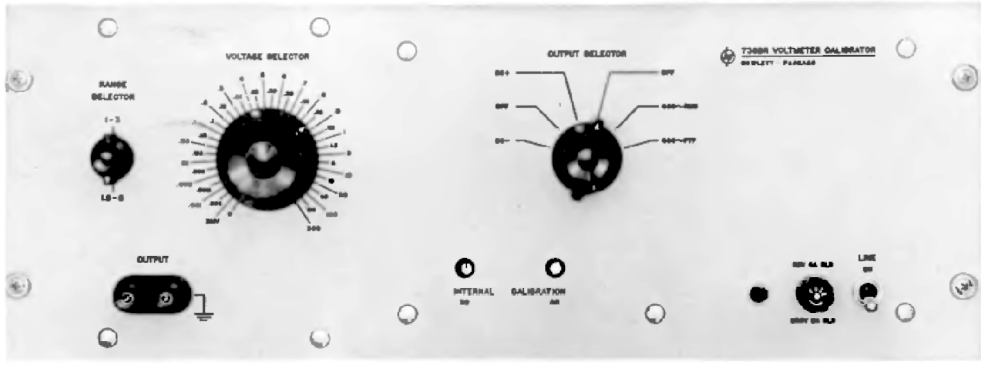
OPERATING AND SERVICE MANUAL

VOLTMETER CALIBRATOR

738BR



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HP 738BR

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CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet 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 provided they are returned to Hewlett-Packard. No other warranty is expressed or implied. We are not liable for consequential damages.

Service contracts or customer assistance agreements are available for Hewlett-Packard products that require maintenance and repair on-site.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

OPERATING AND SERVICE MANUAL

HP PART NO. 00738-90002

MODEL 738BR
VOLTMETER CALIBRATOR

SERIALS PREFIXED: 446-, 503-, 963-

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

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Printed MARCH 1970

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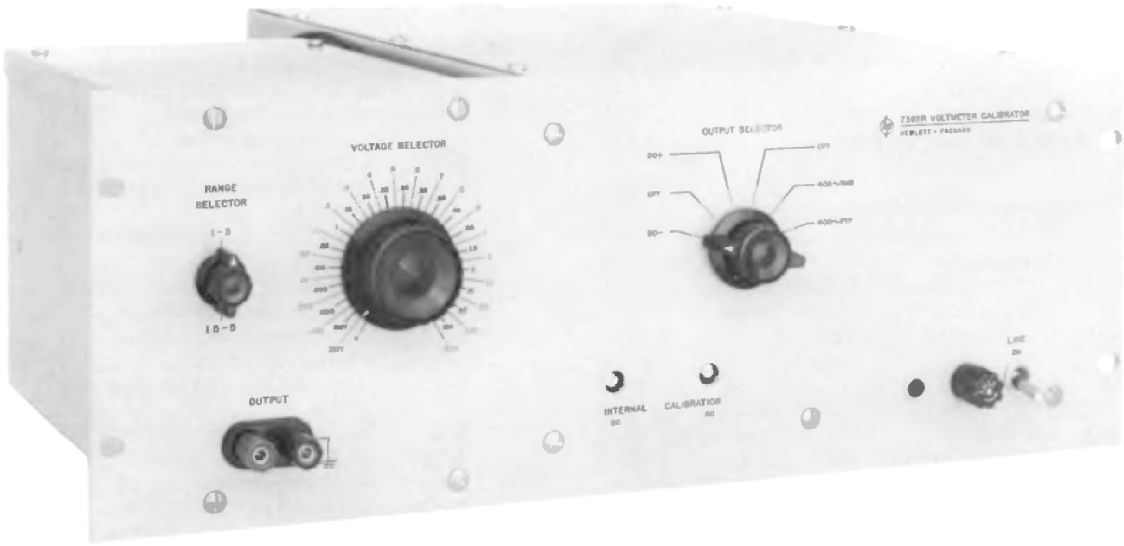


Figure 1-1. Model 738BR Voltage Calibrator

Table 1-1. Specifications

VOLTAGE RANGE: 300 μv to 300 v, dc or ac (rms and peak-to-peak, 400 cps). LEVELS: Calibration voltage 300 μv to 300 v in steps of 1, 3, 1.5, and 5. Tracking voltages 0.1 to 1.0 volts in 0.1 volt steps and 0.05 to 0.5 volts in 0.05 volt steps. ACCURACY: 300 v working voltage into attenuator, accurate within 0.1% dc and 0.2% ac after a 30-minute warm-up. LONG-TERM STABILITY: Less than 0.1% dc drift per week, less than 0.2% ac drift per week.	ATTENUATOR ACCURACY: Within ±0.1% or ±2.5 μv, whichever is larger, open circuit. POWER SUPPLY: 115/230 volts ±10%, 50-60 cycles, 350 watts. DIMENSIONS: Rack Mount: 19 inches (482, 6 mm) wide, 6-31/32 inches (177, 0 mm) high, 15-1/16 inches (382, 6 mm) deep. WEIGHT: Rack Mount: Net 38 lbs. (17 kg). Shipping approximately 53 lbs. (24 kg)

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. The hp Model 738BR Voltmeter Calibrator is a compact, completely self-contained, precision generator for calibrating high impedance electronic voltmeters, oscilloscopes etc. Special design assures accurate and reliable calibrating voltages from 0.3 millivolts up to 300 volts, in precision steps. Accuracy of the output attenuator is within ±0.1% or ±2.5 μvolts, whichever is greater. The attenuator section is in a separate compartment. It is designed to operate into an open circuit, but it is within specifications when operated into a load as small as 10 megohms. The only operating adjustments required are adjustment of ac and dc source voltages and bi-yearly standardization.

1-3. The hp Model 738BR Voltmeter Calibrator has been designed to calibrate voltmeters which have ranges of 300, 100 and successive submultiples of 10 and voltmeters which have ranges of 150, 50 and submultiples of 10.

1-4. The hp Voltmeter Calibrator consists of two separate interconnected units mounted on one standard rack panel. The voltage generator section includes a regulated power supply which produces the 300 volts dc working standard, a conventional low distortion rc oscillator with AGC, and a stabilized amplifier which generates the 400 Hz, 300 volt rms working standard. The 300 volt peak-to-peak voltage is derived from the 300 volt rms voltage through a resistive network. The type of voltage required is selected by a simple output selector and fed to the attenuator section.

1-5. The Attenuator section for the 738BR consists of a precision voltage divider, located on two etched circuit boards, and a dual switch located on the front panel. The electronic portion of the 738BR is identical to that of the 738AR, serial prefixed 441- and above.

1-6. The calibrating voltages run from 300 microvolts to 300 volts in two ranges of 20 precise steps each. Tracking voltages are for the 1 volt range in steps of 0.1 volt, and 0.5 volt range in steps of 0.05 volts.

1-7. No standardizing voltmeter is included with the Model 738BR. The amplitude of the 738BR output voltage cannot be adjusted accurately against a conventional voltmeter since the 0.1% accuracy of the 738BR is better than the accuracy of most meters. See the performance check procedure in Section V for proper test equipment used in checking the accuracy of the 738BR.

1-8. Physically, the instrument is built in two separately housed sections mounted on the front panel; an attenuator section and a generator section. The attenuator section is easily removed for service or replacement by removing four screws, two knobs, and one BNC connector. The circuitry of the generator section is easily accessible from below the chassis.

1-9. INSTRUMENT IDENTIFICATION.

1-10. 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 738BR described in this manual.

1-11. SPECIAL INSTRUMENTS.

1-12. Any ac output frequency from 400 Hz to 1000 Hz is available on special order.

SECTION II

INSPECTION AND INSTALLATION

2-1. INCOMING 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 5-12. If there is damage or deficiency, see the warranty on the inside front cover of this manual.

2-3. INSTALLATION.

2-4. The Model 738BR is designed for mounting in a standard 19-inch relay rack. A fan in the cabinet assures adequate ventilation.

2-5. POWER SOURCE REQUIREMENTS.

2-6. This instrument is normally supplied for 115 volt operation unless specifically ordered for 230 volt operation. The power transformer has a dual primary that may be easily connected for either 115 or 230 volt operation. The schematic diagram illustrates both methods of connection. Always replace the power line fuse with the rating specified in Section VI, Table of Replaceable Parts, for the particular line voltage you are using.

2-7. THREE-CONDUCTOR POWER CABLE.

2-8. 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. Refer to Section III for ground connections.

2-9. REPACKAGING FOR SHIPMENT.

2-10. The following is a general rule for repackaging an instrument for shipment. If you have any questions, contact your local hp Sales and Service Office (see lists in Appendix for location).

a. Place instrument in original container if available. If original container is not available, it 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.

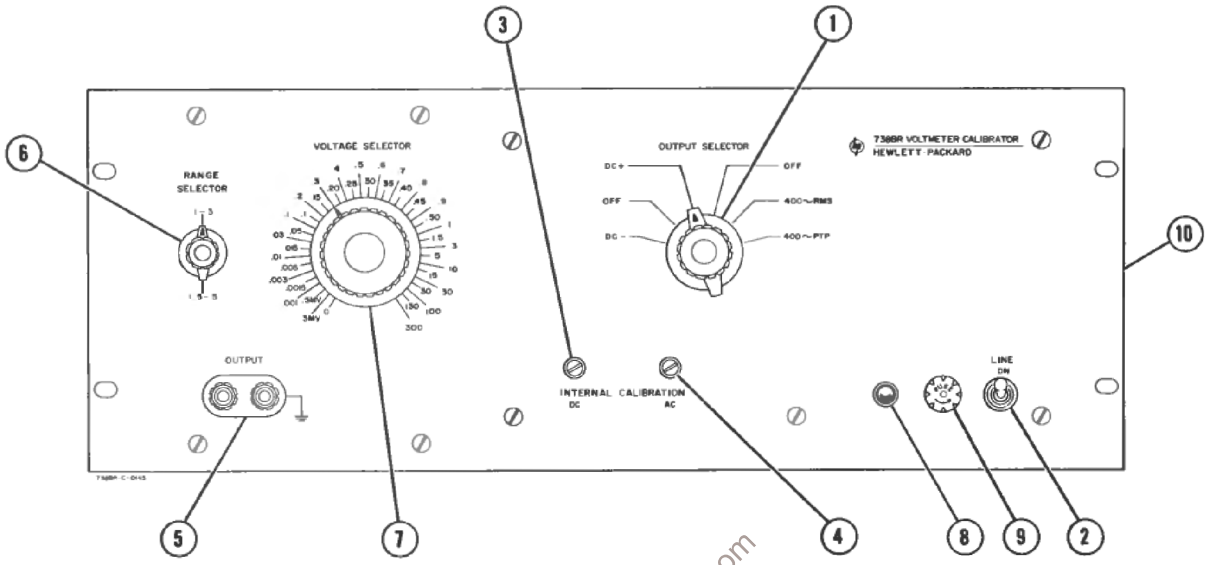
c. Use plenty of packing material around all sides of instrument and protect panel faces with cardboard strips.

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

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

NOTE

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



1. OUTPUT SELECTOR: Connects +DC, -DC, 400 Hz RMS or 400 Hz p-p voltage to the Attenuator and thence to the OUTPUT terminals. The two OFF positions remove the voltage from the attenuator.
2. LINE ON: Applies primary power to the power transformer.
3. DC INTERNAL CALIBRATION: Adjustment for 300 volts DC. Adjusted weekly for normal operation. For optimum accuracy, adjust before use.
4. AC INTERNAL CALIBRATION: Adjustment for 300 volt 400 Hz RMS. Used only after DC adjustment is made.
5. OUTPUT: Output voltage is applied to the instrument to be calibrated. Observe the location of the (⏚) ground terminal.
6. RANGE SELECTOR: This two-position switch is mechanically connected to the VOLTAGE SELECTOR switch. Changing the RANGE SELECTOR rotates the VOLTAGE SELECTOR one position, either clockwise or counterclockwise.
7. VOLTAGE SELECTOR: This rotary switch selects the desired voltage. When rotating the switch one position, it moves across two contact points. This selects every other voltage, depending on the range selected.
8. PANEL LIGHT: Lights when the instrument is turned on.
9. Fuse: 4 amp slow-blow (for 115 v operation)
   2 amp slow-blow (for 230 v operation)
10. POWER CABLE: Located at the rear of the instrument.

Figure 3-1. Front Panel Description

SECTION III
OPERATING INSTRUCTIONS

3-1. GENERAL.

3-2. The hp Model 738B Voltmeter Calibrator Panel controls are shown in Figure 3-1 and the Operating Instructions are given in Figure 3-2.

3-3. A fan in the cabinet assures adequate ventilation provided the air filter is kept clean and the ventilating holes in the right side are not blocked. Adequate air flow through the filter must be maintained. Inspect the air filter weekly. Damage to the instrument can occur if the filter becomes clogged and air flow is restricted. See Paragraph 5-3 for cleaning instructions.

WARNING

THE OUTPUT OF THIS INSTRUMENT MAY CONTAIN VOLTAGES WHICH ARE DANGEROUS! When connecting or disconnecting the output of this instrument, first rotate the OUTPUT SELECTOR switch to the OFF position.

3-4. EXTERNAL LOAD.

3-5. This instrument is designed to operate into an open circuit. Loads down to 10 megohms may be used without degrading the specifications of the instrument. See Table 3-1 for load and voltage variations. If less than a 1 megohm load is desired, a series resistor may be used to increase the resistance of the load to 1 megohm. For example, if a meter with a 100 K ohm input impedance is to be connected to the output of the 738BR, then a resistor of at least .9 megohms should be placed in series with the meter to be calibrated (Table 3-1).

3-6. PREVENTING ERRORS FROM GROUND CURRENTS.

3-7. Ground currents between the instrument being calibrated and the Model 738BR must be minimized to realize the rated accuracy of the Calibrator. A 10 microvolt signal, developed by ground currents between the two instruments, will introduce a 1% error on the 1 millivolt range and a 3.3% error on the 0.3 millivolt range. When using the lower voltage ranges, you must minimize ground currents in the signal leads.

3-8. Most instruments that operate from a power line develop spurious voltages between their chassis and ground. The 738BR is designed to minimize the development of such signals on its own chassis. To minimize the effects of these currents further, the instrument being calibrated should be grounded with its own low-resistance ground, or the 738BR may be insulated from ground so that it cannot provide the ground-return path. This insulation from power ground may be accomplished by placing an insulating adapter (3 female pins to 2 male pins) between the power source outlet and the power input connector for the 738BR. The hp Part Number for this adapter connector is 1251-0048. The instrument under test must be connected to power ground. (See Figure 3-3.)

