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OPERATING AND SERVICE MANUAL

-hp- Part No. 00403-90010

MODEL 403B AC VOLTMETER

Serials Prefixed: 0986A

If other serial prefixes require modification of this manual, the changes will appear in Appendix C or in an associated "Manual Changes" supplement.

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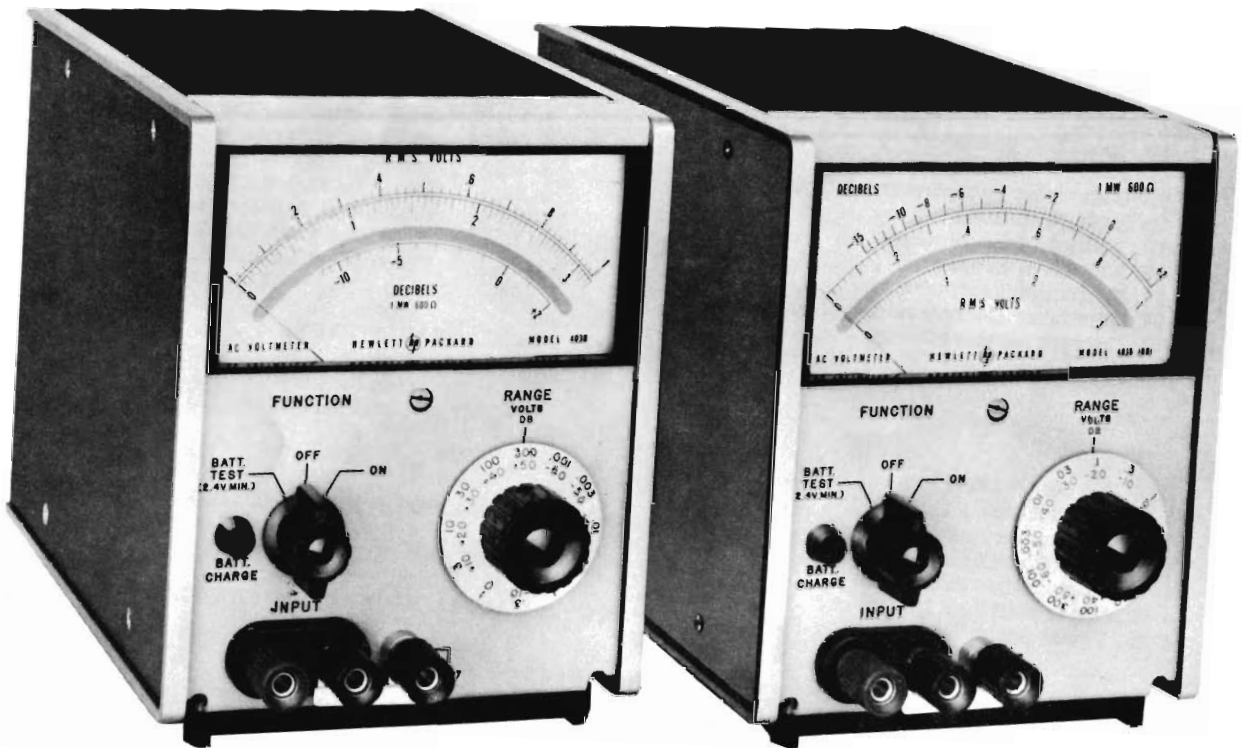
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Model 403B AC Voltmeter
Standard

Model 403B AC Voltmeter
Option 01

Figure 1-1. Model 403B AC Voltmeter

SECTION I GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The -hp- Model 403B Transistorized AC Voltmeter is a general purpose instrument that measures rms values of ac voltages in the 5 Hz to 2 MHz range. The instrument has full-scale ranges from 1 mV to 300 volts (-72 dBm to +52 dBm) in a 1, 3, 10 sequence. The Model 403B meter face is calibrated with the upper scale in volts (rms); the Model 403B Option 01 meter face is calibrated with the upper scale in dB. Models 403B and 403B Option 01 are shown in Figure 1-1, and specifications are given in Table 1-1.

1-3. The Model 403B operates from Nickel Cadmium batteries. The instrument also includes a self-contained battery charger which operates on 115 or 230 volts ac.

1-5. INSTRUMENT AND MANUAL IDENTIFICATION.

1-6. Hewlett-Packard uses a two-section serial number. If the first section (serial prefix) of the serial number on your instrument does not agree with those

on the title page of this manual, change sheets supplied with the manual will define the differences between your instrument and the Model 403B described in this manual. Some serial numbers may have a letter separating the two sections of the number. This letter indicates the country in which the instrument was manufactured.

1-7. ACCESSORIES AVAILABLE.

1-8. To increase the usefulness of your instrument, the following accessories are available:

- a. -hp- Model 11005A Line Bridging Transformer.
- b. -hp- Model 11039A Capacitive Voltage Divider.
- c. -hp- Model 10111A BNC-To-Binding Post Adapter.

1-9. Table 1-2 provides information and use of the accessories mentioned above as well as other useful accessories.

Table 1-1. Specifications

<p>RANGE: 0.001 to 300 volts rms full scale (12 ranges) in a 1, 3, 10 sequence.</p> <p>FREQUENCY RANGE: 5 Hz to 2 MHz</p> <p>ACCURACY: % of Full Scale.</p> <p>MODEL 403B ACCURACY SPECIFICATION</p> <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 30%;">Frequency</th> <th style="width: 35%;">0 to 50°C</th> <th style="width: 35%;">0 to -20°C</th> </tr> </thead> <tbody> <tr> <td>10 Hz to 1 MHz</td> <td>±2%</td> <td>±8%</td> </tr> <tr> <td>5 to 10 Hz and 1 to 2 MHz</td> <td>±5%</td> <td>±8%</td> </tr> </tbody> </table> <p>MODEL 403B OPTION 01 ACCURACY SPECIFICATION</p> <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 30%;">Frequency</th> <th style="width: 35%;">0 to 50°C</th> <th style="width: 35%;">0 to -20°C</th> </tr> </thead> <tbody> <tr> <td>10 Hz to 1 MHz</td> <td>±0.2 dB</td> <td>±0.7 dB</td> </tr> <tr> <td>5 to 10 Hz and 1 to 2 MHz</td> <td>±0.4 dB</td> <td>±0.7 dB</td> </tr> </tbody> </table> <p>METER: Individually calibrated, taut band. Responds to average value of input waveform and is calibrated in the rms value of a sine wave.</p>	Frequency	0 to 50°C	0 to -20°C	10 Hz to 1 MHz	±2%	±8%	5 to 10 Hz and 1 to 2 MHz	±5%	±8%	Frequency	0 to 50°C	0 to -20°C	10 Hz to 1 MHz	±0.2 dB	±0.7 dB	5 to 10 Hz and 1 to 2 MHz	±0.4 dB	±0.7 dB	<p>NOMINAL INPUT IMPEDANCE: 2 megohms; shunted by < 60 pF on 0.001-volt to 0.03-volt ranges, < 30 pF on 0.1-volt to 300-volt ranges.</p> <p>OVERLOAD PROTECTION: Fuse protected:</p> <p>DC ISOLATION: Signal ground may be ±500 Vdc from external chassis.</p> <p>POWER SUPPLY: 4 rechargeable batteries (furnished). 40-hour operation per recharge (20 hours at -20°C), up to 500 recharging cycles (expected battery life of 20,000 hours). Recharging circuit is self-contained and functions automatically when instrument is operated from ac line (115 or 230V ±10% 48 to 440 Hz, < 3 watts).</p> <p>TEMPERATURE RANGE: -20°C to +50°C.</p> <p>DIMENSIONS: 5-1/8 in. wide, 6-3/32 in. high, 8 in. deep.</p> <p>ACCESSORIES AVAILABLE: -hp- 11002A Test Leads, 5 ft. long, dual banana plug to alligator clips. -hp- 11003A Test Leads, 5 ft. long, dual banana plug to probe and alligator clip.</p> <p>ACCESSORY FURNISHED: Detachable power cord.</p>
Frequency	0 to 50°C	0 to -20°C																	
10 Hz to 1 MHz	±2%	±8%																	
5 to 10 Hz and 1 to 2 MHz	±5%	±8%																	
Frequency	0 to 50°C	0 to -20°C																	
10 Hz to 1 MHz	±0.2 dB	±0.7 dB																	
5 to 10 Hz and 1 to 2 MHz	±0.4 dB	±0.7 dB																	

Table 1-2. Accessories Available

Model No.	Use	Features						
11002A 11003A	Test Leads	Dual Banana Plug to Alligator Clips Dual Banana Plug to Probe and Alligator Clip						
11011A	Adapter	Binding Post to BNC						
11005A	Line Bridging Transformer Provides balanced 600-ohm input to unbalanced 600-ohm output for measurements on balanced lines.	Terminating Resistance: 600 or 10 K ohms Frequency Range: 20 Hz to 45 kHz Power Handling Capacity: +15 dBm (4.5 V into 600 Ω)						
11039A	Capacitive Voltage Divider (Division ratio: 1000:1)	Accuracy: $\pm 3\%$ Input Capacity: 15 pF \pm 1 pF Max. Voltage Rating: 60 Hz 25 kV, 100 kHz 22 kV, 1 MHz 20 kV, 10 MHz 15 kV, 20 MHz 7 kV						
456A	AC Current Probe 1 mV/mA $\pm 1\%$ at 1 kHz	<table border="0"> <thead> <tr> <th>Resistance</th> <th>Max. Current</th> <th>Accuracy</th> </tr> </thead> <tbody> <tr> <td>< 50 milliohms</td> <td>1 amp rms 1.5 amp peak</td> <td>$\pm 2\%$ 100 Hz to 3 MHz</td> </tr> </tbody> </table>	Resistance	Max. Current	Accuracy	< 50 milliohms	1 amp rms 1.5 amp peak	$\pm 2\%$ 100 Hz to 3 MHz
Resistance	Max. Current	Accuracy						
< 50 milliohms	1 amp rms 1.5 amp peak	$\pm 2\%$ 100 Hz to 3 MHz						
11004A	Line Matching Transformer Provides balanced 135 or 600 ohm input to 600 ohm unbalanced output for measurements on balanced lines.	Terminating Resistance: 600 or 10 K ohms Frequency Range: 5 kHz to 600 kHz Power Handling Capacity: 22 dBm (10 V into 600 Ω)						

SECTION II INSTALLATION

2-1. INSPECTION.

2-2. Unpack the instrument upon receipt and inspect it for signs of physical damage such as scratched panel knobs etc. If there is any apparent damage, file a claim with the carrier and refer to the warranty page on the back side of the front cover of this manual.

2-3. An electrical inspection should be performed as soon as possible after receipt. To aid in electrical inspection, performance checks are included in Section V, Paragraph 5-10.

2-4. POWER REQUIREMENTS.

2-5. The ac power circuit which provides charging current to the Nickel-Cadmium batteries in the instrument can be connected to a 115- or 230- volt, 48-440 Hz, source. A switch located on the rear panel of the instrument allows the user to select 115- or 230-volt modes of operation.

WARNING

WHEN THE 403B IS USED WITHOUT
THE POWER CORD, THERE IS NO
GROUND RETURN. USE CAUTION
TO AVOID ELECTRICAL SHOCK.

2-6. INSTALLATION.

2-7. The -hp- Model 403B is fully transistorized; therefore no special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 50°C (131°F).

2-8. REPACKAGING FOR SHIPMENT.

—————NOTE—————

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

2-9. The following is a general guide for repacking for shipment. If you have any questions, contact your local -hp- Sales and Service Office. (See Appendix B for office locations.)

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

If original container is not used,

- b. Wrap instrument in heavy paper or plastic before placing in an inner container.
- c. Use plenty of packing material around all sides of instrument and protect panel faces with cardboard strips.
- d. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.
- e. Mark shipping container with "Delicate Instrument," "Fragile" etc.

SECTION III

OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. This voltmeter is ready for use upon receipt from the factory and will give specified performance after a short warm-up period. Allow approximately 60 seconds warm-up for optimum performance.

3-3. FRONT PANEL DESCRIPTION.

3-4. A description of front panel controls is given in Figure 3-1. The descriptions are keyed to the photo that accompanies the figure.

3-5. OPERATING PROCEDURE.

3-6. The operating procedure for the Model 403B is given in Figure 3-2. Instructions are keyed to the photo that accompanies the figure.

3-7. BATTERY CHARGING INFORMATION.

3-8. The 403B has a self-contained battery charger. This instrument is continually charging the batteries whenever the FUNCTION switch is ON and the line cord connected to a 115 or 230 volt source. In the event of complete discharge, the 403B can be used after twenty minutes of recharging with the line cord connected to an ac source. Complete recharge requires approximately 60 hours (depending on setting of R39) when the Nickel Cadmium cells are completely discharged. (Refer to Section IV, Paragraph 4-25).



THE FOUR NICKEL CADMIUM BATTERIES IN THE -HP- 403B ARE IN HERMETICALLY-SEALED CONTAINERS. UNDER HIGH TEMPERATURES (ABOVE 50°C), HYDROGEN IN THE HERMETICALLY-SEALED BATTERY CONTAINER CAN BUILD UP TO LARGE PRESSURE, CAUSING DAMAGE TO THE BATTERIES AND/OR INSTRUMENT. (REFER TO SECTION IV, PAGE 4-3.)

3-9. INSTRUMENT TEMPERATURE LIMITS.

3-10. This instrument has certain temperature limitations. The design of this instrument has provided for safe and stable operation over the range of -20 to +50°C (-4 to +131°F). This temperature range is quite adequate for most users; however, keep these limits in mind when operating under field conditions. Internal temperatures in excess of 122°F are quite easy to obtain if the instrument is left in the sun, even if the air temperature is quite moderate. A good practice is to be certain that the instrument is not stored or operated in direct sunlight to avoid the possibility of reduced performance. When using 403B

at temperatures below 0°C, be certain the batteries are fully charged prior to subjecting instrument to this temperature.

3-11. INPUT PROTECTION.

3-12. A 1/16 A fuse is included in series with the input circuit which will open with repeated or excessive overload. This fuse is accessible when the cabinet is removed. A spare fuse is included inside the instrument.

3-13. VOLTAGE MEASUREMENTS.

3-14. Always leave the instrument on the 1-volt range or higher when making initial connections to circuits which have dc levels over 25 volts. Then switch to the appropriate lower range to obtain an up-scale reading. This practice should be used when making power supply ripple measurements where the dc voltage may be as much as 600 volts, but the ac ripple is only a few millivolts. To obtain specified accuracy, the ground strap should be connected except when the signal ground is dc offset from chassis ground.

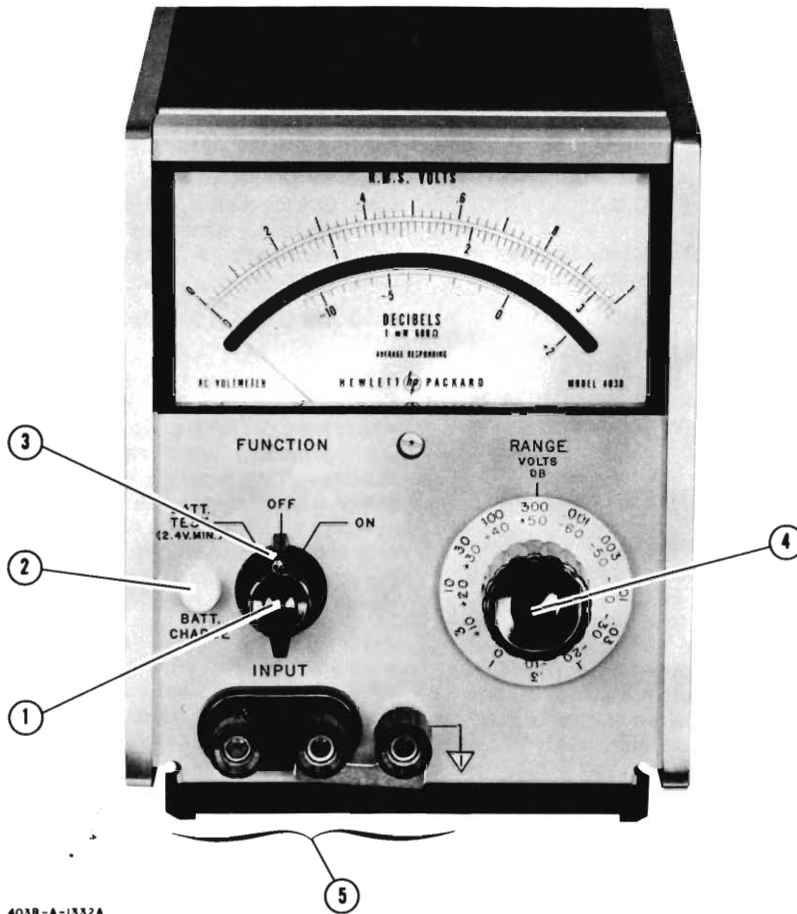
3-15. If measurements are made from a high-impedance source, hum pick-up can affect the meter indication because of high impedance of both the source and voltmeter. Shielded leads will reduce pick-up although they will cause an increase in the capacity shunted across the source, with the possibility of excessive circuit loading.

3-16. The rated 2 megohms input resistance will be effectively reduced (above 1 kHz) by shunt input capacity. (This fact is true for any ac voltmeter.) 50 pF has a reactance of 0.8 megohm at 4 kHz, 80,000 ohms at 40 kHz, etc. The shunt capacity decreases on the higher ranges (see Table 1-1). This factor should be considered when measuring higher frequency voltages in circuits of moderate impedance level.

3-17. Severe RF circulating currents are generated at potentials approaching 300 volts in the 1 to 2 MHz frequency range. These severe ground currents limit the accuracy of the 403B to ±10% on the 300-volt range. By using -hp- accessories 10001A (10:1 divider) and a 10111A (adapter) shunted by a 2-megohm resistor, the accuracy of the 403B can be retained to ±5%.

3-18. WAVEFORM ERRORS.

