INSTRUCTION MANUAL

Type 1808
Ac Millivoltmeter

A

GENERAL RADIO

Contents

WARRANTY

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, District Office, or authorized repair agency personnel will be repaired or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

Type 1808 Ac Millivoltmeter

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West Concord, Massachusetts, U.S.A. 01781
Form 1808-0100-A
March, 1970
ID-0200

Specifications

Range: 150 μV to 150 V (to 1500 V with X 100 probe) in six 20-dB ranges. *Overload*, 100 V max on 1.5-mV to 1.5-V full-scale ranges up to 10 kHz, decreasing linearly to 10 V max at 10 MHz; 200 V max on 15-V and 150-V ranges.

Input Impedance: 10 MΩ//10 pF except 12.5 MΩ on 15-V and 150-V ranges.

DC Output: > 1 V dc for full-scale deflection. Output resistance, 10 kΩ.

Accuracy (for dc output and full-scale meter reading; for less-than-full-scale reading, add meter-tracking accuracy):

	10 Hz to 40 Hz	40 Hz to 0.5 MHz	0.5 MHz to 4 MHz
1.5-mV range	±(3% of reading +0.2% of full scale)	±(2% of reading +0.1% of full scale)	±(3% of reading +0.2% of full scale +0.05% of reading/ °C)
	10 Hz to 40 Hz	40 Hz to 5 MHz	5 MHz to 10 MHz
15-mV to 150-V ranges	±(2% of reading +0.3% of full scale)	±(1% of reading +0.1% of full scale)	±(3% of reading +0.3% of full scale)

Meter-Tracking Accuracy: 0.15% of full scale from 0 to 0.15, 1.5% of reading from 0.15 to 0.5, 1% of reading from 0.5 to 1.5.

Power: 100 to 125 or 200 to 250 V, 50-400 Hz, 10 W.

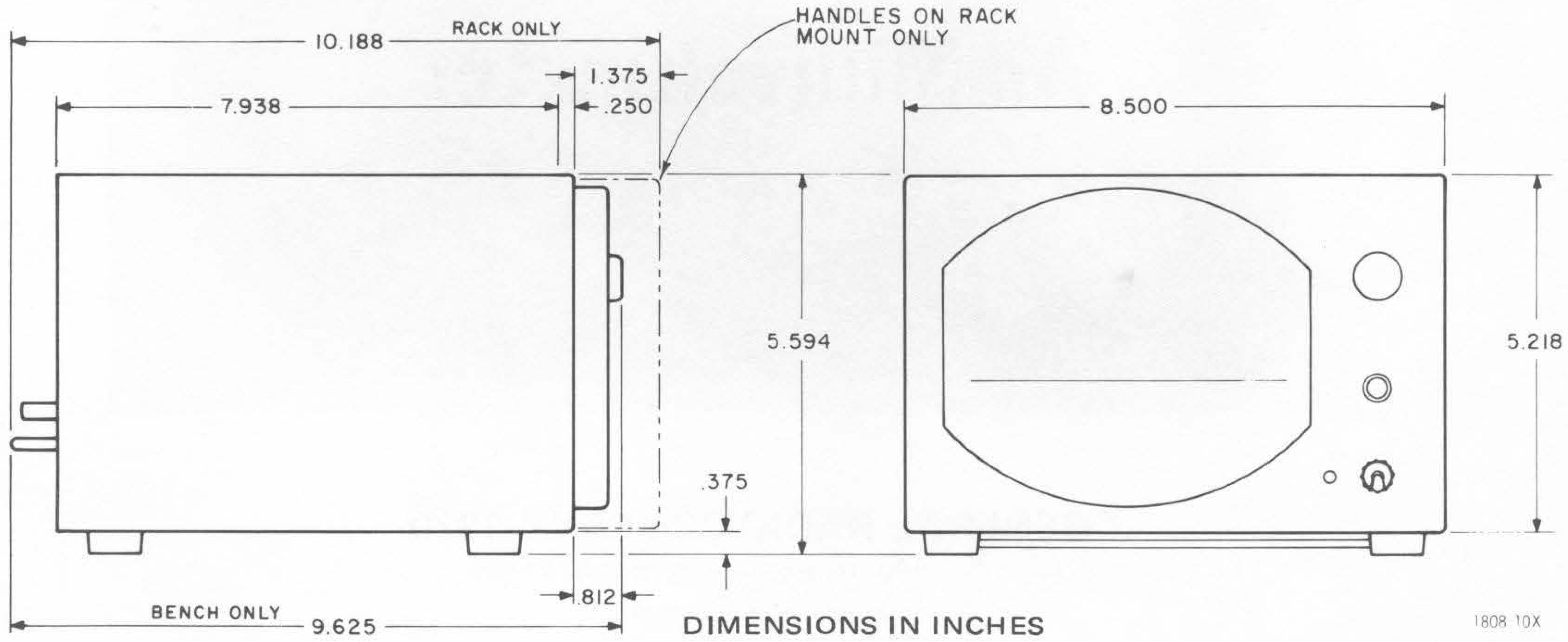
Supplied: Power cable.

Available: 0480-9723 Rack Adaptor Set, 1808-P1 Probe Adaptor to permit use of Tektronix voltage probes.

Mechanical: Convertible-bench cabinet. *Dimensions* (w x h x d): Bench, 8.5 x 5.594 x 9.625 in. (216 x 142 x 244 mm); rack, 19 x 5.218 x 10.188 in. (483 x 133 x 259 mm). *Weight:* Bench, 6.5 lb (3 kg) net, 9.5 lb (4.4 kg) shipping; rack 9.75 lb (4.5 kg) net, 12.75 lb (6 kg) shipping.

Catalog Number	Description
	1808 AC Millivoltmeter
1808-9700	Bench Model
1808-9701	Rack Model
1808-9600	**1808-P1 Probe Adaptor**
0480-9723	**Rack Adaptor Set**

See *General Radio Experimenter,* November-December 1969.



DIMENSIONS IN INCHES

Introduction—Section 1

1.1 PURPOSE.

The 1808 Ac Millivoltmeter (Figure 1-1) is a wide-band, average-reading instrument calibrated to read rms sine-wave and dBm values ranging from 150-μV to 150-V full scale in six discrete 20-dB ranges (or to 1500-V full scale with an external probe and adaptor). The instrument will accurately measure sine-waves within a bandwidth ranging from 10 Hz to 10 MHz on the 15-mV through 150-V ranges, and to 4 MHz on the 1.5-mV range. In addition, the unit possesses a wide 20-dB dynamic range per range, which makes it ideal for such applications as amplifier-response measurements, attenuator-calibration, and high-resolution ac measurements.

The front panel contains a large 5½-in meter calibrated in ac volts and dBm. A panel switch selects any of six 20-dB operating ranges. Voltage levels within these ranges can be read directly on the meter face or coupled through rear-panel FLOATING DC OUTPUT connectors to other high-resolution devices, such as the GR 1807 Dc Microvoltmeter/Nanoammeter, where 0.1% resolution is required, or a GR 1522 Dc recorder, if a permanent recording is desired.

1.2 DESCRIPTION.

The 1808 is contained in a metal cabinet ready for bench use. A rack adaptor set (P/N 0480-9723) is available for installation of the instrument in an EIA standard 19-in. relay rack, when required.

An easily accessible etched-circuit board within the instrument contains the majority of electrical components. Signal inputs are coupled through a standard BNC INPUT jack mounted on the front panel (or an additional INPUT connector that can be added to the rear panel for rack installations). A solid-state power supply delivers all operating voltages and is controlled by a front-panel POWER switch. The instrument can be operated from either 100-125 V or 200-250 V, 50-400 Hz.

1.3 CONTROLS, INDICATORS, AND CONNECTORS.

Table 1-1 lists the function of front-panel controls, indicators, and connectors shown in Figure 1-1. Table 1-2 lists the function of all rear panel controls, and connectors shown in Figure 1-2.

1.4 ACCESSORIES SUPPLIED.

A 3-wire, 7-ft power cord (P/N 4200-9622) is supplied with the instrument.

1.5 ACCESSORIES AVAILABLE.

Table 1-3 lists the accessories and related equipment available.

A series of accessory Tektronix voltage probes may be used with the 1808 to extend the range of the instrument to 1500-V full scale or measure compact circuitry. An accessory 1808-P1 Probe Adaptor is available for use with the voltage probes. The probe adaptor matches the 1 MΩ resistance of the voltage probe selected to the 1808 input circuits. While General Radio does not supply the voltage probes, the 1808-P1 Probe Adaptor, which must be used with the probes, is available. Special adaptor brackets are provided at the rear of the instrument to hold the probe adaptor when not in use.

Table 1-3

ACCESSORIES AND RELATED EQUIPMENT AVAILABLE

Name	Type or Part No.	Function
Rack Adaptor Set	GR P/N 0480-9723	Rack mount instrument
Voltage probes	*Tektronix type: P6009 X100 Voltage probe.	Used with GR 1808-P1 Probe Adaptor to extend the 1808 range to 1500 V full scale.
	P6006, P6008, P6012 X10 Voltage probes	Used with GR 1808-P1 Probe Adaptor for applications requiring a X10 Voltage probe.
	P6011 X1 Voltage probe	Used with GR 1808-P1 Probe Adaptor for any application requiring a X1 voltage probe
1808-P1 Probe Adaptor	GR P/N 1808-9600	Provides correct impedance match between Tektronix voltage probes and 1808 input circuits.
1807 Dc Microvoltmeter/ Nanoammeter	GR P/N 1807-9700	High resolution measurement of 1808 FLOATING DC OUTPUT voltage.
1522 Dc Recorder	GR P/N 1522-9700	High-resolution permanent recording of 1808 FLOATING DC OUTPUT voltage or 1807 output.
Automatic Voltage Regulator	GR P/N 1591-9700	Automatic regulation of line voltage

*Probes not supplied by General Radio. Consult Tektronix specifications to obtain voltage ratings and operating frequencies of probes listed.

Installation–Section 2

2.1 GENERAL.

The 1808 Ac Millivoltmeter is available in either bench- or rack-mounted configurations. Bench models are equipped with a supporting bail that allows the instrument to be tilted for a more advantageous view of operating controls. Both models are equipped with an easily accessible INPUT connector mounted on the front panel. In addition, a rear panel plastic plug covers a prepunched hole that will easily accept another INPUT connector, if required for rack operation.

2.2 DIMENSIONS.

An outline drawing showing overall dimensions of the Type 1808 in bench and rack configurations is shown with the specifications at the front of the manual.

2.3 ELECTRICAL CONNECTIONS.

The 1808 operates on 50- to 400-Hz line voltages of either 100 to 125 V or 200 to 250 V, depending on the setting of the line-voltage switch on the rear panel.

Set the line-voltage switch for the appropriate line-voltage provided, using a narrow-blade screwdriver, and connect the 3-wire power cord to the line and 3-terminal male connector on the rear panel.

2.4 BENCH MOUNTING.

To set the instrument in a tilted position, pull the bail between the front feet down as far as possible.

2.5 RACK MOUNTING.

2.5.1 Single Instrument.

With the Rack Adaptor Set, P/N 0480-9723, the 1808 portable bench model can be converted for use in an EIA standard 19-in. relay rack. Table 2-1 lists the parts included in the Rack Adaptor Set.

Table 2-1

PARTS INCLUDED IN THE RACK ADAPTOR SET, P/N 0480-9723 (see Figure 2-1)

Fig. 2-1 Ref.	No. Used	Item	GR Part No.
E	1	Blank Panel	0480-8933
D	1	Sub-Panel	0480-8953
–	2	Rack Adaptor Assembly	0480-4903
H	1	Support Bracket	0480-8524
–	1	Hardware Set includes	0480-3080
F, J, K, L, M,		8 Screws, BH 10-32, 5/16 in.	
N		4 Screws, BH 10-32, 9/16 in. w. nylon cup washers	

Mount the instrument as follows (see Figure 2-1):

a. Loosen the two captive 10/32 screws in the rear of the cabinet until the chassis is free; slide the chassis forward, out of the cabinet.

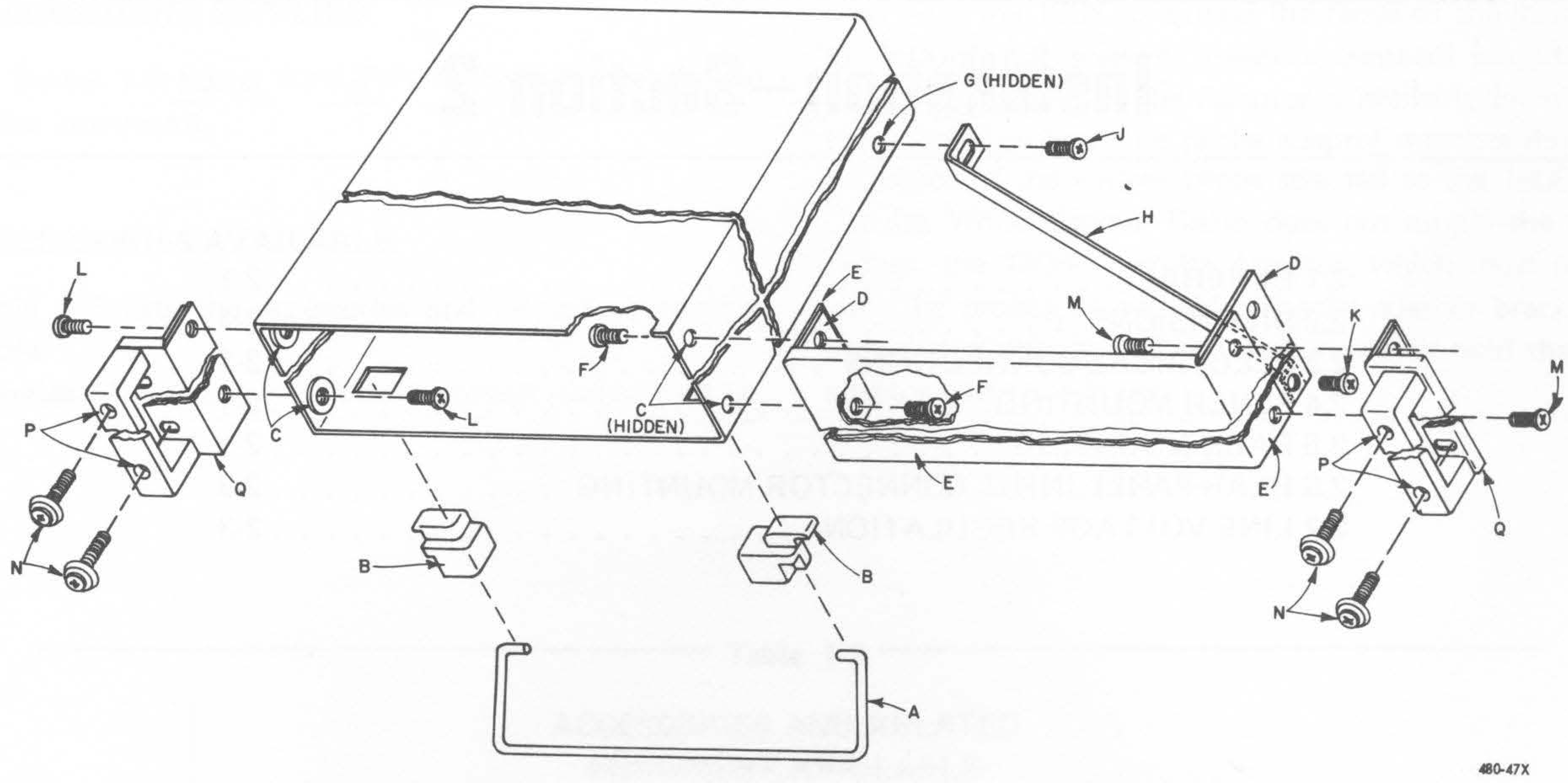


Figure 2-1. Method of mounting the 1808 and a blank panel in a relay rack.