3-9. CHECKING FOR PRESENCE OF UNWANTED GROUND CURRENTS.

3-10. PREFERRED METHOD.

a. Connect the OUTPUT of the 738BR to the meter to be calibrated. (Connect as in Figure 3-3.)

b. Connect the 738BR OUTPUT to an -hp- Model 130C oscilloscope (200 μv/cm sensitivity) or equivalent.

c. Place the 738BR in the 1 millivolt position (0.001) at 400 cps RMS.

d. Adjust the Oscilloscope as follows:

VERTICAL.	.2 mv
HORIZONTAL	internal sweep X10
SWEEP.	2 ms

e. If a 60 cycle modulation appears on the 400 cycle signal, ground currents are present.

f. Eliminate these currents before calibrating the instrument under test.

1) Check for low resistance to power ground on instrument under test.

2) Check for proper isolation from power ground on 738BR.

3-11. ALTERNATE METHOD (to be used if oscilloscope is not available).

a. Place the 738BR in the 1 mv range.

b. Connect the 738BR to the voltmeter to be calibrated. Note the reading on the voltmeter.

c. Reverse the two prong power input connector in the 3 prong to 2 prong adapter. Note reading again. If there is an appreciable difference, ground currents are present.

3-12. STABILITY.

3-13. Allow at least 30 minutes of warm-up time before using the 738BR Calibrator.

3-14. The 738BR has been accurately set at the factory. If performance checks are made on the instrument, use test equipment listed in Section V or its equivalent.

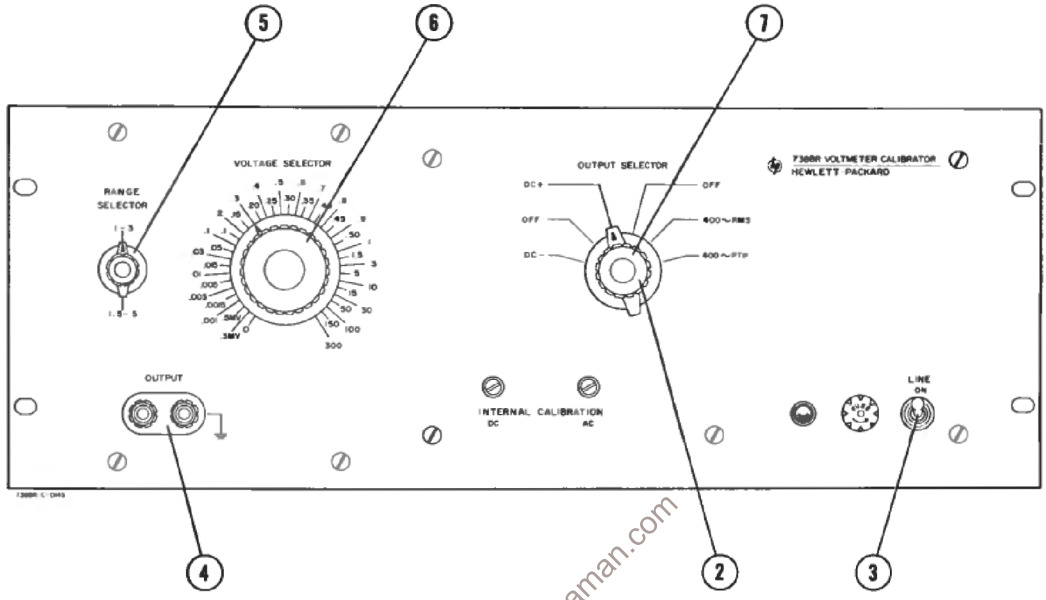
3-15. Accuracy of the 738BR is determined by:

a. The precision with which it is calibrated (the accuracy of the calibrating meter).

b. The accuracy of the output attenuator.

c. The amplitude stability vs time.

d. The value of the external load resistance. (Attenuator performance check is advised once every six months.)



1. Ensure instrument has been calibrated in accordance with Table 5-2.
2. Rotate OUTPUT SELECTOR switch to the OFF position.
3. Turn LINE ON switch to the ON position; panel light glows. Allow instrument to warm up for at least one half hour.
4. Connect instrument to be calibrated to OUTPUT terminals (observe polarity).
5. Select proper range for instrument to be calibrated.
6. Rotate VOLTAGE SELECTOR switch to proper position for full-scale reading.
7. Rotate OUTPUT SELECTOR to the type of voltage for the instrument to be calibrated.

CAUTION

ROTATE OUTPUT SELECTOR TO THE OFF POSITION BEFORE REMOVING OUTPUT CABLE.

Figure 3-2. Operation

Table 3-1. Loading Errors for 738BR Attenuator

SELECTED OUTPUT VOLTAGE	APPARENT SOURCE RESISTANCE	OPEN/INFINITY CIRCUIT VOLTAGE	10 MEG LOAD % ERROR	3 MEG LOAD % ERROR	2 MEG LOAD % ERROR	1 MEG LOAD % ERROR
300	0.3 Ω	300.000	.0	.0	.0	.0
150	4500.075	150.000	-0.045	-0.150	-0.229	-0.445
100	4000.033	100.000	-0.040	-0.134	-0.200	-0.399
50	2500.008	50.000	-0.024	-0.084	-0.126	-0.250
30	1620.003	30.000	-0.017	-0.053	-0.080	-0.163
15	855.000	15.000	-0.008	-0.029	-0.043	-0.086
10	580.000	10.000	-0.006	-0.019	-0.020	-0.058
5	295.000	5.000	-0.003	-0.010	-0.015	-0.029
3	178.200	3.000	-0.002	-0.006	-0.009	-0.018
1.5	490.537	1.5000	-0.005	-0.016	-0.025	-0.049
1.0	418.016	1.0000	-0.004	-0.014	-0.022	-0.042
.9	392.593	.9000	-0.004	-0.013	-0.020	-0.039
.8	363.530	.8000	-0.004	-0.011	-0.018	-0.036
.7	330.828	.7000	-0.003	-0.011	-0.017	-0.033
.6	294.486	.6000	-0.003	-0.010	-0.015	-0.029
.5	254.504	.5000	-0.003	-0.008	-0.013	-0.025
.45	233.409	.4500	-0.003	-0.008	-0.013	-0.028
.4	210.883	.4000	-0.002	-0.007	-0.011	-0.021
.35	188.978	.3500	-0.002	-0.006	-0.010	-0.019
.3	163.621	.3000	-0.002	-0.005	-0.008	-0.016
.25	364.245	.2500	-0.003	-0.012	-0.018	-0.040
.2	466.661	.2000	-0.005	-0.016	-0.023	-0.047
.15	487.997	.15000	-0.005	-0.017	-0.024	-0.049
.1	416.665	.10000	-0.004	-0.014	-0.022	-0.042
.05	254.166	.05000	-0.003	-0.008	-0.013	-0.025
.03	163.500	.03000	-0.002	-0.005	-0.008	-0.016
.015	82.074	.01500	-0.001	-0.003	-0.004	-0.009
.01	56.881	.01000	-0.001	-0.002	-0.003	-0.006
.005	31.720	.00500	-0.000	-0.001	-0.002	-0.003
.003	20.455	.00300	-0.000	-0.001	-0.001	-0.002
.0015	57.195	.00150	-0.001	-0.002	-0.003	-0.006
.001	48.679	.00100	-0.001	-0.002	-0.002	-0.005
.0005	29.670	.00050	-0.000	-0.001	-0.001	-0.003
.0003	19.081	.00030	-0.000	-0.001	-0.001	-0.002

CAUTION

In no case use a load numerically less than 1,000 ohms per volt.

NOTE

The % figures in this table are rounded off to the third decimal place, the nearest 10 PPM.

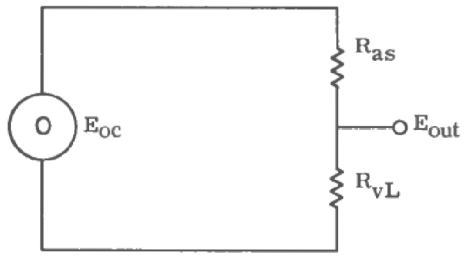
The accuracy of this table is in addition to the guaranteed accuracy of the attenuator which is ±0.10%.

Table 3-1. Loading Errors for 738BR Attenuator (Cont'd)

The last four columns in this table are illustrations of percent error for loads of 1, 2, 3 and 10 megohms. However, the effect of any load on the output of the 738BR may be determined by use of Equation (1) and the first 3 columns of this table.

The procedure for finding load errors other than those in this table is as follows: The operator first determines the load presented to the 738BR for the output voltage selected and then enters the table at that value of voltage in column 1. The apparent source resistance of the 738BR is obtained from column 2, and the open circuit voltage from column 3. With these values, equation (1) may be used to determine the actual output voltage, from which the percent error can be calculated, if desired.

$$E_{out} = \frac{R_{vL} \times E_{oc}}{R_{vL} + R_{as}} \qquad (1)$$



where:

R_{as} = apparent source resistance of 738BR.

R_{vL} = resistance of voltmeter as a "load".

E_{oc} = open circuit voltage.

E_{out} = actual output voltage under voltmeter load.

NOTE

The load (voltmeter) and the apparent source resistance (738BR) may be considered as a simple voltage divider supplied by a zero resistance source of the open circuit voltage for that particular output voltage selected.

Example: What is the output voltage at 30 volts position when calibrating a voltmeter with a 1 megohm input resistance?

$$E_{out} = \frac{10^6 \times 30.000}{10^6 + 1620.003} = 29.951$$

$$E_{out\ error} = \frac{(30.000 - 29.951)}{30} \times 100 = -.163$$

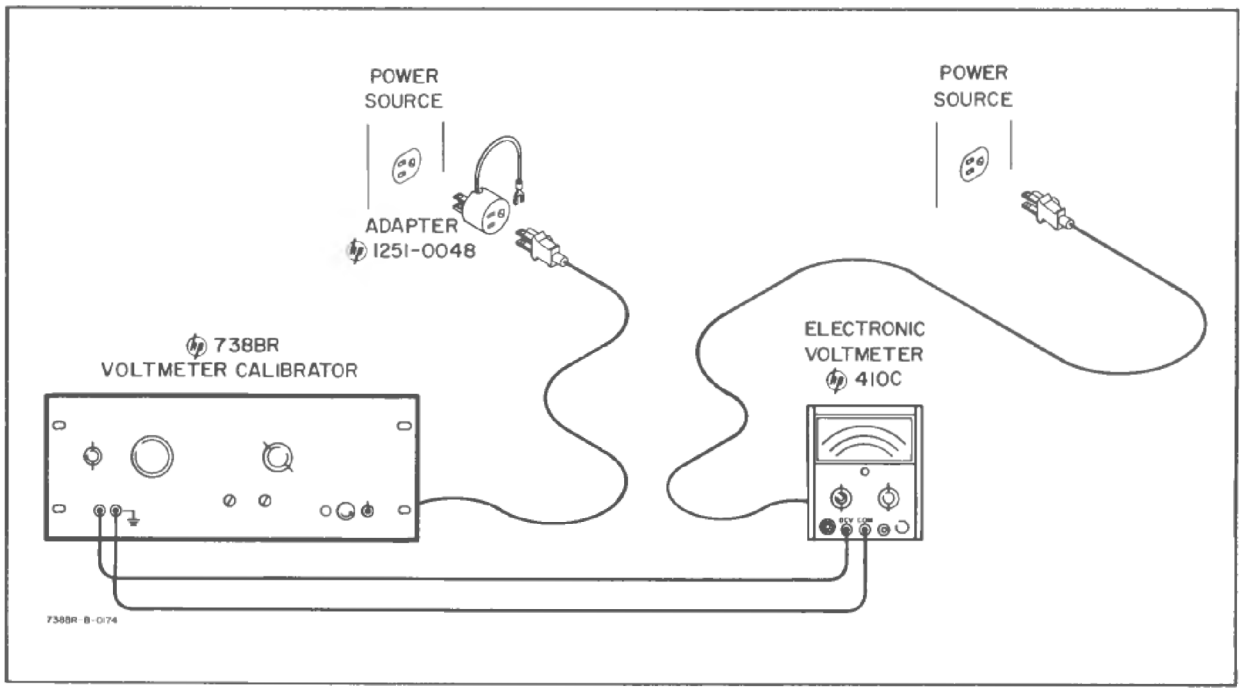


Figure 3-3. Connection for Eliminating Ground Current

SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. The -hp- Model 738BR Voltmeter Calibrator consists of a precision DC and AC Generator section and a precision attenuator section. Each is enclosed in its own compartment. Figure 4-1 shows the block diagram of the major circuit sections. The overall operation of the generator section is explained first.

4-3. GENERATOR SECTION.

4-4. The regulated dc power supply provides both 300 volts working standard and dc power for most of the circuits in the ac generator section. The ac generator is composed of a Wien bridge RC feedback oscillator and level control tube. It is followed by a three-section amplifier with a positive peak detector which operates an AGC circuit providing the stability for the 300 volt RMS output voltage. The 300 peak-to-peak voltage is obtained through an adjustable voltage divider setup. The OUTPUT SELECTOR switch selects the desired type of voltage and connects it to the attenuator section of the 738BR.

4-5. DC GENERATOR SECTION.

4-6. The dc power supply consists of a power transformer T1; a full-wave rectifier tube V14; filter network R50, R51, C26ABC and C27ABC; and an electronic voltage regulator. Two outputs, approximately +440 volts unregulated and the regulated +300 volts are used in the instrument.

4-7. The electronic regulator consists of a series regulator tube V13, which acts as a variable resistor, a regulator reference gas tube V10, and a two-stage differential amplifier V11 and V12.

4-8. The voltage regulating process is as follows: If the 300 volt output tends to change, a portion of this change is coupled to differential amplifier V11. This amplifier compares the change against the reference level of the Voltage Reference Tube V10, amplifies and inverts the difference voltage and applies it to the grid of Series Regulator Tube V13. If the 300 volt level tends to decrease, the current through V13 will increase and will instantly counteract the tendency of the output voltage to decrease. A differential amplifier is used to amplify the degenerative feedback because it is relatively insensitive to changes in tube characteristics and supply voltages (heater voltages and cathode emission in particular.