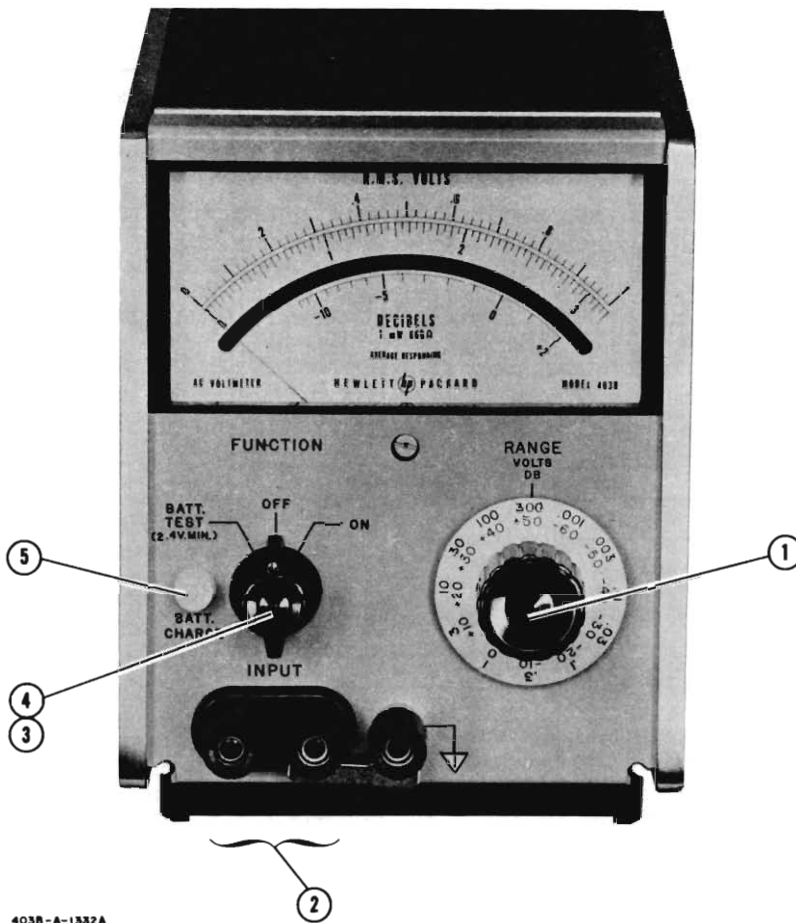
3-19. In order to maintain accuracy of measurement, one must remember that this instrument is an average responding device, but the meter scale is calibrated in terms of the rms value of a pure sine wave. If the waveform of the voltage being measured contains appreciable harmonics or other spurious voltages, the meter indication will deviate from the true rms value on the order indicated by Table 3-1.



403B-A-1332A

- ① **FUNCTION:** Three-position switch checks battery charge when the switch is in the ON position; it applies 27.5 volts from the Nickel-Cadmium batteries to the Model 403B circuitry. When in the BATT. TEST position, the meter should read above 2.4 volts on the "0-3" meter scale, which is equivalent to 24 Vdc at the battery.
- ② **BATT. CHARGE:** Glows when instrument is connected to an AC source with the FUNCTION switch turned to the ON position.
- ③ **Fluorescent Indicator:** Glows when instrument is on.
- ④ **RANGE:** Selects range from 0.001 volt to 300 volts rms full scale in a 1, 3, 10 sequence.
- ⑤ **INPUT:** Connect voltage to be measured to these terminals.

Figure 3-1. Front Panel Description



403B-A-1332A

- ① Select range which gives a reading in the upper 2/3 of the meter scale (This will insure the highest degree of accuracy).
- ② Connect voltage to be measured at the INPUT terminals (red terminal positive and ungrounded black terminal negative).
- ③ Set FUNCTION switch to BATT. TEST; front panel meter reading should be greater than 2.4 volts (corresponds to 24 volts at battery). If less than 2.4 volts, the battery needs re-charging. Refer to Paragraph 3-7 for battery charging instructions.
- ④ Set FUNCTION switch to ON; lamp function knob will glow, and the instrument is ready for voltage measurement.
- ⑤ When the instrument is connected to an AC power source and the FUNCTION switch is to ON, the BATT. CHARGE lamp will glow, indicating that the battery is being charged.

———— NOTE ————

The outer black ground terminal is connected to chassis ground. For voltage measurements at chassis ground, connect the ungrounded black terminal to the grounded black terminal.

Figure 3-2. Voltage Measurements

Table 3-1. Effect of Harmonics on Model 403B Voltage Measurements

Input Voltage Characteristics	True RMS Value	Value Indicated by 403B
Fundamental = 100	100	100
Fundamental +10% 2nd harmonic	100.5	100
Fundamental +20% 2nd harmonic	102	100 - 102
Fundamental +50% 2nd harmonic	112	100 - 110
Fundamental +10% 3rd harmonic	100.5	96 - 104
Fundamental +20% 3rd harmonic	102	94 - 108
Fundamental +50% 3rd harmonic	112	90 - 116

3-20. This table is a general one and applies to any average responding rms calibrated voltmeter. As can be seen in the table, errors are small even with a badly distorted signal (e. g.; 20% 2nd harmonic gives +0, -2% error).

3-21. DECIBEL MEASUREMENTS.

3-22. Measurements in terms of decibels are made in the same way as voltage measurements except that the indication is read on the dB scale (-12 to +2 dB). The decibel level is the algebraic sum of the meter dB scale indication and DB VOLTS (RANGE) position.

3-23. To read power directly in dBm, (0 dBm=1 milli-watt into 600 ohms) the measurement must be made across 600 ohms. Comparative dB measurements (without respect to reference level) may be obtained by direct reading provided each measurement is made across the same impedance value. The difference in decibels between two or more measurements may be obtained by reading directly from the dB-scale indications. (For examples of dB measurements, refer to Table 3-2.)

3-24. IMPEDANCE CORRECTION GRAPH.

3-25. To obtain the level in dBm with respect to impedances other than 600 ohms, the meter correction graph shown in Figure 3-3 may be used. The level in dBm will be the algebraic sum of the level as indicated on the meter and the correction shown on the graph. For example, if the range switch is at the +30 dB position, the measurement made across 90 ohms, and the indication on the DB scale +1, the level in dBm is obtained as follows:

$$\begin{aligned}
 &+ 1 \quad (\text{dB-scale indication}) \\
 &+30 \quad (\text{range switch position}) \\
 &+31 \quad (\text{level in dB as indicated by meter}) \\
 &+ 8 \quad (\text{correction for 90-ohm impedance}) \\
 &+39 \quad \text{dBm}
 \end{aligned}$$

Table 3-2. Examples of Voltage and DB Measurements

Range Switch	Meter Scale	Meter Indicates	Actual Level
Voltage measurements:			
300	3	1.8	180
10	1	0.44	4.4
.003	3	2.3	.0023
.001	1	.27	.00027
DB measurements:			
+40 dB	dB	+2 dB	+42 dB
+40 dB	dB	-7 dB	+33 dB
+10 dB	dB	-6 dB	+ 4 dB
-30 dB	dB	0 dB	-30 dB
-30 dB	dB	-8 dB	-38 dB
*-50 dB	dB	-9 dB	-59 dB
-60 dB	dB	+1 dB	-59 dB

*NOTE: In cases where a meter scale reading below -8 dB is obtained, it is best to switch to the next lower range on the instrument so a reading will be obtained in the upper portion of the scale where highest accuracy may be obtained.

The same situation exists for voltage measurements. When a reading is obtained in the lower 1/3 scale, the range switch should be switched to the next lower range to obtain a reading in the upper 2/3 scale.

3-26. For the same conditions, with the measurement made across 10,000 ohms:

$$\begin{aligned}
 &+ 1 \quad (\text{dB-scale indication}) \\
 &+30 \quad (\text{range switch position}) \\
 &+31 \quad (\text{level in dB as indicated by meter}) \\
 &-12.5 \quad (\text{correction for 10,000-ohm impedance}) \\
 &+18.5 \text{ dBm}
 \end{aligned}$$

3-27. CURRENT MEASUREMENTS.

3-28. CLIP-ON PROBE.

3-29. The -hp- Model 456A Current Probe provides quick measurement of current from 1 mA to 1 amp full scale with minimum circuit loading.

3-33. To use the Model 456A, simply clamp the probe around the current carrying wire and plug the output into the Model 403B. The probe output is 1 mV/mA.

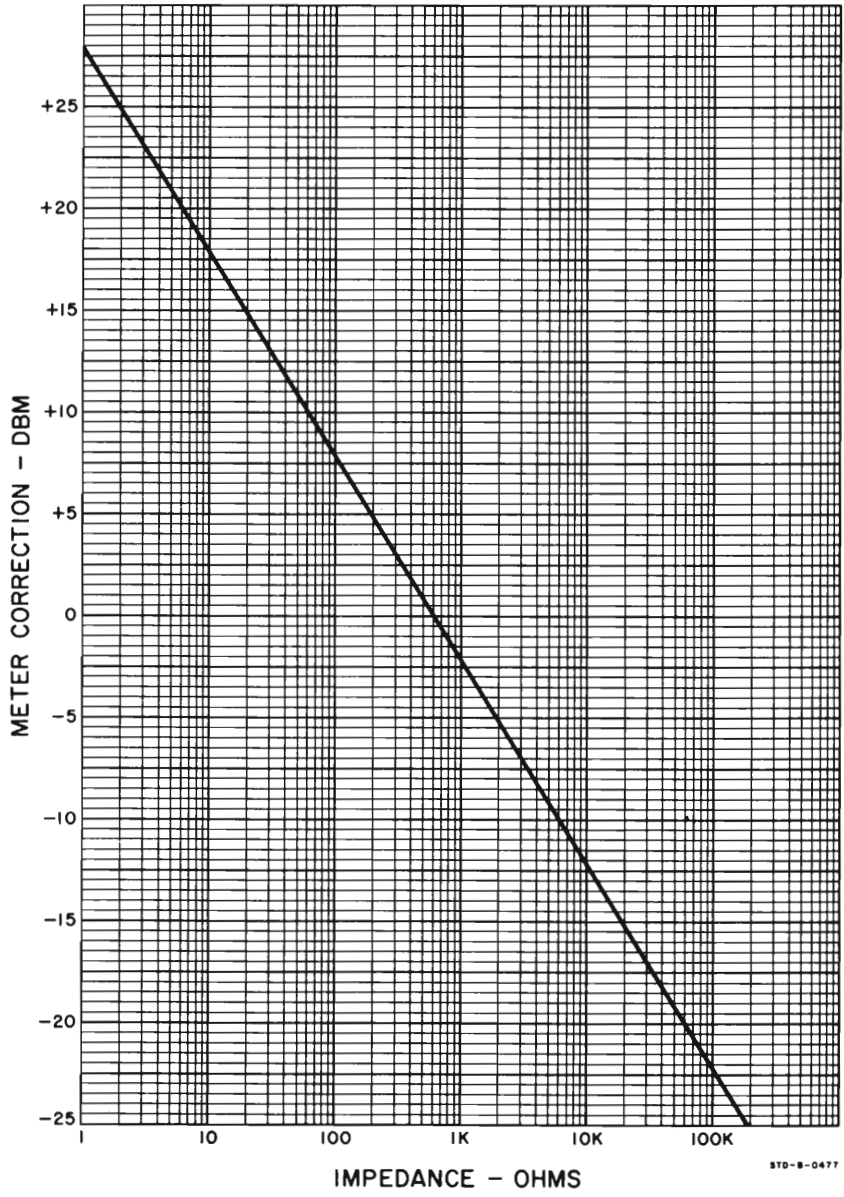


Figure 3-3. Model 403B Impedance Correction Graph

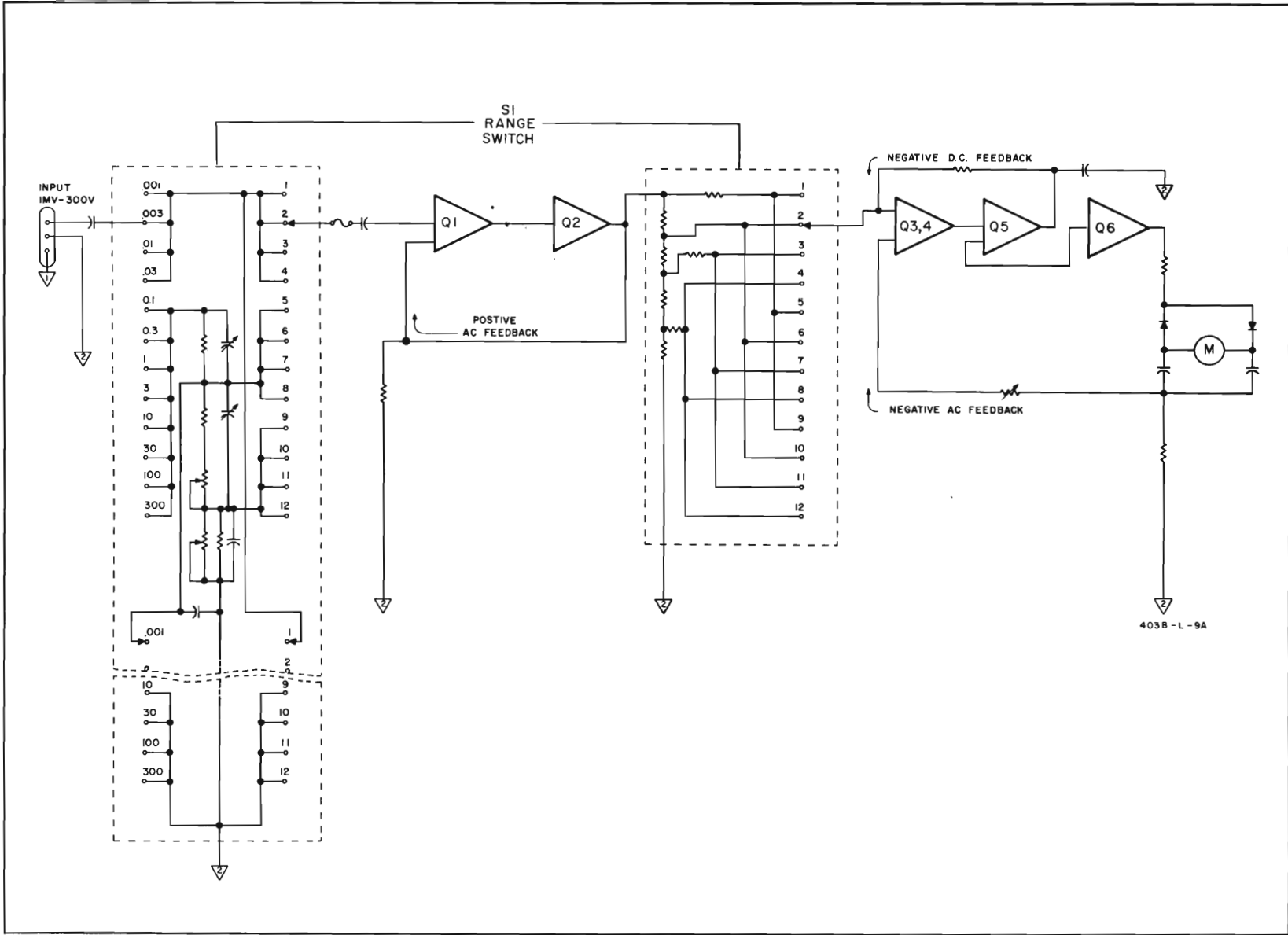


Figure 4-1. Model 403B Functional Block Diagram

SECTION IV

THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. The Model 403B includes a preliminary input attenuator, a high impedance emitter follower circuit, a range attenuator and a wide range fixed gain amplifier. Refer to Figure 4-1.

4-3. PRELIMINARY ATTENUATOR.

4-4. The RANGE switch is divided up into two sections: the preliminary attenuator, located between the input terminals and Q1, and the intermediate attenuator, located between Q2 and Q3. The preliminary input attenuator has two ranges, 100:1 and 10,000:1, which are switched in at the appropriate time to keep the input voltage to Q1 less than 0.030 volt. This not only prevents overloading the input system, but also provides the necessary accurate attenuation to work with the intermediate attenuator to produce the conventional 1, 3, 10 sequence for correct meter operation.

4-5. The attenuators are of the compensated resistor-capacitor (rc) type, with the capacitive division ratio made equal to the resistive ratio to maintain a constant division ratio at all frequencies. By making one of the capacitors adjustable, the small variations in stray circuit capacity can be compensated for, so the voltmeter will have a flat response. The exact division ratio is set at low audio frequencies by the trimmer potentiometers, which bring the resistor division ratio to the exact value.

4-6. INPUT CIRCUIT.

4-7. R11, CR1, and CR2 make up a limiting circuit which is used for overload protection to prevent high instantaneous voltages from being impressed on the base of Q1. F1 is a 1/16 amp fuse used to protect the 403B against a continuous or repeated overload.

4-8. Since transistors are inherently low impedance devices, a need for a high input impedance is required. Referring to Figure 4-2, it would seem that the input resistance of the first stage would be approximately R_i of a grounded collector configuration in parallel with R9, plus the R7-R8 combination. Q1 and Q2 are emitter followers, exhibiting unity gain and no phase reversal. (R_i = approx. input Z of a common collector stage.)

4-9. The output of Q2 is fed back to the junction of R9 and R7-R8. There is an ac voltage existing at this point that is very nearly the same amplitude as, and in phase with, the input voltage. Since a very small ac voltage exists across R9 (due to the feedback from Q2), the input current I_{in} will be very small. Thereby:

$$Z_{in} = \frac{E_{in}}{I_{in}}$$

It can be seen that when I_{in} is very small, the apparent Z_{in} becomes very large.

4-10. The R_i of Q1 is increased in a similar manner by feeding the Q2 emitter voltage to both the collector and emitter of Q1.

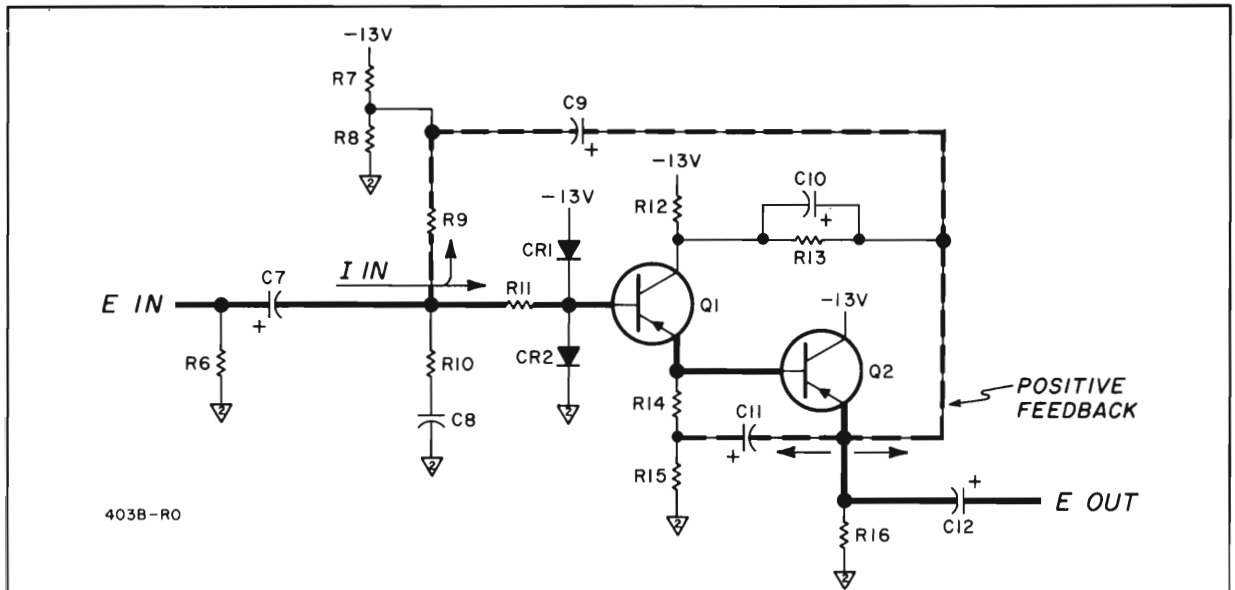


Figure 4-2. Input Amplifier

4-11. INTERMEDIATE ATTENUATOR.