b. Remove the four rubber feet from the cabinet. Simply push out the two rear feet. Spread the bail (A, Figure 2-1) slightly and the two front feet (B) and the bail will drop out. Be sure to save all parts as they are removed for possible reconversion of the instrument to bench mounting.

c. Pierce and push out the plugs from the four bosses (C) on the inner sides of the cabinet, near the front.

d. Press the subpanel (D) into the blank panel (E) to form a support liner for the latter.

e. Attach the short flange of the blank panel to the front of the cabinet (on either side of the cabinet, as desired) using two 5/16-in. screws (F). Note that the screws enter in opposite directions – one from inside the cabinet and one from the flange side, as shown.

f. Pierce and push out the plug in the rear boss (G) *on the side toward the blank panel only,* as shown.

g. Attach one end of the support bracket (H) to the lower rear boss. The bracket must be placed so that the screw passes through a clearance hole into a tapped hole.

h. Attach the other end of the support bracket to the lower rear hole in the wide flange, as shown, using a 5/16-inch screw (K).

i. Attach one Rack-Adaptor Assembly (handle) to the side of the cabinet opposite the blank panel using two 5/16-inch screws (L). Again note that the screws enter in opposite directions, one from inside the cabinet and one from outside. Use the upper and lower holes in the assembly.

j. Attach the other Rack-Adaptor Assembly (handle) to the wide flange on liner (D) and the flange on the blank panel (E). Use two 5/16-inch screws (M) through the two flange holes nearest the panel and through the upper and lower holes in the handle. Again, the screws enter in the opposite directions.

k. Install the instrument in the cabinet and lock it in place with the two captive screws in the rear that were loosened in step a.

l. Place a straight edge across both the instrument panel and the blank panel. Loosen the screw (J) ***through the slot*** in the support bracket (H). Exert a slight pressure on the blank panel (E) so that it forms a straight line with the instrument panel, and tighten the screw (J) in the bracket to lock the panels in this position.

m. Slide the entire assembly into the relay rack and lock it in place with the four 9/16-in. screws (N) with captive nylon cup washers. Use two screws on each side and tighten them by inserting a screwdriver through the holes (P) in the handles.

2.5.2 Reconversion to Bench Mounting.

a. To reconvert the instrument for bench use, reverse the procedures of paragraph 2.5.1 first removing the entire assembly of instrument, cabinet, and blank panel from the rack.

b. Remove:

1. Chassis from the cabinet.
2. Support bracket (H) from the cabinet.
3. Blank panel (with handle attached) from one side of the cabinet.
4. Rack-adaptor set (handle) from the other side of the cabinet.

c. Push the two rear feet into the cabinet, and slide the bail (A) and two front feet (B) into place. Install the instrument in its cabinet and lock it in place with the two captive screws through the rear panel.

2.5.3 Rack-Mounting Two Instruments.

Two instruments of the same panel size (such as two 1808's can be mounted side-by-side in a standard 19-in. relay rack. Use the procedure of paragraph 2.5.1, substituting the second instrument for the blank panel. Do not use the support bracket (H, Figure 2-1), but insert three screws through the bosses in the adjacent sides of the cabinet, two near the front (C) and one near the rear (G). The four feet and the bail must, of course, be removed from each cabinet. Use the four screws (N) with nylon washers to lock the instruments in the rack. The required hardware is:

1. Three screws, BH 10-32, 5/16 in.
2. Four screws, BH 10-32, 9/16 in., with nylon washers.

2.6 REAR-PANEL INPUT CONNECTOR MOUNTING.

If desired, an additional BNC INPUT connector can be mounted at the rear of the instrument and wired in parallel with the existing front-panel INPUT connector. A prepunched chassis hole covered by a plastic plug insert (4, Figure 1-2), is provided for this purpose. The chassis will accept a UG-1094 /U BNC jack or equivalent. Make sure that the jack utilized is isolated from the instrument chassis through the use of suitable insulating materials such as nylon insulating bushings. When installed, the jack can be wired in a parallel configuration with the front panel INPUT jack using an 8 1/2-in. length of RG-59/U coaxial cable or equivalent.

2.7 LINE-VOLTAGE REGULATION.

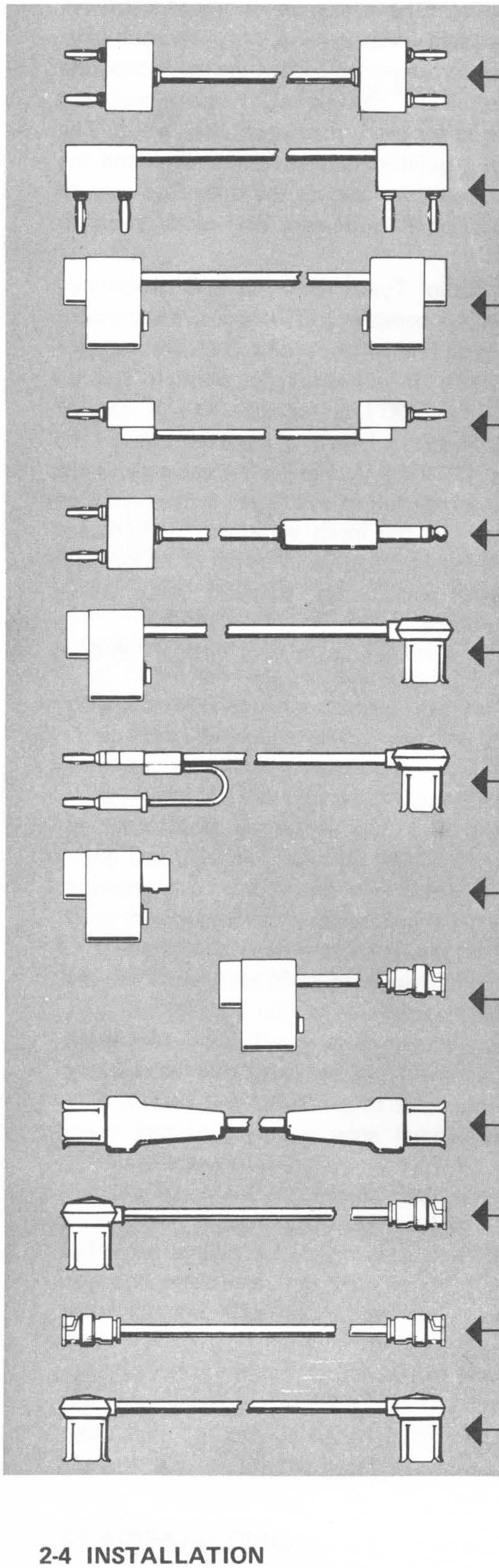
The accuracy of measurements accomplished with precision electronic test equipment operated from ac line sources can often be seriously degraded by fluctuations in primary input power. Line-voltage variations of ±15% are commonly encountered, even in laboratory environments. Although most modern electronic instruments incorporate some degree of regulation, possible power-source problems should be considered for every instrumentation setup. The use of line-voltage regulators between power lines and the test equipment is recommended as the only sure way to rule out the effects on measurement data of variations in line voltage.

The General Radio Type 1591 Variac® Automatic Voltage Regulator is a compact and inexpensive equipment capable of holding ac line voltage within 0.2% accuracy for input ranges of ±13%. It will assure, for example, that an instrument rated for 100-125 (or 200-250) V can be operated reliably in spite of varying input voltages in the range 85-135 (or 170-270) V. The 1 kVA capacity of the 1591 will handle a rack full of solid-state instrumentation with no distortion of the input waveform. This rugged electromechanical regulator comes in bench or rack-mount versions, each with sockets for standard 2- or 3-wire instrument power cords.

Further details can be found in your GR catalog or in the *GR Experimenter* for October, 1967.

Table 2-2

AVAILABLE INTERCONNECTION ACCESSORIES



TYPE NO.	DESCRIPTION	CATALOG NO.
274-NQ	Double-plug patch cord, in-line 36" long	0274-9860
274-NQM	Double-plug patch cord, in-line 24" long	0274-9896
274-NQS	Double-plug patch cord, in-line 12" long	0274-9861
274-NP	Double-plug patch cord, right-angle 36" long	0274-9880
274-NPM	Double-plug patch cord, right-angle 24" long	0274-9892
274-NPS	Double-plug patch cord, right-angle 12" long	0274-9852
274-NL	Shielded double-plug patch cord, 36" long	0274-9883
274-NLM	Shielded double-plug patch cord, 24" long	0274-9882
274-NLS	Shielded double-plug patch cord, 12" long	0274-9862
274-LLB	Single-plug patch cord, black, 36" long	0274-9468
274-LLR	Single-plug patch cord, red, 36" long	0274-9492
274-LMB	Single-plug patch cord, black, 24" long	0274-9847
274-LMR	Single-plug patch cord, red, 24" long	0274-9848
274-LSB	Single-plug patch cord, black, 12" long	0274-9849
274-LSR	Single-plug patch cord, red, 12" long	0274-9850
1560-P95	Adaptor cable, double-plug to telephone plug, 36"	1560-9695
874-R34	Coaxial patch cord, double plug to GR874, 36" long	0874-9692
874-R33	Coaxial patch cord, two plugs to GR874, 36" long	0874-9690
274-QBJ	Adaptor, shielded double plug to BNC jack	0274-9884
776-A	Patch cord, shielded double plug to BNC plug, 36" long	0776-9701
874-R22A	Coaxial patch cord GR874 to GR874, 36" long	0874-9682
776-B	Patch cord, GR874 (right-angle) to BNC plug, 36" long	0776-9702
776-C	Patch cord, BNC plug to BNC plug, 36" long	0776-9703
776-D	GR874 to GR874, both right-angle, 36" long	0776-9704

274-13XA

Operation—Section 3

CAUTION

Do not apply more than 100-V on the 1.5-mV, 15-mV, 150-mV, and 1.5-V ranges, or more than 200-V on the 15-V, and 150-V ranges without an external probe and 1808-P1 Probe Adaptor or equipment damage could result.

3.1 GENERAL.

This section contains operating instructions for the millivoltmeter together with a description of some of the applications in which the instrument can be used.

3.1.1 Equipment Turn-on.

To prepare the instrument for use, perform the following steps:

a. Set the rear panel line-voltage selector switch to the line-voltage used (100-125 V or 200-250 V, 50-400 Hz), and connect the instrument to the power line, using the power cable supplied.

b. Set the POWER switch to POWER. The white power lamp should glow. Refer to the appropriate paragraph in this section for instructions covering the type of measurement desired (voltage or dBm).

3.1.2 Meter Zeroing.

NOTE

If a static charge on the 1808 meter cover is suspected, wet the cover with an anti-static solution such as Weston Statnul* or equivalent.

The 1808 Ac Millivoltmeter has been zeroed at the factory. If re-zeroing should become necessary, proceed as follows:

a. Set the POWER switch to OFF. The white power lamp should extinguish.

b. Allow at least two minutes for the meter indicator to stabilize near the zero point. Gently tap the meter face occasionally during adjustment.

c. Adjust the meter zero adjust screw (6, Figure 1-1) for a zero indication. The position of the range-selector switch is not critical for this adjustment.

3.2 VOLTAGE MEASUREMENTS.

3.2.1 Use of Voltage Probes and Probe Adaptor.

An 1808-P1 accessory probe adaptor is available for use with a series of Tektronix voltage probes. The probe adaptor is an impedance matching device that will adequately match the probes to the instrument.

Table 1-3 lists Tektronix voltage probes that can be used with the 1808-P1 Probe Adaptor To measure voltages with the probe selected, proceed as follows:

a. Remove the 1808-P1 Probe Adaptor from the mounting clips (1, Figure 1-2) at the rear of the instrument, and attach it to the INPUT jack.

b. Connect the voltage probe selected to the probe adaptor.

c. Check that the X100 and X10 voltage probes have been compensated for high frequency response before use (X1 voltage probes do not require compensation). The voltage probe is frequency compensated while attached to the 1808-P1 Probe Adaptor and instrument. Once compensation has been accomplished, the

* Registered Trademark of Weston Instruments, Inc.

procedure does not have to be repeated, unless another voltage probe is used or probe compensation is changed for any reason (refer to para. 5-4).

d. Set the range-selector switch to the desired voltage range.

e. Attach the voltage probe to the unknown signal and read the meter scale, taking into account the position of the range switch.

3.2.2 Use Without Voltage Probe.

The signal to be measured can be coupled directly to the 1808 INPUT jack. A series of interconnecting patch cords and adaptors are available for this purpose (refer to Table 2-2). To measure voltage without a voltage probe, proceed as follows:

a. Set the range-selector switch to the desired voltage range.

b. Connect the unknown signal to the 1808 INPUT jack, and read the meter scale, taking into account the position of the range switch.

3.3 dBm MEASUREMENTS.

The meter reads dBm (0 dBm = 1 mW into 600 Ω) and can be read directly when the range selector switch is set to the 1.5 V 0 dB range.

If the range-selector switch is set to another position, subtract or add the range-switch dBm marking from the dBm meter reading to determine the correct output in dBm. As an example, if the range-selector switch is set to the 150 mV, –20 dBm range, the meter dBm reading obtained would be added to or subtracted from –20 dBm (depending on whether the meter reading was + or – dBm). If the range-selector switch is set to the 15 V, +20 dBm range, the meter dBm reading obtained would be added to or subtracted from +20 dBm.