4-9. The operation of the differential amplifier is as follows: Tube V11, the input stage, compares a sample of the dc output with the constant voltage from Voltage Reference Tube V10. The comparison is accomplished by applying a portion of the +300 vdc to the grid of V11A which is normally equal to the output of Voltage Reference Tube V10. Assume the voltage applied to the grid of V11A tends to go positive; the current in V11A will increase; and due to the large common cathode resistor, the current in V11B will decrease. The plate voltages of V11A and B will have changed by equal amounts and will be 180° out of phase. The plates of V11 are direct-coupled to the grids of V12A and B which is another differential amplifier whose operation is similar to the one just described. The control voltage of the desired polarity for Series Regulator V13 is obtained from the plate of V12B.

4-10. The amplitude of the +300 volt dc regulated output is adjusted by potentiometer R63 (designated DC on the front panel). The common side of this voltage, designated ⏚ on the schematic (Figure 5-2), is floating so that the two outputs may be reversed in the -DC position of the OUTPUT SELECTOR switch.

4-11. AC GENERATOR SECTIONS.

4-12. The ac voltage generator consists of a conventional rc oscillator followed by a level control tube, a filter, a preamplifier, an output amplifier and an automatic gain control (AGC) circuit. The oscillator generates a highly stable, low-distortion signal whose frequency is adjusted to the exact resonant frequency of the 400 - Hz filter which follows. The signal from the oscillator is applied to Level Control Tube V3. The output from V3 is kept constant by application of AGC bias to its variable-mu control grid. The output of the Level Control Tube is filtered to remove harmonics introduced by the variable-mu grid characteristic.

4-13. The output of the level control tube is applied to a two-stage voltage preamplifier V4, then to the two-stage voltage amplifier and phase inverter V5. The cathode and plate of the second half of V5 is ac coupled to the push-pull power amplifier V6 and V7. The output of the power amplifier, coupled through T3, is connected both to the function selector for further application to the output attenuator, and to the automatic gain control circuit. The automatic gain control circuit consists of reference peak detecting diodes CR2 and CR3 followed by amplifier V9 and rectifier CR1. CR2 and CR3 are biased by an exact dc voltage. Any portion of the ac wave that is above this voltage is passed by the diodes to amplifier V9 and is then rectified by CR1 to produce AGC bias for Level Control Tube V3. C32, AGC Sine Neutralizer, is adjusted for a minimum ripple at pin 6 of V9 to create a pure dc bias for the Level Control Tube, V3. The gain of the preamplifier and output amplifier is such that the ac output level would always tend to rise were it not held down by the AGC bias applied to the grid of V3. Consequently, any tendency for the ac output level to decrease (due to loading etc.) would be corrected automatically, as amplifier V9 is always trying to maintain the level established by the reference peak detecting diodes bias. If the output level tends to rise, the diodes pass more of the ac which, when rectified, develops more bias. The increase in bias reduces the gain of the amplifier and holds the output constant.

4-14. To produce rms voltages, the cathode of CR2 is returned through series resistors R71, R67, R68, and R69 to +300 volts. To produce peak-to-peak voltages, the cathode return resistors R71, R67, R68, and R69 are made into a voltage divider by returning potentiometer R67 to ground through R66 and S2A. The wiper arm of R67 taps off a potential from the voltage divider which is connected to the cathode of CR2 through R71. At the same time, OUTPUT SELECTOR switch S2 also reduces the level of the 400 ~ input to V3. Thus, the desired reduction in output voltage is obtained with a small increase in AGC bias. This arrangement avoids the increase in distortion which would result with the greater grid bias.

4-15. THE OUTPUT SELECTOR SWITCH.

4-16. In the +DC position, the OUTPUT SELECTOR switch S2 connects the regulated +300 volts to the end of the attenuator marked "input" and the common floating connection to chassis ground. In the -DC position, the two connections are reversed. The floating common is connected to the input and +300 volts is connected to chassis ground. In the 400 Hz RMS and 400 Hz peak-to-peak positions, the ac output is connected to the attenuator. The amplitudes of these voltages are controlled as explained in Paragraph 4-13.

4-17. ATTENUATOR SECTION.

4-18. The Attenuator section of the 738BR consists of a precision voltage divider located on two etched circuit boards, and two switches located on the front panel. The 738BR Attenuator provides for voltages necessary to calibrate the -hp- Models 403B and 410C Voltmeters and other high impedance voltmeters and oscilloscopes.

4-19. The RANGE SELECTOR switch is a two-position switch which is mechanically connected to the rotary VOLTAGE SELECTOR switch. When the RANGE SELECTOR switch is changed from one position to the other, it moves the rotary switch one position (either forward or backward). Rotating the VOLTAGE SELECTOR switch moves the rotary switch two positions. Therefore, when the RANGE SELECTOR switch is in the 1-3 position, the long red marks are the positions of the VOLTAGE SELECTOR switch. When the RANGE SELECTOR switch is in the 1.5-5 position, the short black marks are the positions of the VOLTAGE SELECTOR switch.

4-20. The tracking voltages are obtained from the appropriate attenuator taps. The one volt range provides for 10 tracking points in 0.1 volt steps. The 0.5 volt range provides for 10 tracking points in 0.05 volt steps.

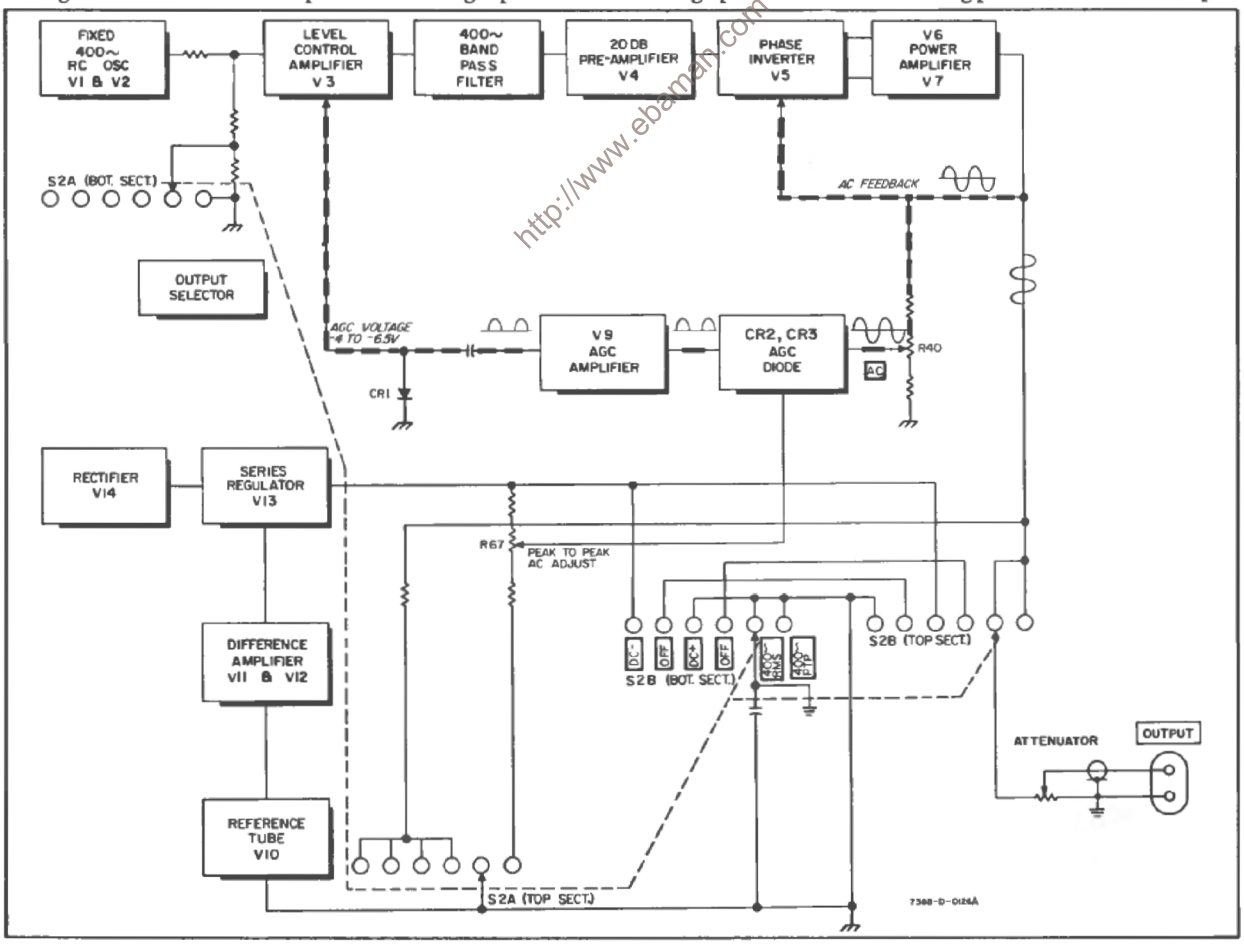


Figure 4-1. Model 738BR Block Diagram

Table 5-1. Test Equipment Required

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
AC-DC Differential Voltmeter	Accuracy: ±0.06% at 400 Hz (ac) Voltage Range: 100 and 1000 volts end scale Resolution: 0.005% end scale Input Impedance: 1 megohm (ac); 10^9 ohms (dc)	Voltage Calibration Checks and Adjustments	-hp- Model 741B
DC Differential Voltmeter	Accuracy: ±0.005% Voltage Range: 300 μv to 300 volts Resolution: 6 digits, all ranges Input Impedance: >10 megohms	Attenuator Accuracy Check	-hp- Model 740B
Distortion Analyzer	Resolution: At least 0.2% Frequency: 400 Hz Distortion Accuracy: ±3% Input Impedance: 1 megohm	Distortion Check	-hp- Model 331A
AC Voltmeter	Range: 0-300 VRMS Accuracy: ±2% f. s. Input Impedance: 10 megohms	AGC Amplifier Neutralization; Troubleshooting	-hp- Model 400D
DC Voltmeter-Ohmmeter	DC Voltage Range: ±500 VDC Voltmeter Accuracy: ±1% f. s. Input Resistance: >10 megohms Ohmmeter Range: 1 ohm-100 megohms Ohmmeter Accuracy: ±5% of reading	Troubleshooting	-hp- Model 412A
Oscilloscope	Vertical Bandwidth: DC - 400 cps Sensitivity: 1 mv/cm Input Impedance: 1 megohm	Hum Adjustment; Troubleshooting	-hp- Model 130C
Electronic Counter	Frequency: 400 Hz Accuracy: ±0.1%	Oscillator Frequency Adjustment	-hp- Model 5211A
NEMA Adaptor	3-prong to 2-prong line cord adaptor	Isolating ground currents	-hp- Part No. 1251-0048
Variable Line Voltage Transformer	Voltage Range: 103.5-126.5 VRMS Power: 350 watts	Line Regulation Check	Superior Type UC1M
Wheatstone Bridge	Accuracy: ±.05% Range: 14-1000 ohms	Troubleshooting	Leeds and Northrup Model 4735
Resistor	Resistance: 10 megohms Tolerance: ±5% Wattage: 1/2 watt	Load Impedance Check	-hp- Part No. 0686-1065

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains maintenance and service information for the Model 738BR Voltmeter Calibrator. Included are Performance Checks, Adjustment and Calibration Procedures and Troubleshooting Techniques.

5-3. SERVICING THE AIR FILTER.

5-4. This instrument contains a fan-air filter combination for cooling. The filter must be kept clean for the fan to be effective. Overheating can cause serious inaccuracies and possible damage to components. Inspect the air filter at regular intervals and when dirty:

a. Remove the filter from its holder.

b. Wash filter in warm water and detergent; dry thoroughly.

c. Apply coating compound (-hp- Part No. 3150-0002).

d. Replace air filter.

5-5. COVER REMOVAL.

WARNING

115/230 VAC AND DC SUPPLY WIRES ARE EXPOSED WHEN COVERS ARE REMOVED. EXERCISE CAUTION DURING TROUBLESHOOTING, ADJUSTMENT OR REPAIR.

5-6. To remove covers from Generator Section:

a. Remove air filter from its holder.

b. Remove top cover by removing six binding head screws from the top and four from the rear.

c. Remove bottom cover by removing four binding head screws from the bottom.

d. Reverse procedure to replace covers.

5-7. To remove covers from Attenuator Section:

a. Remove top cover by removing four binding head screws from the top.

b. Remove bottom cover by removing four binding head screws from the bottom.

c. Reverse procedure to replace covers.

5-8. TEST EQUIPMENT REQUIRED.

5-9. Test equipment used in the calibration of the Model 738BR is given in Table 5-1, Test Equipment Required. This table lists the type of equipment to be used, the critical specifications required for testing, and recommended commercially available test equipment.

5-10. ROUTINE MAINTENANCE.

5-11. Table 5-2 gives a schedule of recommended routine maintenance. Since typical applications of the Model 738BR involve calibrating other precision devices against its output, it is necessary that the accuracy and other pertinent specifications of the Model 738BR be verified periodically. It is recommended that a routine maintenance log be kept for the Model 738BR with calibration entries so that compensation can be made for minor discrepencies.

Table 5-2. Routine Maintenance Schedule

MAINTENANCE	REF. PARAGRAPH	FREQUENCY
DC Voltage Calibration	5-30	Weekly
AC RMS Voltage Calibration	5-31	Weekly
AC PTP Voltage Calibration	5-32	Weekly
Attenuator Accuracy Check	5-19	6 Mo.
Line Regulation Check	5-21	6 Mo.
Distortion Check	5-22	6 Mo.
Air Filter	5-3	6 Mo. *

*Recommended under typical laboratory environment. Should be performed more frequently if atmosphere is dusty or dirty.

5-12. PERFORMANCE CHECKS.

5-13. The performance Checks are in-cabinet procedures that can be used to verify instument performance. These procedures can be used as a periodic maintenance, checking specifications after a repair or incoming quality control checks.

5-14. The Performance Checks are performed with the ac power cord connected to nominal line voltage (115/230 volt) 50 to 60 Hz, unless otherwise specified.

5-15. Before proceeding with the Performance Checks, operate the Model 738BR for at least 30 minutes to permit circuitry to reach its proper operating temperature.

NOTE

The DC, AC RMS and AC PTP Voltage Calibration Checks should be performed in the order prescribed. If the 300 VDC is not in specification, it will affect the accuracy of the RMS and PTP supplies, and should be recalibrated. Likewise, if the 300 V RMS is not in specification, it will affect the accuracy of the PTP supply, and should be recalibrated.