4-12. The output of Q2 is fed to the intermediate section of the range attenuator. The range attenuator is a voltage divider, in sequence with the preliminary attenuator. A (1, 3, 10 etc.) ratio is obtained resulting in 10 DB steps. Refer to Figure 4-1.

4-13. Refer to schematic diagram (Figure 5-8) in the back of this manual.

4-14. Transistors Q3 through Q6 make up the fixed gain amplifier which is used to develop the current for (full scale) meter deflection and to provide the meter circuit with a high impedance source for linear operation at all current levels.

4-15. The output of the intermediate range attenuator is fed to the base of Q3 (differential amplifier), and compared with a feedback signal to its emitter from the meter circuit. This difference signal is fed to Q4 which in turn is directly coupled to Q5 and Q6. Q4 is a grounded emitter amplifier. Q5 is a common collector amplifier which impedance matches Q6, a common base amplifier. The direct couple feature of the amplifiers is necessary because of the low-frequency (5 hertz) response of the 403B. R24 through R26 make up the dc feedback loop which tends to minimize any tendency for dc drift due to ambient temperature change. R33 corrects the total gain of Q3 through Q6.

4-16. The meter source impedance is increased by the use of negative feedback from the output of the meter rectifier bridge to the emitter of Q3. Resistor R28 through R30, and C15 and C16 correct the phase of the feedback at high frequencies.

4-17. The necessity of high meter source impedance can be understood by referring to Figures 4-3 and 4-4.

4-18. To have correct voltmeter action, it is necessary that the change in meter circuit be proportional to a change in amplifier input voltage. The load resistance, then, should remain constant. Note in Figure 4-3, however, that when I_o (and therefore the diode voltage E_d) decreases, the diode resistance R_d (and therefore the load resistance) increases, affecting meter linearity. Note in Figure 4-4 that R_d appears in series with R_o , the source impedance. The effect on output current, due to changes in diode resistance with voltage, can be minimized by feeding the meter circuit from a constant current or high impedance source. In this way, changes of diode resistance will have a negligible effect on the total current passing through them and hence through the meter.

4-19. The effect of diode resistance change is further minimized by Q6 current through R35 which impresses a fixed 0.3 volt across CR3 and CR4, biasing them close to their contact potential.

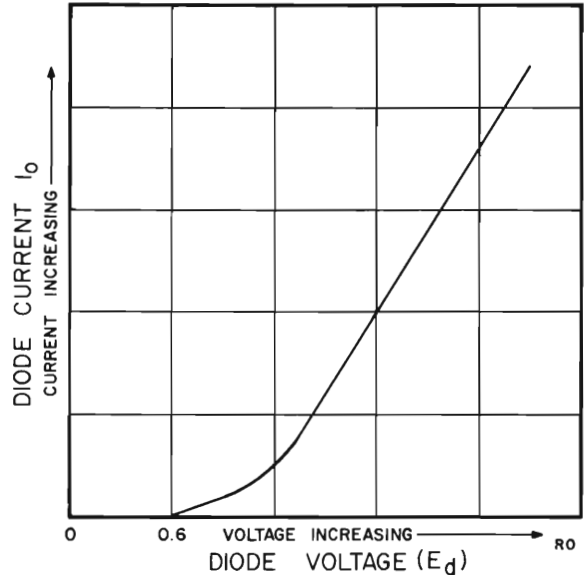


Figure 4-3. Diode Current Vs Diode Voltage

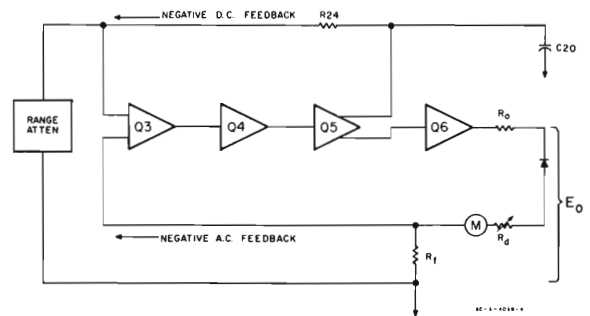


Figure 4-4. Fixed Amplifier Block Diagram

4-20. METER RECTIFIER CIRCUIT.

4-21. The meter rectifier circuit is arranged in a bridge-type configuration, with a crystal diode and a capacitor in each branch and a dc microammeter connected across its midpoints. The current through the meter is proportional to the average value of the input voltage waveform.

4-22. The 403B meter rectifier circuit operation can best be explained by analyzing the circuit in a simplified

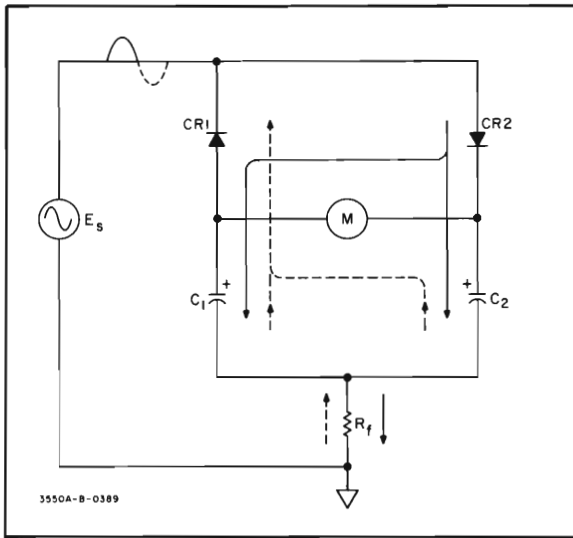


Figure 4-5. Meter Rectifier, Simplified Diagram

form. Figure 4-5 shows a voltage source generating a voltage E_s across a circuit made up of CR1, CR2, M1, R_f , and C1, C2. Note that the current flow for each half cycle (as indicated by the arrows) always passes through the meter in the same direction.

4-23. In this circuit, disregarding contact potential and assuming zero meter resistance, the circuit could be considered as a small resistance made up of CR1 and CR2, in series with one capacitor ($C_1 + C_2$) in series with R_f . Therefore, there will be a voltage across R_f proportional to the input signal.

4-24. In the actual 403B meter rectifier circuit, capacitors C17 and C18 provide a path for the AC feedback loop. The generator (Q3-Q6) with its large internal impedance (R_o) develops a voltage across the bridge. The meter is deflected according to the average value of the input voltage. The signal across R_f as in Figure 4-6 provides negative feedback, resulting in extreme linear meter operation and large R_o .

4-25. POWER SUPPLY.

4-26. The Model 403B operates on batteries only. This instrument uses four 6.5 volt nickel cadmium batteries and is designed to have a battery life of 40 hours before recharging.

4-27. R39 has been adjusted at the factory for a charging rate of 6.2 mA to prolong battery life. If the instrument is used frequently in the field, R39 can be adjusted for a charging rate of 11 mA.



IF R39 IS ADJUSTED TO THE 11 mA RATE, THE INSTRUMENT SHOULD BE USED ON BATTERIES ONLY EXCEPT WHEN RECHARGING BATTERIES. THE BATTERIES ARE RECHARGED WHEN THE 403B IS CONNECTED TO AN AC SOURCE WITH THE FUNCTION SWITCH TO ON. THE BATTERY LIFE OF THE INSTRUMENT CAN BE PROLONGED AT THE 11 mA CHARGING RATE IF THE INSTRUMENT IS NOT CONTINUOUSLY OVERCHARGED.

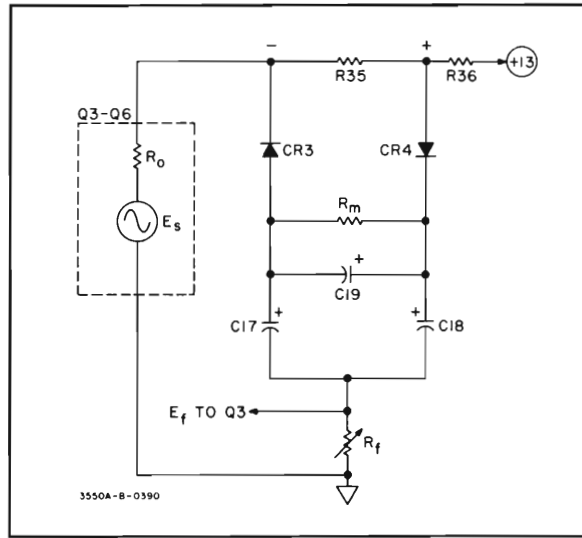


Figure 4-6. Meter Rectifier Circuit

4-28. When the function switch is in the BATT TEST position, and the instrument indicates a battery voltage of 2.4 volts, recharge the batteries for 20 to 25 hours at the 6.2 mA rate to completely recharge the batteries in the instrument. A longer charging period will be required if the batteries have been allowed to discharge below 24 volts.

4-29. Figure 5-8 illustrates the Power Supply Assembly, which supplies 4.8 mA of current to the instrument and 6.2 mA of current to the batteries. R39 is used to control the amount of current used to charge the batteries and caution must be used if R39 is adjusted to maximum charging rate.



THE FOUR NICKEL-CADMIUM BATTERIES IN THE 403B ARE IN HERMETICALLY SEALED CONTAINERS. THE USER MUST BE COGNIZANT OF TEMPERATURE EXTREMES WHILE CHARGING THE BATTERIES. UNDER HIGH TEMPERATURE (ABOVE 50° CENTIGRADE), HYDROGEN IN THE HERMETICALLY SEALED BATTERY CONTAINER CAN BUILD UP LARGE PRESSURE CAUSING DAMAGE TO THE BATTERIES AND/OR INSTRUMENT. DO NOT CHARGE BATTERIES ABOVE 40° CENTIGRADE OR 104° FAHRENHEIT, IF R39 IS SET ABOVE 6.2 MA CHARGING RATE.

4-30. Figure 5-8 illustrates a conventional power supply. For 115 volt operation, the power transformer primaries are connected in parallel, and in series when used for 230 volt operation. The rectifier circuit is a conventional full wave bridge using C21 for a filter capacitor. Diode CR9 (7 volt breakdown diode) and Q7 make up the Constant Current Generator. The collector current of Q7 is equal to the voltage across CR9 divided by R37 and R39.

4-31. CR10 prevents the batteries from discharging to the charging circuit when the instrument is in the OFF position.

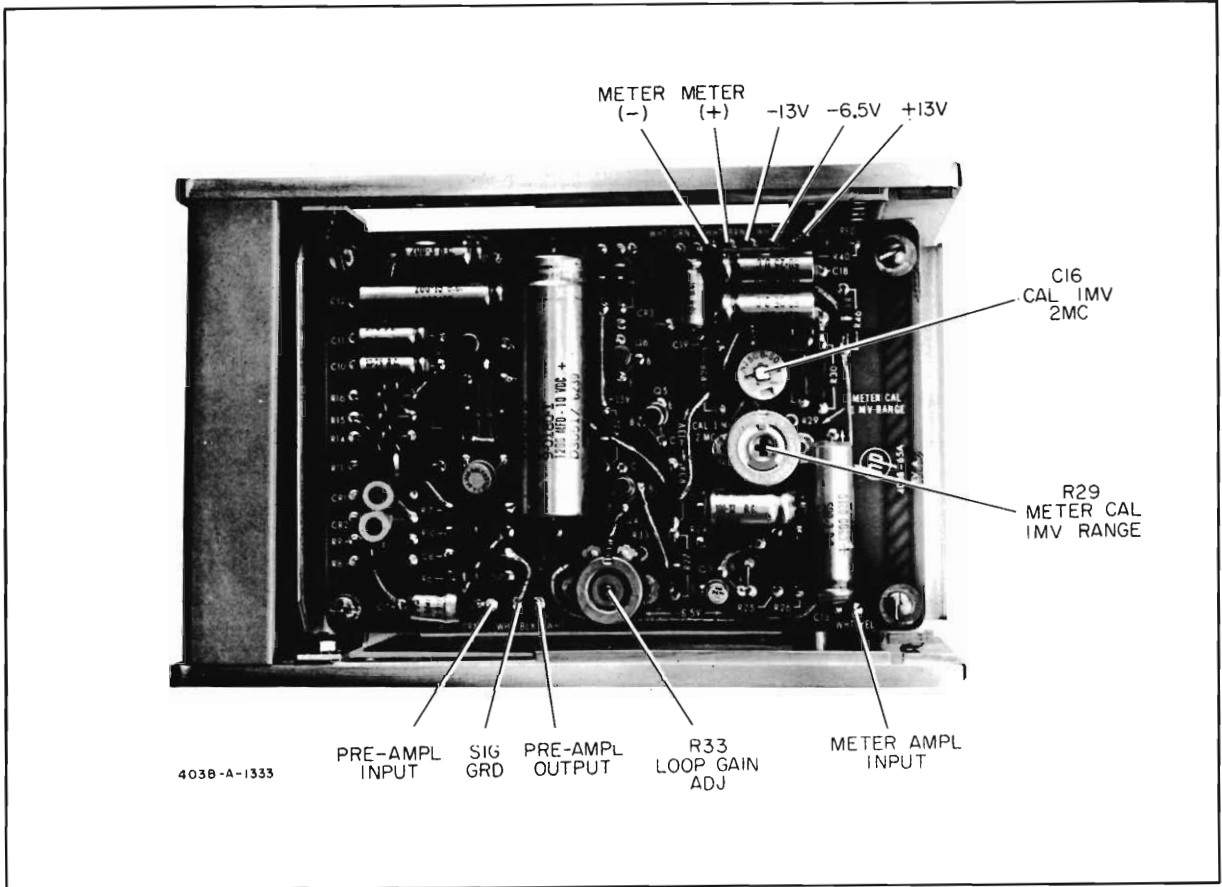


Figure 5-1. Model 403B Top View

SECTION V MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains test and maintenance information for your 403B. Included is a quick performance check that may be made with the instrument in its cabinet, as a part of routine maintenance or as a part of incoming quality control inspection.

5-3. This instrument should require very little maintenance. Should failure occur, however, a troubleshooting paragraph (5-27) has been included to assist in locating the failure. An exploded view of the Model 403B is given in Figure 6-1 to help in locating parts.

5-4. If it becomes apparent that transistor replacement is necessary, consult Paragraph 3-33 to avoid damage to the new transistor. Care should be taken not to damage the printed circuit board.

5-5. Errors may be introduced in the 403B because of the capacity added in the circuit after cabinet replacement. Therefore, after making gain or frequency response adjustments, temporarily place covers back on instrument and recheck the adjustment.

5-6. TEST INSTRUMENTS REQUIRED.

5-7. Table 5-1 gives the test equipment required to check the 403B.

5-8. METER, MECHANICAL ZERO.

5-9. When the meter is properly zero-set, the pointer will rest over the zero mark on the meter scale when the voltmeter is 1) at normal operating temperature, 2) in its normal operating position, and 3) turned off. Zero-set as follows to obtain best accuracy and mechanical stability.

- a. Allow the voltmeter to operate for at least 20 minutes; this allows the meter movement to reach normal operating temperature.
- b. Turn voltmeter off and allow 30 seconds for all capacitors to discharge.
- c. Rotate mechanical zero-adjustment screw **CLOCKWISE**.
- d. Continue to rotate adjustment screw **CLOCKWISE**; **STOP** when pointer is right on zero.
- e. Rotate adjustment screw **COUNTERCLOCKWISE** 15° to remove tension.
- f. If step e causes the meter to move off zero, repeat procedure, making the **COUNTERCLOCKWISE** rotation less than 15°.

Table 5-1. Test Instruments Required

INSTRUMENT TYPE	MINIMUM REQUIRED SPECIFICATIONS	RECOMMENDED -hp- INSTRUMENTS
DC Electronic Voltmeter	Sensitivity: 1 volt full scale minimum Input resistance: 10 megohms or higher	Model 412A Vacuum Tube Voltmeter
Voltmeter Calibration Generator	Output voltage range: .001 to 300 volts Signal frequency: 400 Hz Distortion: less than 0.2%; Accuracy ±0.25%	Model 738BR Voltmeter Calibrator
Termination Resistor Resistor	Feedthrough, 50 ohm 15 kilohm ± 10%, 10 watt 200 kilohm ± 1%	Model 11048B 0811-9034 0757-0128
AC Electronic Voltmeter	Input impedance: 10 megohms shunted by 25 pF (below the 0.3 volt range) Accuracy: ±2% from 20 Hz to 1 MHz	Model 400E/EL Electronic Voltmeter
Clip On DC Milliammeter	Current Range: 3 mA to 1 ampere Accuracy: ±3% ±0.1 mA	Model 428A/B DC Milliammeter
Oscillator	Frequency range: 5 Hz - 2 MHz Output impedance: 600 ohms, 50 ohms Output level: 0 to 1 V rms into 600 ohms Monitor: meter circuit with expand function	Model 652A

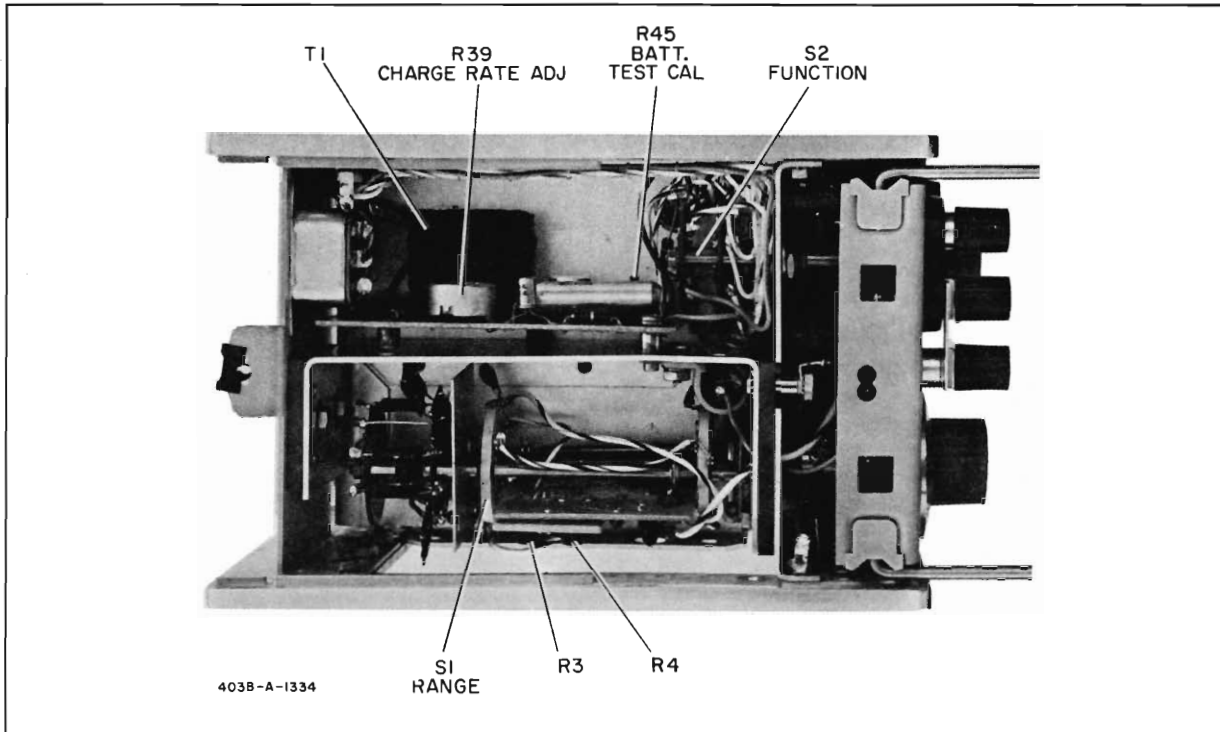


Figure 5-2. Model 403B Bottom View

5-10. PERFORMANCE CHECKS.