3.4 HIGH RESOLUTION MEASUREMENTS.

If it is desired to obtain ac measurements with a higher resolution than the meter will provide, accessory equipment can be connected to the rear chassis FLOATING DC OUTPUT connectors (2, 3, Figure 1-2). Some possible equipment configurations are listed in the following paragraphs.

NOTE

The FLOATING DC OUTPUT connectors are isolated from the instrument chassis. If one of the terminals is grounded, accuracy will deteriorate.

3.4.1 GR 1807 Dc Microvoltmeter/Nanoammeter.

This instrument contains an interpolation feature that will enable the user to read the dc output voltage from the 1808 with 0.1% resolution, if desired.

Before attempting to use the 1807, make sure there is sufficient output to be measured, as indicated by some deflection on the 1808 meter scale. Always take into account the position of the 1808 range selector switch when noting meter indications.

Since the dc output of the 1808 is greater than 1-V for a full scale meter deflection, a voltage divider should be connected between the 1808 output and the INPUT terminals of the 1807. The voltage divider can be set to provide full scale deflection of the 1807 meter for a corresponding full scale deflection of the 1808 meter scale. A suitable test set up is shown in Figure 5-1. Use all instruments, adaptors, and patchcords listed for the 1 kHz signal source test except the digital voltmeter. Replace the digital voltmeter with the 1807. The greater than 1-V output of the 1808 is limited by the voltage divider circuits to a 150 mV signal that will provide full scale deflection of the 1807. Once both instruments have been calibrated for full scale deflection, the 1807 can be used to monitor the dc output voltage from the 1808 in either the direct or interpolate mode.

3.4.2 GR 1522 Dc Recorder.

This instrument can be coupled directly to the 1808 to obtain a permanent recording of the dc output voltage or it can be coupled to the 1807 Microvoltmeter/Nanoammeter to record the output of that instrument.

Accessory patchcords suitable for coupling any of the instruments together are listed in Table 2-2. Make sure the 1808 dc output voltage is floating at all times. Do not ground this output to the chassis of any instrument.

3.5 APPLICATIONS.

3.5.1 General.

The 1808 is a general-purpose instrument for laboratory and production-test applications. Some typical applications are described in the following paragraphs.

3.5.2 Operational Amplifier Measurements.

The 1808 can be used to measure the frequency at which the second breakpoint of an operational amplifier occurs (f_2, Figure 3-1). The 10-MHz bandwidth of the instrument makes it ideal for this type of measurement.

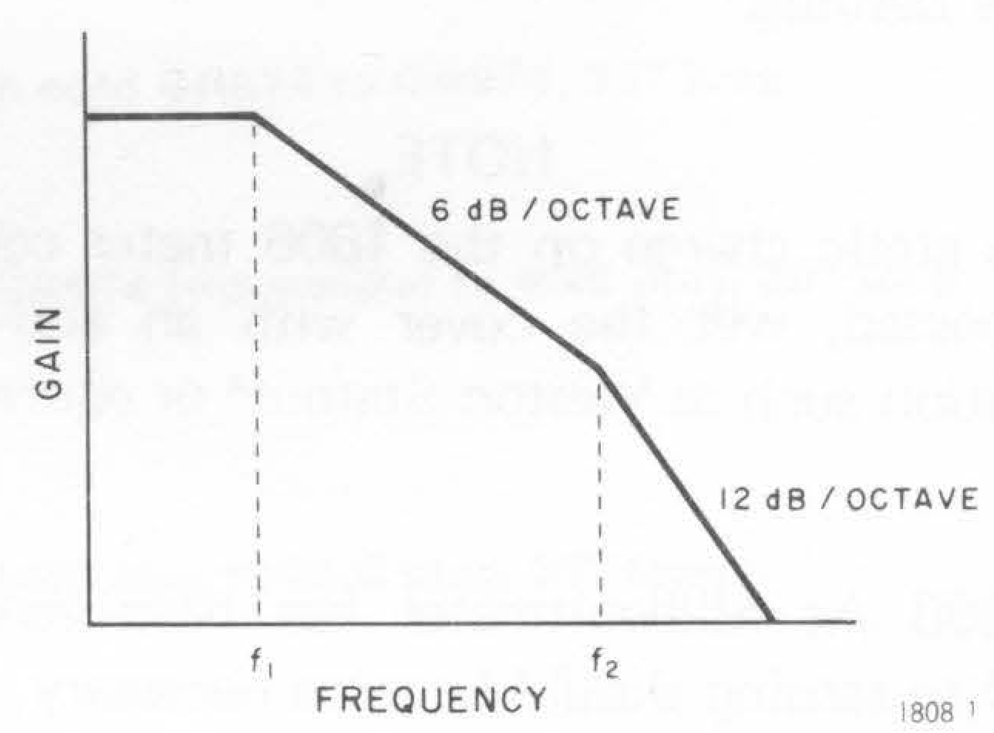


Figure 3-1. A typical operational amplifier open loop frequency response curve.

3.5.3 Attenuator Testing and Calibration.

The wide dynamic range and wide bandwidth of the 1808 make it ideal for attenuator calibration or testing.

The range-selector switch is divided into six discrete 20-dB ranges, thus making it unnecessary to change ranges when testing 10- or 20-dB attenuators. For higher-value attenuators, a minimum amount of range changing is involved.

3.5.4 Transducer Measurements.

The accuracy and very low input capacitance of the 1808 make it ideal for transducer-voltage measurements.

Transducers contained in accelerometers, strain gauges, microphones or other similar devices usually have a voltage range of less than 100-mV, and a capacitance ranging from a few hundred to a few thousand picofarads.

When the output of the transducer under test is coupled through a Tektronix voltage probe and GR 1808-P1 Probe Adaptor to the 1808, the sensitivity of the resulting combination is only 15-mV for full scale deflection (see Figure 3-2).

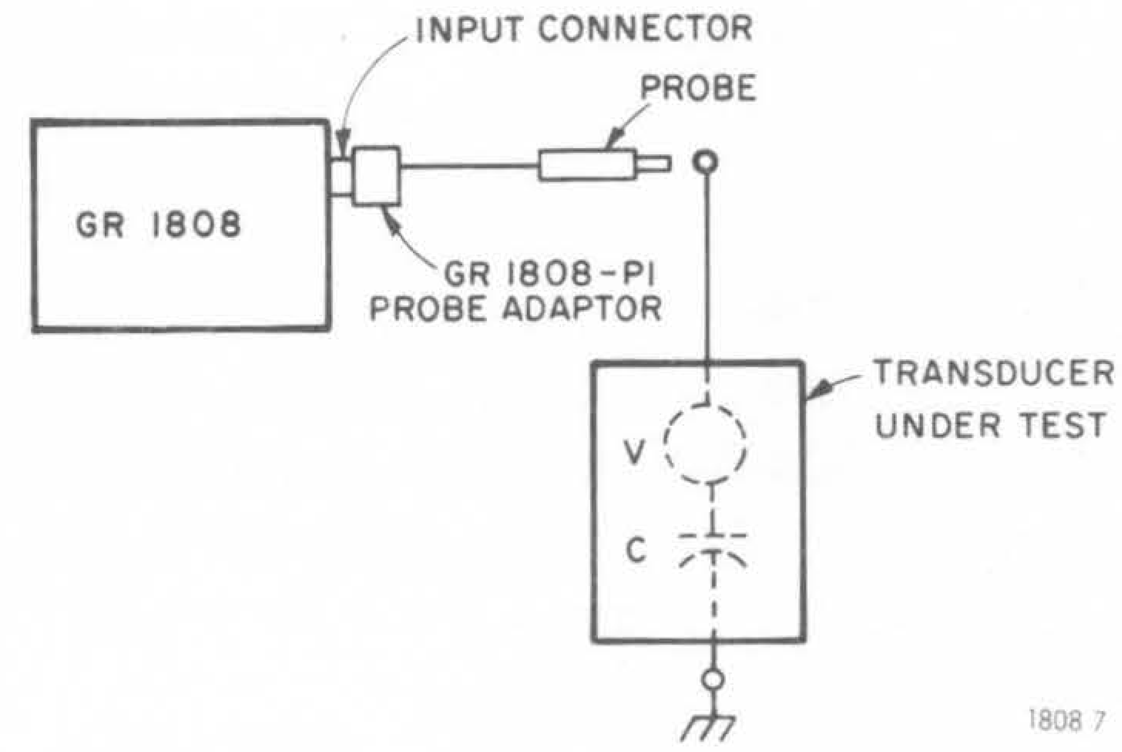


Figure 3-2. Typical test set up for transducer measurements.

Theory–Section 4

4.1 GENERAL.

This section contains both a functional description to the block diagram level, and a more detailed circuit analysis that follows the schematic diagram. Reference designators referred to throughout the text are identified in the following manner:

1. A letter preceding a hyphen identifies the assembly upon which the component is mounted (Ex: A-F1 is a fuse mounted on the main frame, while B-K1 is a relay mounted on the B voltmeter board).

2. The letter and number combination following the hyphen identify the electrical component. Sometimes it is possible to have two components with the same letter – number grouping but mounted on different assemblies (Ex: B-R1 is a resistor mounted on the B-voltmeter board, while C-R1 is a resistor mounted in the 1808-P1 Probe Adaptor).

4.2 FUNCTIONAL DESCRIPTION (Figure 4-1).

The 1808 is a solid-state, average reading voltmeter that is capable of measuring signal magnitudes ranging from 150-μV to 150-V (1500-V with an accessory external probe and adaptor) in discrete 20-dB dynamic ranges per range. Major functional elements are described in the following paragraphs.

4.2.1 Attenuator No. 1.

The ac signal to be measured is applied through the front-panel BNC INPUT connector (or an accessory parallel-connected rear-panel connector) to a completely shielded input attenuator. A front-panel range-selector switch controls a series of reed-type relay switches that provide 40-dB attenuation for large signal inputs (15 and 150 V ranges), and no attenuation on the lower ranges (1.5 V and below).

4.2.2 Buffer and Attenuator No. 2.

The ac signal from attenuator No. 1 is applied to an X1 amplifier and attenuator. The X1 amplifier is a buffer with

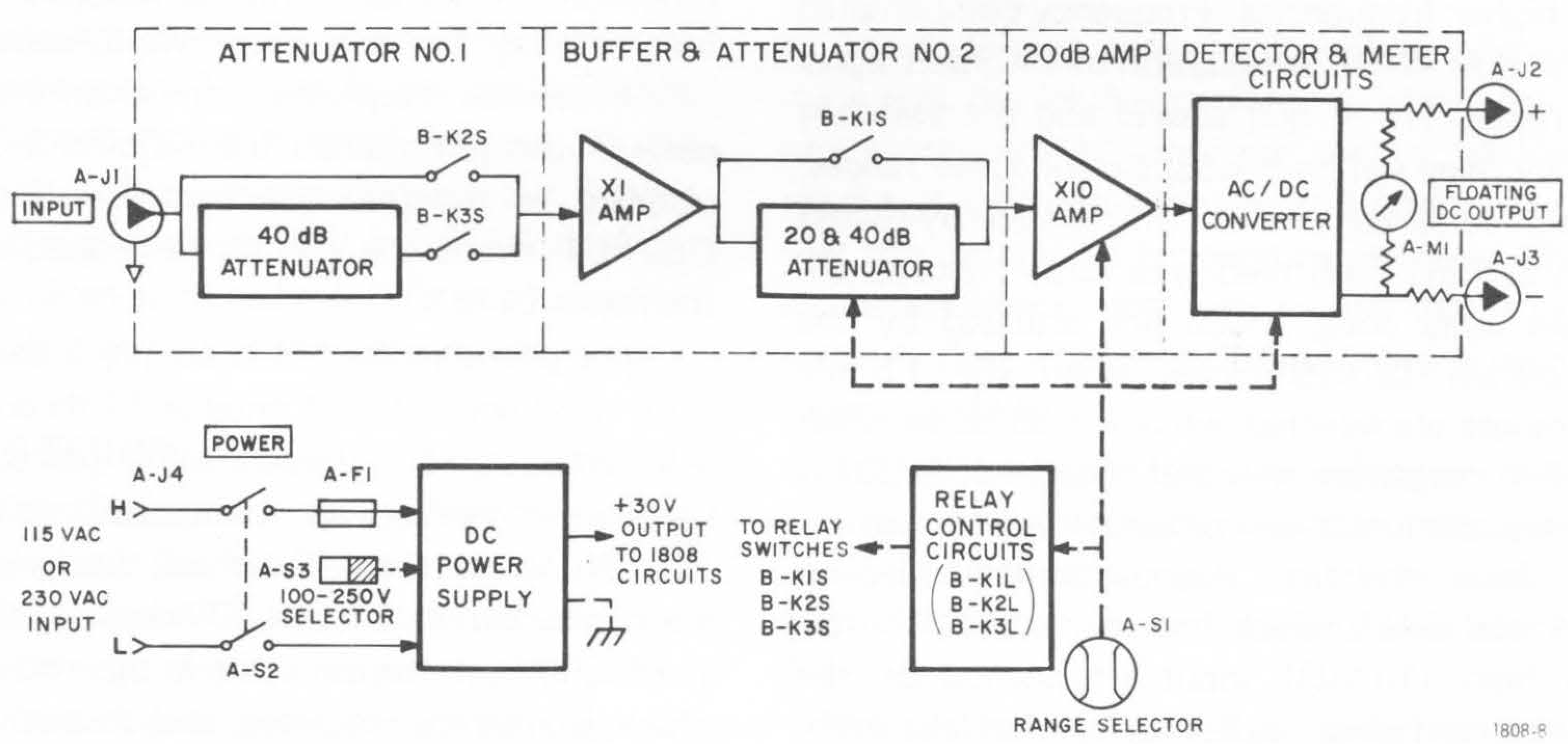


Figure 4-1. Block diagram of the Type 1808 Ac Millivoltmeter.

a 10-MΩ input impedance that matches the high-impedance input signal to the much lower impedance of the second attenuator. The second attenuator is also controlled by the range-selector switch and can provide either 40-dB, 20-dB, or no signal attenuation, as required, to present the proper drive signal to the 20-dB amplifier that follows it.

4.2.3 20-dB Amplifier.

The 20-dB amplifier accepts signals in the range of 150 µV to 15 mV. It is a wide-band X10 amplifier that provides frequency compensation for the detector and meter circuits that follow it. In order to obtain maximum stability, the amplifier gain is never changed; instead, attenuator No. 2 supplies the proper signal levels for the range selected.

4.2.4 Detector and Meter Circuits.

The frequency-compensated signal from the 20-dB amplifier is applied to a high-gain wide-band amplifier within the detector and meter circuits. Diodes connected to the feedback loop of the amplifier convert the ac output to a rectified dc signal. The current obtained deflects the meter in proportion to the INPUT signal, while the dc voltage developed is available as a FLOATING DC OUTPUT that can be monitored by other measuring devices, if required.