5-16. DC VOLTAGE CALIBRATION CHECK.

a. A DC Differential Voltmeter (-hp- Model 740B) and a NEMA 3-prong to 2-prong line cord adaptor (-hp- Part No. 1251-0048) are required for this test.

b. Connect Model 738BR OUTPUT to the differential voltmeter DC INPUT terminals. Connect Model 738BR to power outlet through NEMA adaptor.

c. Set differential voltmeter controls as follows:

FUNCTION. . . . . DC ΔVM
RANGE. 1000

d. Set Model 738BR controls for DC+, 300 volts out.

e. Measure the output of the Model 738BR.

f. The Differential Voltmeter should read 300.00 ±0.3 volts.

g. If reading in step f is out of specification, adjust front panel DC INTERNAL CALIBRATION for exactly 300 volts on the differential voltmeter, before proceeding with the next Performance Check.

5-17. AC RMS VOLTAGE CALIBRATION CHECK.

NOTE

Before checking the accuracy of the AC RMS voltage, the 300 VDC supply must be in calibration per Paragraph 5-16.

a. An AC Differential Voltmeter (-hp- Model 741B) and a NEMA 3-prong to 2-prong adaptor (-hp- Part No. 1251-0048) will be required for this test.

b. Connect differential voltmeter AC INPUT probe to Model 738BR OUTPUT terminals. Connect Model 738BR to power outlet through NEMA adaptor.

c. Set differential voltmeter controls as follows:

FUNCTION. . . . . AC ΔVM
RANGE. 1000

d. Set Model 738BR controls for 400 ~ RMS, 300 volts out.

e. Measure the output of the Model 738BR.

f. The differential voltmeter should read 300.00 ±0.6 volts.

g. If reading in step f is out of specification, the AC RMS voltage must be recalibrated per Paragraph 5-31, before proceeding with the next Performance Check.

5-18. AC PTP VOLTAGE CALIBRATION CHECK.

NOTE

Before checking the accuracy of the AC PTP voltage, the 300 VDC and 300 VRMS supplies must be in calibration per Paragraphs 5-16 and 5-17, respectively.

a. An AC Differential Voltmeter (-hp- Model 741B) and a NEMA 3-prong to 2-prong adaptor (-hp- Part No. 1251-0048) will be required for this test.

b. Connect differential voltmeter AC INPUT probe to Model 738BR OUTPUT terminals. Connect Model 738BR to power outlet through NEMA adaptor.

c. Set differential voltmeter controls as follows:

FUNCTION. . . . . AC ΔVM
RANGE. 1000

d. Set Model 738BR controls for 400~ PTP, 300 volts out.

e. Measure the output of the Model 738BR.

f. The differential voltmeter should read 106.06 ±0.3 volts, which is the RMS value of 300 V PTP.

g. If reading in step f is out of specification, adjust R67 (located on left rear side of Generator section) for exactly 106.06 volts.

5-19. ATTENUATOR ACCURACY CHECK.

NOTE

Before checking the accuracy of the attenuator, the 300 VDC supply must be in calibration per Paragraph 5-16.

a. A DC Differential Voltmeter (-hp- Model 740B) and a NEMA 3-prong to 2-prong adaptor (-hp- Part No. 1251-0048) will be required for this test. Figure 5-1 shows the test setup recommended.

b. Set differential voltmeter controls as follows:

FUNCTION. . . . . ΔVM
RANGE. 1000

c. Set Model 738BR OUTPUT SELECTOR to DC+.

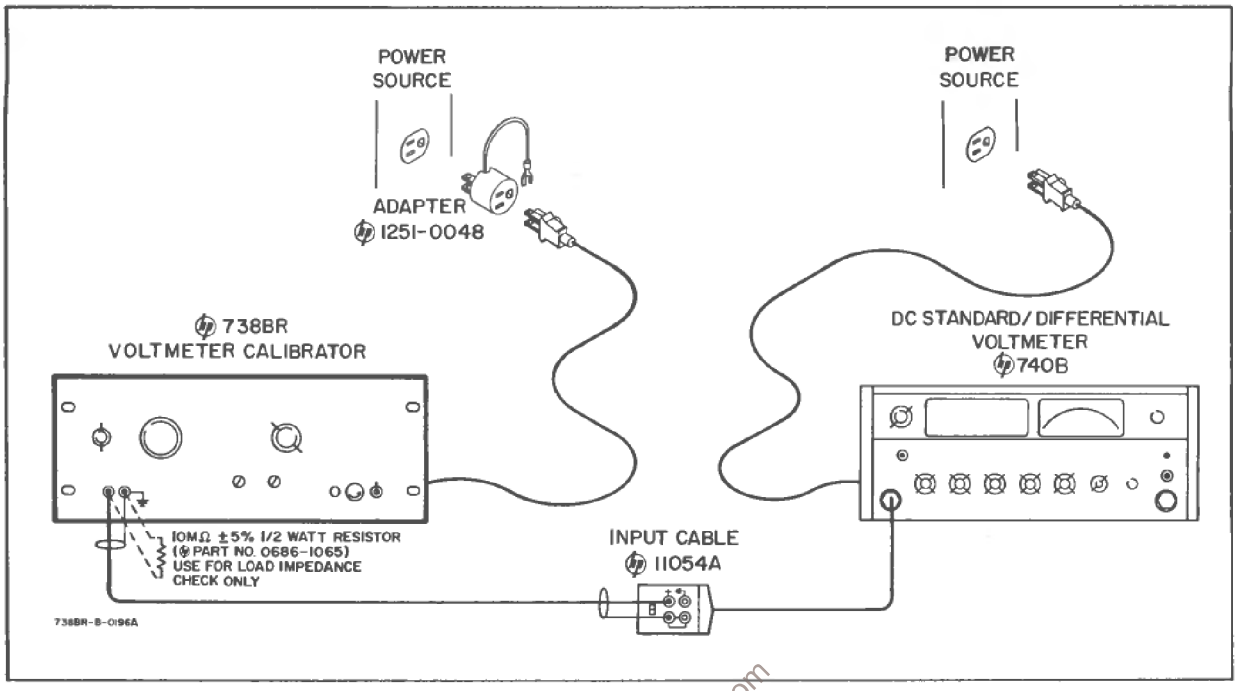


Figure 5-1. Attenuator Accuracy Test Setup

d. Measure the output of the Model 738BR at the settings listed in Table 5-3.

e. The differential voltmeter should read within the limits specified in Table 5-3. (Includes ±0.1% max error of 300 VDC supply; ±0.1% or ±2.5 μv, whichever is larger and max error of attenuator.)

5-20. LOAD IMPEDANCE CHECK.

a. A DC Differential Voltmeter (-hp- Model 740B), a NEMA 3-prong to 2-prong adaptor (-hp- Part No. 1251-0048) and a 10 megohm ±5%, 1/2 watt resistor (-hp- Part No. 0686-1065) will be required for this test. Figure 5-1 shows the test setup recommended.

b. With 10 megohm load on Model 738BR OUTPUT, repeat Paragraph 5-19.

c. The Differential Voltmeter should read within the limits specified in Table 5-3.

5-21. LINE REGULATION CHECKS.

a. An AC Differential Voltmeter (-hp- Model 741B), a DC Differential Voltmeter (-hp- Model 740B), a NEMA 3-prong to 2-prong adaptor (-hp- Part No. 1251-0048) and a Variable Voltage Line Transformer (Superior Type UC1M) will be required for these tests.

b. Repeat Paragraphs 5-16 through 5-18 with the line voltage set to (1) 103.5 volts RMS; (2) 126.5 volts RMS.

c. The 300 volt supplies should remain within the tolerances specified in these tests.

5-22. DISTORTION CHECK.

a. A Distortion Analyzer (-hp- Model 331A) and a NEMA 3-prong to 2-prong adaptor (-hp- Part No. 1251-0048) will be required for this test.

b. Connect Model 738BR OUTPUT to Model 331A INPUT terminals. Connect Model 738BR to power outlet through NEMA adaptor.

c. Set Model 331A controls as follows:

FUNCTION	SET LEVEL
SENSITIVITY	MIN.
METER RANGE	100 PERCENT
FREQUENCY RANGE	X10
FREQUENCY DIAL	40

d. Set Model 738BR controls as follows:

RANGE SELECTOR	1-3
VOLTAGE SELECTOR	10
OUTPUT SELECTOR	400 ~ RMS

e. Adjust Model 331A SENSITIVITY controls for an indication of 1.0 on the "1" scale.

f. Switch Model 331A FUNCTION selector to DISTORTION. Adjust Frequency Dial and BALANCE Controls for minimum meter indication (null). Lower METER RANGE selector setting, as necessary.

g. The Model 331A should read less than 2.0 on the .3 PERCENTAGE-METER RANGE. This indicates less than 0.2% distortion and hum.

Table 5-3. Attenuator Accuracy

RANGE SELECTOR	VOLTAGE SELECTOR	DIFFERENTIAL VOLTMETER READING
1-3	100	100 ±. 2 v
	30	30 ±. 06 v
	10	10 ±. 02 v
	3	3 ±. 006 v
	1	1 ±. 002 v
	.9	.9 ±. 0018 v
	.8	.8 ±. 0016 v
	.7	.7 ±. 0014 v
	.6	.6 ±. 0012 v
	.5	.5 ±. 001 v
	.4	.4 ±. 0008 v
	.3	.3 ±. 0006 v
	.2	.2 ±. 0004 v
	.1	100 ±. 2 mv
	.03	30 ±. 06 mv
	.01	10 ±. 02 mv
	.003	3 ±. 006 mv
	.001	1 ±. 0025mv
	.3 mv	.3 ±. 0025 mv
1.5-5	150	150 ±. 3 v
	50	50 ±.1 v
	15	15 ±. 03 v
	5	5 ±. 01 v
	1.5	1.5 ±. 003 v
	.50	.5 ±. 001 v
	.45	.45 ±. 0009 v
	.40	.4 ±. 0008 v
	.35	.35 ±. 0007 v
	.30	.3 ±. 0006 v
	.25	.25 ±. 0005 v
	.20	.2 ±. 0004 v
	.15	.15 ±. 0003 v
	.1	100 ±. 2 mv
	.05	50 ±. 1 mv
	.015	15 ±. 03 mv
	.005	5 ±. 0 mv
	.0015	1. 5 ±. 003 mv
	.5 mv	.5 ±. 0025 mv

5-23. ADJUSTMENT AND CALIBRATION PROCEDURE.

5-24. The following is a complete adjustment and calibration procedure for the Model 738BR. Before proceeding with these adjustments, the Performance Checks (Paragraph 5-12) should be performed to determine whether adjustments are necessary. If your instrument does not meet the limits specified after performing the following adjustments, refer to Trouble-shooting Procedure (Paragraph 5-33) for possible cause and corrective action.

5-25. The Adjustment and Calibration Procedure is performed with the ac power cord connected to nominal line voltage (115 v/230 v) 50 to 60 Hz, unless otherwise specified.

5-26. Before performing the Adjustment and Calibration Procedure, operate the Model 738BR for at least 30 minutes to permit circuitry to reach its proper operating temperature.

NOTE

These procedures must be performed in the order prescribed. Each parameter affects the parameters of the following procedures.

5-27. OSCILLATOR FREQUENCY ADJUSTMENT.

a. An Electronic Counter (-hp- Model 5211A) and a DC Voltmeter (-hp- Model 412A) will be required for this adjustment.

b. Set the 738BR controls as follows:
OUTPUT SELECTOR. . . . . 400 ~ RMS
RANGE SELECTOR. . . . . 1 - 3
VOLTAGE SELECTOR. 10

c. Connect the dc voltmeter (-hp- Model 412A) to the junction of R15 and C7 using the common black lead as reference.

d. Connect the output of the 738BR to the input of the electronic counter.

e. Adjust C3 for a maximum voltage as monitored by the dc voltmeter. The electronic counter should read 400 Hz ±5 cps.

NOTE

If the 400 cycle output is not within specifications, change the size of C11 and repeat steps b through c. Increasing the size of C11 will decrease the frequency.

5-28. AGC AMPLIFIER NEUTRALIZATION.

a. An AC Voltmeter (-hp- Model 400D) is required for this adjustment.

b. Connect the AC Voltmeter to V9 pin 6. Connect common lead to circuit common.

c. Adjust C32 for minimum reading on Model 400D. This voltage should be less than 0.5 V RMS.

5-29. HUM ADJUSTMENT.

NOTE

This adjustment should not be necessary unless coil L1 or tubes V1 through V7 are replaced.

a. An Oscilloscope (-hp- Model 130C) and a NEMA 3-prong to 2-prong line cord adaptor (-hp- Part No. 1251-0048) will be required for this adjustment.

b. Connect Model 738BR to power outlet through NEMA adaptor.

c. Set OUTPUT SELECTOR to 400 ~ RMS. Set VOLTAGE SELECTOR to 300.

d. Connect a short test lead between the ground side of L1 and the junction of C9 and R18.

e. Connect Oscilloscope Vertical Input to Model 738BR OUTPUT.

f. Loosen mounting nut on Coil L1 and rotate L1 for minimum line hum pickup.

g. There should be less than 0.5 v p-p hum on the output.

h. Tighten nut and remove test lead.

5-30. DC VOLTAGE CALIBRATION.

a. A DC Differential Voltmeter (-hp- Model 740B) and a NEMA 3-prong to 2-prong adaptor (-hp- Part No. 1251-0048) are required for this test.

b. Connect Model 738BR OUTPUT to the differential voltmeter DC INPUT terminals. Connect Model 738BR to power outlet through NEMA adaptor.

c. Set differential voltmeter controls as follows:
FUNCTION. . . . . DC ΔVM
RANGE. 1000

d. Set Model 738BR controls for DC+, 300 volts out.

e. Using the differential voltmeter, measure the output of the Model 738BR.

f. Adjust front panel DC INTERNAL CALIBRATION screwdriver adjustment for exactly 300.00 VDC.

5-31. AC RMS VOLTAGE CALIBRATION.

NOTE

Before calibrating AC RMS voltage, the 300 VDC supply must be in calibration per Paragraph 5-30.

a. An AC Differential Voltmeter (-hp- Model 741A) and a NEMA 3-prong to 2-prong adaptor (-hp- Part No. 1251-0048) will be required for this test.

b. Connect differential voltmeter AC INPUT probe to Model 738BR OUTPUT terminals. Connect Model 738BR to power outlet through NEMA adaptor.

c. Set differential voltmeter controls as follows:
FUNCTION. . . . . AC ΔVM
RANGE. 1000

d. Set Model 738BR controls for 400 ~ RMS, 300 volts out.

e. Using the differential voltmeter, measure the output of the Model 738BR.

f. Adjust front panel AC INTERNAL CALIBRATION screwdriver adjustment for exactly 300.00 V RMS.