5-11. The performance checks are in-cabinet tests that compare the 403B with its specifications. These procedures can be used both for incoming and periodic inspections. Refer to Table 5-1 for test equipment required throughout this procedure.

5-12. CALIBRATION CHECKS.

- a. Rotate the 403B FUNCTION switch to BATT TEST. Meter should read 2.4 volts on the 3.0 volt scale. If 403B does not read 2.4 volts, recharge the batteries.
- b. Connect the 403B as shown in Figure 5-4.
- c. Set the Voltmeter Calibrator for 400 Hz and 300 V rms and set the 403B to the 300 V range.
- d. The 403B should indicate between 294 V and 306 V.
- e. Repeat steps c and d for each voltage indicated in Table 5-2.

5-13. FREQUENCY RESPONSE CHECKS.

5-14. HIGH FREQUENCY RESPONSE CHECK.

- a. Connect the 403B as shown in Figure 5-5.
- b. Set the 652A for 400 Hz and adjust the output level for 0.94 mV indication on 1 mV range of the 403B meter.
- c. Place the 652A OUTPUT MONITOR switch to EXPAND and adjust the REF SET control for a convenient reference point.

NOTE

Do not adjust the REF SET control for the remainder of the check.

Table 5-2. Calibration Check Table

VOLTMETER CALIBRATOR OUTPUT (400 CPS RMS)	MODEL 403B INDICATION (V RMS)	
	Minimum	Maximum
300V	294V	306V
100V	98V	102V
30V	29.4V	30.6V
10V	9.8V	10.2V
3V	2.94V	3.06V
1V	0.98V	1.02V
0.3V	0.294V	0.306V
0.1V	0.098V	0.102V
30 mV	29.4 mV	30.6 mV
10 mV	9.8 mV	10.2 mV
3 mV	2.94 mV	3.06 mV
1 mV	0.98 mV	1.02 mV

- d. Change the 652A frequency to 500 kHz and adjust the output level for the same reference level as in step c.
- e. The 403B meter indication should be within 0.92 mV and 0.96 mV.
- f. Repeat step d for 1 MHz and 2 MHz. The 403B meter reading should be between 0.89 mV and 0.99 mV.
- g. Repeat the same procedure for the 0.003, 0.01, 0.03, 0.1 and 3 volt range.

- h. Turn the 403B RANGE switch to 30 volts.
- i. Connect an oscillator (-hp- Model 200 CD) to the 403B INPUT. Set the frequency to 400Hz.
- j. Connect an AC Voltmeter (-hp- Model 400E EL) to the oscillator output.
- k. Adjust the oscillator for a 20.0 volt reading on the 403B meter. Record the reading on the monitoring voltmeter (connected in Step j).
- l. Adjust the oscillator frequency to 300 kHz. Adjust the oscillator AMPLITUDE control until the monitoring voltmeter indicates the reference level recorded in Step k.
- m. The 403B meter should indicate between 19.4V and 20.6V.

5-15. LOW FREQUENCY RESPONSE CHECK.

- a. Connect the 403B as shown in Figure 5-5.
- b. Set the 652A for 400 Hz and adjust output level for 0.94 mV indication on 1 mV range of 403B.
- c. Place OUTPUT MONITOR switch on 652A to EXPAND and adjust REF SET control for a convenient reference point.

NOTE

Do not adjust the REF SET control for the remainder of the check.

- d. Change the 652A frequency to 5 Hz and adjust the OUTPUT AMPLITUDE for the same reference level as in Step c.
- e. The 403B meter indication should be between 0.89 mV and 0.99 mV.
- f. Repeat the same procedure for the 0.003, 0.01, 0.03, 0.1, and 3 volt range.

5-16. NOISE CHECK.

- a. Disconnect the 403B from the setup shown in Figure 5-4 and rotate the 403B FUNCTION switch to ON.
- b. Terminate the 403B input with a 100K ohm-shielded load. The 403B meter deflection should be less than 3% with battery operation and less than 8% on any range with ac operation.

5-17. INPUT RESISTANCE CHECK.

- a. Connect the 403B as shown in Figure 5-4 (Position B).
- b. Rotate the 403B RANGE switch to 0.01.
- c. Adjust Voltmeter Calibrator for an output of 0.01 volt 400 Hz rms.
- d. The 403B meter should indicate between 9.0 mV and 9.5 mV.

NOTE

This corresponds to an input resistance of 1.8 to 3.8 megohms where:

$$R_{\text{input}} = \frac{E_{\text{meter}}}{E_{\text{input}} - E_{\text{meter}}} \times R_{\text{series}}$$

5-18. ADJUSTMENT AND CALIBRATION PROCEDURES.

5-19. The following is a complete adjustment and calibration procedure and should be made only if it has been definitely determined that the 403B is out of adjustment. Transistor changes are usually not cause for complete adjustment (see Table 5-5). If the instrument fails any of the limits given in the following steps, carefully recheck your connections and procedure. If the instrument still fails the step, refer to Table 5-3 and 5-4 for possible cause and corrective action.

NOTE

In order to avoid the effects of hand capacity, a tuning wand with a non-metallic shank should be used for all adjustments.

5-20. POWER SUPPLY ADJUSTMENT.

- a. Connect the 403B to a variable line transformer. Set the line voltage to 115 volts; turn on the AC Voltmeter, and allow five minutes for warmup.
- b. Connect a Clip-On DC Ammeter (-hp- Model 428A/B) probe around the violet wire connected to battery BT4. Adjust R39 (see Figure 5-2) for an indication of 6.2 mA on the DC Ammeter.

NOTE

If the instrument is to be used frequently in the field, R39 can be adjusted for a fast charging rate of 11 mA. Do not charge batteries at temperatures above 40°C if R39 is set for 11 mA charging rate. Battery life will be prolonged at the lower charging rate.

- c. Vary the input line voltage from 103 to 127 volts; the Clip-On DC Ammeter reading should not vary more than 1.0 mA from the reference setting in step b.
- d. Set line voltage to 115 volts. Using a NEMA three prong to two prong ac adapter for isolation, connect an AC Voltmeter (-hp- Model 400E/EL) across the red (BT1) and violet (BT4) wires connected to the batteries; the ripple voltage should not exceed 1.5 mV.
- e. Set 403B FUNCTION switch to OFF; disconnect ac power source and set FUNCTION switch to ON.

- f. Connect volts probe of a DC Voltmeter (-hp-Model 412A) to red wire connected to battery BT1; connect common lead of dc voltmeter to violet wire connected to battery BT4.

CAUTION

DC VOLTMETER MUST BE ISOLATED FROM 403B GROUND.

- g. Rotate 403B FUNCTION switch to BATT TEST. If DC Voltmeter reading is not 24 volts, recharge batteries in the 403B. (See Paragraph 3-7). Adjust R45 for a 403B-meter indication equal to voltage indicated on DC Voltmeter.

5-21. INPUT RESISTANCE.

5-22. Check the 403B input resistance by following the procedure outlined in Paragraph 5-17. If the input resistance is not within test limits, the value of R6 should be changed (typical range of R6 is from 3.9 to 10 megohms).

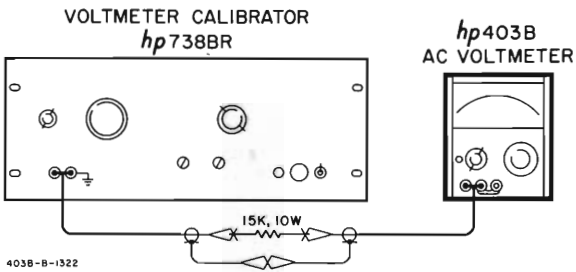


Figure 5-3. Overload Check Setup

5-23. OVERLOAD CHECK.

- a. Connect the 403B as shown in Figure 5-3.

CAUTION

THE 15KΩ RESISTOR MUST BE CONNECTED AS SHOWN IN FIGURE 5-3 TO PREVENT DAMAGE TO VOLTMETER CALIBRATOR.

- b. Rotate the 403B FUNCTION switch to OFF; connect an AC Voltmeter (-hp-Model 400E/EL) between the base of Q1 and chassis ground.
- c. Rotate the 403B FUNCTION switch to ON and RANGE switch to 0.1 volt.
- d. Set Voltmeter-Calibrator (-hp-Model 738BR) OUTPUT SELECTOR to 400 Hz rms and 300 volts; the AC Voltmeter reading should be less than 3.5 volts. (If necessary, check CR1 and CR2).

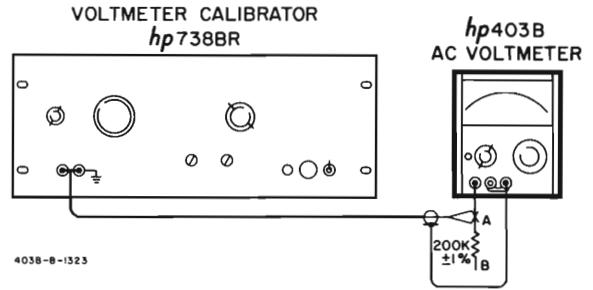


Figure 5-4. Performance Check Setup

5-24. CALIBRATION AND TRACKING.

- a. Disconnect the 403B from the ac power source. (The following procedure should be performed with battery operation).
- b. Connect the 403B as shown in Figure 5-4 (Position A).

NOTE

The 200K resistor is used only for the input resistance check (Paragraph 5-21).

- c. Rotate the 403B RANGE switch to 0.001 volt.
- d. Set the Voltmeter Calibrator (-hp-Model 738BR) for 0.001 volt rms at 400 Hz.
- e. Preset R33 (loop gain adj) 1/3 clockwise and adjust R29 (meter cal. 1 mV range) for a full-scale indication on the 403B.
- f. Rotate the 403B RANGE switch to 0.1 volt. Set the Voltmeter Calibrator to 0.1 volt rms at 400 Hz.
- g. Adjust R3 (cal. 0.1 V 400 Hz) for a full-scale indication on the 403B meter.
- h. Rotate 403B RANGE switch to 30.0 volts and set Voltmeter Calibrator to 30.0 volts at 400 Hz rms.
- j. Adjust R4 (see Figure 5-2) for a full-scale indication on the 403B meter.
- k. Check calibration on the 0.003, 0.01, and 0.03 volt ranges; accuracy should be within $\pm 2.0\%$ of full scale on all ranges.
- m. Set Voltmeter Calibrator for 1.0 volt. Rotate 403B FUNCTION switch to 1.0 volt.
- n. Check 403B meter tracking at 0.1 volt increments. Variation should be less than $\pm 2\%$ of full scale.

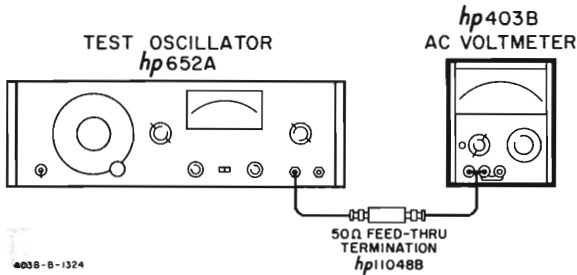


Figure 5-5. Frequency Response Setup

5-25. HIGH FREQUENCY RESPONSE.

- a. Connect the 403B as shown in Figure 5-5.
- b. Set oscillator (-hp- Model 652A) to 1 mV rms range at 400 Hz.
- c. Adjust OUTPUT AMPLITUDE control for reading of 0.94 mV on the 403B.
- d. Place OUTPUT MONITOR switch to expand and adjust REF SET for a convenient reference point on 652A meter.
- e. Vary the 652A frequency dial between 1 MHz and 3 MHz keeping the same reference point as in Step d. Adjust C16 (cal. 1 mV 2 MHz) for 0.94 mV $\pm 5\%$ frequency response between 1 and 2 MHz with a gradual roll-off between 2 and 3 MHz. If C16 does not have sufficient range, the value of C15 should be changed (range of C15 is from 100 pF to 160 pF).
- f. Adjust 652A Oscillator for a 300 kHz output frequency and same output level as in Step d.
- g. Rotate 652A frequency dial between 300 kHz and 1 MHz while maintaining same reference on meter. The 403B meter should indicate 0.9 mV ± 0.02 mV ($\pm 2\%$). If necessary, adjust R33 for a flat response.

NOTE

Repeat Paragraphs 5-24 and 5-25 if R33 is adjusted.

- h. Rotate the 403B RANGE switch to 0.1.
- j. Set the 652A Oscillator for 400 Hz and 0.1 RANGE.
- k. Adjust the OUTPUT AMPLITUDE control for an indication of 0.96 of full scale on the 403B meter.
- m. Readjust the 652A OUTPUT AMPLITUDE control for a convenient reference on the 652A meter.

- n. Change the 652A frequency to 300 kHz while maintaining reference on meter.
- p. Adjust C2 for a 0.96 of full scale reading on the 403B meter.

5-26. 10 VOLT RESPONSE CALIBRATION.

- a. Turn the 403B RANGE switch to the 10 V RANGE.

Connect Wide Range Oscillator (-hp- Model 200CD) to the 403B INPUT. Set the Oscillator frequency to 400 Hz.
- c. Connect an AC Voltmeter (-hp- Model 400E/EL) to the Oscillator OUTPUT.
- d. Adjust the Oscillator AMPLITUDE for 9.40 volt indication on the 403B meter. Record the AC Voltmeter (-hp- Model 400E/EL) reading.
- e. Set the oscillator frequency to 300 kHz. Adjust the Oscillator AMPLITUDE control until the AC Voltmeter indicates the reference level recorded in Step d. The 403B should indicate 9.2 to 9.6 volts.

NOTE

The AC Voltmeter used in this procedure should have been recently calibrated and have a known frequency response from 400 Hz to at least 300 kHz. If there is a variation in response between 400 Hz and 300 kHz, this should be considered when adjusting the 403B.

- f. Adjust C3 for a 403B meter indication of 10.0 volts.
- g. Repeat Paragraph 5-25, Steps h thru p, adjusting C2 and C3 for optimum performance between 0.1 volt range at 300 kHz and 10 volt range at 300 kHz.

5-27. TROUBLESHOOTING.

5-28. To assist in troubleshooting, Tables 5-3 and 5-4 are included in this section of the manual. Table 5-3, Troubleshooting, is used for evaluating problems that may be encountered and easily recognized by the operator, and therefore consists mainly of front-panel indications. Tables 5-3 and 5-4, Test Procedure Troubleshooting, is for the technician to localize areas of trouble encountered while testing the Model 403B.

NOTE

When replacing any crystal diodes or transistors in the Model 403B, refer to Paragraph 5-33 and Table 5-5.

Table 5-3. Troubleshooting

SYMPTOM	CAUSE
No response to input	Fuse F1 blown Batteries low Shorted transistor CR1 or CR2 shorted Open contacts in range switch
Low reading on Batt. test Noise indication on known quiet source	Recharge Batteries CR1 or CR2 noisy Noisy transistors (usually Q1 or Q2) CR3 or CR4
Meter pins when switching through ranges	Dirty contacts in range switch C7, C12, or C13 leaky
Meter pulsates at frequencies below 15 Hz	C17, 18, 20 open or leaky
Meter calibration off on ranges above 0.03	Resistors or capacitors bad in range switch
Meter calibration off on ranges below 0.1	Resistors bad in intermediate attenuator Dirty contacts in range switch
Battery will not hold charge	CR10 shorted Shorted cell in battery
Battery charge inoperative	Q7, CR5, CR6, CR7, CR8, CR9, C21 Switch on 230V position when using 115V
0.001, 0.1, 10 calibration okay but all other ranges out of calibration at 400 Hz	Replace C13
If all ranges on 400 Hz calibration check out okay except for one or two ranges and the stick resistors check okay	Change Q3
At 3 volts 2 MHz meter reads high	Shorten leads on R18. If this doesn't fix problem, replace R18
No adjustment on charging current	Check for solder splashes on backside of R39

5-29. REPAIR.**5-30. CABINET REMOVAL.**

- a. Top Cover: remove the single screw which holds the cover to the rear panel and slide the cover toward the rear.

- b. Bottom Cover: remove the flat head screw holding the cover to the rear panel and slide the cover toward the rear. The bail must be up.
- c. Side Covers: remove the flat head screws which hold the cover to the side casting of the instrument.

Table 5-4. Test Procedure Troubleshooting

SYMPTOM	CAUSE
R29 will not adjust for full scale indication	CR1, 2 CR3, 4 bad Q1 through Q6 bad
Noise (403B input terminated with a shielded 100K resistor)	Usually Q1 or Q2 noisy
Input resistance out of specs	Q1 or Q2 bad C9, C10, C11, R6
Meter does not track properly 1) Meter reads consistently above or below all meter divisions 2) Meter reads above some but below other divisions	CR3, CR4 bad R35 wrong value Diodes CR3, CR4 bad Meter M1 bad
Low frequency response bad	C1, 7, 12, 13, 18-20
400D reads more than 1.5 volts on overload	CR1 or CR2 bad
Excessive Charging Rate R39 No Effect	Bad CR9, Q7

5-31. SERVICING ETCHED CIRCUIT BOARDS.

5-32. One double-sided and two single-sided circuit boards are used in the Model 403B. Follow these general rules when servicing these boards.

- a. Do not apply excessive heat to the conductor or component being soldered.
- b. Use a toothpick or wooden splinter to clean holes before inserting new components.
- c. To remove a damaged component, clip leads near component; then apply heat and remove component lead with a straight upward motion.
- d. To insure good connection between the eyelet and conductor, solder from the conductor side.

5-33. TRANSISTOR REPLACEMENT.

5-34. Transistors can be damaged by excessive heat. When replacing transistors on the Model 403B printed circuit board, use a heat sink, such as an alligator clip, and use a low wattage soldering iron. Refer to Table 5-5 for any adjustments after replacement.

5-35. FUNCTION SWITCH REPAIR.

5-36. Figure 5-7 gives cabling detail on Model 403B FUNCTION switch.