4.2.5 Dc Power Supply.

A single transistorized power supply allows selection of either 100-125 V or 200-250 V, 50-400 Hz power inputs. The regulated +30 V output supplies all stages within the instrument.

4.3. CIRCUIT DESCRIPTION (Figure 6-4).

The ac signal to be measured is applied to the shielded input attenuator through a BNC INPUT connector. The outer terminal of the connector is isolated from the chassis by a 4.7-Ω resistor (A-R57) in order to prevent low-frequency ground loops. A capacitor (A-C50) by-passes the resistor on the higher frequencies. Frequency-compensated resistive dividers allow 40-dB attenuation of the input signal on the higher ranges (15 V and above) and are switched into the circuit by relay switch B-K3S. On the lower ranges, attenuation is not required and the dividers are by-passed by relay switch B-K2S. Both reed-type relay switches are contained within relay coils, which are actuated by the range-selector switch (B-K2S closes when the 1.5-mV through 1.5-V ranges are selected, while B-K3S closes when the 15-V or 150-V ranges are selected). Capacitor B-C37 is the high-frequency attenuator-compensation adjustment.

The output from the first attenuator is applied to transistors B-Q1 and B-Q2, which form a X1 FET buffer amplifier. The high (10-MΩ) input impedance of the amplifier provides sufficient buffering so that the high-impedance input signal is matched to the much lower impedance of the second attenuator. In addition, diodes B-CR5 and B-CR13 supply overload protection for the amplifier.

The second attenuator contains a series of circuits that supply low-impedance output signals suitable for driving the next stage. The range-selector switch controls the amount of attenuation necessary to provide the proper output. When the range switch is in the 1.5-mV or 15-mV positions, both the 20-dB and 40-dB attenuators are disconnected from the circuit. In addition, relay switch B-K1S closes, providing no attenuation of the output signal. When the range-selector switch is in any other position, relay switch B-K1S is open and, in conjunction with the range switch, allows the selection of the proper amount of signal attenuation (20 dB for the 150-mV and 15-V ranges, 40 dB for the 1.5-V and 150-V ranges). Capacitor B-C40 supplies high-frequency attenuator adjustment on the 1.5-V range, while capacitor B-C45 provides attenuator adjustment on the 150 mV range.

Transistors B-Q3, B-Q4, and B-Q5 form the X10 20-dB amplifier. The amplifier has a wide bandwidth that is comparable to the bandwidth of the instrument. Frequency adjustment is such that it compensates for the amplifier and detector contained in the next stage. Output is maintained at 150-mV, maximum, on all ranges except the most-sensitive range, where it is 15-mV. Capacitor B-C4 provides amplifier adjustment on the 15-mV range, while potentiometer B-R18 supplies the amplifier gain adjustment. Capacitors B-C7, B-C8, B-C9, and B-C43 supply amplifier frequency compensation on all ranges except the 1.5-mV range.

Transistors B-Q6, B-Q7, and B-Q8 form a very-high-gain wide-band amplifier with an open-loop voltage gain of approximately 80-dB. Transistor B-Q9 presents a high output impedance to transistor B-Q8 in order to maintain the large gain required. Diodes B-CR3, and B-CR4 are inserted in the feedback loop of the amplifier and rectify the output signal. Resistor B-R30 serves as the sampling resistor on all ranges except the 1.5-mV range. The range-selector switch connects resistors B-R31 and B-R42 for sampling on this range while capacitors B-C42 and B-C44 provide frequency compensation. The rectified dc output voltage obtained from diodes B-CR3 and B-CR4 is supplied to external connectors as the FLOATING DC OUTPUT, while the current developed is read directly by the meter (A-M1).

Input power to the power supply is connected to the primary windings of transformer A-T1 through selector switch A-S3. When 200-250 V operation is desired, the two primary transformer windings are connected together in series. When 100-125 V operation is desired, the two primary windings are connected in parallel. Diodes B-CR6, B-CR7, B-CR8, and B-CR9 form the arms of a bridge rectifier, the output of which is filtered, regulated, and decoupled by the remaining circuit components. The power supply provides a stable +30 V output to all circuits of the instrument.

Service and Maintenance–Section 5

5.1 GR FIELD SERVICE.

Our two-year warranty attests to the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please contact our Service Department (see last page), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial, type, and ID numbers of the instrument.

5.2 INSTRUMENT RETURN.

Before returning an instrument to General Radio for service, please contact our Service Department or nearest District Office, requesting a "Returned Material" number. Use of this number will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

5.3 MINIMUM PERFORMANCE STANDARDS.

5.3.1 General.

The following paragraphs contain information to determine that the 1808 is performing within specifications. The procedures enable customer service facilities to perform checks at periodic intervals, and after repair, to determine that the instrument is operating properly. These procedures are bench checks that require the use of only front-panel controls (i.e., instrument disassembly is neither required or recommended).

Table 5-1 lists the test equipment required to accomplish minimum performance checks, calibration procedures, probe compensation, and trouble analysis. A typical test setup for all service and maintenance checks is shown in Figure 5-1.

The following minimum performance checks are included to determine that the instrument is operating properly, and must be accomplished in sequence. If

Table 5-1
TEST EQUIPMENT

Item	Requirements	Recommended Type*
Audio Oscillator	Frequency: 1 kHz ±1% Level: 100 V ± 0.1%	GR 1311
Rms Voltmeter	Range: 10 and 100 V rms Accuracy: ± 0.05% of reading	Fluke Type 931A
Decade Transformer	Range: −0.1111111 to +1.11111110 Impedance: 100 kΩ at 1 kHz	GR 1493
Voltage Divider	Input Resistance: 100 kΩ	GR 1455-AH
Digital Voltmeter	Dc Linear Range: 200.0 mV and 2.000 V full scale	GR 1820 with GR 1820-P2 Plug-in
Decade Attenuator	Accuracy: ± 0.2% of reading Range: 0 – 80-dB in 20-dB steps	GR 1450-TA
Metered Auto-transformer	Output Voltage: 0 – 140 V single phase, 50 – 60 Hz Meter Accuracy: ±3%	GR W5MT3AW
Synthesizer	Output Frequency: 1 kHz – 10 MHz Output Level: 0 – 2 V rms into 50 Ω load	GR 1163
Hf Transfer Voltmeter	Output Level: 1 – 100 V Frequency Range: 25 Hz – 30 MHz	Ballantine Type 393
Lf Oscillator	Frequency Range: 10 Hz – 1 kHz Accuracy: ± 2% of setting Output Level: 5.0 V ± 5% open circuit	GR 1309
Patchcords (4)	GR 274 double-plug (binding post) connectors each end	GR 274-NQ
Patchcords (2)	GR 274 double-plug (binding post) connectors to BNC	GR 776-A
Patchcord	GR874® connectors each end	GR 874-R22A
Tee Connectors (2)	GR874 connectors each end	GR 874-T
20-dB Attenuators (4)	GR874 connectors each end	GR 874-G20
600-Ω Fixed Resistor (2)	Accuracy: ± 5%	GR 500-G
50-Ω Termination	GR874 connector	GR 874-W50B
Adaptor	GR874-to-BNC	GR 874-QBPA
Adaptor	GR874-to-GR 274 double plug	GR 874-Q2

*or equivalent

satisfactory indications cannot be obtained, calibration is required (refer to paragraph 5.5).

1. Power-circuit check.
2. 1-kHz linearity check.
3. 1-kHz range check.
4. High-frequency response check.
5. Low-frequency response check.

5.3.2 Power-Circuit Check.

a. Connect the 1808 under test to a metered autotransformer set to 0-V. Set the 1808 rear-panel power-selector slide switch to 100-125 V.

b. Slowly increase the line voltage to 115 V. The 1808 pilot lamp should glow at full brilliance while the input power should be 10 W (nominal).

c. Maintain the line voltage at 115 V for all further checks.

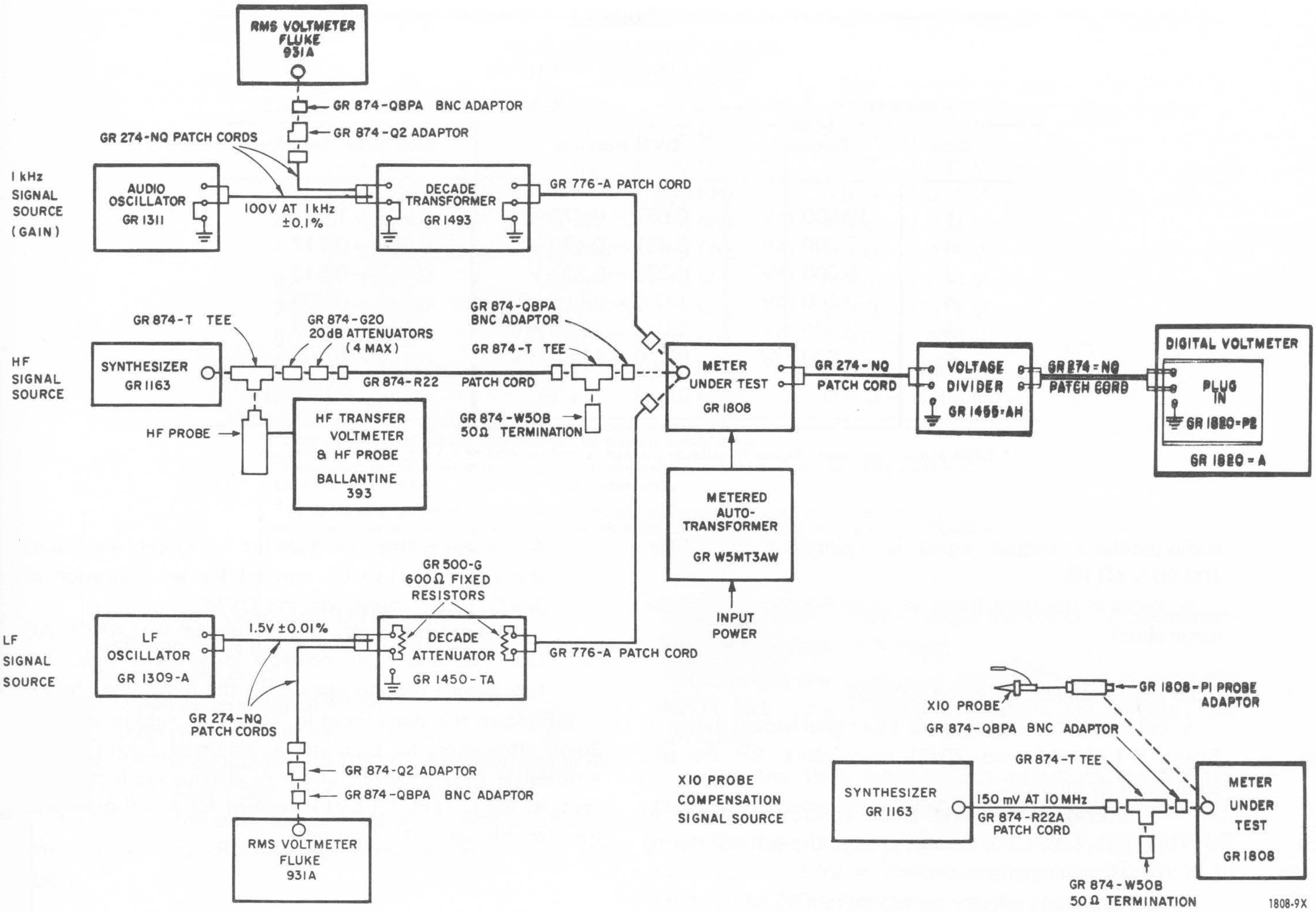


Figure 5-1. Typical Test Setup.

5.3.3 1-kHz Linearity Check.

a. Establish the test setup for a 1-kHz signal source shown in Figure 5-1. Set the test equipment controls as follows:

1. Voltage divider to 0.999X.
2. 1808 range-selector switch to 15 mV.
3. Decade transformer to 15.00 mV (0.000150), and CONTINUOUS DECADE switch to OUT.
4. DVM MEASUREMENT switch to DC, and RANGE switch to AUTO.
5. Check that all equipment ground links are attached or removed from input/output terminals as shown in Figure 5-1.

NOTE

The dc output from the 1808 is a FLOATING DC OUTPUT. If one of the terminals is grounded, accuracy will deteriorate.

6. Observe that power is applied to all units, and adjust the audio oscillator for a 1 kHz, 100.00 V ±0.1% output signal.
7. Check the 1808 meter scale for a reading of 15 ±0.17 mV.
8. Check the DVM for a reading of greater than 1 V (1.1 V nominal).
9. Adjust the voltage-divider dials until a reading of 1.000 V ±2 counts is obtained on the DVM. Do not change the voltage-divider or DVM settings during the remaining checks.

b. Perform the steps listed in Table 5-2 to complete the linearity check.

5.3.4 1-kHz Range Check.

a. Establish the test set-up used for the 1-kHz linearity check (refer to paragraph 5.3.3 a). Make sure that all instruments are set as indicated in step a, and the

Table 5-2

1-kHz LINEARITY CHECK

Step	1493 Output *	DVM Readings	1808 Meter Readings
1	10.000 mV	0.657 – 0.675 V	0.977 – 1.023
2	7.000 mV	0.461 – 0.473 V	0.683 – 0.717
3	5.000 mV	0.329 – 0.337 V	0.487 – 0.513
4	3.000 mV	197.0 – 203.0 mV	0.291 – 0.309
5	2.000 mV	131.3 – 135.3 mV	0.193 – 0.207
6	1.500 mV	098.0 – 102.0 mV	0.144 – 0.156

* 1493 output to 1808. Audio Oscillator output is maintained at 1 kHz, 100 V ±0.1%.

audio-oscillator output signal is maintained at 1 kHz, 100.00 V ±0.1%.

b. Perform the steps listed in Table 5-3 to complete the range check.

5.3.5 High-Frequency Response Check.

a. Establish the test setup for a hf signal source shown in Figure 5-1. Install two 20-dB attenuators. Set the test equipment as follows:

1. Voltage-divider and DVM controls as listed in paragraph 5.3.3 a. Do not change the settings during the remaining checks.
2. 1808 range selector switch to 15 mV.
3. Synthesizer OUTPUT LEVEL control to zero (full ccw). MONITOR switch to OUTPUT VOLTS and CAD OFF switch depressed.
4. Set the synthesizer dials for 1.000 kHz and adjust the OUTPUT LEVEL control for an indication of 1.000 V ±2 counts on the DVM.
5. Adjust the hf transfer voltmeter BALANCE AC COARSE and FINE controls for a meter null. Do not change the settings during the remaining checks.

b. Perform the steps listed in Table 5-4. Add or subtract 20-dB attenuators for each step as indicated. Each time the synthesizer frequency or number of attenuators is changed, readjust the OUTPUT LEVEL control for a null on the hf transfer voltmeter (±½ division).