5-32. AC PTP VOLTAGE CALIBRATION.

NOTE

Before calibrating AC PTP voltage, the 300 VDC and 300 VRMS supplies must be in calibration per Paragraphs 5-30 and 5-31, respectively

a. An AC Differential Voltmeter (-hp- Model 741A) and a NEMA 3-prong to 2-prong adaptor (-hp- Part No. 1251-0048) are required for this test.

b. Connect differential voltmeter AC INPUT probe to Model 738BR OUTPUT terminals. Connect Model 738BR to power outlet through NEMA adaptor.

c. Set differential voltmeter controls as follows:
FUNCTION. . . . . AC ΔVM
RANGE. 1000

d. Set Model 738BR controls for 400 ~ PTP, 300 volts out.

e. Using the differential voltmeter, measure the output of the Model 738BR.

f. Adjust R67 (located on left rear side of Generator Section) screwdriver adjustment for exactly 106.06 V RMS (300 V PTP).

5-33. TROUBLESHOOTING TECHNIQUES.

5-34. This section contains procedures designed to assist in the isolation of malfunctions. These operations should be undertaken only after it has been established that the difficulty cannot be eliminated by the Adjustment and Calibration Procedures, Paragraph 5-23. An investigation should also be made to insure that the trouble is not a result of conditions external to the Model 738BR.

5-35. Conduct a visual check of the Model 738BR for possible burned or loose components, loose connections, or any other obvious conditions which might suggest a source of trouble.

5-36. Troubleshooting should be performed with the ac power cord connected to nominal line voltage (115/230 volts) 50 to 60 Hz, unless otherwise specified.

5-37. If any components are changed or adjustments made during the course of troubleshooting, the 300 volt supplies must be checked and readjusted if necessary per the Adjustment and Calibration Procedure, Paragraph 5-23.

5-38. Table 5-4 contains a summary of several output symptoms that may be encountered. It should be used in initial efforts to select a starting point for troubleshooting operations.

Table 5-4. Output Malfunction Indications

Indication	Action
No output in any mode; line power indicator not lit	Check F1, S1 and T1.
No output in any mode; line power indicator lit.	Check V14 and interconnecting cable to attenuator.
300 volts rms and/or 300 volts p-p low.	Check 300 VDC and adjust; adjust R40 and R67; check V1 through V7, V9, V13 and T3.
300 volts dc low.	Adjust R63; check V10 through V13.
Distortion in AC outputs.	Check oscillator frequency, C32 adjustment, V6 and V7 balance, V1, V2, V4, V9 and RT1.
Hum in AC outputs.	Adjust L1; check V1 through V7 and V9 filaments; check V10 through V14.
Hum in DC outputs.	Check V11 through V14.
300 VDC supplies normal; errors in attenuated voltages.	See Paragraph 5-40.

5-39. Table 5-5 lists typical waveform amplitudes for the ac generator circuits. These values can be used in conjunction with Table 5-4 to localize malfunctions in the 400 ~ RMS and 400 ~ PTP outputs. Values given are typical and may differ among instruments and change with aging. Therefore, no attempt should be made to duplicate these values.

Table 5-5. Typical Waveforms

LOCATION	AMPLITUDE
V1, pin 1	3 v p-p
V1, pin 2, 7	25 v p-p
V1, pin 5	15 v p-p
V2, pin 1, 7	8 v p-p
V2, pin 2	15 v p-p
V2, pin 6, 8	80 v p-p
V3, pin 1	0.2 v p-p
V3, pin 2, 7	0 v (Gnd.)
V3, pin 5	4.5 v p-p
V4, pin 1	2.5 v p-p
V4, pin 2	1.5 v p-p
V4, pin 3	1.5 v p-p
V4, pin 6	25 v p-p
V4, pin 7	2.5 v p-p
V4, pin 8	2 v p-p
V5, pin 1, 7	20 v p-p
V5, pin 2	25 v p-p
V5, pin 3	22 v p-p
V5, pin 6	18 v p-p
V5, pin 8	18 v p-p
V6, pin 3	300 v p-p
V6, pin 5	13 v p-p
V6, pin 8	0.7 v p-p
V7, pin 3	300 v p-p
V7, pin 5	13 v p-p
V7, pin 8	0.7 v p-p

*Note: All waveforms for values shown are 400 cps sinusoidal. Test conditions as follows:

OUTPUT SELECTOR. . . . 400 ~RMS
VOLTAGE SELECTOR. . . 1 volt

5-40. REPAIRING ATTENUATOR.

5-41. Table 5-6 lists several symptoms of malfunction in the attenuator. Since the resistors in the Model 738BR attenuator are all close tolerance (±0.05% and ±0.1%) it will be necessary to confirm malfunctions by either substituting the suspected resistor with one of known value or measuring the resistor with a Wheatstone Bridge (such as Leeds and Northrup Model 4735, or equivalent).

Table 5-6. Attenuator Troubleshooting

OUTPUTS IN ERROR	CHECK
150 V	R101 - 109
100 V	R110 - 112
50 V	R113 - 115
30 V	R116 - 117
15 V	R118
10 V	R119
5 V	R120
3 V - .35 V	R122
.3 V - .05 V	R205
.03 V - .005 V	R212
.003 V - .3 MV	R217

5-42. If repair of the attenuator is necessary, the following precautions must be observed:

a. Use a low-heat (25 to 50 watts) small-tip soldering iron when removing or replacing components on the printed circuit board.

b. Circuit components can be removed by placing the soldering iron on the component lead on either side of the board, and pulling up on the lead. If a component is obviously damaged, clip leads as close to the component as possible and remove. Excess heat can cause the circuit and board to separate, or cause damage to the component.

c. Clean component lead hole by heating hole area with soldering iron and inserting a wooden toothpick in the hole. Remove toothpick after solder has cooled.

d. To replace components, shape new leads and insert them in holes. Reheat with iron and add solder as required to insure a good electrical connection.

e. Use a small diameter rosin core solder with 1-2% flux (such as Alpha-C, manufactured by Alpha Metals Co., Jersey City, N. J.).

f. Clean excess flux from the connection and adjoining area.

CAUTION

DO NOT USE COMMERCIAL RADIO AND TV SWITCH CLEANERS OR CARBON TETRACHLORIDE ON THE PRINTED CIRCUIT BOARDS AND SWITCHES IN THE INSTRUMENTS. THESE AGENTS ARE EXTREMELY CONTAMINATING, AND MAY CAUSE PERMANENT DAMAGE TO CIRCUITRY.

g. To avoid surface contamination of the printed circuit, clean with weak solution of warm water and mild detergent after repair. Rinse thoroughly with clean water. When completely dry spray lightly with Krylon. (#1302 or equivalent).

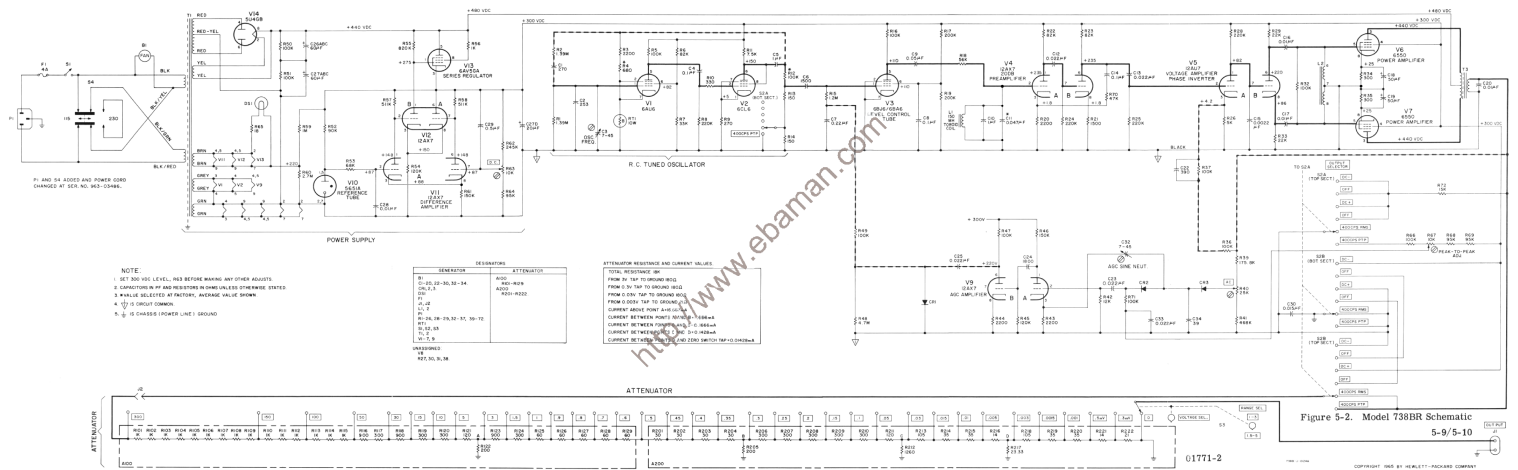


Figure 5-2. Model 738BR Schematic

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alpha-numerical order of their reference designators and indicates the description and (hp) part number of each part, together with any applicable notes. Table 6-2 lists parts in alpha-numerical order of their (hp) part number and provides the following information on each part:

a. Description of the part (see list of abbreviations below).

b. Typical manufacturer of the part in a five-digit code (see list of manufacturers in Appendix).

c. Manufacturer's part number.

d. Total quantity used in the instrument (TQ column).

6-3. Miscellaneous parts are listed at the end of Table 6-1.

6-4. ORDERING INFORMATION.

6-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office (see lists at rear of this manual for addresses). Identify parts by their Hewlett-Packard part numbers.

6-6. NON-LISTED PARTS.

6-7. 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	MP	= mechanical part	TC	= thermocouple
B	= motor	FL	= filter	P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
BT	= battery	HR	= heater	Q	= transistor		
C	= capacitor	IC	= integrated circuit	QCR	= transistor-diode	W	= cable
CR	= diode	J	= jack	R	= resistor	X	= socket
DL	= delay line	K	= relay	RT	= thermistor	XDS	= lampholder
DS	= lamp	L	= inductor	S	= switch	XF	= fuseholder
E	= misc electronic part	M	= meter	T	= transformer	Z	= network

ABBREVIATIONS

Ag	= silver	ID	= inside diameter	ns	= nanosecond (s) = 10^{-9} seconds	sl	= slide
Al	= aluminum	impg	= impregnated	nsr	= not separately replaceable	SPDT	= single-pole double-throw
A	= ampere (s)	incd	= incandescent			SPST	= single-pole single-throw
Au	= gold	ins	= insulation (ed)				
C	= capacitor	kΩ	= kilohm (s) = 10^{+3} ohms	Ω	= ohm (s)	Ta	= tantalum
cer	= ceramic	kHz	= kilohertz = 10^{+3} hertz	obd	= order by description	TC	= temperature coefficient
coef	= coefficient			OD	= outside diameter	TiO_2	= titanium dioxide
com	= common	L	= inductor	p	= peak		
comp	= composition	lin	= linear taper	pc	= printed circuit	tog	= toggle
conn	= connection	log	= logarithmic taper			tol	= tolerance
dep	= deposited	m	= milli = 10^{-3}	pF	= picofarad (s) = 10^{-12} farads	trim	= trimmer
DPDT	= double-pole double-throw	mA	= milliampere (s) = 10^{-3} amperes	piv	= peak inverse voltage	TSTR	= transistor
DPST	= double-pole single-throw	MHz	= megahertz = 10^{+6} hertz	p/o	= part of	V	= volt (s)
		MΩ	= megohm (s) = 10^{+6} ohms	pos	= position (s)	vacw	= alternating current working voltage
elect	= elecirolytic	met flm	= metal film	poly	= polystyrene	var	= variable
encap	= encapsulated	mfr	= manufacturer	pot	= potentiometer	vdcw	= direct current working voltage
F	= farad (s)	mtg	= mounting	p-p	= peak-to-peak		
FET	= field effect transistor	mV	= millivolt (s) = 10^{-3} volts	ppm	= parts per million	W	= watt (s)
fxd	= fixed	μ	= micro = 10^{-6}	prec	= precision (temperature coefficient, long term stability, and/or tolerance)	w/	= with
GaAs	= gallium arsenide	μV	= microvolt (s) = 10^{-6} volts			wiv	= working inverse voltage
GHz	= gigahertz = 10^{+9} hertz	my	= Mylar (R)			w/o	= without
gd	= guard (ed)	nA	= nanoampere (s) = 10^{-9} amperes	R	= resistor	ww	= wirewound
Ge	= germantum	NC	= normally closed	Rh	= rhodium	*	= optimum value selected at factory, average value shown (part may be omitted)
grd	= ground (ed)	Ne	= neon	rms	= root-mean-square		
H	= henry (lies)	NO	= normally open	rot	= rotary	**	= no standard type number assigned (selected or special type)
Hg	= mercury	NPO	= negative positive zero (zero temperature coefficient)	Se	= selenium		
Hz	= hertz (cycle (s) per second)			sect	= section (s)		
				Si	= silicon		