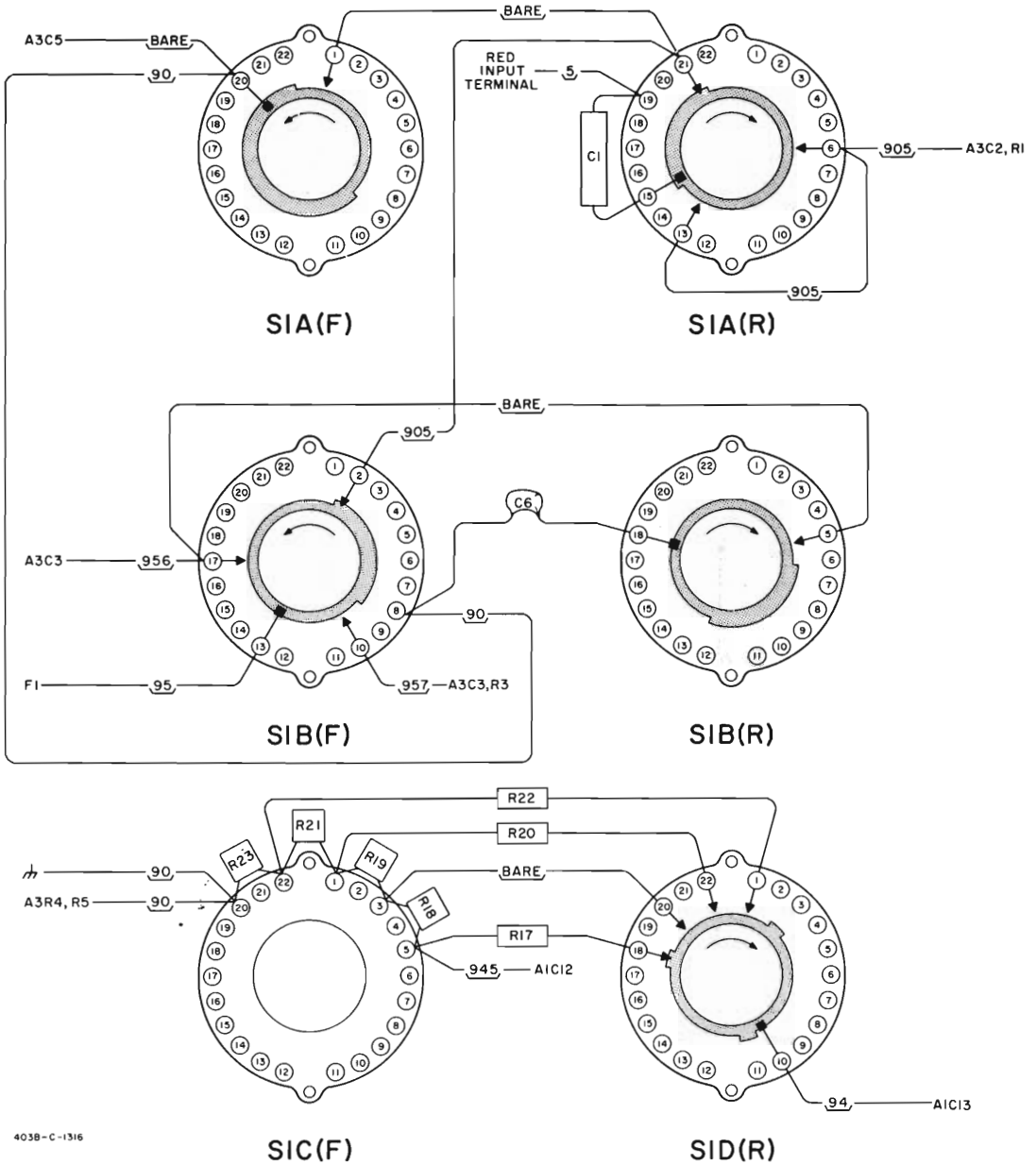
5-37. FLUORESCENT INDICATOR DECAL.

5-38. If the FUNCTION switch is removed for any reason, the fluorescent indicator decal will have to be replaced. This decal has a special adhesive on the back that holds firmly against the FUNCTION switch nut. To assure positive contact, proceed as follows:

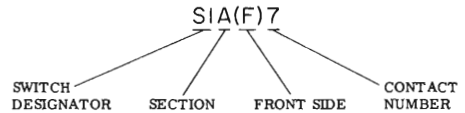
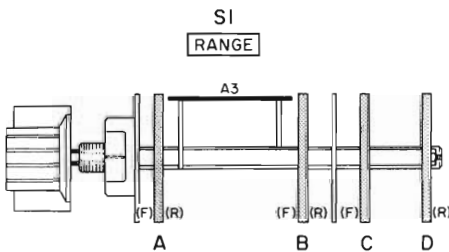
- a. Moisten the back of the decal with a piece of tissue soaked in xylene and allow a few minutes for the adhesive to soften.
- b. Place the decal over the FUNCTION switch shaft, adhesive side down. Position the black area directly over the OFF line on the Model 403B panel and press the decal firmly against the FUNCTION switch nut.
- c. Slide a bushing or nut over the shaft so that it will hold the decal in contact with the FUNCTION switch nut, and allow about 20 minutes for the adhesive to dry.
- d. Remove the bushing or nut used for weighting and install the small spacer and FUNCTION switch knob.

Table 5-5. Transistor Replacement

REFERENCE	FUNCTION	CHECKS OR ADJUSTMENTS REQUIRED	REFER TO PARAGRAPH
Q1, 2	Q1 and Q2 work together to provide a high input impedance (Emitter Follower)	Check input impedance Readjust R29 Check noise	5-17 steps a thru d 5-24 steps a thru e 5-16 steps a and b
Q3, 4 Q5 Q6	Amplifier (Common emitter) Amplifier (Common collector) Amplifies signal (Common base)	Readjust R33 Readjust R33 Readjust R33	5-25 steps a thru g 5-25 steps a thru g 5-25 steps a thru g
CR1, 2	Protects Q1 from overload	Recheck overload characteristics Check noise	5-23 steps a thru d 5-16 steps a and b
CR3, 4	Meter Diodes	Readjust R29 Readjust R45	5-24 steps a thru e 5-20 steps e thru g
CR5,	Rectifier Diodes	Check battery charge current	5-20 steps a and b
CR9 CR10	Zener Diode Isolation Diode	Readjust R39 Check battery charge current	5-20 steps a and b 5-20 steps a and b
Q7	Charging Current Regulation	Readjust R39	5-20 steps a and b









403B-C-1316

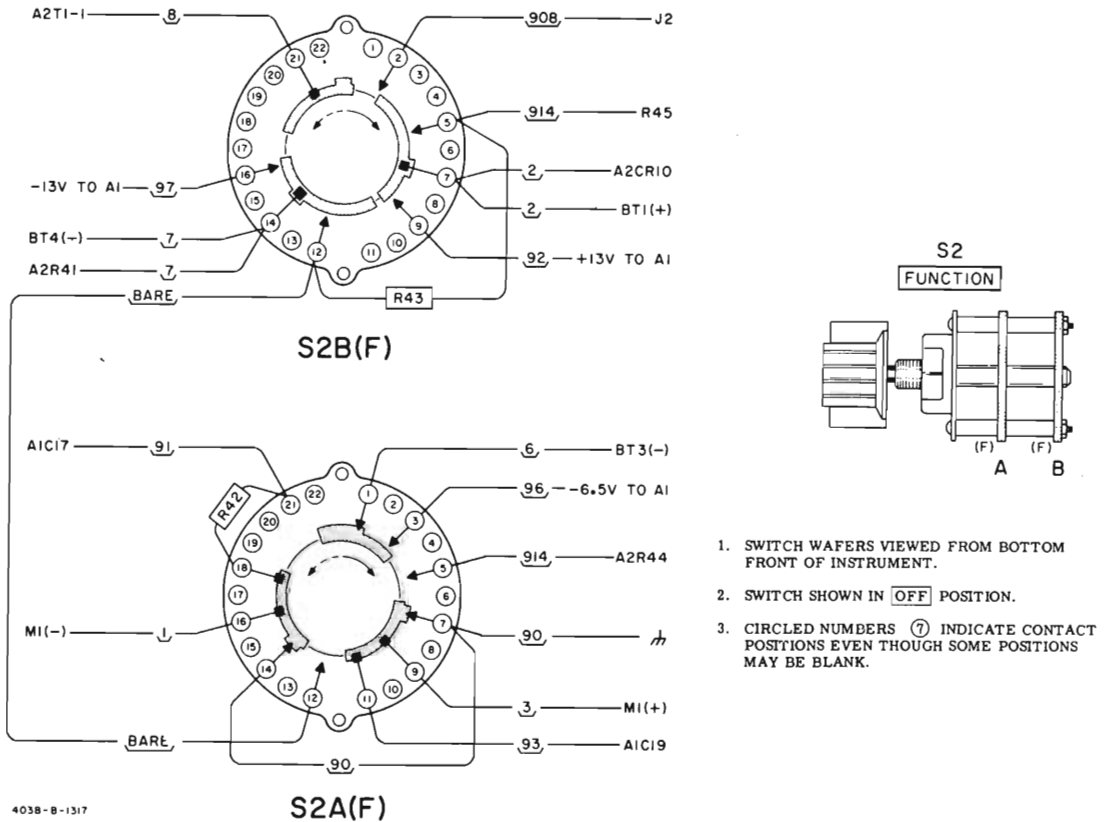


1. WAFER FRONTS (F) VIEWED FROM BOTTOM FRONT OF INSTRUMENT.
2. WAFER REARS (R) VIEWED FROM BOTTOM REAR OF INSTRUMENT.
3. SIC(R) AND SID(F) HAVE NO SWITCHING AND ARE NOT SHOWN.
4. SWITCH SHOWN IN .001 / -60 POSITION.
5. CIRCLED NUMBERS ⑦ INDICATE CONTACT POSITIONS EVEN THOUGH SOME POSITIONS MAY BE BLANK.

Figure 5-6. Range Switch Detail

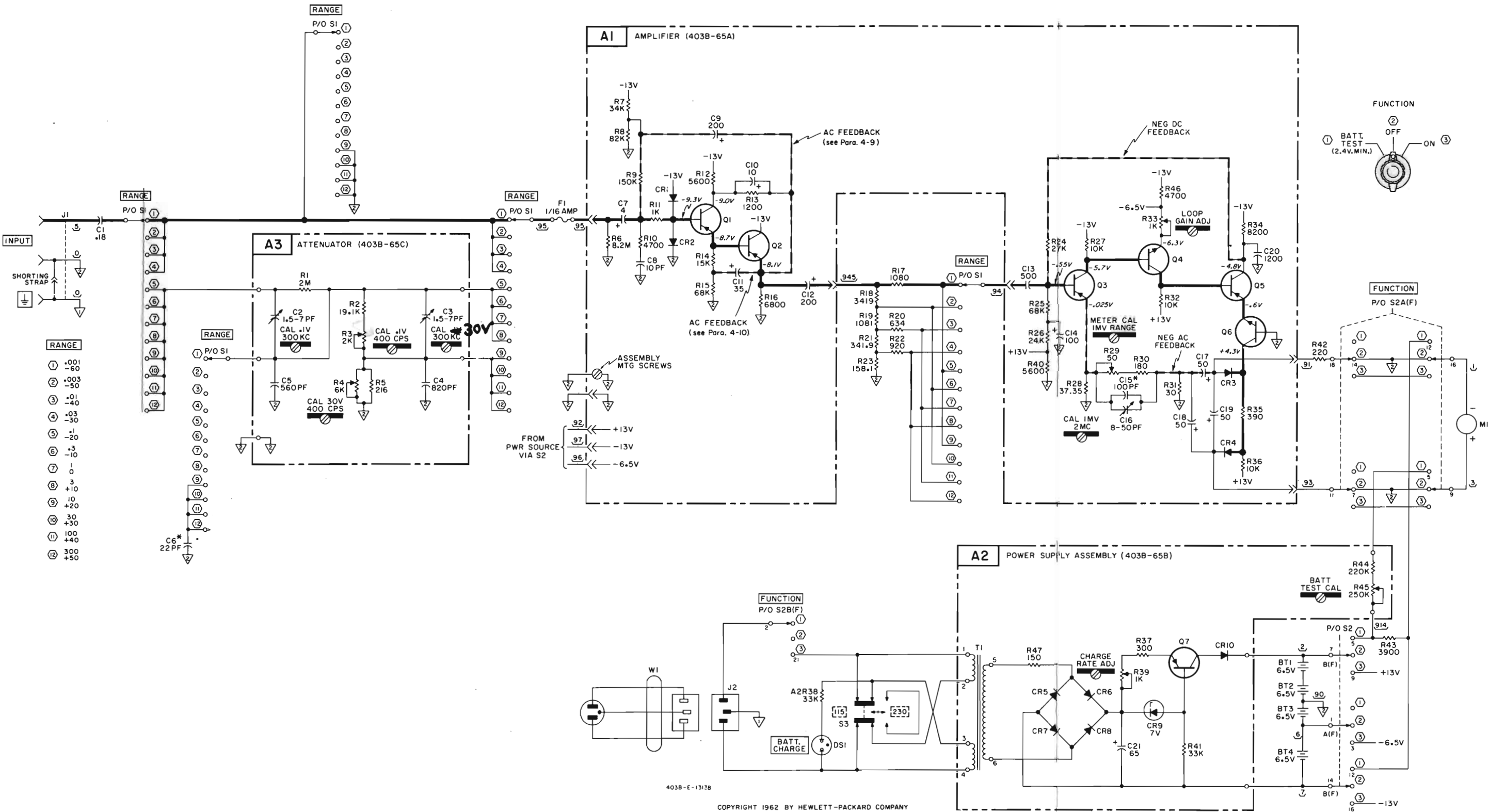
SCHEMATIC NOTES

1. RANGE SWITCH SHOWN ON 0.001 VOLT RANGE.
2. FUNCTION SWITCH SHOWN IN THE OFF POSITION.
3. SWITCH CONNECTIONS ARE SHOWN FOR SCHEMATIC SIMPLICITY AND MAY NOT BE ACCOMPLISHED IN THE MANNER SHOWN.
4. ALL DC VOLTAGES ARE TYPICAL VALUES. A TOLERANCE OF $\pm 10\%$ SHOULD BE ALLOWED WHEN MEASURING THESE VOLTAGES.
5.  DENOTES CHASSIS GROUND.
6.  DENOTES SIGNAL GROUND (FLOATING).
- * OPTIMUM VALUE SELECTED AT FACTORY, AVERAGE VALUE IS SHOWN AND IN SOME CASES THE PART MAY BE OMITTED.
6. RESISTOR VALUES ARE IN OHMS AND CAPACITANCE VALUES ARE IN MICROFARADS UNLESS OTHERWISE DESIGNATED.
7.  DENOTES ASSEMBLY.
8.  DENOTES MAIN SIGNAL PATH.
8.  DENOTES FRONT PANEL MARKING.
9.  DENOTES SCREWDRIVER ADJUST.
9. 924 DENOTES WIRE COLOR: COLOR CODE SAME AS RESISTOR COLOR CODE. FIRST NUMBER IDENTIFIES BASE COLOR, SECOND NUMBER IDENTIFIES WIDER STRIP, THIRD NUMBER IDENTIFIES NARROWER STRIP. (e. g. 924 = WHITE, RED, YELLOW.)



4038-B-1317

Figure 5-7. Function Switch Detail



403B-E-1312B

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Figure 5-8. Schematic Diagram

PERFORMANCE CHECK TEST CARD

Hewlett-Packard Model 403B
 Transistorized AC Voltmeter
 Serial No. _____

Tests Performed by _____
 Date _____

DESCRIPTION	PAR.	CHECK
<p>1. CALIBRATION</p> <p>A. RANGE ACCURACY</p> <p>300 V _____</p> <p>100 V _____</p> <p>30 V _____</p> <p>10 V _____</p> <p>3 V _____</p> <p>1 V _____</p> <p>0.3 V _____</p> <p>0.1 V _____</p> <p>0.03 V _____</p> <p>0.01 V _____</p> <p>0.003 V _____</p> <p>0.001 V _____</p>		<p>_____ Full scale $\pm 2\%$</p> <p>_____ Full scale $\pm 2\%$</p> <p>_____ Full scale $\pm 2\%$</p> <p>_____ Full scale $\pm 2\%$</p> <p>_____ Full scale $\pm 2\%$</p> <p>_____ Full scale $\pm 2\%$</p> <p>_____ Full scale $\pm 2\%$</p> <p>_____ Full scale $\pm 2\%$</p> <p>_____ Full scale $\pm 2\%$</p> <p>_____ Full scale $\pm 2\%$</p> <p>_____ Full scale $\pm 2\%$</p> <p>_____ Full scale $\pm 2\%$</p>
<p>2. HIGH FREQUENCY RESPONSE</p> <p>A. 0.001 RANGE</p> <p>500 kHz _____</p> <p>1 MHz _____</p> <p>2 MHz _____</p> <p>B. 0.003 RANGE</p> <p>500 kHz _____</p> <p>1 MHz _____</p> <p>2 MHz _____</p> <p>C. 0.01 RANGE</p> <p>500 kHz _____</p> <p>1 MHz _____</p> <p>2 MHz _____</p> <p>D. 0.03 RANGE</p> <p>500 kHz _____</p> <p>1 MHz _____</p> <p>2 MHz _____</p> <p>E. 0.1 RANGE</p> <p>500 kHz _____</p> <p>1 MHz _____</p> <p>2 MHz _____</p> <p>F. 3 V RANGE</p> <p>500 kHz _____</p> <p>1 MHz _____</p> <p>2 MHz _____</p> <p>G. 10 V RANGE</p> <p>300 kHz _____</p>		<p>_____ 0.94 Full scale $\pm 2\%$</p> <p>_____ 0.94 Full scale $\pm 2\%$</p> <p>_____ 0.94 Full scale $\pm 5\%$</p> <p>_____ 0.94 Full scale $\pm 2\%$</p> <p>_____ 0.94 Full scale $\pm 2\%$</p> <p>_____ 0.94 Full scale $\pm 5\%$</p> <p>_____ 0.94 Full scale $\pm 2\%$</p> <p>_____ 0.94 Full scale $\pm 2\%$</p> <p>_____ 0.94 Full scale $\pm 5\%$</p> <p>_____ 0.94 Full scale $\pm 2\%$</p> <p>_____ 0.94 Full scale $\pm 2\%$</p> <p>_____ 0.94 Full scale $\pm 5\%$</p> <p>_____ 0.94 Full scale $\pm 2\%$</p> <p>_____ 0.94 Full scale $\pm 2\%$</p> <p>_____ 0.94 Full scale $\pm 5\%$</p> <p>_____ 0.94 Full scale $\pm 2\%$</p>
<p>3. LOW FREQUENCY RESPONSE</p> <p>A. 0.001 RANGE</p> <p>10 cps _____</p> <p>B. 0.003 RANGE</p> <p>10 cps _____</p>		<p>_____ 0.94 Full scale $\pm 2\%$</p> <p>_____ 0.94 Full scale $\pm 2\%$</p>

PERFORMANCE CHECK TEST CARD (Cont'd)

Hewlett-Packard Model 403B
 Transistorized AC Voltmeter
 Serial No. _____

Tests performed by _____
 Date _____

DESCRIPTION	PAR.	CHECK
3. <u>LOW FREQUENCY RESPONSE (Cont'd)</u> C. 0.01 RANGE 10 Hz D. 0.03 RANGE 10 Hz E. 0.1 RANGE 10 cps F. 3 RANGE 10 cps		 _____ 0.94 Full scale \pm 2% _____ 0.94 Full scale \pm 2% _____ 0.94 Full scale \pm 2% _____ 0.94 Full scale \pm 2%
4. <u>NOISE CHECK</u> A. BATTERY OPERATION B. AC OPERATION		 _____ < 3% Deflection _____ < 8% Deflection
5. INPUT RESISTANCE		_____ 9.0 to 9.5 mV

SECTION VI REPLACEABLE PARTS

6-1. INTRODUCTION.