5.3.6 Low-Frequency Response Check.

a. Establish the test setup for a lf signal source shown in Figure 5-1. Set the test equipment controls as follows:

Table 5-3

1-kHz RANGE CHECK

Step	1808 Range	1493 Output *	DVM Readings
1	1.5 mV	1.500 mV	0.979 – 1.021 V
2	1.5 mV	150.0 µV	097.0 – 103.0 mV
3	150 mV	15.00 mV	098.0 – 102.0 mV
4	150 mV	150.0 mV	0.989 – 1.011 V
5	1.5 V	150.0 mV	098.0 – 102.0 mV
6	1.5 V	1.500 V	0.989 – 1.011 V
7	15 V	1.500 V	098.0 – 102.0 mV
8	15 V	15.00 V	0.989 – 1.011 V
9	150 V	15.00 V	098.0 – 102.0 mV
10	150 V	100.0 V	0.658 – 0.674 mV

* 1493 output to 1808. Audio Oscillator output is maintained at 1 kHz, 100 V ±0.1%.

Table 5-4
HIGH FREQUENCY CHECK

Step	Atten[1]	1808 Range	1163[2,3] Frequency	DVM Reading
1	40-dB	15 mV	5 MHz	0.989 – 1.011 V
2	40-dB	15 mV	10 MHz	0.967 – 1.033 V
3	60-dB	1.5 mV	500 kHz	0.979 – 1.021 V
4	60-dB	1.5 mV	4 MHz	0.968 – 1.032 V
5	20-dB	150 mV	5 MHz	0.989 – 1.011 V
6	20-dB	150 mV	10 MHz	0.967 – 1.033 V
7	0-dB	1.5 V	5 MHz	0.989 – 1.011 V
8	0-dB	1.5 V	10 MHz	0.967 – 1.033 V
9	0-dB	15 V	5 MHz	0 980 – 102.0 mV
10	0-dB	15 V	10 MHz	094.0 – 106.0 mV

[1]Add or subtract 20-dB attenuators to obtain totals listed.

[2]Whenever number of attenuators or frequency is changed, readjust 1163 OUTPUT LEVEL control for a Ballantine 393 meter null.

[3]1163 output is maintained at 1.500 V. Signal inputs to 1808 are varied by the amount of attenuation as follows: 40-dB = 15.00 mV; 60-dB = 1.50 mV; 20-dB = 150.00 mV; 0-dB = 1.50 V.

1. Voltage-divider and DVM controls as listed in paragraph 5.3.3 a. Do not change the settings during the remaining checks.
2. Decade-attenuator to 40-dB.
3. 1808 range-selector switch to 15 mV.
4. Set the oscillator for a 1.500 V ±.01% output at 40 Hz. Maintain 1.500 V for all remaining checks.

b. Perform the steps listed in Table 5-5. Add or subtract attenuation and change frequencies as indicated in the table.

5.4 PROBE COMPENSATION.

All X100 and X10 hf voltage probes must be compensated for high-frequency response before use. Once compensation has been accomplished, the procedure does not have to be repeated, unless another voltage probe is used or probe compensation is changed for any reason. Table 5-1 lists the test equipment required to perform the adjustment while Figure 5-1 shows a typical test setup. To compensate the probe, proceed as follows:

a. Connect the synthesizer OUTPUT signal to the 1808 INPUT jack using a 50-Ω termination, tee, adaptor, and patchcord.

b. Set the 1808 range-selector switch to the 150-mV range and observe that power is applied to the instrument.

c. Turn on the synthesizer and adjust the OUTPUT LEVEL control for an indication of exactly 150 mV at 10 MHz on the 1808 meter scale.

d. Disconnect the synthesizer OUTPUT signal from the 1808 INPUT jack.

e. Remove the 1808-P1 probe adaptor from the mounting clips at the rear of the instrument and attach it to the 1808 INPUT jack. Set the 1808 range-selector switch to the 15-mV range.

Table 5-5
LOW FREQUENCY CHECK

Step	Atten	1808 Range	1309 * Frequency	DVM Readings
1	40 dB	15 mV	40 Hz	0.989 – 1.011 V
2	40 dB	15 mV	10 Hz	0.977 – 1.023 V
3	60 dB	1.5 mV	10 Hz	0.968 – 1.032 V
4	60 dB	1.5 mV	40 Hz	0.979 – 1.021 V
5	20 dB	150 mV	40 Hz	0.989 – 1.011 V
6	20 DB	150 mV	10 Hz	0.977 – 1.023 V
7	0 dB	1.5 V	10 Hz	0.977 – 1.023 V
8	0 dB	1.5 V	40 Hz	0.989 – 102.0 mV
9	0 dB	15 V	40 Hz	098.0 – 102.0 mV
10	0 dB	15 V	10 Hz	095.0 – 105.0 mV

*1309 output is maintained at 1.500 V. Signal inputs to 1808 are varied by the amount of attenuation in the following manner: 40-dB = 15.00 mV; 60-dB = 1.50 mV; 20-dB = 150.00 mV; 0-dB = 1.50 V.

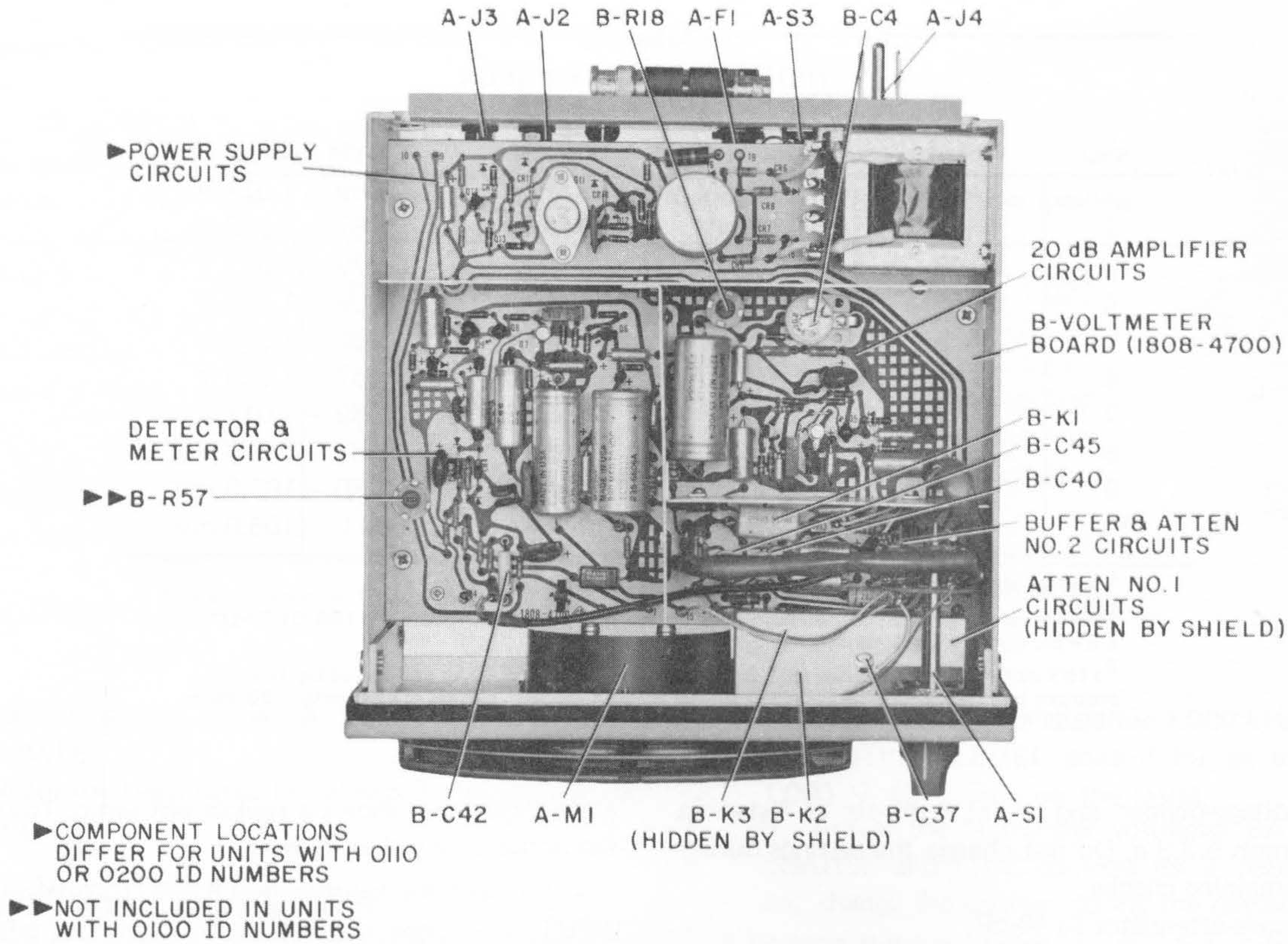


Figure 5-2. Top interior view of Millivoltmeter.

f. Connect the voltage probe to the probe adaptor. Attach the probe end and probe-ground lead to the synthesizer output available at the BNC adaptor, tee, and 50-Ω termination.

g. Adjust the voltage-probe compensating capacitor for an 1808 meter indication of exactly 15 mV (150 mV ÷10). The probe may now be used for normal voltage measurements (refer to Section 3).

5.5 CALIBRATION.

5.5.1 General.

NOTE

Perform calibration in an ambient temperature of 23°C (73°F) ±3°C at less than 60% relative humidity.

Calibrate the millivoltmeter whenever minimum performance standards, operating procedures, troubleshooting, or maintenance checks indicate that the instrument is out of calibration. Table 5-1 lists the test equipment recommended to perform the calibration while Figure 5-1 shows a typical test setup. All controls requiring adjustment are mounted on the B-voltmeter board, and are identified in Figure 5-2. To gain access to the controls requiring adjustment, remove the chassis from the cabinet, as described in paragraph 5.7.1. Make sure that all shields remain in place during the calibration. Allow the 1808 to stabilize in an ambient temperature of 23°C for at least one hour before performing the calibration.

5.5.2 1-kHz Gain Adjustment.

NOTE

If a static charge on the 1808 meter cover is suspected, wet the cover with an antistatic solution such as Weston Statnul* or equivalent.

a. Establish the test setup used for the 1-kHz linearity check (refer to paragraph 5.3.3 a). Make sure that all instruments are set as indicated in step a and the oscillator output signal is maintained at 1 kHz, 100.00 V ±0.1%.

b. Adjust the 15-mV gain-adjust potentiometer (B-R18) for an exact indication of 1.5 (full scale) on the 1808 meter scale.

c. Adjust the voltage-divider dials until a reading of 1.000 V ±2 counts is obtained on the DVM. Do not change the voltage-divider setting during the remaining checks.

NOTE

Perform steps d, e, and f for units equipped with B-R57. Units without the potentiometer do not require a 1.5 mV gain adjustment. Perform step f only.

*Registered trademark of Weston Instruments, Inc.

d. Set the 1493 decade transformer to 1.5 mV, and the 1808 range-selector switch to 1.5 mV.

e. Adjust the 1.5 mV gain-adjust potentiometer (B-R57) for an exact indication of 1.5 (full scale) on the 1808 meter and 1000 V ±2 counts on the DVM.

f. Perform the 1-kHz Linearity Check (paragraph 5.3.3) and 1-kHz Range Check (paragraph 5.3.4) to complete the gain adjustment.

5.5.3 High-Frequency Adjustments.

a. Establish the test setup for the high frequency response check (refer to paragraph 5.3.5). Make sure that all instruments are set up as indicated in step a.

NOTE

Do not remove either the top shield (covering Atten No. 1) or the bottom shield during calibration or readings obtained could be in error.

b. Perform the steps listed in Table 5-6. If DVM readings are out of tolerance, adjust the capacitor indicated. If steps 5, 6, 7 or 8 are out of tolerance, proceed as follows:

1. Capacitor B-C42 (Figure 5-2) is attached to the etched-circuit board by two solderless plug-in jacks. To remove the capacitor, gently pull the leads out of each jack.
2. The nominal value of B-C42 is 470 pF. Select another capacitor slightly higher or lower in value.
3. Carefully insert the capacitor leads into the etched-circuit board jacks. Repeat steps 5, 6, 7, and 8 of Table 5-6 changing the value of B-C42 until the DVM readings obtained are within limits.

c. Perform the High Frequency Response Check (paragraph 5.3.5) to complete the high frequency adjustment.

5.5.4 Low-Frequency Adjustments.

Low-frequency response is set by fixed circuit components, and, there are no low-frequency adjustments. Perform the Low Frequency Response Check (paragraph 5.3.6) to complete calibration.

5.6 TROUBLE ANALYSIS.

Table 5-1 lists the equipment recommended for trouble analysis. Major fault indications and probable causes are listed in Table 5-7. Use Table 5-7 and the schematic diagram (Figure 6-4) as aides in trouble analysis. Voltages listed on the schematic diagram are nominal (±10%), and are measured with an ac millivoltmeter (GR 1808 or

Table 5-6
HIGH–FREQUENCY ADJUSTMENTS

Step	Atten.[1]	1808 Range	1163[2,3] Frequency	DVM Readings	If Out of Tolerance
1	40 dB	15 mV	10 MHz	0.998 – 1.002 V	Adjust B-C4.
2	0 dB	1.5 V	10 MHz	0.998 – 1.002 V	Adjust B-C40.
3	20 dB	150 mV	10 MHz	0.998 – 1.002 V	Adjust B-C45. Repeat steps 2 and 3 until no interaction occurs.
4	0 dB	15 V	50 kHz	099.5 – 100.5 μV	Adjust B-C37.
5	60 dB	1.5 mV	3 MHz	0.968 – 1.032 V	Select value of B-C42.
6	60 dB	1.5 mV	4 MHz	0.968 – 1.032 V	(See Note 4).
7	60 dB	1.5 mV	1 MHz	0.968 – 1.032 V	(See Note 4).
8	60 dB	1.5 mV	500 kHz	0.979 – 1.021 V	(See Note 4).

[1] Add or subtract 20-dB attenuators to obtain totals listed.

[2] Whenever number of attenuators or frequency is changed, readjust 1163 OUTPUT LEVEL control for a Ballantine 393 meter null.

[3] 1163 output is maintained at 1.500 V. Signal inputs to 1808 are varied by the amount of attenuation as follows: 40-dB = 15.00 mV; 20-dB = 150.00 mV; 0-dB = 1.50 V; 60-dB = 1.50 mV.

[4] Re-select value of B-C42 as necessary until steps 5 through 8 are within limits.