rev 6

(R) Dupont de Nemours

Table 6-1. Reference Designation Index

REFERENCE DESIGNATION	PART NO.	DESCRIPTION	NOTE
B1	3140-0010	Motor: fan	
C1	0160-0769	C: fixed, mica, 270 pf ±10%, 500 vdcw	
C2	0140-0108	C: fixed, mica, 253 pf ±2%, 300 vdcw	
C3	0130-0001	C: Var., cer., 7-45 pf, 500 vdcw	
C4	0170-0022	C: fixed, mylar, .1 μf ±20%, 600 vdcw	
C5	0160-0079	C: fixed, paper, 1 μf ±10%, 600 vdcw	
C6	0160-0012	C: fixed, paper, 1500 pf ±10%, 600 vdcw	
C7	0170-0038	C: fixed, mylar, .22μf ±10%, 200 vdcw	
C8	0170-0019	C: fixed, mylar, .1 μf ±5%, 200 vdcw	
C9	0160-0021	C: fixed, paper, .051 μf ±5%, 600 vdcw	
C10	0160-0079	C: fixed, paper, 1 μf ±10%, 600 vdcw	
C11*	0170-0019	C: fixed, mylar, .1 μf ±5%, 200 vdcw	
C12, C13	0170-0043	C: fixed, mylar, .022 μf ±10%, 400 vdcw	
C14	0170-0022	C: fixed, mylar, .1 μf ±20%, 600 vdcw	
C15	0160-0007	C: fixed, paper, .0022 μf ±10%, 600 vdcw	
C16, C17	0160-0002	C: fixed, paper, .01 μf ±10%, 600 vdcw	
C18, C19	0180-0141	C: fixed, elect., 50 μf -10% +200%, 50 vdcw	
C20	0160-0023	C: fixed, paper, .01 μf ±10%, 1600 vdcw	
C21		Not Assigned	
C22	0140-0114	C: fixed, mica, 390 pf ±2%, 500 vdcw	
C23	0170-0043	C: fixed, mylar, .022 μf ±10%, 400 vdcw	
C24	0170-0035	C: fixed, mylar, .0018 μf ±2%, 600 vdcw	
C25	0170-0043	C: fixed, mylar, .022 μf ±10%, 400 vdcw	
C26, C27	0180-0125	C: fixed, elect., 4 sect. 20 μf/sect., 450 vdcw	
C28	0160-0002	C: fixed, paper, .01 μf ±10%, 600 vdcw	
C29	0160-0024	C: fixed, paper, .5 μf ±10%, 400 vdcw	
C30	0160-0065	C: fixed, paper, .015 μf ±10%, 600 vdcw	
C31		Not Assigned	
C32	0130-0001	C: Var., cer., 7-45 pf, 500 vdcw	
C33	0170-0043	C: fixed, mylar, .022 μf ±10%, 400 vdcw	
C34	0140-0035	C: fixed, Molded mica, 39 pf ±5%	
CR1	1901-0005	Diode, silicon: 3ES2	
CR2	1901-0033	Diode, silicon	
CR3	1901-0190	Diode	
DS1	2140-0012	Lamp, miniature pin base No. 12, 6.3 v.	
F1	2110-0055	Fuse, cartridge: 4 amp, slow blow, for 115V operation	
	2110-0002	Fuse, cartridge: 2 amp, slow blow, for 230V operation	
L1		Coil: toroid, assembly	
L2	9120-0050	Coil: type A-11	
P1	12 51-2357	Connector: power, added at Ser. No. 963-03486	
	8120-0015	Cable: power, for Ser. No. 503-03485 and below	
	8120-1348	Cable: power, for Ser. No. 963-03486 and up	
R1, R2	0730-0109	R: fixed, deposited carbon, 1.39 megohms ±1%, 1 W	
R3	0693-2221	R: fixed, comp., 2200 ohms ±10%, 2 W	
R4*	0690-6811	R: fixed, comp., 680 ohms ±10%, 1 W Optimum value selected at factory Average value shown	
R5	0690-1041	R: fixed, comp., 100,000 ohms ±10%, 1 W	
R6	0690-8231	R: fixed, comp., 82,000 ohms ±10%, 1 W	
R7	0690-3331	R: fixed, comp., 33,000 ohms ±10%, 1 W	
R8	0687-2241	R: fixed, comp., 220,000 ohms ±10%, 1/2W	
R9	0771-0001	R: fixed, metal film, 270 ohms ±10%, 4 W	
R10	0687-3311	R: fixed, comp., 330 ohms ±10%, 1/2W	

* Optimum value selected at factory, average value shown

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	PART NO.	DESCRIPTION	NOTE
R11	0816-0007	R: fixed, ww, 7500 ohms ±10%, 10 W	
R12*	0690-1041	R: fixed, comp., 100,000 ohms ±10%, 1 W	
R13, R14	0687-1511	R: fixed, comp., 150 ohms ±10%, 1/2 W	
R15	0687-1251	R: fixed, comp., 1.2 megohms ±10%	
R16	0690-1041	R: fixed, comp., 100,000 ohms ±10%, 1 W	
R17	0686-2045	R: fixed, comp., 200,000 ohms ±5%, 1/2 W	
R18	0687-5631	R: fixed, comp., 56,000 ohms ±10%, 1/2 W	
R19	0686-2045	R: fixed, comp., 200,000 ohms ±5%, 1/2 W	
R20	0687-2221	R: fixed, comp., 2200 ohms ±10%, 1/2 W	
R21	0687-1521	R: fixed, comp., 1500 ohms ±10%, 1/2 W	
R22, R23	0687-8231	R: fixed, comp., 82,000 ohms ±10%, 1/2 W	
R24, R25	0687-2241	R: fixed, comp., 220,000 ohms ±10%, 1/2 W	
R26	0811-0006	R: fixed, ww, 5000 ohms ±1%, 5 W	
R27		Not Assigned	
R28	0690-2241	R: fixed, comp., 220,000 ohms ±10%, 1 W	
R29	0692-2235	R: fixed, comp., 22,000 ohms ±5%, 2 W	
R30		Not Assigned	
R31		Not Assigned	
R32	0690-1041	R: fixed, comp., 100,000 ohms ±10%, 1 W	
R33	0692-2235	R: fixed, comp., 22,000 ohms ±5%, 2 W	
R34, R35	0815-0007	R: fixed, ww,300 ohms ±5%, 10 W	
R36, R37	0730-0069	R: fixed, deposited carbon, 100,000 ohms ±1%, 2 W	
R38		Not Assigned	
R39	0811-0039	R: fixed, ww, 175,800 ohms ±1%, 1 W	
R40	2100-0247	R: var., ww, 25,000 ohms ±10%, 4 W	
R41	0811-0013	R: fixed, ww, 468,000 ohms ±1%, 1/2 W	
R42	0686-1235	R: fixed, comp., 12,000 ohms ±5%, 1/2 W	
R43, R44	0687-2221	R: fixed, comp., 2200 ohms ±10%, 1/2 W	
R45	0687-1241	R: fixed, comp., 120,000 ohms ±10%, 1/2 W	
R46	0687-1541	R: fixed, comp., 150,000 ohms ±10%, 1/2 W	
R47	0687-1041	R: fixed, comp., 100,000 ohms ±10%, 1/2 W	
R48	0687-4751	R: fixed, comp., 4.7 megohms ±10%, 1/2 W	
R49	0687-1041	R: fixed, comp., 100,000 ohms ±10%, 1/2 W	
R50, R51	0690-1041	R: fixed, comp., 100,000 ohms ±10%, 1 W	
R52	0730-0064	R: fixed, deposited carbon, 90,000 ohms ±1%, 1 W	
R53	0690-6831	R: fixed, comp., 68,000 ohms ±10%, 1 W	
R54	0690-1241	R: fixed, comp., 120,000 ohms ±10%, 1 W	
R55	0690-8241	R: fixed, comp., 820,000 ohms ±10%, 1 W	
R56	0690-1021	R: fixed, comp., 1000 ohms ±10%, 1 W	
R57, R58	0757-0135	R: fixed, comp., 511,000 ohms ±10%, 1/2 W	
R59	0687-1051	R: fixed, comp., 1 megohm ±10%, 1/2 W	
R60	0687-2751	R: fixed, comp., 2.7 megohms ±10%, 1/2 W	
R61	0690-1541	R: fixed, comp., 150,000 ohms ±10%, 1 W	
R62	0811-0037	R: fixed, ww, 245,000 ohms ±1%, 1 W	
R63	2100-0246	R: var., ww, 10,000 ohms ±20%, 2 W	
R64	0811-0146	R: fixed, ww, 95,000 ohms ±1%, 1 W	
R65	0690-1801	R: fixed, comp., 18 ohms ±10%, 1 W	
R66	0811-0019	R: fixed, ww, 100.000 ohms ±1%, 1 W	
R67	2100-0053	R: var., ww, 10,000 ohms	
R68, R69	0811-0146	R: fixed, ww, 95,000 ohms ±1%, 1 W	
R70	0690-4731	R: fixed, comp., 47,000 ohms ±10%, 1 W	
R71	0687-1041	R: fixed, comp., 100,000 ohms ±10%, 1/2 W	
R72	0819-0008	R: fixed, ww, 15,000 ohms ±10%, 20 W	

* Optimum value selected at factory, average value shown

See introduction to this section

Table 7-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	PART NO.	DESCRIPTION	NOTE
R73 thru R100		Not Assigned	
RT1	2140-0007	Lamp, incandescent: 250V, 10 W	
S1	3101-0030	Switch, toggle: SPST, OFF-ON	
S2	3100-0202	Switch, rotary, 2-sect. 6 pos. (OUTPUT SELECTOR)	
S4	3101-1234	Switch: slide 115/230, added at Ser. No. 963-03486	
T1	9100-0082	Transformer, power	
T2		Not Assigned	
T3	9120-0030	Transformer, output	
V1	1923-0021	Tube, electron: 6AU6	
V2	1923-0030	Tube, electron: 6CL6	
V3	1923-0025	Tube, electron: 6BA6	
V4	1932-0030	Tube, electron: 12AX7	
V5	1932-0029	Tube, electron: 12AU7	
V6, V7	1923-0009	Tube, electron: 6550	
V8		Not Assigned	
V9	1932-0030	Tube electron: 12AX7	
V10	1940-0011	Tube, electron: 5651A	
V11, V12	1932-0030	Tube, electron: 12AX7	
V13	1923-0023	Tube, electron: 6AV5CA	
V14	1930-0008	Tube, electron: 5U4CB	
		MISCELLANEOUS	
	0370-0035	Knob	
	1400-0084	Holder, fuse	
	1450-0022	Lampholder, candelabra	
	1450-0020	Jewel	
	3150-0002	Oil, soluble: for air filter; 1-pint can with spray dispenser	
	3150-0005	Filter, air	
	3160-0014	Blade, fan	
	00738-63401	Attenuator Ass'y (includes A100, A200, S3, J2, sub panel, frame, and cover.)	
J1	0340-0086	Insulator - Binding Post	
	0340-0131	Insulator - Binding Post	
	5080-1278	Binding Post - Red, gold plated copper body	
	5080-1277	Binding Post - Black, glod plated copper body	
J2	1250-0061	Connector - BNC	
S3	3100-0866	Switch	
		MISCELLANEOUS	
	0370-0039	Knob	
	0370-0077	Knob	
	00738-00201	Panel	
	00738-00202	Panel - sub	
	00738-04101	Cover	
	00738-04401	Frame	
A100	00738-66501	Board Ass'y - High Voltage	
R101 thru R115	0811-1381	R: ww, 1000 ohm, ±0.1%, 1/2 W	
R116	0811-1380	R: fixed, ww, 900 ohm ±.05%, 1/2 W	
R117	0811-1379	R: ww, 300 ohm ±.05%, 1/2 W	
R118	0811-1380	R: fixed, ww, 900 ohm ±.05%, 1/2 W	
R119	0811-1379	R: ww, 300 ohm, ±.05%, 1/2 W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	PART NO.	DESCRIPTION	NOTE
R120	0811-1379	R: ww, 300 ohm ±.05%, 1/2 W	
R121	0811-1377	R: ww, 120 ohm ±.05%, 1/2 W	
R122	0811-1378	R: ww, 200 ohm ±.05%, 1/2 W	
R123	0811-1380	R: fixed, ww, 900 ohm ±.05%, 1/2 W	
R124	0811-1379	R: ww, 300 ohm ±.05%, 1/2 W	
R125 thru R129	0811-1375	R: fixed, ww, 60 ohm ±.05%, 1/2 W	
A200	00738-66502	Board Ass'y - Low Voltage	
R201 thru R204	0811-1373	R: fixed, ww, 30 ohm ±.1%, 1/2 W	
R205	0811-1378	R: ww, 200 ohm ±.05%, 1/2 W	
R206 thru R210	0811-1379	R: ww, 300 ohm ±.05%, 1/2 W	
R211	0811-1377	R: ww, 120 ohm ±.05%, 1/2 W	
R212	0811-1383	R: fixed, ww, 1260 ohm ±.05%, 1/2 W	
R213	0811-1376	R: fixed, ww, 105 ohm ±.05%, 1/2 W	
R214, R215	0811-1374	R: fixed, ww, 35 ohm ±.05%, 1/2 W	
R216	0811-1372	R: fixed, ww, 14 ohm ±.05%	
R217	0811-1388	R: ww, 23.334 ohm ±.05%, 1/4 W	
R218	0811-1376	R: ww, 105 ohm ±.05%, 1/2 W	
R219, R220	0811-1374	R: fixed, ww, 35 ohm ±.05%, 1/2 W	
R221	0811-1372	R: fixed, ww, 14 ohm ±.05%	
R222	0811-1387	R: fixed, ww, 21 ohm ±.05%, 1/4 W	