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

- a. Total quantity used in the instrument (TQ column). The total quantity of a part is given the first time the part number appears.
- b. Description of the part. (See list of abbreviations below.)
- c. Typical manufacturer of the part in a five-digit code. (See Appendix A for list of manufacturers.)
- d. Manufacturer's part number.

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 Appendix B for list of office locations.) Identify parts by their Hewlett-Packard part numbers. Include instrument model and serial 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.

ABBREVIATIONS					
Ag silver	Hz hertz (cycle(s) per second)				
Al aluminum	ID inside diameter				
A ampere(s)	imp impregnated				
Au gold	incd incandescent				
C capacitor	ins insulation(ed)				
cer ceramic	kΩ kilohm(s) = 10 ³ ohms				
coef coefficient	kHz kilohertz = 10 ³ hertz				
com common	L inductor				
comp composition	lin linear taper				
conn connection	log logarithmic taper				
dcp deposited	mA milliampere(s) = 10 ⁻³ amperes				
DPDT double-pole double-throw	MHz megahertz = 10 ⁶ hertz				
DPST double-pole single-throw	MΩ megohm(s) = 10 ⁶ ohms				
elect electrolytic	met flm metal film				
encap encapsulated	mfr manufacturer				
F farad(s)	ms millisecond				
FET field effect transistor	mtg mounting				
fxd fixed	mV millivolt(s) = 10 ⁻³ volts				
GaAs gallium arsenide	μF microfarad(s)				
GHz gigahertz = 10 ⁹ hertz	μs microsecond(s)				
gd guard(ed)	μV microvolt(s) = 10 ⁻⁶ volts				
Ge germanium	mv Mylar®				
gnd ground(ed)	nA nanoampere(s) = 10 ⁻⁹ amperes				
H henry (ies)	NC normally closed				
Hg mercury	Ne neon				
	NO normally open				
	NPO negative positive zero (zero temperature coefficient)				
	ns nanosecond(s) = 10 ⁻⁹ seconds				
	nstr not separately replaceable				
	Ω ohm(s)				
	obd order by description				
	OD outside diameter				
	p peak				
	pA picoampere(s)				
	pc printed circuit				
	pF picofarad(s) = 10 ⁻¹² farads				
	piv peak inverse voltage				
	p/o part of				
	pos position(s)				
	poly polystyrene				
	pot potentiometer				
	p-p peak-to-peak				
	ppm parts per million				
	prec precision (temperature coefficient, long term stability and/or tolerance)				
	R resistor				
	Rh rhodium				
	rms root-mean-square				
	rot rotary				
	Se selenium				
	sect section(s)				
	Si silicon				
	sl slide				
	SPDT single-pole double-throw				
	SPST single-pole single-throw				
	Ta tantalum				
	TC temperature coefficient				
	TiO ₂ titanium dioxide				
	tog toggle				
	tol tolerance				
	trim trimmer				
	TSTR transistor				
	V volt(s)				
	vacw alternating current working voltage				
	var variable				
	vw direct current working voltage				
	W watt(s)				
	w/ with				
	w/w working inverse voltage				
	w/o without				
	ww wirewound				
	* optimum value selected at factory, average value shown (part may be omitted)				
	** no standard type number assigned selected or special type				
	® Dupont de Nemours				
DECIMAL MULTIPLIERS					
Prefix	Symbols	Multiplier	Prefix	Symbols	Multiplier
tera	T	10 ¹²	centi	c	10 ⁻²
giga	G	10 ⁹	milli	m	10 ⁻³
mega	M or Meg	10 ⁶	micro	μ	10 ⁻⁶
kilo	K or k	10 ³	nano	n	10 ⁻⁹
hecto	h	10 ²	pico	p	10 ⁻¹²
deka	da	10	femto	f	10 ⁻¹⁵
deci	d	10 ⁻¹	atto	a	10 ⁻¹⁸
DESIGNATORS					
A assembly	FL filter	Q transistor	TS terminal strip		
B motor	HR heater	QCR transistor-diode	U microcircuit		
BT battery	IC integrated circuit	R resistor	V vacuum tube, neon bulb, photocell, etc.		
C capacitor	J jack	RT thermistor	W cable		
CR diode	K relay	S switch	X socket		
DL delay line	L inductor	T transformer	XDS lampholder		
DS temp	M meter	TC terminal board	XF fuseholder		
E misc electronic part	MP mechanical part	TC thermocouple	Y crystal		
F fuse	P plug	TP test point	Z network		

STD-B-2734

Table 6-1 Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A1	403B-65A		Assembly, printed circuit: includes, C7 thru C20 Q1 thru Q6 CR1 thru CR4 R6 thru R16 R24 thru R36 R40 R46		
A2	403B-65B		Assembly, resistor board: includes, C21 R37 thru R39 CR5 thru CR10 R41 T1 R44 Q7 R45 R47		
A3	403B-65C		Assembly, resistor board: includes, C2 thru C5 R1 thru R5		
BT1, 2, 3, 4	1420-0015	4	Battery, Nickel Cadmium 6.5 V nom, 225 mAh	88220	6.0V/225B
C1	0170-0033	1	C: fxd 0.18 μ F $\pm 10\%$ 600 vdcw	09134	Type 27
C2, C3	0130-0003	2	C: var cer 1.5-7 pF $\pm 10\%$ 500 vdcw	72982	503-000-COPO-10R
C4	0140-0151	1	C: fxd mica 820 pF $\pm 2\%$ 300 vdcw	04062	DM15F821G
C5	0140-0178	1	C: fxd mica 560 pF $\pm 2\%$ 300 vdcw	04062	DM15F561G
*C6	0140-0145	1	C: fxd mica 22 pF $\pm 5\%$ 500 vdcw	04062	DM15C220J
C7	0180-0100	1	C: fxd elect 4.7 μ F $\pm 10\%$ 35 vdcw	56289	150D475X9035B2-DYS
C8	0160-0205	1	C: fxd mica 10 pF $\pm 5\%$ 500 vdcw	04062	DM15C220J
C9	0180-0060	1	C: fxd elect 200 μ F $+100\%$ -10% 3 vdcw	56289	30D116A1
C10	0180-0059	1	C: fxd elect 10 μ F 10 vdcw	56289	30D182A1
C11	0180-0064	1	C: fxd elect 35 μ F $+100\%$ -10% 3 vdcw	56289	30D122A1
C12	0180-0104	1	C: fxd elect 200 μ F 15 vdcw	56289	30D174A1
C13	0180-0063	1	C: fxd elect 500 μ F $+100\%$ -10% 3 vdcw	56289	30D120A1
C14	0180-0039	1	C: fxd elect 100 μ F 12 vdcw	56289	30D154A1
*C15	0140-0176	1	C: fxd mica 100 pF $\pm 2\%$ 300 vdcw	04062	
C16	0130-0017	1	C: var cer 8-50 pF 500 vdcw	72982	557-019-U2 PO34R
C17, C18	0180-0058	2	C: fxd elect 50 μ F $+100\%$ -10% 25 vdcw	56289	30D186A1
C19	0180-0033	1	C: fxd elect 50 μ F 6 vdcw	56289	30D133A1
C20	0180-0150	1	C: fxd elect 1200 μ F 10 vdcw	56289	Type 34D
C21	0180-0149	1	C: fxd elect 65 μ F 60 vdcw	56289	Type 30D
CR1, CR2	1901-0044	2	Diode: Si 20 mA/+1V 10 mA/-10V/50 wiv 2 pF	73293	HD
CR3, CR4	1901-0535	2	Diode: hybrid hot carrier	-hp-	
CR5 thru CR8	1901-0025	5	Diode: Si 100 mA 100 wiv 2 pF	03877	SG-817
CR9	1902-0074	1	Diode: breakdown 7.15V $\pm 5\%$ 400 mW	07910	CE 35664
CR10	1901-0025	1	Diode: Si 100 mA 100 wiv 2 pF	03877	SG-817
DS1	1450-0419	1	Indicator: neon	72765	599-237 white
F1	2110-0011	1	Fuse, 1/16 amp 250 V maximum 5.4 ohm	75915	#312.062
J1	1510-0008	3	Terminals: three female		
	1510-0009	1	Assembly binding post: red	-hp-	
	5060-0626	1	Assembly binding post: black	-hp-	
	0340-0090	1	Assembly binding post: black with strap	-hp-	
J2	1251-2357	1	Insulator: B. P. double keyed	-hp-	
		1	Connector: ac power	82389	EAC-301
M1	1120-0315	1	Meter: 0-100 μ A dc	-hp-	
	1120-0316	1	Meter: 0-100 μ A dc DB Scale (option 01)	-hp-	
Q1, Q2, Q3, Q5	1853-0020	4	TSTR: Si PNP	01295	SKA1123
Q4, Q6	1854-0071	2	TSTR: Si NPN	01295	SKA1124

Table 6-1. Replaceable Parts (Cont'd)

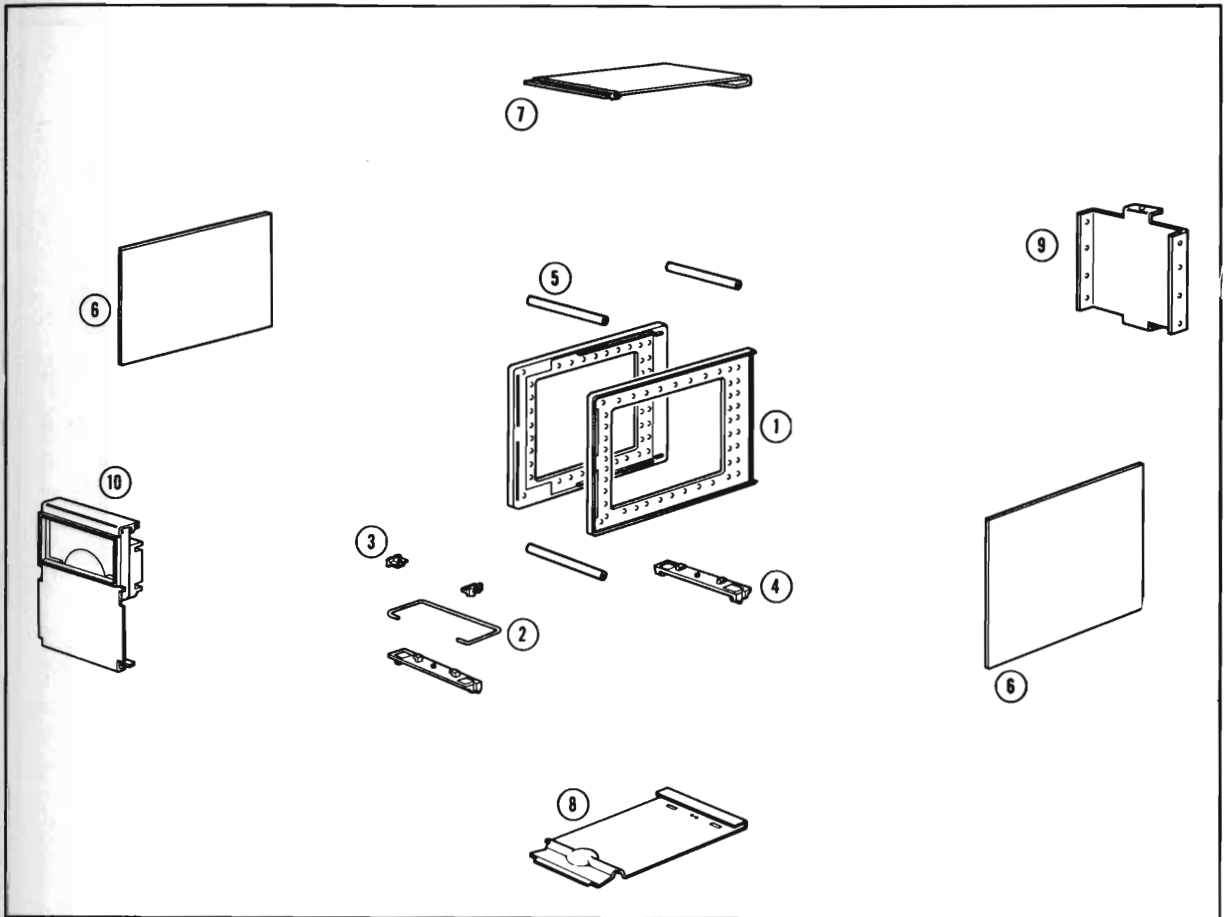
REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
Q7	1853-0016	1	TSTR: PNP 2N3638	01295	2N3638
R1	0727-0287	1	R: fxd comp 2M $\pm 1\%$ 1/2 W	19701	DC 1/2 CR5
R2	0727-0443	1	R: fxd comp 19.1k Ω $\pm 1\%$ 1/2 W	19701	DC 1/2 CR5
R3, R4	2100-0390	1	R: var comp dual 2k and 6k ohms 1-1/4 W	71590	Series Type 73-2
R5	0727-0056	1	R: fxd carbon flm 216 ohms $\pm 1/2\%$ 1/2 W	19701	DC 1/2 AR5
*R6	0687-8251	1	R: fxd comp 8.2M $\pm 10\%$ 1/2 W	01121	EB 8251
R7	0698-4493	1	R: fxd flm 34 k Ω $\pm 1\%$ 1/8 W	91637	CMF-1/10-32 T-1
R8	0758-0022	1	R: fxd comp 82k Ω $\pm 5\%$ 1/2 W	07115	C20
R9	0687-1541	1	R: fxd comp 150k Ω $\pm 10\%$ 1/2 W	01121	EB 1541
R10	0687-4721	2	R: fxd comp 4.7k Ω $\pm 10\%$ 1/2 W	01121	EB 4721
R11	0693-1021	1	R: fxd comp 1k Ω $\pm 10\%$ 1/2 W	01121	HB 1021
R12	0687-5621	2	R: fxd comp 5.6k Ω $\pm 10\%$ 1/2 W	01121	EB 5621
R13	0687-1221	1	R: fxd comp 1.2k Ω $\pm 10\%$ 1/2 W	01121	EB 1221
R14	0687-1531	1	R: fxd comp 15k Ω $\pm 10\%$ 1/2 W	01121	EB 1531
R15	0687-6831	1	R: fxd comp 68k Ω $\pm 10\%$ 1/2 W	01121	EB 6831
R16	0687-6821	1	R: fxd comp 6.8k Ω $\pm 10\%$ 1/2 W	01121	EB 6821
R17	0727-0103	1	R: fxd carbon flm 1080 Ω $\pm 1\%$ 1/2 W	19701	DC 1/2 CR5
R18	403B-26A	1	R: fxd ww 3.41k Ω $\pm 0.2\%$ 1/2 W	-hp-	
R19	403B-26B	1	R: fxd ww 1.081k Ω $\pm 0.2\%$ 1/2 W	-hp-	
R20	0727-0084	1	R: fxd carbon flm 634 Ω $\pm 1\%$ 1/2 W	19701	DC 1/2 CR5
R21	403B-26C	1	R: fxd ww 341.9 Ω $\pm 0.2\%$ 1/2 W	-hp-	
R22	0727-0096	1	R: fxd carbon flm 920 Ω $\pm 1\%$ 1/2 W	19701	DC 1/2 CR5
R23	403B-26D	1	R: fxd ww 158.1 Ω $\pm 0.2\%$ 1/2 W	-hp-	
R24	0758-0074	1	R: fxd met oxide 27k Ω $\pm 5\%$ 1/2 W	07115	C5
R25	0758-0076	1	R: fxd met oxide 68k Ω $\pm 5\%$ 1/2 W	07115	C5
R26	0758-0073	1	R: fxd met oxide 24k Ω $\pm 5\%$ 1/2 W	07115	C5
R27	0687-1031	2	R: fxd comp 10k Ω $\pm 10\%$ 1/2 W	01121	EB 1031
R28	0727-0017	1	R: fxd carbon flm 37.35 Ω $\pm 1/2\%$ 1/2 W	19701	DC 1/2 CR5
R29	2100-0240	1	R: var ww 50 Ω $\pm 20\%$ 1 W	11236	Series 110
R30	0727-0050	1	R: fxd carbon flm 180 Ω $\pm 1\%$ 1/2 W	19701	DC 1/2 CR5
R31	403A-26G	1	R: fxd ww 2 sect 30 Ω	-hp-	
R32	0687-1031		R: fxd comp 10k Ω $\pm 10\%$ 1/2 W	01121	EB 1031
R33	2100-0154	1	R: var comp 1k Ω $\pm 30\%$ 3/10 W	11237	UPE70 C5
R34	0758-0048	1	R: fxd met oxide 8.2k Ω $\pm 5\%$ 1/2 W	07115	C5
R35	0687-3911	1	R: fxd comp 390 Ω $\pm 10\%$ 1/2 W	01121	EB 3911
R36	0687-1031		R: fxd comp 10k Ω $\pm 10\%$ 1/2 W	01121	EB 1031
R37	0686-3015	1	R: fxd comp 300 Ω $\pm 5\%$ 1/2 W	01121	EB 3015
R38	0687-3331	2	R: fxd comp 33k Ω $\pm 10\%$ 1/2 W	01121	EB 3331
R39	2100-0391	1	R: var ww 1k Ω $\pm 20\%$ 1.25 W	11236	Series 110
R40	0687-5621		R: fxd comp 5.6k Ω $\pm 10\%$ 1/2 W	01121	EB 5621
R41	0687-3331		R: fxd comp 33k Ω $\pm 10\%$ 1/2 W	01121	EB 3331
R42	0687-2211	1	R: fxd comp 220 Ω $\pm 10\%$ 1/2 W	01121	EB 2211
R43	0687-3921	1	R: fxd comp 3.9k Ω $\pm 10\%$ 1/2 W	01121	EB 3921
R44	0687-2241	1	R: fxd comp 220k Ω $\pm 10\%$ 1/2 W	01121	EB 2241
R45	2100-0144	1	R: var comp 250k Ω $\pm 30\%$ 0.2 W	11237	UPE70
R46	0687-4721		R: fxd comp 4.7k Ω $\pm 10\%$ 1/2 W	01121	EB 4721
R47	0758-0007	1	R: fxd met oxide 150 Ω $\pm 5\%$ 1/2 W	07115	C5
S1	403B-19W	1	Assembly RANGE switch 3 sect 12 pos includes: C2 thru C6, A3, and R17 thru R23	-hp-	
S2	403B-19A	1	Assembly FUNCTION switch 2 sect 3 pos includes: R42 and R43	-hp-	
	7123-0101	1	Washer fluorescent indicator for use with Function Switch Knob	-hp-	
S3	3101-1234	1	Switch-Slide: DPDT 115-230V	82389	11A-1242A

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
T1	9100-0172		1	Transformer	98734	6-2249
W1	8120-1348		1	Assembly cable power	70903	KHS-7041
XF1	1400-0008		1	Holder fuse 1/2" wide 3/16" thick 1-5/8" long	75915	3510-11
				MISCELLANEOUS		
	00403-90008		1	Operating and Service Manual	-hp-	

Table 6-2. Mechanical Parts

Cabinet Parts



Item Number	Ⓟ Stock No.	Description	Note
1	5060-0702	Frame Assembly	
2	1490-0031	Stand: Tilt	
3	5040-0700	Hinge	
4	5060-0727	Foot Assembly	
5	5020-0700	Spacer	
6	5000-8563	Cover: Side	
7	5060-8547	Cover Assembly: Top	
8	5000-8564	Cover Assembly: Bottom	
9	00403-00202	Panel: Rear	
10	00403-00203	Panel: Front (See Figure 6-1.)	

