Radio Industries	Des Plaines, Ill.
18583	Curtis Instrument Inc.	Mt. Kisco, N.Y.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21226	Executive, Inc.	New York, N.Y.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Corp.	Hawkesbury, Ontario, Canada
37942	P.R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
52090	Rowan Controller Co.	Baltimore, Md.
63743	Ward Leonard Electric	Mt. Vernon, N.Y.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
59730	Thomas & Betts Co.	Elizabeth 1, N.J.
60741	Tripplett Electrical Inc.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66295	Wittek Manufacturing Co.	Chicago 23, Ill.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70319	Allmetal Screw Prod. Co., Inc.	Garden City, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A.O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72092	Eitel-McCullough, Inc.	San Bruno, Calif.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
71707	Coto Coil Co., Inc.	Providence, R.I.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72699	General Instrument Corp., Semiconductor Div.	Newark, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co, Inc.	Hicksville, N.Y.
73490	Beckman Helipot Corp.	So. Pasadena, Calif.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Prod. Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N. Y.
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phaostran Instrument and Electronic Co.	South Pasadena, Calif.
77250	Phoell Mfg. Co.	Chicago, Ill.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association. Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W.L. Maxson Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Adhesive Label Corp.	Monrovia, Calif.
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Electronics Co., Inc.	Norwalk, Conn.

From: FSC. Handbook Supplements
H4-1 Dated DECEMBER 1964
H4-2 Dated MARCH 1962

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

Code No.	Manufacturer	Address
81349	Military Specification	.....
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81541	The Airpax Products Co.	Cambridge, Mass.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs, Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83740	Eveready Battery	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronis, Inc.	New York, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A.B. Boyd Co.	San Francisco, Calif.
85474	R.M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	Seattle, Wash.
87930	Tower Mfg. Corp	Providence, R. I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89462	Waldes Kohinoor, Inc.	Cambridge, Mass.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers', Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Minneapolis-Honeywell Regulator Co., Microswitch Div.	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92196	Universal Metal Prod., Inc.	Bassett Puente, Calif.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92607	Tinsolite Insulated Wire Co.	Tarrytown, N.Y.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93788	Howard J. Smith Inc.	Port Monmouth, N. J.
93929	G. V. Controls	Livingston, N. J.
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94222	Southco Div. of S. Chester Corp.	Lester, Pa.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94330	Wire Cloth Products Inc.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95023	Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
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95348	Gordas Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Chicago, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
97979	Reon Resistor Corp.	Yonkers, N.Y.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98731	General Mills	Minneapolis, Minn.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp of Calif.	Newbury Park, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

J0000	Winchester Electronics, Inc.	Santa Monica, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000AB	ETA	England
000AC	Indiana General Corp., Elect. Div.	Indiana
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Manufacturing Co.	San Jose 27, Calif.
000QQ	Cooltron	Oakland, Calif.
000SS	Control of Elgin Watch Co.	Burbank, Calif.
000WW	California Eastern Lab.	Burlingame, Calif.
000YY	S.K. Smith Co.	Los Angeles 45, Calif.

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