See introduction to this section

Table 6-2. Replaceable Parts

PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	RS
0130-0001	C: var, cer, 7-45 pf, 500 vdcw	72982	503 000 D2P0 33R	2	1
0140-0015	C: fixed, mica, 270 pf ±10%, 500 vdcw	00853	RCM20E271K	1	1
0140-0035	C: fixed, molded mica, 39 pf ±5%	14655	RCM15E390J	1	1
0140-0108	C: fixed, mica, 253 pf ±2%, 300 vdcw	76433	RCM15E(253)G	1	1
0140-0114	C: fixed, mica, 390 pf ±2%, 500 vdcw	76433	RCM20E391G	1	1
0160-0002	C: fixed, paper, 0.01μf ±10%, 600 vdcw	56289	160P10396	3	1
0160-0007	C: fixed, paper, 0.0022 μf ±10%, 600 vdcw	56289	160P22296	1	1
0160-0012	C: fixed, paper, 1500 pf ±10%, 600 vdcw	56289	160P15296	1	1
0160-0021	C: fixed, paper, 0.051 μf ±5%, 600 vdcw	56289	160P51356	1	1
0160-0023	C: fixed, paper, 0.01 μf ±10%, 1600 vdcw	00656	73P103916	1	1
0160-0024	C: fixed, paper, 0.5 μf ±10%, 400 vdcw	14655	PM 4P5	1	1
0160-0065	C: fixed, paper, 0.015 μf ±10%, 600 vdcw	56289	obd#	1	1
0160-0079	C: fixed, paper, 1 μf ±10%, 600 vdcw	24466	#23F467	2	1
0170-0043	C: fixed, mylar, .022 μf ±10%, 400 vdcw	24446	64FDA223	5	1
0170-0019	C: fixed, mylar, .051 μf ±5%, 600 vdcw	56289	192P10452	1	1
0170-0022	C: fixed, mylar, .1 μf ±20%, 600 vdcw	09134	148P175A	2	1
0170-0035	C: fixed, mylar, .0018 μf ±2%, 600 vdcw	09134	obd#	1	1
0170-0038	C: fixed, mylar, .22 μf ±10%, 200 vdcw	56289	#148P22492	1	1
0180-0141	C: fixed, elect, 50 μf -10% +200%, 50 vdcw	56289	30D506G050DD2	2	1
0180-0125	C: fixed, elect, 4 sect. 20 μf/sect., 460 vdcw	56289	Type PL1	2	1
0340-0086	Insulator - Binding Post, without locating key	28480	0340-0086	1	1
0340-0131	Insulator - Binding Post	28480	0340-0131	1	1
0370-0035	Knob	28480	0370-0035	1	1
0370-0039	Knob	28480	0370-0039	1	1
0370-0077	Knob	28480	0370-0077	1	1
0686-1235	R: fixed, comp. 12,000 ohms ±5%, 1/2 W	01121	EB-1235	1	1
0686-2045	R: fixed, comp. 200,000 ohms ±5%, 1/2 W	01121	EB-2045	2	1
0687-1041	R: fixed, comp. 100,000 ohms ±10%, 1/2 W	01121	EB-1041	3	1
0687-1051	R: fixed, comp. 1 megohm, ±10%, 1/2 W	01121	EB-1051	1	1
0687-1241	R: fixed, comp. 120,000 ohms ±10%, 1/2 W	72758	obd#	1	1
0687-1251	R: fixed, comp. 1.2 megohms ±10%, 1/2 W	01121	EB-1251	1	1
0687-1511	R: fixed, comp. 150 ohms ±10%, 1/2 W	01121	EB-1511	2	1
0687-1521	R: fixed, comp. 1500 ohms ±10%, 1/2 W	01121	EB-1521	1	1
0687-1541	R: fixed, comp. 150,000 ohms ±10%, 1/2 W	01121	EB-1541	1	1
0687-2221	R: fixed, comp. 2200 ohms ±10%, 1/2 W	01121	EB-2221	3	1
0687-2241	R: fixed, comp. 220,000 ohms ±10%, 1/2 W	01121	EB-2241	3	1
0687-2751	R: fixed, comp. 2.7 megohms ±10%, 1/2 W	01121	EB-2751	1	1
0687-3311	R: fixed, comp. 330 ohms ±10%, 1/2 W	01121	EB-3311	1	1
0687-4751	R: fixed, comp. 4.7 megohms ±10%, 1/2 W	01121	EB-4751	1	1
0687-5631	R: fixed, comp. 56,000 ohms ±10%, 1/2 W	01121	EB-5631	1	1
0687-8231	R: fixed, comp. 82,000 ohms ±10%, 1/2 W	01121	EB-8231	2	1
0689-5145	R: fixed, comp. 510,000 ohms ±10%, 1 W	01121	EB-5145	2	1
0690-1021	R: fixed, comp. 1000 ohms ±10%, 1 W	01121	GB-1021	1	1
0690-1041	R: fixed, comp. 100,000 ohms ±10%, 1 W	01121	GB-1041	5	2
0690-1241	R: fixed, comp. 120,000 ohms ±10%, 1 W	01121	GB-1241	1	1
0690-1541	R: fixed, comp. 150,000 ohms ±10%, 1 W	01121	GB-1541	1	1
0690-1801	R: fixed, comp. 18 ohms ±10%, 1 W	01121	GB-1801	1	1
0690-2241	R: fixed, comp. 220,000 ohms ±10%, 1 W	01121	GB-2241	1	1
0690-3331	R: fixed, comp. 33,000 ohms ±10%, 1 W	01121	GB-3331	1	1
0690-3911	R: fixed, comp. 390 ohms ±10%, 1 W	01121	GB-3911	1	1
0690-4731	R: fixed, comp. 47,000 ohms ±10%, 1 W	01121	GB-4731	1	1

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	RS
0690-6831	R: fixed, comp. 68,000 ohms ±10%, 1 W	01121	GB-6831	1	1
0690-8231	R: fixed, comp. 82,000 ohms ±10%, 1 W	01121	GB-8231	1	1
0690-8241	R: fixed, comp. 820,000 ohms ±10%, 1 W	01121	GB-8241	1	1
0692-2235	R: fixed, comp. 22,000 ohms ±5%, 2 W	01121	HB-2235	2	1
0693-2221	R: fixed, comp. 2,200 ohms ±10%, 2 W	01121	HB-2221	1	1
0730-0064	R: fixed, depc. 90,000 ohms ±1%, 1 W	19701	obd#	1	1
0730-0069	R: fixed, depc. 100 K ohms ±1%, 1 W	19701	A-5950-0835 CVC	2	1
0730-0109	R: fixed, depc. 1.39 megohms ±1%, 1 W	19701	CVC	2	1
0771-0001	R: fixed, met flm, 270 ohms ±10%, 4 W	07115	obd#	1	1
0811-0006	R: fixed, ww, 5000 ohms ±1%, 5 W	91637	obd#	1	1
0811-0013	R: fixed, ww, 468,000 ohms ±1%, 1/2 W	91827	CE 530 E	1	1
0811-0037	R: fixed, ww, 245,000 ohms ±1%, 1 W	91827	obd#	1	1
0811-0039	R: fixed, ww, 175,800 ohms ±1%, 1 W	91827	obd#	1	1
0811-0146	R: fixed, ww, 95,000 ohms ±1%, 1 W	71471	obd#	4	1
0811-1372	R: fixed, ww, 14 ohm ±.05%	28480	0811-1372	2	1
0811-1373	R: fixed,ww, 30 ohm ±0.1%, 1/2 W	28480	0811-1373	4	0
0811-1374	R: fixed, ww, 35 ohm ±0.05%, 1/2 W	28480	0811-1374	4	0
0811-1375	R: fixed, ww, 60 ohm ±0.05%, 1/2 W	28480	0811-1375	5	0
0811-1376	R: fixed, ww, 105 ohm ±0.05%, 1/2 W	28480	0811-1376	2	0
0811-1377	R: ww, 120 ohm ±0.05%, 1/2 W	28480	0811-1377	1	0
0811-1378	R: ww, 200 ohm ±0.05%, 1/2 W	28480	0811-1378	1	0
0811-1379	R: ww, 300 ohm ±0.05%, 1/2 W	28480	0811-1379	5	0
0811-1380	R: ww, 900 ohm ±0.05%, 1/2 W	28480	0811-1380	3	0
0811-1381	R: ww, 1000 ohm,±0.1%, 1/2 W	28480	0811-1381	15	0
0811-1383	R: fixed, ww, 1260 ohm ±0.05%, 1/2 W	14508	CB-6	1	0
0811-1387	R: fixed, ww, 21 ohm ±0.05%, 1/4 W	28480	0811-1387	1	0
0811-1388	R: ww, 23,334 ohm ±0.05%, 1/2 W	28480	0811-1388	1	1
0815-0007	R: fixed, ww, 300 ohms ±5%, 10 W	35434	VIOF	2	2
0816-0007	R: fixed, ww, 7500 ohms ±10%, 10 W	35434	VIOF	1	1
0819-0008	R: fixed, ww, 15,000 ohms ±10%, 20 W	94310	obd#	1	1
1250-0083	Connector - BNC	91737	UG-1094/U	1	1
1251-2357	Connector - power	28018	6061-3	1	1
1400-0084	Holder, fuse	75915	342014	1	1
1450-0013	Lampholder, candelabra	95263	4309-016	1	1
Pending	Binding post - Red	28480	1510-0026	1	1
Pending	Binding post - Black	28480	1510-0027	1	1
1901-0005	Diode, silicon/3ES2	81483	obd#	1	1
1901-0033	Diode	82219	D6238	1	1
1901-0190	Diode	28480	1901-0190	1	1
1923-0009	Tube, electron:6550	80131	6550	2	2
1923-0021	Tube, electron:6AU6	80131	6AU6	1	1
1923-0023	Tube, electron:6AV5GA	80131	6AV5GA	1	1
1923-0025	Tube, electron:6AB6	80131	6AB6	1	1
1923-0030	Tube, electron:6CL6	80131	6CL6	1	1
1930-0008	Tube, electron:5U4CB	80131	5U4CB	1	1
1932-0029	Tube, electron:12AU7	73445	ECC-82/12AU7	1	1
1932-0030	Tube, electron:12AX7	73445	12AX7	4	4
1940-0011	Tube, electron:5651A	80131	5651A	1	1
2100-0053	R: Variable, ww, 10,000 ohms	71590	Type 252	1	1

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

HP PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	RS
2100-0246	R: Var, ww, 10,000 ohms±20%, 2 W	79727	obd#	1	1
2100-0247	R: Var, ww, 25,000 ohms ±10%, 4 W	79727	obd#	1	1
2110-0002	Fuse, cartridge: 2 amp	71400	MDL2	1	10
2110-0055	Fuse, cartridge: 4 amp	71400	MDX-4	1	10
2140-0007	Lamp, incandescent: 250 V, 10 W	24455	8 A/S6-12V	1	1
2140-0009	Lamp, incandescent: 6-8V, . 15 amp,	24455	#47	1	1
3100-0202	Switch, rotary, 2-sect. 6 pos.	71471	obd#	1	1
3100-0866	Switch, Ass'y, Part of the Attenuator Ass'y	28480	3100-0866	1	0
3101-1234	Switch: slide 115/230	82389	11A-1242	1	0
3101-0030	Switch, toggle: SPST, OFF-ON	88140	8835K3	1	1
3140-0010	Motor: fan	28480	3140-0010	1	1
3150-0002	Oil, soluble: for air filter:1-pt. can with spray dispenser	82866	obd#	1	0
3150-0005	Filter, air	82866	obd#	1	1
3160-0014	Blade, fan	06812	obd#	1	1
5080-1277	Binding Post black, gold plated copper body	28480	5080-1277	1	0
5080-1278	Binding Post red, gold plated copper body	28480	5080-1278	1	0
8120-1348	Cable: power	83148	KH 7041	1	1
9100-0082	Transformer, power	28480	9100-0082	1	1
9100-1412	Coil: toroid	28480	9100-1412	1	1
9120-0030	Transformer, output	28480	9120-0030	1	1
9120-0050	Coil: type A-11	89665	obd#	1	1
00738-00202	Panel - sub	28480	00738-00202	1	0
00738-00601	Shield	28480	00738-00601	1	0
00738-04101	Cover	28480	00738-04101	2	0
00738-04401	Frame	28480	00738-04401	1	0
00738-66501	Board Ass'y	28480	00738-66501	1	0
00738-66502	Board Ass'y	28480	00738-66502	1	0
00738-90002	Manual	28480	00738-90002	1	0

See introduction to this section

CODE LIST OF MANUFACTURERS

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.
00287	Cemco Inc.	Danielson, Conn.
00334	Humidial	Colton, Calif.
00348	Microtron Co., Inc.	Valley Stream, N. Y.
00373	Garlock Inc.	Cherry Hill, N. J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp. Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N. J.
00809	Croven Ltd.	Whitby, Ontario Canada
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Co., Pickens Div.	Pickens, S. C.
00866	Goe Engineering Co.	City of Industry, Cal.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
00929	Microlab Inc.	Livingston, N. J.
01002	General Electric Co., Capacitor Dept.	Hudson Falls, N. Y.
01009	Alden Products Co.	Brockton, Mass.
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
01538	Small Parts Inc.	Los Angeles, Calif.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01670	Gudebrod Bros. Silk Co.	New York, N. Y.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N. Y.
02116	Wheelock Signals, Inc.	Long Branch, N. J.
02286	Cole Rubber and Plastics Inc.	Sunnyvale, Calif.
02660	Amphenol-Borg Electronics Corp.	Broadview, 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.
02875	Hudson Tool & Die Co.	Newark, N. J.
03508	G. E. Semiconductor Prod. Dept.	Syracuse, N. Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	Compton, Calif.
03818	Parker Seal Co.	Los Angeles, Calif.
03877	Transition Electric Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N. J.
03954	Singer Co., Diehl Div. Finderne Plant	Somerville, N. J.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N. J.
04062	Arco Electronic Inc.	Great Neck, N. Y.
04217	Essex Wire	Los Angeles, Calif.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S. C.
04354	Precision Paper Tube Co.	Wheeling, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Products, Microwave Device Div.	Mountain View, Calif.
04673	Dakota Engr. Inc.	Culver City, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P. M. Motor Company	Westchester, Ill.
04919	Component Mfg. Service Co.	W. Bridgewater, Mass.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05245	Components Corp.	Chicago, Ill.
05277	Westinghouse Electric Corp. Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05397	Union Carbide Corp., Elect. Div.	New York, N. Y.
05574	Viking Ind. Inc.	Canoga Park, Calif.
05593	Icore Electro-Plastics Inc.	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	Metro-Tel Corp.	Westbury, N. Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	Bassick Co., Div. of Stewart Warner Corp.	Bridgeport, Conn.
06090	Raychem Corp.	Redwood City, Calif.
06175	Bausch and Lomb Optical Co.	Rochester, N. Y.
06402	E. T. A. Products Co. of America	Chicago, Ill.
06540	Amatom Electronic Hardware Co., Inc.	New Rochelle, N. Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N. H.
06666	General Devices Co., Inc.	Indianapolis, Ind.
06751	Components Inc., Ariz. Div.	Phoenix, Ariz.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
06980	Varian Assoc. Eimac Div.	San Carlos, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
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.
07256	Silicon Transistor Corp.	Carle Place, N. Y.
07261	Avnet Corp.	Culver City, Calif.
07263	Fairchild Camera & Inst. Corp. Semiconductor Div.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	Britcher Corp., The	Monterey Park, Calif.
07397	Sylvania Elect. Prod. Inc., Mt. View Operations	Mountain View, Calif.
07700	Technical Wire Products Inc.	Cranford, N. J.
07829	Bodine Elect. Co.	Chicago, Ill.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, Calif.
07980	Hewlett-Packard Co., Boonton Radio Div.	Rockaway, N. J.
08145	U. S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08524	Deutsch Fastener Corp.	Los Angeles, Calif.
08664	Bristol Co., The	Waterbury, Conn.
08717	Sloan Company	Sun Valley, Calif.
08718	ITT Cannon Electric Inc., Phoenix Div.	Phoenix, Arizona
08727	National Radio Lab. Inc.	Paramus, N. J.
08792	CBS Electronics Semiconductor Operations, Div of C. B. S. Inc.	Lowell, Mass.
08806	General Electric Co. Miniat. Lamp Dept.	Cleveland, Ohio
08984	Mel-Ram	Indianapolis, Ind.
09026	Babcock Relays Div.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Tech. Ind. Inc. Atohm Elect.	Burbank, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09353	C & K Components Inc.	Newton, Mass.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
09922	Burndy Corp.	Norwalk, Conn.
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Tri-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.
11242	Bay State Electronics Corp.	Waltham, Mass.
11312	Teledyne Inc., Microwave Div.	Palo Alto, Calif.
11314	National Seal	Downey, Calif.
11453	Precision Connector Corp.	Jamaica, N. Y.
11534	Duncan Electronics Inc.	Costa Mesa, Calif.
11711	General Instrument Corp., Semiconductor Div., Products Group	Newark, N. J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12040	National Semiconductor	Danbury, Conn.
12136	Philadelphia Handle Co.	Camden, N. J.
12361	Grove Mfg. Co., Inc.	Shady Grove, Pa.
12574	Gulton Ind. Inc. Data System Div.	Albuquerque, N. M.
12697	Clarostat Mfg. Co.	Dover, N. H.
12728	Elmar Filter Corp.	W. Haven, Conn.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12881	Metex Electronics Corp.	Clark, N. J.
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
12954	Dickson Electronics Corp.	Scottsdale, Arizona
13019	Airco Supply Co., Inc.	Witchita, Kansas
13103	Thermolloy	Dallas, Texas
13396	Telefunken (GmbH)	Hanover, Germany
13835	Midland-Wright Div. of Pacific Industries, Inc.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14433	ITT Semiconductor, A Div. of Int. Telephone & Telegraph Corp.	West Palm Beach, Fla.
14493	Hewlett-Packard Company	Loveland, Colo.
14655	Cornell Dublier Electric Corp.	Newark, N. J.
14674	Corning Glass Works	Corning, N. Y.
14752	Electro Cube Inc.	San Gabriel, Calif.
14960	Williams Mfg. Co.	San Jose, Calif.
15106	The Sphere Co., Inc.	Little Falls, N. J.
15203	Webster Electronics Co.	New York, N. Y.
15287	Scionics Corp.	Northridge, Calif.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15558	Micron Electronics	Garden City, Long Island, N. Y.
15566	Amprobe Inst. Corp.	Lynbrook, N. Y.
15631	Cabletronics	Costa Mesa, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15801	Fenwal Elect. Inc.	Framingham, Mass.
15818	Ameico Inc.	Mt. View, Calif.
16037	Spruce Pine Mica Co.	Spruce Pine, N. C.
16179	Omni-Spectra Inc.	Farmington, Mich.
16352	Computer Diode Corp.	Lodi, N. J.
16585	Boots Aircraft Nut Corp.	Pasadena, Calif.
16688	Ideal Prec. Meter Co., Inc. De Jur Meter Div.	Brooklyn, N. Y.
16758	Delco Radio Div. of G. M. Corp.	Kokoma, Ind.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
17554	Components Inc.	Biddeford, Ma.
17675	Hamlin Metal Products Corp.	Akron, Ohio
17745	Angstrohm Prec. Inc.	No. Hollywood, Calif.
17856	Siliconix Inc.	Sunnyvale, Calif.