Table 5-7

FAULT INDICATIONS AND PROBABLE CAUSE

Fault Indication	Probable Cause	Notes
No meter indications on any range, and white power lamp is extinguished.	DC power supply, regulator, or decoupling circuits.	Check fuse A-F1, power cord, and input power source. Check the power supply circuits stage by stage (see Figure 6-4).
No meter indications on any range, and no FLOATING DC OUTPUT; however, white power lamp lights.	Regulator or decoupling circuits. Detector and meter circuits. Atten. No. 1 circuits or relay control circuits.	Check regulator and decoupling circuits. If trouble persists, check detector and meter stage, Atten. No. 1 circuits or relay control circuits.
White power lamp does not light when power is applied; however, all other indications are normal.	Power lamp.	Check the lamp and power supply circuits.
Meter indicates properly, however, no FLOATING DC OUTPUT is available.	Meter circuit.	Check the meter circuit, connectors, and associated wiring.
	FLOATING DC OUTPUT signal grounded.	Check all 1808 output circuit wiring for possible grounds.
Incorrect meter indications on any range while measuring mid-frequency (100-Hz-10-kHz signals).	Faulty instrument stage.	Perform trouble analysis to determine which stage is faulty.
	Meter requires calibration.	Calibrate meter (refer to paragraph 5-5).
Incorrect meter indications on any range while measuring frequency extremes (10-100 Hz, 10 kHz - 10 MHz.)	Faulty instrument stage. Meter requires calibration.	Perform trouble analysis to determine which stage is faulty. Calibrate meter (refer to paragraph 5-5).
Incorrect meter indications on any range while using a voltage probe and probe adaptor.	X100 or X10 hf voltage probe not compensated.	Compensate the voltage probe (refer to paragraph 5-4).
	Faulty probe or probe adaptor.	Perform trouble analysis (paragraph 5-6). Do not use the probe adaptor. If satisfactory results are obtained, check the probe and probe adaptor.

Table 5-8

FIGURE 6-4 TEST LOCATION VOLTAGE LEVELS[1]

1808 Range	A[2]	B, C	D, F	E,G,J,K	H	L[3]
1.5 mV	1 mV	1 mV	1 mV	12 mV	1.7 V	0.8 V
15 mV	10 mV	10 mV	10 mV	120 mV	1.7 V	0.8 V
150 mV	100 mV	100 mV	10 mV	120 mV	1.7 V	0.8 V
1.5 V	1 V	1 V	10 mV	120 mV	1.7 V	0.8 V
15 V	10 V	100 mV	10 mV	120 mV	1.7 V	0.8 V
150 V	100 V	1 V	10 mV	120 mV	1.7 V (pk-pk)	0.8 V

[1] Unless otherwise indicated, all voltage levels are nominal (±10%) rms values, appearing at circled letter locations in Figure 6-4.

[2] Requires a 1-kHz sine-wave INPUT signal at rms values listed for test location A. Use the test setup for a 1-kHz signal source shown in Figure 5-1.

[3] Vdc.

equivalent) using a 10-MΩ voltage probe and probe adaptor referenced to circuit ground on the 1.5 V range. Test locations specified are general locations between stages. Major stage locations are shown in Figure 5-2.

Table 5-8 reflects nominal voltage levels for all range-selector switch positions at test locations indicated on the schematic diagram. Table 5-9 lists the stage gain and relay conditions for each range-selector switch position. Generally, a check on the range in use when trouble develops should be sufficient to isolate faults to a particular instrument stage. Data has been included, however, for all ranges so that a complete check can be accomplished, if trouble persists.

5.7 REPLACEMENT PROCEDURES.

5.7.1 Cabinet.

Loosen the 2 captive screws in the rear panel, one near each side, to release the instrument chassis. Slide the instrument forward out of the cabinet, whether rack or bench mounted. Reassemble by reversing this procedure.

5.7.2 Knobs.

CAUTION

Do not use a screwdriver or other tool to pry off the knob if it is tight. Do not lose the spring clip in the knob while it is off.

To remove the knob from a front-panel control, to replace a damaged knob or the associated control, proceed as follows:

a. Grasp the knob firmly with dry fingers, close to the panel, and pull the knob straight away.

b. Observe the position of the setscrew in the bushing when the control is fully ccw.

c. Release the setscrew with an Allen wrench; pull the bushing off the shaft.

Table 5-9

STAGE GAIN AND RELAY DATA*

	Stage Gain (dB)				Relay Switch Positions		
1808 Range	Atten No. 1	Atten No. 2	Det & Meter	Total Gain	B-K1S	B-K2S	B-K3S
1.5 mV	0	0	+40	+40	closed	closed	open
15 mV	0	0	+20	+20	closed	closed	open
150 mV	0	–20	+20	0	open	closed	open
1.5 V	0	–40	+20	–20	open	closed	open
15 V	–40	–20	+20	–40	open	open	closed
150 V	–40	–40	+20	–60	open	open	closed

* Gain switching is accomplished in the Atten No. 1, Atten No. 2, and Det and Meter stages only.

NOTE

To separate the bushing from the knob, if for any reason they should be combined off of the shaft, drive a machine tap one of two turns into the bushing to provide sufficient grip for easy separation. To return the spring clip, if that falls out, install it in the interior groove; push its curved flange into the small slit in the wall of the knob.

5.7.3 Lamp.

To replace the power lamp, slide the metal clip off the back of the lamp holder and remove the lamp. Insert a new lamp (Chicago Miniature Lamp Works, No. 327 lamp; or equivalent), and replace the clip.

5.7.4 Attenuator No. 1 Shield.

To remove the shield covering attenuator No. 1 circuit components on the chassis top section, proceed as follows:

a. Remove the bottom shield from the bottom of the chassis to gain access to the screw securing the shield for attenuator No. 1 to the chassis.

b. Remove the nut and washer from the shield screw and carefully pull the shield up from the top of the chassis until the screw clears the chassis.

c. Carefully slide the shield out from under the rotary selector switch until it is clear of the chassis.

d. To replace the shield, reverse steps a through c.

NOTE

Both top and bottom shields must be isolated from the instrument chassis at all times. When replacing shields, make sure they do not contact the chassis.

5.7.5 Panel Finish.

If the front panel is marred or scratched, retouch with a light gray color, conforming with Federal Standard 595 (gray, 26492).

5.7.6 Servicing Etched-Circuit Board.

The 1808 has one etched-circuit board. The board has the parts on one side and the circuitry on the opposite side.

When removing or replacing parts, use a low-heat soldering iron and a small-diameter rosin-core solder. Do not subject the parts or boards to excessive or prolonged heat. If a part is obviously faulty or damaged, clip the leads close to the part and then remove the leads from the circuit side.

Parts Lists and Diagrams—Section 6

6.1 GENERAL.

This section contains the mechanical and electrical replaceable-parts lists, a schematic diagram, and etched-board layout for the millivoltmeter. It includes illustrations showing locations of front and rear panel components. Illustrations showing the location of internal components are contained in Section 5.

6.2 REFERENCE DESIGNATORS.

Reference designators referred to in the text, parts lists, and diagrams are identified in the following manner:

a. A letter preceeding a hyphen identifies the assembly upon which the component is mounted. In the 1808, the letter A identifies the main frame, B identifies the B-voltmeter board (etched-circuit board), and C identifies the accessory 1808-P1 Probe Adaptor.

b. The letter and number combination following the hyphen identify the electrical component. Sometimes it is possible to have two components with the same letter-number grouping but mounted on different assemblies (Ex: B-R1 is a resistor mounted on the B-voltmeter board, while C-R1 is a resistor mounted in the 1808-P1 Probe Adaptor.

MECHANICAL PARTS LIST

Ref No.	Description	GR Part No.	FMC	Mfg. Part No.	Fed. Stock No.
Fig. 6-1					
1	Cabinet gasket	5331-3100	24655	5331-3100	
2	Meter cover	5720-6713	24655	5720-6713	
3	Knob, RANGE, including retainer 5220-5402	5500-5221	24655	5500-5221	
4	Insulating Bushing	4120-2710	51957	10221-N	
5	Connector , INPUT, A-J1	4230-2301	09408	UG-1094/U	
6	Dress nut, 15/32-32	5800-0800	24655	5800-0800	5310-344-3634
7	Toggle switch, POWER-OFF, A-S2	7910-1300	04009	83053-SA	5930-909-3510
8	Lamp holder	5600-1021	24655	5600-1021	
9	Cabinet asm:	4181-3629	24655	4181-3629	
	Foot, left front	5250-2120	24655	5250-2120	
	Foot, right front	5250-2121	24655	5250-2121	
	Foot, rear	5260-2060	24655	5260-2060	
	Bail	5250-2123	24655	5250-2123	
Fig. 6-2					
10	Threaded metal bushing, A-J2, A-J3:	4150-2600	24655	4150-2600	
	Bushing insulator	4120-0900	24655	4120-0900	5970-503-4401
	Terminal	7930-1900	24655	7930-1900	
	Nut, hex 0.250-28	5810-0700	24655	5810-0700	5310-965-1872
11	Snap button, poly	4160-0210	19396	207-320401-00-0108	
12	Fuse mounting device	5650-0100	71400	HKP-H	5920-284-7144
13	Line voltage selector, slide, A-S3	7910-0831	42190	4603	
14	Input power plug, A-J4	4240-0600	24655	4240-0600	5935-816-0254

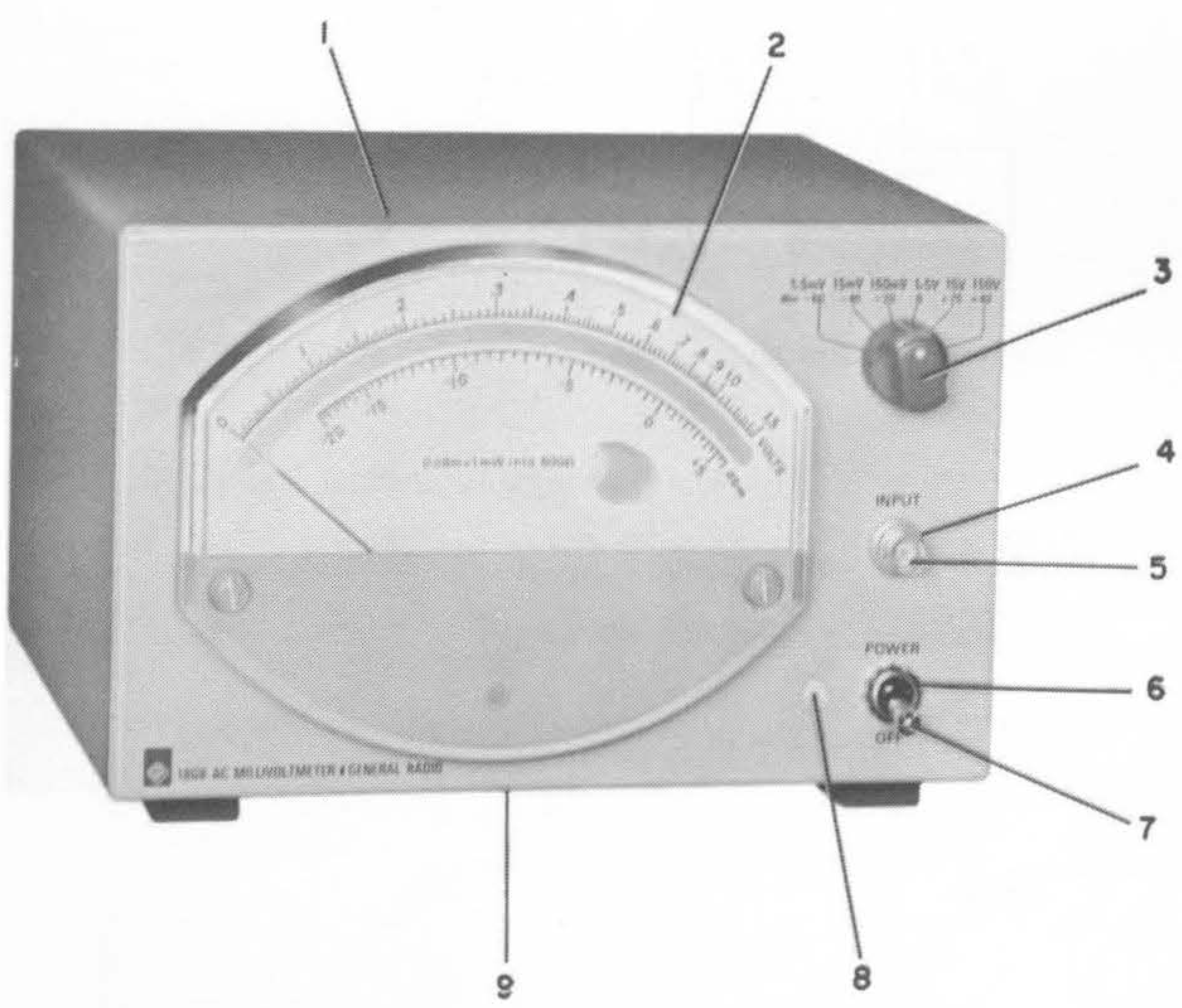


Figure 6-1. Front view, mechanical replaceable parts identified.