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

NUMBER ON ILLUSTRATION ON FIGURE 6-1	NAME/DESIGNATOR	STOCK NUMBER
1	Indicator, Neon	See DS1, table 6-1
2	Retainer clip	0510-0123
3	Insulation, vinyl tubing (specify 1" length)	0890-0057
4	Knob, bar w/indicator, black	0370-0087
5	Special washer 3/8 inch OD x 0.26 inch ID	3050-0014
6	Wafer, fluorescent indicator for use with Function Switch Knob	7123-0101
7	Panel, front	00403-00203
8	Meter, 0-100 μ A dc (403B) or Meter, 0-100 μ A dc, DB Scale (Option 01)	See M1, Table 6-1
9	3/8" - 32 x 1/2" nut, hex.	2950-0001
10	AC shield	403B-6D
11	Vertical shield	403B-6A
12	Bushing, threaded 3/8 - 32	1410-0003
13	6.32 x 5/16" nut, hex. w/lock	2420-0001
14	Assembly FUNCTION Switch: 2 sect, 3 pos	See S2, Table 6-1
15	Screw 6-32 x 3/8 flat head phillips drive	2370-0013
16	Screw 6-32 x 3/8 flat head slot drive	2370-0002
17	Cover 1/3 module 8 inch deep, top	5060-8547
18	Assembly, printed circuit	See A1, Table 6-1
19	Battery holder	5040-0615
20	Screw, 6-32 x 1-1/2 binding head with lock	2370-0010
21	Screw 6-32 x 3/8 pan head	2390-0010
22	Not assigned	
23	Rear panel, 1/3 module, 1/2 recess	00403-00202
24	Side frame 6 x 8 sub-module	5060-0702
25	Switch shield	403B-6B
26	Side cover, 6 x 8, SM	5000-8563
27	Same as 15	
28	Bottom cover 1/3 module, 8 inch DP	5000-8569
29	Assembly RANGE Switch: 3 sect, 12 pos	See S1, Table 6-1
30	Same as 15	
31	6.32 x 5/16" nut	2420-0002
32	#6 split lock, SS	2190-0006
33	Same as 16	
34	Spacer No. 6 x 5/16	0380-0007
35	3/8" ID x 5/8" OD flat washer	3050-0067
36	#6 internal lock washer	2190-0007
37	3/8" internal lock (heavy) washer	2190-0022
38	#6 solder lug "L"	0360-0042
39	Tinnerman retainers	0590-0039
40	Same as 9	
41	Same as 13	
42	Coupler, shaft 1/4"	5020-0237
43	#10 solder lug	0360-0007
44	Same as 43	
45	#10 internal-external lock washer	2190-0028
46	#10 internal lock washer	2190-0011
47	Insulator B. P. double without locating key	0340-0086
48	Hinge	5040-0700
49	Stand, third mod. tilt	1490-0031
50	Foot assembly, third mod.	5060-0727
51	Assembly, dial	403B-99
52	Insulator, binding post: double keyed	0340-0090
53	Spacer binding post	0400-0084
54	Assembly, binding post: black w/strap Assembly, binding post: red Assembly, binding post: black	See J1, Table 6-1
55	Meter trim, third mod.	5020-6852
56	Battery, nickel cadmium, 6.25 V nom. 225 mAh	See BT1, 2, 3, 4, Table 6-1
57	Assembly, resistor board	See A3, Table 6-1

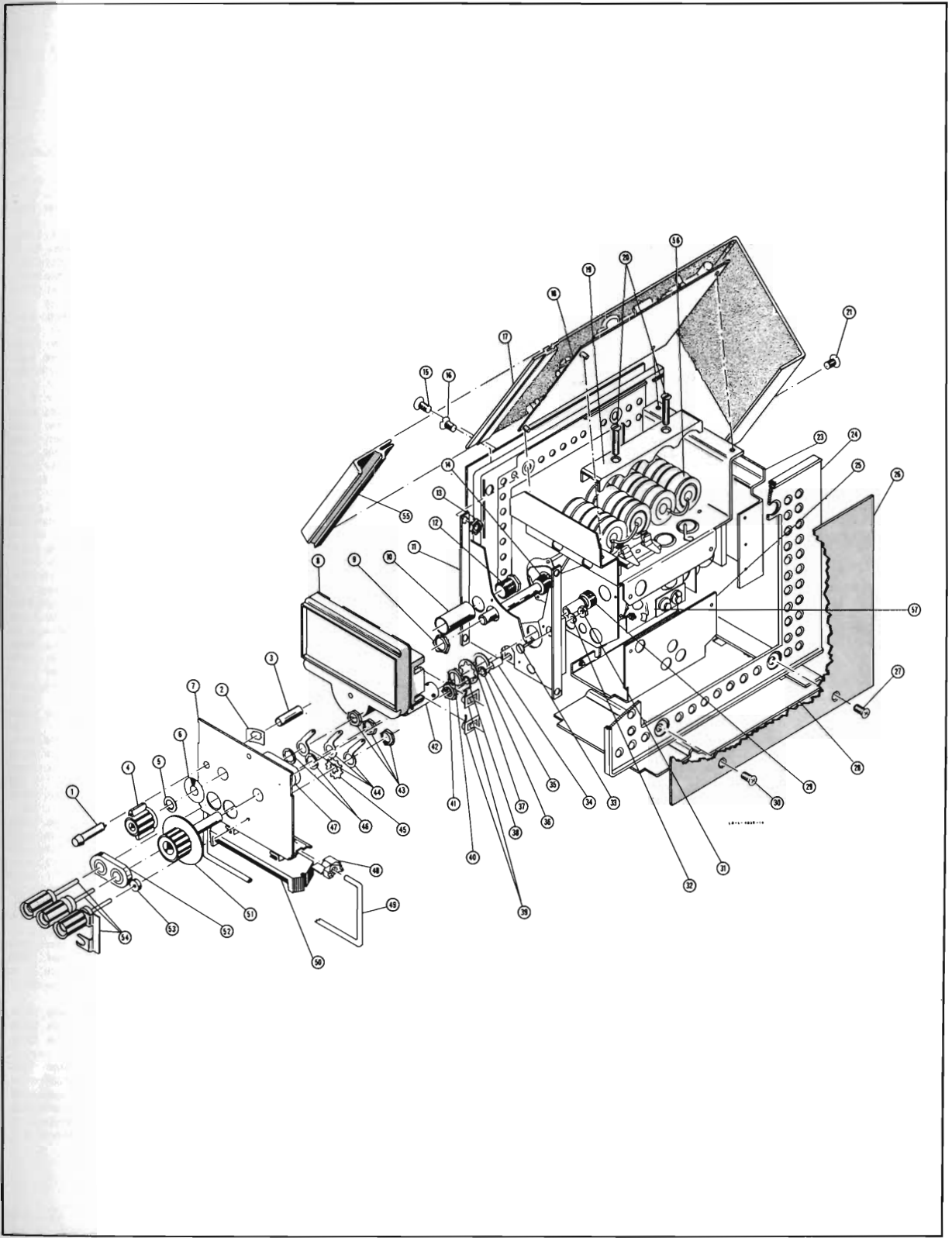


Figure 6-1. Exploded View

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	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address
00000	U. S. A. Common	Any supplier of U. S.	05347	Ultronic, Inc.	San Mateo, Calif.	10411	Ti-Tal, Inc.	Berkeley, Calif.
00136	McCoy Electronics	Mount Holly Springs, Pa.	05397	Union Carbide Corp., Linde Div.	Kemet Dept. Cleveland, Ohio	10646	Carborundum Co.	Niagara Falls, N. Y.
00213	Sage Electronics Corp.	Rochester, N. Y.	05574	Viking Ind. Inc.	Canoga Park, Calif.	11236	CTS of Berne, Inc.	Berne, Ind.
00287	Cemco Inc.	Danielson, Conn.	05593	Illumitronic Engineering Co.	Sunnyvale, Calif.	11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
00334	Humidial	Colton, Calif.	05616	Cosmo Plastic	Cleveland, Ohio	11242	Bay State Electronics Corp.	Waltham, Mass.
00348	Microtron Co., Inc.	Valley Stream, N. Y.	05624	Barber Colman Co.	Rockford, Ill.	11312	Teledyne Inc., Microwave Div.	Palo Alto, Calif.
00373	Garlock Inc.	Cherry Hill, N. J.	05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N. Y.	11314	National Seal	Downey, Calif.
00656	Aerovox Corp.	New Bedford, Mass.	05729	Metro-Tel Corp.	Westbury, N. Y.	11534	Duncan Electronics Inc.	Costa Mesa, Calif.
00779	Amp. Inc.	Harrisburg, Pa.	05783	Stewart Engineering Co.	Santa Cruz, Calif.	11711	General Instrument Corp., Semiconductor Div., Products Group	Newark, N. J.
00781	Aircraft Radio Corp.	Boonton, N. J.	05820	Wakefield Engineering Inc.	Wakefield, Mass.	11717	Imperial Electronic, Inc.	Buena Park, Calif.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.	06004	Bassick Co., Div. of Stewart Warner Corp.	Bridgeport, Conn.	11870	Melabs, Inc.	Palo Alto, Calif.
00853	Sangamo Electric Co., Pickens Div.	Pickens, S. C.	06090	Raychem Corp.	Redwood City, Calif.	12136	Philadelphia Handle Co.	Camden, N. J.
00866	Goe Engineering Co.	City of Industry, Cal.	06175	Bausch and Lomb Optical Co.	Rochester, N. Y.	12361	Grove Mfg. Co., Inc.	Shady Grove, Pa.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.	06402	E. T. A. Products Co. of America	Chicago, Ill.	12574	Gulton Ind. Inc. Data System Div.	Albuquerque, N. M.
00929	Microlab Inc.	Livingston, N. J.	06555	Beede Electrical Instrument Co., Inc.	New Rochelle, N. Y.	12697	Clarostat Mfg. Co.	Dover, N. H.
01002	General Electric Co., Capacitor Dept.	Hudson Falls, N. Y.	06666	General Devices Co., Inc.	Indianapolis, Ind.	12728	Elmar Filter Corp.	W. Haven, Conn.
01009	Alden Products Co.	Brockton, Mass.	06751	Semcor Div. Components Inc.	Phoenix, Ariz.	12859	Nippon Electric Co., Ltd.	Tokyo, Japan
01121	Allen Bradley Co.	Milwaukee, Wis.	06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.	12881	Metex Electronics Corp.	Clark, N. J.
01255	Litton Industries, Inc.	Beverly Hills, Calif.	06980	Varian Assoc. Eimac Div.	San Carlos, Calif.	12930	Delta Semiconductor Inc.	Newport Beach, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.	07088	Kelvin Electric Co.	Van Nuys, Calif.	12954	Dickson Electronics Corp.	Scottsdale, Arizona
01295	Texas Instruments, Inc., Transistor Products Div.	Dallas, Texas	07126	Digitran Co.	Pasadena, Calif.	13103	Thermolloy	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio	07137	Transistor Electronics Corp.	Minneapolis, Minn.	13396	Telefunken (GmbH)	Hanover, Germany
01589	Pacific Relays, Inc.	Van Nuys, Calif.	07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N. Y.	13835	Midland-Wright Div. of Pacific Industries, Inc.	Kansas City, Kansas
01930	Amerock Corp.	Rockford, Ill.	07149	Filmohm Corp.	New York, N. Y.	14099	Sem-Tech	Newbury Park, Calif.
01961	Pulse Engineering Co.	Santa Clara, Calif.	07233	Cinch-Graphik Co.	City of Industry, Calif.	14193	Calif. Resistor Corp.	Santa Monica, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N. Y.	07256	Silicon Transistor Corp.	Carle Place, N. Y.	14298	American Components, Inc.	Conshohocken, Pa.
02116	Wheelock Signals, Inc.	Long Branch, N. J.	07261	Avnet Corp.	Culver City, Calif.	14433	ITT Semiconductor, A Div. of Int. Telephone & Telegraph Corp.	West Palm Beach, Fla.
02286	Cole Rubber and Plastics Inc.	Sunnyvale, Calif.	07263	Fairchild Camera & Inst. Corp. Semiconductor Div.	Mountain View, Calif.	14493	Hewlett-Packard Company	Loveland, Colo.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.	07322	Minnesota Rubber Co.	Minneapolis, Minn.	14655	Cornell Dublier Electric Corp.	Newark, N. J.
02730	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N. J.	07387	Bircher Corp., The	Monterey Park, Calif.	14674	Corning Glass Works	Corning, N. Y.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.	07397	Sylvania Elect. Prod. Inc., Mt. View Operations	Mountain View, Calif.	14752	Electro Cube Inc.	San Gabriel, Calif.
02777	Hopkins Engineering Co.	San Fernando, Calif.	07700	Technical Wire Products Inc.	Cranford, N. J.	14960	Williams Mfg. Co.	San Jose, Calif.
03508	G. E. Semiconductor Prod. Dept.	Syracuse, N. Y.	07829	Bodine Elect. Co.	Chicago, Ill.	15203	Webster Electronics Co.	New York, N. Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio	07910	Continental Device Corp.	Hawthorne, Calif.	15287	Scronics Corp.	Norridge, Calif.
03797	Eldema Corp.	Compton, Calif.	07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, Calif.	15291	Adjustable Bushing Co.	N. Hollywood, Calif.
03818	Parker Seal Co.	Los Angeles, Calif.	07980	Hewlett-Packard Co., Boonton Radio Div.	Rockaway, N. J.	15568	Micro Electronics	Garden City, Long Island, N. Y.
03877	Transitron Electric Corp.	Wakefield, Mass.	08145	U. S. Engineering Co.	Los Angeles, Calif.	15566	Amprobe Inst. Corp.	Lynbrook, N. Y.
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N. J.	08289	Blinn, Delber Co.	Pomona, Calif.	15631	Cabletronics	Costa Mesa, Calif.
03954	Singer Co., Diehl Div. Findene Plant	Sumerville, N. J.	08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada	15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.	08524	Deutsch Fastener Corp.	Los Angeles, Calif.	15801	Fenwal Elect. Inc.	Framingham, Mass.
04013	Taurus Corp.	Lambertville, N. J.	08664	Bristol Co., The	Waterbury, Conn.	15818	Amelco Inc.	Mt. View, Calif.
04062	Arco Electronic Inc.	Great Neck, N. Y.	08717	Sloan Company	Sun Valley, Calif.	16037	Spruce Pine Mica Co.	Spruce Pine, N. C.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S. C.	08718	ITT Cannon Electric Inc., Phoenix Div.	Phoenix, Arizona	16179	Omni-Spectra Inc.	Detroit, Ill.
04354	Precision Paper Tube Co.	Wheeling, Ill.	08727	National Radio Lab. Inc.	Paramus, N. J.	16352	Computer Diode Corp.	Lodi, N. J.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.	08792	CBS Electronics Semiconductor Operations, Div. of C. B. S. Inc.	Lowell, Mass.	16688	Ideal Prec. Meter Co., Inc. De Jur Meter Div.	Brooklyn, N. Y.
04651	Sylvania Electric Products, Microwave Device Div.	Mountain View, Calif.	08984	Mel-Rain	Indianapolis, Ind.	16758	Delco Radio Div. of G. M. Corp.	Kokoma, Ind.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona	09026	Babcock Relays Div.	Costa Mesa, Calif.	17109	Thermonetics Inc.	Canoga Park, Calif.
04732	Filtrol Co., Inc. Western Div.	Culver City, Calif.	09134	Texas Capacitor Co.	Houston, Texas	17474	Tranex Company	Mountain View, Calif.
04773	Automatic Electric Co.	Northlake, Ill.	09145	Tech. Ind. Inc. Atohm Elect.	Burbank, Calif.	17675	Hamlin Metal Products Corp.	Akron, Ohio
04796	Sequoia Wire Co.	Redwood City, Calif.	09250	Electro Assemblies, Inc.	Chicago, Ill.	17745	Angstrom Prec. Inc.	No. Hollywood, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.	09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada	17870	McGraw-Edison Co.	Manchester, N. H.
04870	P. M. Motor Company	Westchester, Ill.	10214	General Transistor Western Corp.	Los Angeles, Calif.	18042	Power Design Pacific Inc.	Palo Alto, Calif.
04919	Component Mfg. Service Co.	W. Bridgewater, Mass.				18083	Clevite Corp., Semiconductor Div.	Palo Alto, Calif.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.				18324	Signetics Corp.	Sunnyvale, Calif.
05277	Westinghouse Electric Corp. Semi-Conductor Dept.	Youngwood, Pa.				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 Intertechnology, 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.