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
17870	McGraw-Edison Co.	Manchester, N.H.
18042	Power Design Pacific Inc.	Palo Alto, Calif.
18083	Clevite Corp., Semiconductor Div.	Palo Alto, Calif.
18324	Signetics Corp.	Sunnyvale, Calif.
18476	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
18486	TRW Elect. Comp. Div.	Des Plaines, Ill.
18583	Curtis Instrument, Inc.	Mt. Kisco, N.Y.
18612	Vishay Instruments Inc.	Malvern, Pa.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
18911	Durant Mfg. Co.	Milwaukee, Wis.
19315	The Bendix Corp., Navigation & Control Div.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19589	Concoa	Baldwin Park, Calif.
19644	LRC Electronics	Horseheads, N.Y.
19701	Electra Mfg. Co.	Independence, Kansas
20183	General Atronics Corp.	Philadelphia, Pa.
21226	Executone, Inc.	Long Island City, N.Y.
21335	Fafnir Bearing Co., The	New Britain, Conn.
21520	Fansteel Metallurgical Corp.	N. Chicago, Ill.
23042	Texscan Corp.	Indianapolis, Ind.
23783	British Radio Electronics Ltd.	Washington, D.C.
24455	G.E. Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
24681	Memcor Inc., Comp. Div.	Huntington, Ind.
24796	Pareico Inc.	San Juan Capistrano, Calif.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26851	Compac/Hollister Co.	Hollister, Calif.
26992	Hamilton Watch Co.	Lancaster, Pa.
27251	Specialities Mfg. Co., Inc.	Stratford, Conn.
28480	Hewleit-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
30817	Instrument Specialties Co., Inc.	Little Falls, N.J.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Coil Products Ltd.	Hawkesbury, Ontario, Canada
36287	Cunningham, W.H. & Hill, Ltd.	Toronto 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.
46384	Penn Eng. & Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer & Inst. Co.	Southampton, Pa.
49956	Microwave & Power Tube Div.	Waltham, Mass.
52090	Rowan Controller Co.	Westminster, Md.
52983	Sanborn Company	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Raytheon Co. Commercial Apparatus & Systems Div.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex Corp.	Tulsa, Okla.
59730	Thomas & Betts Co.	Elizabeth, N.J.
60741	Triplett Electrical Inst. Co.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, 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. Inc. Weston-Newark	Newark, N.J.
66295	Wittek Mfg. Co.	Chicago, Ill.
66346	Minnesota Mining & Mfg. Co. Revere Mincom Div.	St. Paul, Minn.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control	New York, N.Y.
70318	Allmetal Screw Product Co., Inc.	Garden City, N.Y.
70417	Amplex, Div. of Chrysler Corp.	Detroit, Mich.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	Union City, N.J.
70674	ADC Products Inc.	Minneapolis, Minn.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71034	Bliley Electric Co., Inc.	Erie, Pa.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionics Corp.	Cambridge, Mass.
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Cardwell Condenser Corp.	Lindenhurst, L.I., N.Y.
71400	Bussmann Mfg. Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71447	Calif. Spring Co., Inc.	Pico-Rivera, Calif.
71450	CTS Corp.	Elkhart, Ind.
71468	ITT Cannon Electric Inc.	Los Angeles, Calif.
71471	Cinema, Div. Aerovox Corp.	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	Cornish Wire Co., The	New York, N.Y.
71707	Coto Coil Co., Inc.	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co., Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	Indiana General Corp., Electronics Div.	Keasby, N.J.
72699	General Instrument Corp., Cap. Div.	Newark, N.J.
72765	Drake Mfg. Co.	Harwood Heights, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72962	Elastic Stop Nut Corp.	Union, N.J.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Technological Products, Inc.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Inst., Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Elect Co.	Hicksville, L.I., N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73586	Circle F Mfg. Co.	Trenton, N.J.
73682	George K. Garrett Co., Div. MSL Industries Inc.	Philadelphia, Pa.
73734	Federal Screw Products Inc.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	General Industries Co., The	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Corp.	San Jose, Calif.
73957	Groov-Pin Corp.	Ridgefield, N.J.
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.
75263	Keystone Carbon Co., Inc.	St. Marys, Pa.
75378	CTS Knights Inc.	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	General Instrument Corp., Micamold Division	Newark, N.J.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Cinch-Monadnock, Div. of United Carr Fastener Corp.	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76703	National Union	Newark, N.J.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	The Bendix Corp., Electrodynamics Div.	N. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phanostran Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine & Foundry Co. Potter & Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77638	General Instrument Corp., Rectifier Div.	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.
78277	Sigma	So. Braintree, Mass.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78424	Specialty Leather Prod. Co.	Newark, 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	San Gabriel, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79136	Waldes Kohinoor Inc.	Long Island City, N.Y.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continential-Wirl Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80033	Prestole Corp.	Toledo, Ohio
80120	Schnitzer Alloy Products Co.	Elizabeth, N.J.
80131	Electronic Industries Association. Any brand Tube meeting EIA Standards-Washington, DC.	
80207	Unimax Switch, Div. Maxon Electronics Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Controls Co.	Columbus, Ohio

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Label Co.	Monrovia, Calif.
80583	Hammarlund Co., Inc.	Mars Hill, N.C.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
80813	Dimco Gray Co.	Dayton, Ohio
81030	International Instruments Inc.	Orange, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Elec. Div. Litton Ind., Inc.	Oakville, Conn.
81349	Military Specification	
81483	International Rectifier Corp.	El Segundo, Calif.
81541	Airpax Electronics, Inc.	Cambridge, Maryland
81860	Barry Controls, Div. Barry Wright Corp.	Watertown, Mass.
82042	Carter Precision Electric Co.	Skokie, Ill.
82047	Sperb Faraday Inc., Copper Hewitt Electric Div.	Hoboken, N.J.
82116	Electric Regulator Corp.	Norwalk, Conn.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Fairchild Camera & Inst. Corp. Space & Defense System Div.	Paramus, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Division	Emporium, Pa.
82376	Astron Corp.	East Newark, Harrison, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals & Controls Inc. Spencer Products	Attleboro, Mass.
82768	Phillips-Advance Control Co.	Joliet, Ill.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83014	Hartwell Corp.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	General Instrument Corp., Capacitor Div.	Darlington, S.C.
83148	ITT Wire and Cable Div.	Los Angeles, Calif.
83186	Victory Eng. Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83324	Rosan Inc.	Newport Beach, Calif.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83332	Tech Labs	Palisade's Park, N.J.
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	Union Carbide Corp. Consumer Prod. Div.	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
83942	Aeronautical Inst. & Radio Co.	Lodi, N.J.
84171	Arco Electronics Inc.	Great Neck, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	TRW Capacitor Div.	Ogallala, Nebr.
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 Koids, Inc.	Hamden, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86174	Fafnir Bearing Co.	Los Angeles, Calif.
86197	Clifton Precision Products Co., Inc.	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, Electronic Comp. & Devices Div.	Harrison, N.J.
86928	Seastrom Mfg. Co.	Glendale, Calif.
87034	Marco Industries	Anaheim, Calif.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	San Francisco, Calif.
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.
89473	G.E. Distributing Corp.	Schenectady, N.Y.
89665	United Transformer Co.	Chicago, Ill.
90030	United Shoe Machinery Corp.	Beverly, Mass.
90179	US Rubber Co., Consumer Ind. & Plastics Prod. Div.	Passaic, N.J.
90763	United Carr Fastener Corp.	Chicago, Ill.
90970	Bearing Engineering Co.	San Francisco, Calif.
91146	ITT Cannon Elect, Inc., Salem Div.	Salem, Mass.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Willow Grove, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91886	Malco Mfg. Co., Inc.	Chicago, Ill.
91929	Honeywell Inc., Micro-Switch Div.	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92367	Elgeet Optical Co. Inc.	Rochester, N.Y.
92607	Tensolite Insulated Wire Co., Inc.	Tarrytown, N.Y.
92702	IMC Magnetics Corp.	Wesbury Long Island, N.Y.
92966	Hudson Lamp Co.	Kearney, N.J.
93332	Sylvania Electric Prod. Inc. Semiconductor Div.	Woburn, Mass.
93369	Robbins & Myers Inc.	Palisades Park, N.J.
93410	Stemco Controls, Div. of Essex Wire Corp.	Mansfield, Ohio
93632	Waters Mfg. Co.	Culver City, Calif.
93929	G.V. Controls	Livingston, N.J.
94137	General Cable Corp.	Bayonne, N.J.
94142	Phelps Dodge	Yonkers, N.Y.
94144	Raytheon Co., Comp. Div., Ind. Comp. Operations	Quincy, Mass.
94148	Scientific Electronics Products, Inc.	Loveland, Colo.
94154	Wagner Elect. Corp., Tung-Sol Div.	Newark, N.J.
94197	Curtiss-Wright Corp. Electronics Div.	East Paterson, N.J.
94222	South Chester Corp.	Chester, Pa.
94330	Wire Cloth Products, Inc.	Bellwood, Ill.
94375	Automatic Metal Products Co.	Brooklyn, N.Y.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
94696	Magnecraft Electric Co.	Chicago, Ill.
95023	George A. Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.,	Dania, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	Long Island, N.Y.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordos Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Rolling Meadows, Ill.
95566	Arnold Engineering Co.	Marengo, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95984	Sremon Mfg. Co.	Wayne, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Microwave Assoc., West Inc.	Sunnyvale, Calif.
96095	Hi-Q Div. of Aerovox Corp.	Olean, N.Y.
96256	Thordarson-Meissner Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96306	Microswitch, Div. of Minn.-Honeywell	Freeport, Ill.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
96508	Xcelite Inc.	Orchard Park, N.Y.
96733	San Fernando Elect. Mfg. Co.	San Fernando, Calif.
96881	Thomson Ind. Inc.	Long Is., N.Y.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic & Precision Mfg.	Englewood, N.J.
97979	Reon Resistor Corp.	Yonkers, N.Y.
97983	Litton System Inc., Adler-Westrex Commun. Div.	New Rochelle, N.Y.
98141	R-Troncis, Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.
98220	Hewlett-Packard Co., Moseley Div.	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98376	Zeric Mfg. Co.	Burbank, Calif.
98410	Etc Inc.	Cleveland, Ohio
98731	General Mills Inc., Electronics Div.	Minneapolis, Minn.
98734	Paeco Div. of Hewlett-Packard Co.	Palo Alto, Calif.
98821	North Hills Electronics, Inc.	Glen Cove, N.Y.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99378	Atlee Corp.	Winchester, Mass.
99515	Marshall Ind., Capacitor Div.	Monrovia, 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.
99928	Branson Corp.	Whippany, N.J.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Electronics Corp. Semiconductor Div.	El Monte, Calif.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

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

0000F	Malco Tool and Die	Los Angeles, Calif.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AB	ETA	England
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CS	Hewlett-Packard Co., Colorado Springs	Colorado Springs, Colorado
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Mfg. Co.	San Jose, Calif.
000QQ	Cooltron	Oakland, Calif.
000WW	California Eastern Lab.	Burlington, Calif.
000YY	S.K. Smith Co.	Los Angeles, Calif.