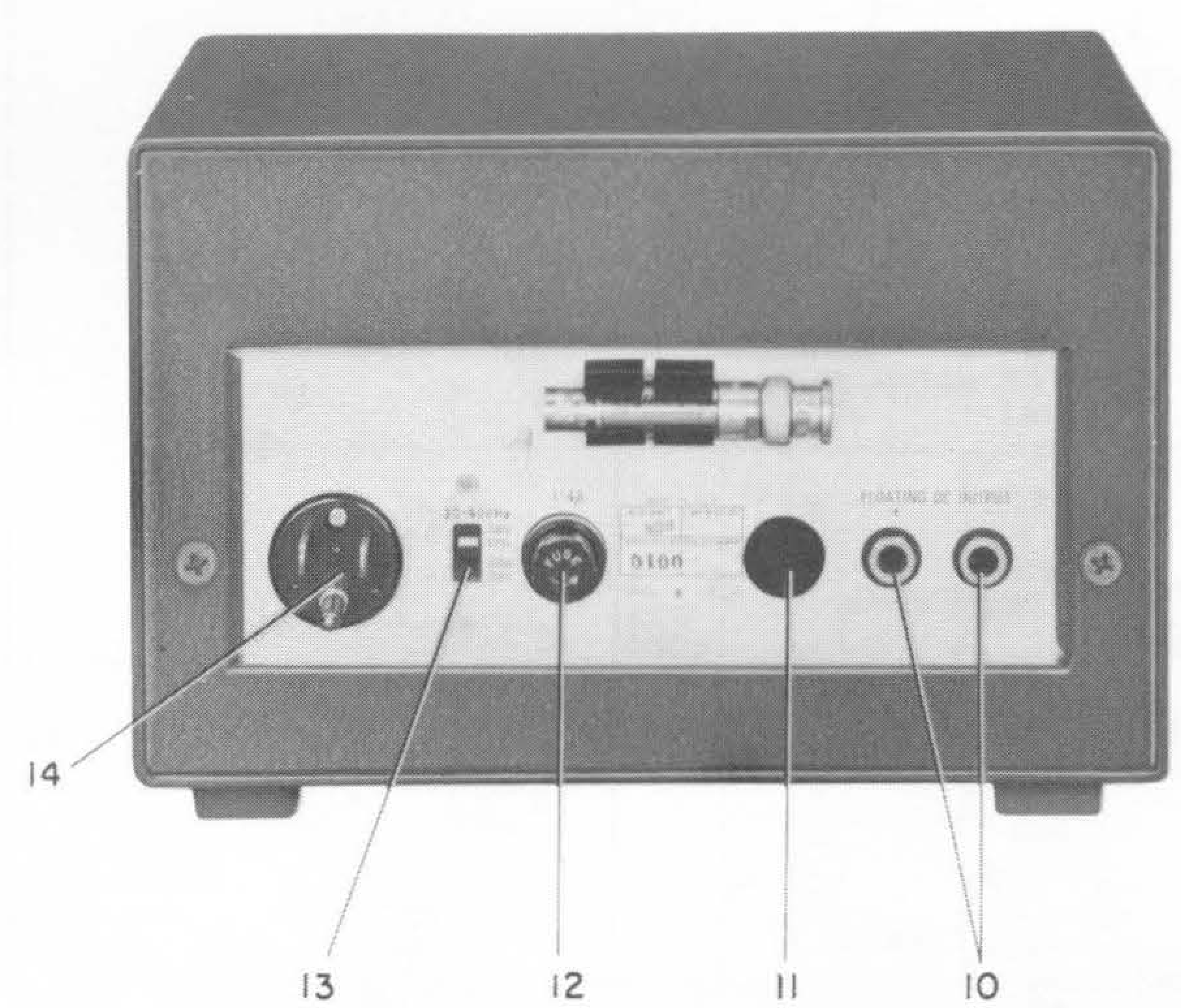


Figure 6-2. Rear view, mechanical replaceable parts identified.

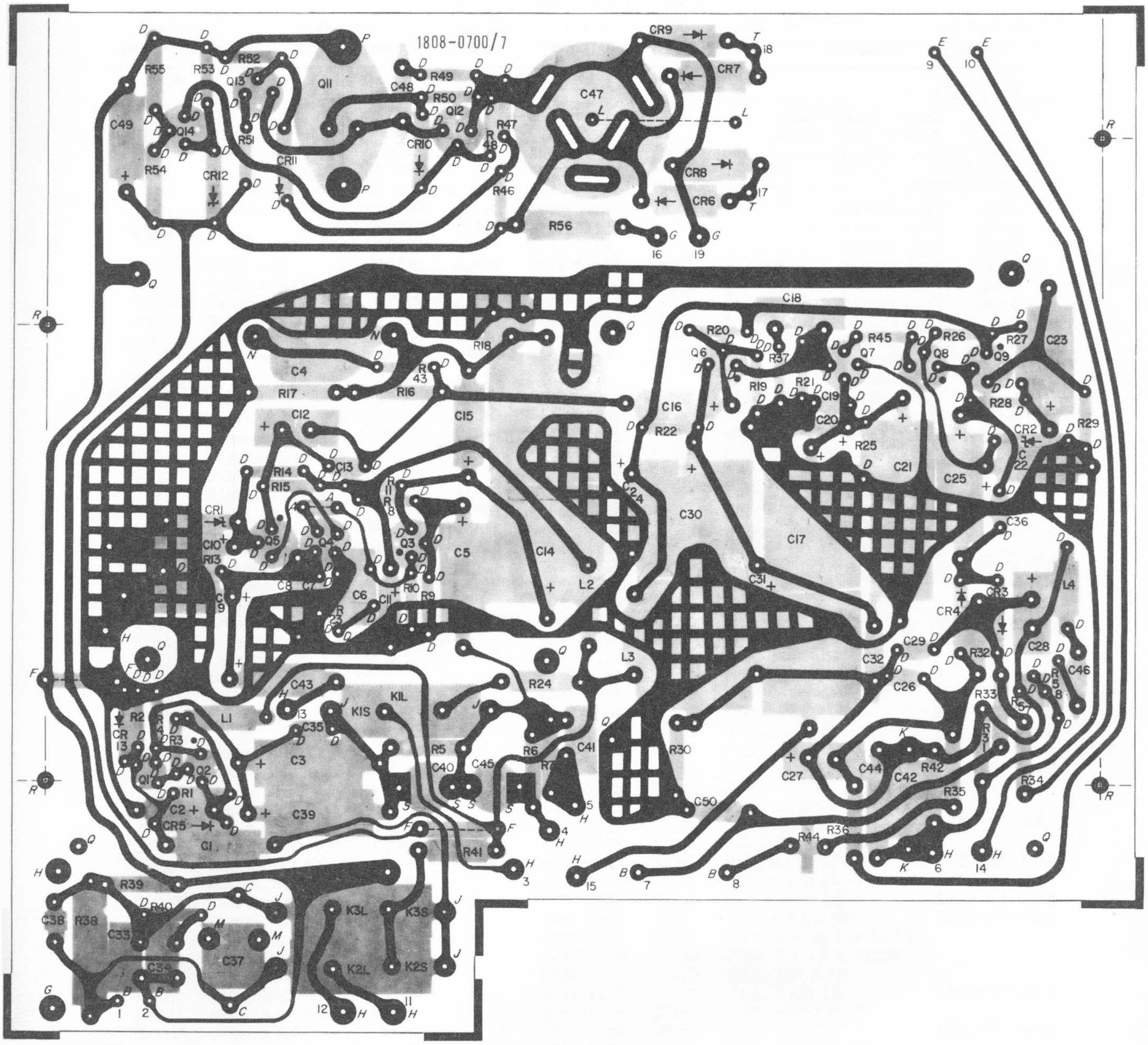


Figure 6-3. Etched-circuit board assembly, B-Voltmeter board (P/N 1808-4700).

NOTE: Parts on the board are on the side away from the viewer, indicated by the lighter tones; foil on that side is also lighter. The number etched on the foil-only (solid) side is *not* the part number. The dot on the foil at the transistor socket indicates the collector lead.

1 For units with 0110 or 0200 ID Numbers only. Refer to parts list for values used in other models.

2 Not included in units with 0100 ID Numbers.

Figure 6-4. Schematic Diagram of the 1808.

ELECTRICAL PARTS (1808)

Ref Des	Description	GR Part No.	Fed Mfg Code	Mfg Part No.	Fed Stock No.
CAPACITORS					
B-C1	Plastic, 0.022 μF ±10% 200 V	4860-7855	84411	663 UW, 0.022 μF, 10%	
B-C2	Electrolytic, 1.0 μF ±20% 35 V	4450-4300	56289	150D105X0035A2	5910-726-5003
B-C3	Electrolytic, 68 μF ±20% 15 V	4450-5615	80183	150D686X0015R2	
B-C4	Trimmer, 20 pF ±10% 500 V	4910-0400	72982	TSaAN300, 5 to 20 pF	5910-034-5429
B-C5	Electrolytic, 47 μF ±20% 20 V	4450-5614	56289	150D476X0020R2	
B-C6	Mica, 680 pF ±5% 300 V	4700-0810	14655	22A, 680 pF 5%	5910-899-0680
B-C7	Ceramic, 0.001 μF ±10% 500 V	4405-2108	72982	801, 0.001 μF 10%	5910-914-0087
B-C8	Electrolytic, 4.7 μF ±20% 10 V	4450-4700	56289	150D465X0015B2	5910-813-8160
B-C9	Electrolytic, 47 μF ±20%	4450-5630	56289	150D686X9015R	
B-C10	Electrolytic, 10 μF ±20% 20 V	4450-5100	56289	150D106X0020B2	5910-855-6343
B-C11	Electrolytic, 1.0 μF ±20% 35 V	4450-4300	56289	150D105X0035A2	5910-726-5003
B-C12	Electrolytic, 100 μF ±20% 20 V	4450-6253	37942	TT, 100 μF, 20%	
B-C13	Ceramic, 0.001 μF ±10% 500 V	4405-2108	72982	801, 0.001 μF 10%	5910-914-0087
B-C14	Electrolytic, 1225 μF +150-10% 15 V	4450-6115	37942	TT, 1225 μF +150-10%	
B-C15	Electrolytic, 10 μF ±20% 20 V	4450-5100	56289	150D106X0020B2	5910-855-6343
B-C16	Electrolytic, 10 μF ±20% 20 V	4450-5100	56289	150D106X0020B2	5910-855-6343
B-C17	Electrolytic, 890 μF +150-10% 10 V	4450-6010	37942	TT, 890μF, +150-10%	
B-C18	Mica, 0.001 μF ±5% 300 V	4700-1190	14655	22A3D1, 1KpF 5%	
B-C19	Ceramic, 0.001 μF ±20% 500 V	4405-2108	72982	801, 0.001 μF 10%	5910-914-0087
B-C20	Electrolytic, 4.7 μF ±20% 6 V	4450-5500	56289	150D476X0006B2	5910-752-4185
B-C21	Electrolytic, 200 μF +150-10% 6 V	4450-2610	37942	TT, 200 μF +150-10%	5910-945-1836
B-C22	Electrolytic, 10 μF ±20% 20 V	4450-5100	56289	150D106X0020B2	5910-855-6343
B-C23	Electrolytic, 68 μF ±20% 15 V	4450-5615	80183	150D686X0015R2	
B-C24	Electrolytic, 1.0 μF ±20% 35 V	4450-4300	56289	150D105X0035A2	5910-726-5003
B-C25	Electrolytic, 47 μF ±20% 20 V	4450-5614	56289	150D476X0020B2	
B-C26	Ceramic, 0.001 μF ±10% 500 V	4405-2108	72982	801, 0.001 μF 10%	5910-914-0087
B-C27	Electrolytic, 330 μF ±20% 6 V	4450-6250	37942	TT, 330 μF ±20%	
B-C28	Electrolytic, 330 μF ±20% 6 V	4450-6250	37942	TT, 330 μF ±20%	
B-C29	Ceramic, 0.001 μF ±10% 500 V	4405-2108	72982	801, 0.001 μF 10%	5910-914-0087
B-C30	Electrolytic, 880 μF +150-10% 20 V	4450-6120	37942	TT, 880 μF +150-10%	
B-C31	Electrolytic, 10 μF ±20% 20 V	4450-5100	56289	150D106X0020B2	5910-855-6343
B-C32	Ceramic, 0.1 μF ±20% 100 V	4403-4100	80131	CC63, 0.1 μF +80-20%	5910-811-4788
B-C33	Mica, 453 pF ±1% 300 V	4710-0524	14655	22A, 453 pF ±1%	
B-C34	Mica, 137 pF ±1% 500 V	4710-0137	14655	22A, 137 pF ±1%	
B-C35	Ceramic, 0.001 μF ±10% 500 V	4405-2108	72982	801, 0.001 μF 10%	5910-914-0087
B-C36	Ceramic, 0.001 μF ±10% 500 V	4405-2108	72982	801, 0.001 μF 10%	5910-914-0087
B-C37	Collar, 1.2-3.5 pF	4380-6003	74970	189-1-1, 1.2-3.5 pF	
B-C38	Ceramic, 3.3 pF ±10% 500 V	4400-0400	78488	GA, 3.3 pF 10%	5910-708-5197
B-C39	Electrolytic, 47 μF ±20% 20 V	4450-5614	56289	150D476X0020R2	
B-C40	Trimmer, 2- 8 pF ±5%	4910-2045	72982	538-002, 2 to 8 pF	
B-C41	Mica, 270 pF ±5% 500 V	4700-0528	14655	22A, 270 pF 5%	
B-C42	Mica*, 470 pF ±10% (nominal) 500 V	4640-0900	72136	CM15, 470 pF	
B-C43	Electrolytic, 22 μF ±20% 15 V	4450-5300	56289	150D226X0015B2	5910-752-4270
B-C44	Plastic, 0.0056 μF 100 V	4860-7398	84411	663UW, 0.0056 μF	
B-C45	Trimmer, 8-50 pF	4910-1170	72982	538-002, 8 to 50 pF	
B-C46	Ceramic, 0.01 μF ±10% 100 V	4402-3108	72982	801, 0.01 μF ±10%	
B-C47	Electrolytic, 200-200 μF +100-10% 50 V	4450-5591	80183	D38858	5910-959-4572
B-C48	Ceramic, 0.05 μF +80-20% 100 V	4403-3500	01121	40-503W	5910-883-7321
B-C49	Electrolytic, 6.8 μF ±20% 35 V	4450-5000	56289	150D685X0035B2	5910-814-5869
A-C50	Ceramic, 0.1 μF +80-20% 100 V	4403-4100	80183	CC63, 0.1 μF +80-20%	5910-811-4788
A-C51	Ceramic, 0.0068 μF +80-20% 500 V	4406-2689	72982	811, 0.0068 μF +80-20%	
A-C52	Ceramic, 0.01 μF +80-20% 500 V	4406-3109	72982	811, 0.01 μF +80-20%	5910-754-7049
CONNECTORS					
A-J1	INPUT Connector	4230-2301	09408	UG-1094/U	
A-J2	FLOATING DC OUTPUT + Connector	4150-2600	24655	4150-2600	
A-J3	FLOATING DC OUTPUT - Connector	4150-2600	24655	4150-2600	
A-J4	Power Plug	4240-0600	24655	4240-0600	5935-816-0254
DIODES					
B-CR1	Type IN959B 8.2 V ±5% 0.4 W	6083-1037	07910	IN959B	
B-CR2	Type IN759A 12 V ±5% 0.4 W	6083-1014	81349	IN759A	5961-846-9157
B-CR3	Type ID-6-050T	6082-1031	81483	ID-6-050T	
B-CR4	Type ID-6-050T	6082-1031	81483	ID-6-050T	
B-CR5	Type IN3604	6082-1001	24446	IN3604	5961-995-2199
B-CR6	Type IN3253	6081-1001	79089	IN3253	5961-814-4251
B-CR7	Type IN3253	6081-1001	79089	IN3253	5961-814-4251
B-CR8	Type IN3253	6081-1001	79089	IN3253	5961-814-4251
B-CR9	Type IN3253	6081-1001	79089	IN3253	5961-814-4251
B-CR10	Type IN4009	6082-1012	24446	IN4009	5961-892-8700
B-CR11	Type IN4009	6082-1012	24446	IN4009	5961-892-8700
B-CR12	Type IN970B 24 V ±5% 0.4 W	6083-1054	80211	IN970B	
B-CR13	Type IN3604	6082-1001	24446	IN3604	5961-995-2199

*Capacitor value factory adjusted.