CODE LIST OF MANUFACTURERS (Cont'd)

Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N. J.	70998	Bird Electronic Corp.	Cleveland, Ohio	76210	C. W. Marwedel	San Francisco, Calif.
19589	Concoa	Baldwin Park, Calif.	71002	Birnback Radio Co.	New York, N. Y.	76433	General Instrument Corp., Micamold Division	Newark, N. J.
19644	LRC Electronics	Horseheads, N. Y.	71034	Biley Electric Co., Inc.	Erie, Pa.	76487	James Millen Mfg. Co., Inc.	Malden, Mass.
19701	Electra Mfg. Co.	Independence, Kansas	71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.	76493	J. W. Miller Co.	Los Angeles, Calif.
20183	General Atronics Corp.	Philadelphia, Pa.	71218	Bud Radio, Inc.	Willoughby, Ohio	76530	Cinch-Monadnock, Div. of United Carr Fastener Corp.	San Leandro, Calif.
21226	Execulone, Inc.	Long Island City, N. Y.	71279	Cambridge Thermionics Corp.	Cambridge, Mass.	76545	Mueller Electric Co.	Cleveland, Ohio
21335	Fafnir Bearing Co., The	New Britain, Conn.	71286	Camloc Fastener Corp.	Paramus, N. J.	76703	National Union	Newark, N. J.
21520	Fansteel Metallurgical Corp.	N. Chicago, Ill.	71313	Cardwell Condenser Corp.	Lindenhurst L. I., N. Y.	76854	Oak Manufacturing Co.	Crystal Lake, Ill.
23783	British Radio Electronics Ltd.	Washington, D. C.	71400	Bussmann Mfg. Div. of McGraw-Edison Co.	St. Louis, Mo.	77068	The Bendix Corp., Electrodynamics Div.	N. Hollywood, Calif.
24455	G. E. Lamp Division	Nela Park, Cleveland, Ohio	71436	Chicago Condenser Corp.	Chicago, Ill.	77075	Pacific Metals Co.	San Francisco, Calif.
24655	General Radio Co.	West Concord, Mass.	71447	Calif. Spring Co., Inc.	Pico-Rivera, Calif.	77221	Phanostran Instrument and Electronic Co.	South Pasadena, Calif.
24681	Memcor Inc., Comp. Div.	Huntington, Ind.	71450	CTS Corp.	Elkhart, Ind.	77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
26365	Gries Reproducer Corp.	New Rochelle, N. Y.	71468	ITT Cannon Electric Inc.	Los Angeles, Calif.	77342	American Machine & Foundry Co. Potter & Brumfield Div.	Princeton, Ind.
26462	Grobet File Co. of America, Inc.	Carlstadt, N. J.	71471	Cinema, Div. Aerovox Corp.	Burbank, Calif.	77630	TRW Electronic Components Div.	Camden, N. J.
26851	Compac/Hollister Co.	Hollister, Calif.	71482	C. P. Clare & Co.	Chicago, Ill.	77638	General Instrument Corp., Rectifier Div.	Brooklyn, N. Y.
26992	Hamilton Watch Co.	Lancaster, Pa.	71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.	77654	Resistance Products Co.	Harrisburg, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.	71616	Commercial Plastics Co.	Chicago, Ill.	77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N. J.	71700	Cornish Wire Co., The	New York, N. Y.	78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
30317	Instrument Specialties Co., Inc.	Little Falls, N. Y.	71707	Colo Coil Co., Inc.	Providence, R. I.	78277	Sigma	So. Braintree, Mass.
33173	G. E. Receiving Tube Dept.	Owensboro, Ky.	71744	Chicago Miniature Lamp Works	Chicago, Ill.	78283	Signal Indicator Corp.	New York, N. Y.
35434	Lectrohm Inc.	Chicago, Ill.	71785	Cinch Mfg. Co., Howard B. Jones Div.	Chicago, Ill.	78290	Stuthers-Dunn Inc.	Pitman, N. J.
36196	Stanwyck Coil Products Ltd.	Hawkesbury, Ontario, Canada	71984	Dow Corning Corp.	Midland, Mich.	78452	Thompson-Bremer & Co.	Chicago, Ill.
36287	Cunningham, W. H. & Hill, Ltd.	Toronto Ontario, Canada	72136	Electro Motive Mfg. Co., Inc.	Williamantic, Conn.	78471	Tilley Mfg. Co.	San Francisco, Calif.
37942	P. R. Mallory & Co. Inc.	Indianapolis, Ind.	72619	Dialight Corp.	Brooklyn, N. Y.	78488	Stackpole Carbon Co.	St. Marys, Pa.
39543	Mechanical Industries Prod. Co.	Akron, Ohio	72656	Indiana General Corp., Electronics Div.	Keasby, N. J.	78493	Standard Thomson Corp.	Waltham, Mass.
40920	Miniature Precision Bearings, Inc.	Keene, N. H.	72699	General Instrument Corp., Cap. Div.	Newark, N. J.	78553	Tinnerman Products, Inc.	Cleveland, Ohio
42190	Muler Co.	Chicago, Ill.	72765	Drake Mfg. Co.	Harwood Heights, Ill.	78790	Transformer Engineers	San Gabriel, Calif.
43990	C. A. Noirgen Co.	Englewood, Colo.	72825	Hugh H. Eby Inc.	Philadelphia, Pa.	78947	Ucinite Co.	Newtonville, Mass.
44655	Ohmite Mfg. Co.	Skokie, Ill.	72928	Gudeman Co.	Chicago, Ill.	79136	Waldes Kohinor Inc.	Long Island City, N. Y.
46384	Penn Eng. & Mfg. Corp.	Doylestown, Pa.	72962	Elastic Stop Nut Corp.	Union, N. J.	79142	Veeder Root, Inc.	Hartford, Conn.
47904	Polaroid Corp.	Cambridge, Mass.	72964	Robert M. Hadley Co.	Los Angeles, Calif.	79251	Wenco Mfg. Co.	Chicago, Ill.
48620	Precision Thermometer & Inst. Co.	Southampton, Pa.	72982	Erie Technological Products, Inc.	Erie, Pa.	79272	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
49956	Microwave & Power Tube Div.	Waltham, Mass.	73061	Hansen Mfg. Co., Inc.	Princeton, Ind.	79963	Zierick Mfg. Corp.	New Rochelle, N. Y.
52090	Rowan Controller Co.	Westminster, Md.	73076	H. M. Harper Co.	Chicago, Ill.	80031	Mepco Division of Sessions Clock Co.	Morristown, N. J.
52983	Sanborn Company	Waltham, Mass.	73138	Helipol Div. of Beckman Inst., Inc.	Fullerton, Calif.	80120	Schnitzer Alloy Products Co.	Elizabeth, N. J.
54294	Shallcross Mfg. Co.	Selma, N. C.	73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.	80131	Electronic Industries Association. Any brand Tube meeting EIA Standards-Washington, DC.	Washington, DC.
55026	Simpson Electric Co.	Chicago, Ill.	73445	Amperex Elect Co.	Hicksville, L. I., N. Y.	80207	Unimax Switch, Div. Maxon Electronics Corp.	Wallingford, Conn.
55933	Sonotone Corp.	Elmsford, N. Y.	73506	Bradley Semiconductor Corp.	New Haven, Conn.	80223	United Transformer Corp.	New York, N. Y.
55938	Raytheon Co. Commercial Apparatus & Systems Div.	So. Norwalk, Conn.	73559	Carling Electric, Inc.	Hartford, Conn.	80248	Orford Electric Corp.	Chicago, Ill.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N. Y.	73586	Circle F Mfg. Co.	Trenton, N. J.	80294	Bourns Inc.	Riverside, Calif.
56289	Sprague Electric Co.	North Adams, Mass.	73682	George K. Garrett Co., Div. MSL Industries Inc.	Philadelphia, Pa.	80411	Acro Div. of Robertshaw Controls Co.	Columbus, Ohio
59446	Telex Corp.	Tulsa, Okla.	73734	Federal Screw Products Inc.	Chicago, Ill.	80486	All Star Products Inc.	Defiance, Ohio
59730	Thomas & Betts Co.	Elizabeth, N. J.	73743	Fischer Special Mfg. Co.	Cincinnati, Ohio	80509	Avery Label Co.	Monrovia, Calif.
60741	Triplet Electrical Inst. Co.	Bluffton, Ohio	73793	General Industries Co., The	Elyria, Ohio	80583	Hammarlund Co., Inc.	New York, N. Y.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.	73846	Goshen Stamping & Tool Co.	Goshen, Ind.	80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
62119	Universal Electric Co.	Owosso, Mich.	73899	JFD Electronics Corp.	Brooklyn, N. Y.	80813	Dimco Gray Co.	Dayton, Ohio
63743	Ward-Leonard Electric Co.	Mt. Vernon, N. Y.	73905	Jennings Radio Mfg. Corp.	San Jose, Calif.	81030	International Instruments Inc.	Orange, Conn.
64959	Western Electric Co., Inc.	New York, N. Y.	73957	Groov-Pin Corp.	Ridgefield, N. J.	81073	Grayhill Co.	LaGrange, Ill.
65092	Weston Inst. Inc. Weston-Newark	Newark, N. J.	74276	Signalite Inc.	Neptune, N. J.	81095	Triad Transformer Corp.	Venice, Calif.
66295	Wittek Mfg. Co.	Chicago, Ill.	74455	J. H. Winns, and Sons	Winchester, Mass.	81312	Winchester Elec. Div. Litton Ind., Inc.	Oakville, Conn.
66346	Minnesota Mining & Mfg. Co. Revere Mincom Div.	St. Paul, Minn.	74861	Industrial Condenser Corp.	Chicago, Ill.	81349	Military Specification	...
70276	Allen Mfg. Co.	Hartford, Conn.	74868	R. F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.	81483	International Rectifier Corp.	El Segundo, Calif.
70309	Allied Control	New York, N. Y.	74970	E. F. Johnson Co.	Waseca, Minn.	81541	Airpax Electronics, Inc.	Cambridge, Maryland
70318	Allmetal Screw Product Co., Inc.	Garden City, N. Y.	75042	International Resistance Co.	Philadelphia, Pa.	81860	Barry Controls, Div. Barry Wright Corp.	Waterstown, Mass.
70417	Amplex, Div. of Chrysler Corp.	Detroit, Mich.	75263	Keystone Carbon Co., Inc.	St. Marys, Pa.	82042	Carter Precision Electric Co.	Skokie, Ill.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.	75378	CTS Knights Inc.	Sandwich, Ill.			
70563	Amperite Co., Inc.	Union City, N. J.	75382	Kulka Electric Corporation	Mt. Vernon, N. Y.			
70674	ADC Products Inc.	Minneapolis, Minn.	75818	Lenz Electric Mfg. Co.	Chicago, Ill.			
70903	Belden Mfg. Co.	Chicago, Ill.	75915	Littlefuse, Inc.	Des Plaines, Ill.			
			76005	Lord Mfg. Co.	Erie, Pa.			

CODE LIST OF MANUFACTURERS (Cont'd)

Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address
82047	Sperti Faraday Inc.,	Copper Hewitt Electric Div. Hoboken, N. J.	88220	Gould-National Batteries, Inc.	St. Paul, Minn.	96067	Huggins Laboratories	Sunnyvale, Calif.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.	88698	General Mills, Inc.	Buffalo, N. Y.	96095	Hi-Q Div. of Aerovox Corp.	Olean, N. Y.
82170	Fairchild Camera & Inst. Corp. Space & Defense System Div.	Paramus, N. J.	89231	Graybar Electric Co.	Oakland, Calif.	96256	Thordarson-Meissner Inc.	Mt. Carmel, Ill.
82209	Maguire Industries, Inc.	Greenwich, Conn.	89473	G. E. Distributing Corp.	Schenectady, N. Y.	96296	Solar Manufacturing Co.	Los Angeles, Calif.
82219	Sylvania Electric Prod. Inc. Electronic Tube Division	Emporium, Pa.	89665	United Transformer Co.	Chicago, Ill.	96330	Carlton Screw Co.	Chicago, Ill.
82376	Astron Corp.	East Newark, Harrison, N. J.	90030	United Shoe Machinery Corp.	Beverly, Mass.	96341	Microwave Associates, Inc.	Burlington, Mass.
82389	Switchcraft, Inc.	Chicago, Ill.	90179	US Rubber Co., Consumer Ind. & Plastics Prod. Div.	Passaic, N. J.	96501	Excel Transformer Co.	Oakland, Calif.
82647	Metals & Controls Inc. Spencer Products	Attleboro, Mass.	90970	Bearing Engineering Co.	San Francisco, Calif.	97464	Industrial Retaining Ring Co.	Ivington, N. J.
82768	Phillips-Advance Control Co.	Joliet, Ill.	91146	ITT Cannon Elect, Inc., Salem Div.	Salem, Mass.	97539	Automatic & Precision Mfg.	Englewood, N. J.
82866	Research Products Corp.	Madison, Wis.	91260	Connor Spring Mfg. Co.	San Francisco, Calif.	97979	Reon Resistor Corp.	Yonkers, N. Y.
82877	Rolton Mfg. Co., Inc.	Woodstock, N. Y.	91345	Miller Dial & Nameplate Co.	El Monte, Calif.	97983	Litton System Inc., Adler-Westrex Commun. Div.	New Rochelle, N. Y.
82893	Vector Electronic Co.	Glendale, Calif.	91418	Radio Materials Co.	Chicago, Ill.	98141	R-Tronics, Inc.	Jamaica, N. Y.
83058	Carr Fastener Co.	Cambridge, Mass.	91506	Augat Inc.	Attleboro, Mass.	98159	Rubber Teck, Inc.	Gardena, Calif.
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83125	General Instrument Corp., Capacitor Div.	Darlington, S. C.	91662	Elco Corp.	Willow Grove, Pa.	98278	Microdot, Inc.	So. Pasadena, Calif.
83148	ITT Wire and Cable Div.	Los Angeles, Calif.	91737	Greomar Mfg. Co., Inc.	Wakefield, Mass.	98291	Sealectro Corp.	Mamaroneck, N. Y.
83186	Victory Eng. Corp.	Springfield, N. J.	91827	K F Development Co.	Redwood City, Calif.	98376	Zero Mfg. Co.	Burbank, Calif.
83298	Bendix Corp., Red Bank Div.	Red Bank, N. J.	91886	Malco Mfg. Co., Inc.	Chicago, Ill.	98731	General Mills Inc., Electronics Div.	Minneapolis, Minn.
83315	Hubbell Corp.	Mundelein, Ill.	91929	Honeywell Inc., Micro Switch Div.	Freeport, Ill.	98734	Paeco Div. of Hewlett-Packard Co.	Palo Alto, Calif.
83324	Rosan Inc.	Newport Beach, Calif.	91961	Nahn-Bros. Spring Co.	Oakland, Calif.	98821	North Hills Electronics, Inc.	Glen Cove, N. Y.
83330	Smith, Herman H., Inc.	Brooklyn, N. Y.	92180	Tri-Connector Corp.	Peabody, Mass.	98978	International Electronic Research Corp.	Burbank, Calif.
83332	Tech Labs	Palisades Park, N. J.	92367	Elgeet Optical Co. Inc.	Rochester, N. Y.	99109	Columbia Technical Corp.	New York, N. Y.
83385	Central Screw Co.	Chicago, Ill.	92607	Tensolite Insulated Wire Co., Inc.	Tarrytown, N. Y.	99313	Varian Associates	Palo Alto, Calif.
83501	Gavitt Wire and Cable Co. Div. of Amerace Corp.	Brookfield, Mass.	92702	IMC Magnetics Corp.	Wesbury Long Island, N. Y.	99378	Atlee Corp.	Winchester, Mass.
83594	Burroughs Corp. Electronic Tube Div.	Plainfield, N. J.	92966	Hudson Lamp Co.	Kearney, N. J.	99515	Marshall Ind., Capacitor Div.	Nonrovia, Calif.
83740	Union Carbide Corp. Consumer Prod. Div.	New York, N. Y.	93332	Sylvania Electric Prod. Inc. Semiconductor Div.	Woburn, Mass.	99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.	93369	Robbins & Myers Inc.	Palisades Park, N. J.	99800	Delevan Electronics Corp.	East Aurora, N. Y.
83821	Loyd Scruggs Co.	Festus, Mo.	93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio	99848	Wilco Corporation	Indianapolis, Ind.
83942	Aeronautical Inst. & Radio Co.	Lodi, N. J.	93632	Waters Mfg. Co.	Culver City, Calif.	99934	Renbrandt, Inc.	Boston, Mass.
84171	Arco Electronics Inc.	Great Neck, N. Y.	93929	G. V. Controls	Livingston, N. J.	99942	Hoffman Electronics Corp. Semiconductor Div.	El Monte, Calif.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.	94137	General Cable Corp.	Bayonne, N. J.	99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.
84411	TRW Capacitor Div.	Ogallala, Neb.	94144	Raytheon Co., Comp. Div., Ind. Comp. Operations	Quincy, Mass.			
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.	94148	Scientific Electronics Products, Inc.	Loveland, Colo.			
85454	Boonton Molding Company	Boonton, N. J.	94154	Wagner Elect. Corp., Tung-Sol Div.	Newark, N. J.			
85471	A. B. Boyd Co.	San Francisco, Calif.	94197	Curtiss-Wright Corp. Electronics Div.	East Paterson, N. J.			
85474	R. M. Bracamonte & Co.	San Francisco, Calif.	94222	South Chester Corp.	Chester, Pa.			
85660	Korled Koids, Inc.	Hamden, Conn.	94330	Wire Cloth Products, Inc.	Bellwood, Ill.			
85911	Seal-less Rubber Co.	Chicago, Ill.	94375	Automatic Metal Products Co.	Brooklyn, N. Y.			
86197	Clifton Precision Products Co., Inc.	Clifton Heights, Pa.	94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.			
86579	Precision Rubber Products Corp.	Dayton, Ohio	94696	Magnecraft Electric Co.	Chicago, Ill.			
86684	Radio Corp. of America, Electronic Comp. & Devices Div.	Harrison, N. J.	95023	George A. Philbrick Researchers, Inc.	Boston, Mass.			
87034	Marco Industries	Anaheim, Calif.	95236	Allies Products Corp.,	Dania, Fla.			
87216	Phlco Corporation (Lansdale Division)	Lansdale, Pa.	95238	Continental Connector Corp.	Woodside, N. Y.			
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.	95263	Leecraft Mfg. Co., Inc.	Long Island, N. Y.			
87664	Van Waters & Rogers Inc.	San Francisco, Calif.	95265	National Coil Co.	Sheridan, Wyo.			
87930	Tower Mfg. Corp.	Providence, R. I.	95275	Vitramon, Inc.	Bridgeport, Conn.			
88140	Cutler-Hammer, Inc.	Lincoln, Ill.	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	Siemon Mfg. Co.	Wayne, Ill.			
			95987	Weckesser Co.	Chicago, Ill.			

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.

SUPPLEMENTAL CODE LIST OF MANUFACTURERS

Code No.	Manufacturer	Address
000LM	Newark	Denver, Colorado
13789	Barnes Metal Products Co.	Chicago, Illinois
74163	Phelps Dodge Corp.	New York, New York
08300	Stone Paper Tube Co.	Washington, D. C.
08988	Skottle	Archibald, Pennsylvania

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MANUAL BACKDATING CHANGES

MODEL 403B

TRANSISTORIZED AC VOLTMETER

This manual backdating sheet makes this manual applicable to earlier instruments. Instrument-component values that differ from those in the manual, yet are not listed in the backdating sheet, should be replaced using the part number given in the manual.

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
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225-	1	949-10635 and below	5
523-05300 and below	2		
523-05825 and below	3		
523-09985 and below	4		

CHANGE 1: Table 6-1, Page 6-6:
 Delete index #19, Battery Holder; -hp- Part No. 5040-0615; 2 ea.
 Add Battery Holder; -hp- Part No. 403B-64A and 403B-64B.

CHANGE 2: Page 6-2:
 Change Q7 from 2N3638 (1853-0016) to 2N1183 (1850-0064).

————— NOTE —————

Transistor 2N3638 is a preferred change for all 403B instruments.

CHANGE 3: Page 5-11/5-12, Figure 5-8:
 Change C15 from: 100 pF, Part No. 0146-0176
 to: 120 pF, Part No. 0140-0216

CHANGE 4: Table 6-1:
 Change the following Part Nos:
 DS1 to 1450-0048, J2 to 1251-0148, W1 to 8120-0078.
 Table 6-2:
 Change the following Part Nos:
 Item 9 to 403B-2B, Item 23 (Fig. 6-1) to 403B-2B.

CHANGE 5: Pages 5-9, 6-2, 6-3:
 Change the following parts descriptions:
 Q1 to 5080-9029; TSTR Ge PNP Selected
 Q2, 3, and 5 to 1850-0096; TSTR Ge PNP 2N2189
 Q4, 6 to 1854-0017; TSTR Si NPN 2N706A
 R7 to 0758-0051; R: fxd comp 43K \pm 5% 1/2 W
 The voltages printed in red do not apply to these instruments.

CHANGE 6: The covers, panels, and trim listed in the parts list are for brown instruments.
 Covers, panels, and trim for blue instruments are listed below:

403B-2A	Front Panel
5060-0705	Top Cover Assy
5000-0702	Side Cover
5000-5388	Bottom Cover
5020-5388	Meter Trim



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