FEDERAL MANUFACTURER'S CODE

From Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) as supplemented through August, 1968.

Code	Manufacturer
00192	Jones Mfg. Co, Chicago, Illinois
00194	Walsco Electronics Corp, L.A., Calif.
00434	Schweber Electronics, Westburg, L.I., N.Y.
00656	Aerovox Corp, New Bedford, Mass.
01009	Alden Products Co, Brockton, Mass.
01121	Allen-Bradley, Co, Milwaukee, Wisc.
01295	Texas Instruments, Inc, Dallas, Texas
02114	Ferroxcube Corp, Saugerties, N.Y. 12477
02606	Fenwal Lab Inc, Morton Grove, Ill.
02660	Amphenol Electron Corp, Broadview, Ill.
02768	Fastex, Des Plaines, Ill. 60016
03508	G.E. Semicon Prod, Syracuse, N.Y. 13201
03636	Grayburne, Yonkers, N.Y. 10701
03888	Pyrofilm Resistor Co, Cedar Knolls, N.J.
03911	Clairex Corp, New York, N.Y. 10001
04009	Arrow-Hart & Hegeman, Hartford, Conn. 06106
04713	Motorola, Phoenix, Ariz. 85008
05170	Engr'd Electronics, Santa Ana, Calif. 92702
05624	Barber-Colman Co, Rockford, Ill. 61101
05820	Wakefield Eng, Inc, Wakefield, Mass. 01880
07126	Digitron Co, Pasadena, Calif.
07127	Eagle Signal (E.W. Bliss Co), Baraboo, Wisc.
07261	Avnet Corp, Culver City, Calif. 90230
07263	Fairchild Camera, Mountain View, Calif.
07387	Birtcher Corp, No. Los Angeles, Calif.
07595	Amer Semicond, Arlington Hts, Ill. 60004
07828	Bodine Corp, Bridgeport, Conn. 06605
07829	Bodine Electric Co, Chicago, Ill. 60618
07910	Cont Device Corp, Hawthorne, Calif.
07983	State Labs Inc, N.Y., N.Y. 10003
07999	Borg Inst., Delavan, Wisc. 53115
08730	Vemaline Prod Co, Franklin Lakes, N.J.
09213	G.E. Semiconductor, Buffalo, N.Y.
09408	Star-Tronics Inc, Georgetown, Mass. 01830
09823	Burgess Battery Co, Freeport, Ill.
09922	Burndy Corp, Norwalk, Conn. 06852
11236	C.T.S. of Berne, Inc, Berne, Ind. 46711
11599	Chandler Evans Corp, W. Hartford, Conn.
12040	National Semiconductor, Danbury, Conn.
12498	Crystalonics, Cambridge, Mass. 02140
12672	RCA, Woodbridge, N.J.
12697	Clarostat Mfg Co, Inc, Dover, N.H. 03820
12954	Dickson Electronics, Scottsdale, Ariz.
13327	Solitron Devices, Tappan, N.Y. 10983
14433	ITT Semicondictors, W.Palm Beach, Fla.
14655	Cornell-Dubilier Electric Co, Newark, N.J.
14674	Corning Glass Works, Corning, N.Y.
14936	General Instrument Corp, Hicksville, N.Y.
15238	ITT, Semiconductor Div, Lawrence, Mass.
15605	Cutler-Hammer Inc, Milwaukee, Wisc. 53233
16037	Spruce Pine Mica Co, Spruce Pine, N.C.
17771	Singer Co, Diehl Div, Somerville, N.J.
19396	Illinois Tool Works, Pakton Div, Chicago, Ill.
19644	LRC Electronics, Horseheads, N.Y.
19701	Electra Mfg Co, Independence, Kansas 67301
21335	Fafnir Bearing Co, New Briton, Conn.
22753	UID Electronics Corp, Hollywood, Fla.
23342	Avnet Electronics Corp, Franklin Park, Ill.
24446	G.E., Schenectady, N.Y. 12305
24454	G.E., Electronics Comp, Syracuse, N.Y.
24455	G.E. (Lamp Div), Nela Park, Cleveland, Ohio
24655	General Radio Co, W. Concord, Mass. 01781
26806	American Zettlet Inc, Costa Mesa, Calif.
28520	Hayman Mfg Co, Kenilworth, N.J.
28959	Hoffman Electronics Corp, El Monte, Calif.
30874	I.B.M, Armonk, New York
32001	Jensen Mfg. Co, Chicago, Ill. 60638
33173	G.E. Comp, Owensboro, Ky. 42301
35929	Constanta Co, Mont. 19, Que.
37942	P.R. Mallory & Co Inc, Indianapolis, Ind.
38443	Marlin-Rockwell Corp, Jamestown, N.Y.
40931	Honeywell Inc, Minneapolis, Minn. 55408
42190	Muter Co, Chicago, Ill. 60638
42498	National Co, Inc, Melrose, Mass. 02176
43991	Norma-Hoffman, Stanford, Conn. 06904
49671	RCA, New York, N.Y. 10020
49956	Raytheon Mfg Co, Waltham, Mass. 02154
53021	Sangamo Electric Co, Springfield, Ill. 62705
54294	Shallcross Mfg Co, Selma, N.C.
54715	Shure Brothers, Inc, Evanston, Ill.
56289	Sprague Electric Co, N. Adams, Mass.
59730	Thomas and Betts Co, Elizabeth, N.J. 07207
59875	TRW Inc, (Accessories Div), Cleveland, Ohio
60399	Torrington Mfg Co, Torrington, Conn.
61637	Union Carbide Corp, New York, N.Y. 10017
61864	United-Carr Fastener Corp, Boston, Mass.
63060	Victoreen Instrument Co, Inc, Cleveland, O.
63743	Ward Leonard Electric Co, Mt. Vernon, N.Y.
65083	Westinghouse (Lamp Div), Bloomfield, N.J.
65092	Weston Instruments, Newark, N.J.
70485	Atlantic-India Rubber, Chicago, Ill. 60607
70563	Amperite Co, Union City, N.J. 07087
70903	Belden Mfg Co, Chicago, Ill. 60644
71126	Bronson, Homer D, Co, Beacon Falls, Conn.
71294	Canfield, H.O. Co, Clifton Forge, Va. 24422
71400	Bussman (McGraw Edison), St. Louis, Mo.
71468	ITT Cannon Elec, L.A., Calif. 90031
71590	Centralab, Inc, Milwaukee, Wisc. 53212
71666	Continental Carbon Co, Inc, New York, N.Y.
71707	Coto Coil Co Inc, Providence, R.I.
71744	Chicago Miniature Lamp Works, Chicago, Ill.
71785	Cinch Mfg Co, Chicago, Ill. 60624
71823	Darnell Corp, Ltd, Downey, Calif. 90241
72136	Electro Motive Mfg Co, Wilmington, Conn.
72259	Nytronics Inc, Berkeley Heights, N.J. 07922
72619	Dialight Co, Brooklyn, N.Y. 11237
72699	General Instr Corp, Newark, N.J. 07104
72765	Drake Mfg Co, Chicago, Ill. 60656
72825	Hugh H. Eby Inc, Philadelphia, Penn. 19144
72962	Elastic Stop Nut Corp, Union, N.J. 07083
72982	Erie Technological Products Inc, Erie, Penn.
73138	Beckman Inc, Fullerton, Calif. 92634
73445	Amperex Electronics Co, Hicksville, N.Y.
73559	Carling Electric Co, W.Hartford, Conn.
73690	Elco Resistor Co, New York, N.Y.
73899	JFD Electronics Corp, Brooklyn, N.Y.
74193	Heinemann Electric Co, Trenton, N.J.
74861	Industrial Condenser Corp, Chicago, Iii.
74970	E.F. Johnson Co, Waseca, Minn. 56093
75042	IRC Inc, Philadelphia, Penn. 19108
75382	Kulka Electric Corp, Mt. Vernon, N.Y.
75491	Lafayette Industrial Electronics, Jamica, N.Y.
75608	Linden and Co, Providence, R.I.
75915	Littelfuse, Inc, Des Plaines, Ill. 60016
76005	Lord Mfg Co, Erie, Penn. 16512
76149	Mallory Electric Corp, Detroit, Mich. 48204
76487	James Millen Mfg Co, Malden, Mass. 02148
76545	Mueller Electric Co, Cleveland, Ohio 44114
76684	National Tube Co, Pittsburg, Penn.
76854	Oak Mfg Co, Crystal Lake, Ill.
77147	Patton MacGuyer Co, Providence, R.I.
77166	Pass-Seymour, Syracuse, N.Y.
77263	Pierce Roberts Rubber Co, Trenton, N.J.
77339	Positive Lockwasher Co, Newark, N.J.
77542	Ray-O-Vac Co, Madison, Wisc.
77630	TRW, Electronic Comp, Camden, N.J. 08103
77638	General Instruments Corp, Brooklyn, N.Y.
78189	Shakeproof (Ill. Tool Works), Elgin, Ill. 60120
78277	Sigma Instruments Inc, S.Braintree, Mass.
78488	Stackpole Carbon Co, St. Marys, Penn.
78553	Tinnerman Products, Inc, Cleveland, Ohio
79089	RCA, Rec Tube & Semicond, Harrison, N.J.
79725	Wiremold Co, Hartford, Conn. 06110
79963	Zierick Mfg Co, New Rochelle, N.Y.
80030	Prestole Fastener, Toledo, Ohio
80048	Vickers Inc, St. Louis, Mo.
80131	Electronic Industries Assoc, Washington, D.C.
80183	Sprague Products Co, No. Adams, Mass.
80211	Motorola Inc, Franklin Park, Ill. 60131
80258	Standard Oil Co, Lafeyette, Ind.
80294	Bourns Inc, Riverside, Calif. 92506
80431	Air Filter Corp, Milwaukee, Wisc. 53218
80583	Hammarlund Co, Inc, New York, N.Y.
80740	Beckman Instruments, Inc, Fullerton, Calif.
81030	International Insturment, Orange, Conn.
81073	Grayhill Inc, LaGrange, Ill. 60525
81143	Isolantite Mfg Corp, Stirling, N.J. 07980
81349	Military Specifications
81350	Joint Army-Navy Specifications
81751	Columbus Electronics Corp, Yonkers, N.Y.
81831	Filtron Co, Flushing, L.I., N.Y. 11354
81840	Ledex Inc, Dayton, Ohio 45402
81860	Barry-Wright Corp, Watertown, Mass.
82219	Sylvania Elec Prod, Emporium, Penn.
82273	Indiana Pattern & Model Works, LaPort, Ind.
82389	Switchcraft Inc, Chicago, Ill. 60630
82647	Metals & Controls Inc, Attleboro, Mass.
82807	Milwaukee Resistor Co, Milwaukee, Wisc.
83033	Meissner Mfg, (Maguire Ind) Mt. Carmel, Ill.
83058	Carr Fastener Co, Cambridge, Mass.
83186	Victory Engineering, Springfield, N.J. 07081
83361	Bearing Specialty Co, San Francisco, Calif.
83587	Solar Electric Corp, Warren, Penn.
83740	Union Carbide Corp, New York, N.Y. 10017
83781	National Electronics Inc, Geneva, Ill.
84411	TRW Capacitor Div, Ogallala, Nebr.
84835	Lehigh Metal Prods, Cambridge, Mass. 02140
84971	TA Mfg Corp, Los Angeles, Calif.
86577	Precision Metal Prods, Stoneham, Mass. 02180
86684	RCA (Elect. Comp & Dev), Harrison, N.J.
86687	REC Corp, New Rochelle, N.Y. 10801
86800	Cont Electronics Corp, Brooklyn, N.Y. 11222
88140	Cutler-Hammer Inc, Lincoln, Ill.
88219	Gould Nat. Batteries Inc, Trenton, N.J.
88419	Cornell-Dubilier, Fuquay-Varina, N.C.
88627	K & G Mfg Co, New York, N.Y.
89482	Holtzer-Cabot Corp, Boston, Mass.
89665	United Transformer Co, Chicago, Ill.
90201	Mallory Capacitor Co, Indianapolis, Ind.
90750	Westinghouse Electric Corp, Boston, Mass.
90952	Hardware Products Co, Reading, Penn. 19602
91032	Continental Wire Corp, York, Penn. 17405
91146	ITT (Cannon Electric Inc), Salem, Mass.
91293	Johanson Mfg Co, Boonton, N.J. 07005
91506	Augat Inc, Attleboro, Mass. 02703
91598	Chandler Co, Wethersfield, Conn. 06109
91637	Dale Electronics Inc, Columbus, Nebr.
91662	Elco Corp, Willow Grove, Penn.
91719	General Instruments, Inc, Dallas, Texas
91929	Honeywell Inc, Freeport, Ill.
92519	Electra Insul Corp, Woodside, L.I., N.Y.
92678	E.G.&G., Boston, Mass.
93332	Sylvania Elect Prods, Inc, Woburn, Mass.
93916	Cramer Products Co, New York, N.Y. 10013
94144	Raytheon Co, Components Div, Quincy, Mass.
94154	Tung Sol Electric Inc, Newark, N.J.
95076	Garde Mfg Co, Cumberland, R.I.
95121	Quality Components Inc, St. Mary's, Penn.
95146	Alco Electronics Mfg Co, Lawrence, Mass.
95238	Continental Connector Corp, Woodside, N.Y.
95275	Vitramon, Inc, Bridgeport, Conn.
95354	Methode Mfg Co, Chicago, Ill.
95412	General Electric Co, Schenectady, N.Y.
95794	Anaconda Amer Brass Co, Torrington, Conn.
96095	Hi-Q Div. of Aerovox Corp, Orlean, N.Y.
96214	Texas Instruments Inc, Dallas, Texas 75209
96256	Thordarson-Meissner, Mt. Carmel, Ill.
96341	Microwave Associates Inc, Burlington, Mass.
96791	Amphenol Corp, Jonesville, Wisc, 53545
96906	Military Standards
98291	Sealectro Corp, Mamaroneck, N.Y. 10544
98474	Compar Inc, Burlingame, Calif.
98821	North Hills Electronics Inc, Glen Cove, N.Y.
99180	Transitron Electronics Corp, Melrose, Mass.
99313	Varian, Palo Alto, Calif. 94303
99378	Atlee Corp, Winchester, Mass. 01890
99800	Delevan Electronics Corp, E. Aurora, N.Y.

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