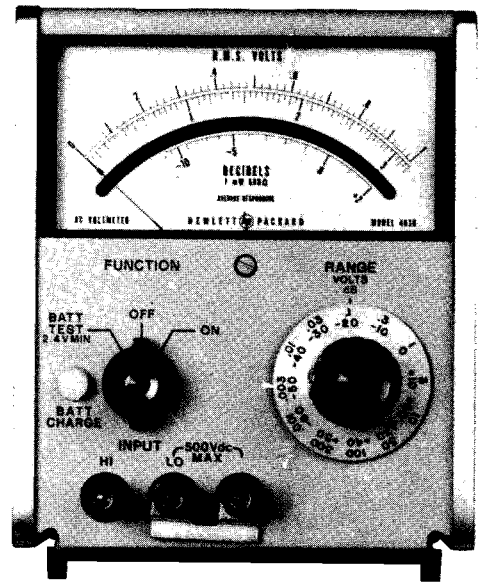
OPERATING AND SERVICE MANUAL

AC VOLTMETER

403B



HEWLETT PACKARD

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OPERATING AND SERVICE MANUAL

MODEL 403B
AC VOLTMETER

Serials Prefixed: 0986A

IMPORTANT NOTICE

Any changes made in instruments with serial numbers greater than those stated on this title page will be noted on a change sheet supplied with this manual. If the serial number of your instrument is lower than that stated above, the manual can contain revisions that do not apply to your instrument. Backdating information located on the schematic and in the Parts List adapts this manual to these instruments.

WARNING

To help minimize the possibility of electrical fire or shock hazards, do not expose this instrument to rain or excessive moisture.

Manual Part No. 00403-90013

Microfiche Part No. 00403-90063

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

Printed: October 1976

HEWLETT PACKARD

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard product is warranted against defects in material and workmanship for a period of one year from date of shipment [,except that in the case of certain components listed in Section I of this manual, the warranty shall be for the specified period] . During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by -hp-. Buyer shall prepay shipping charges to -hp- and -hp- shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to -hp- from another country.

Hewlett-Packard warrants that its software and firmware designated by -hp- for use with an instrument will execute its programming instructions when properly installed on that instrument. Hewlett-Packard does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HEWLETT-PACKARD SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HEWLETT-PACKARD SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

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

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HEWLETT PACKARD

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requiremants. This is a Safety Class 1 instrument.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DANGEROUS PROCEDURE WARNINGS

Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

WARNING

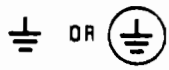
Dangerous voltages, capable of causing death, are presant in this instrument. Use extreme caution when handling, testing, and adjusting.

SAFETY SYMBOLS

General Definitions of Safety Symbols Used On Equipment or In Manuals.

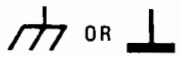
Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.

Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).



Protective conductor terminal. For protection against electrical shock in case of a fault. Used with field wiring terminals to indicate the terminal which must be connected to ground before operating equipment.

Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of a fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (operating) manual, and before operating the equipment.



Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.

Alternating current (power line).

Direct current (power line).

Alternating or direct current (power line).

WARNING

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.

CAUTION

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, condition or the like, which,if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.

NOTE:

The NOTE sign denotes important information. It calls attention to procedure, practice, condition or the like, which is essential to highlight.

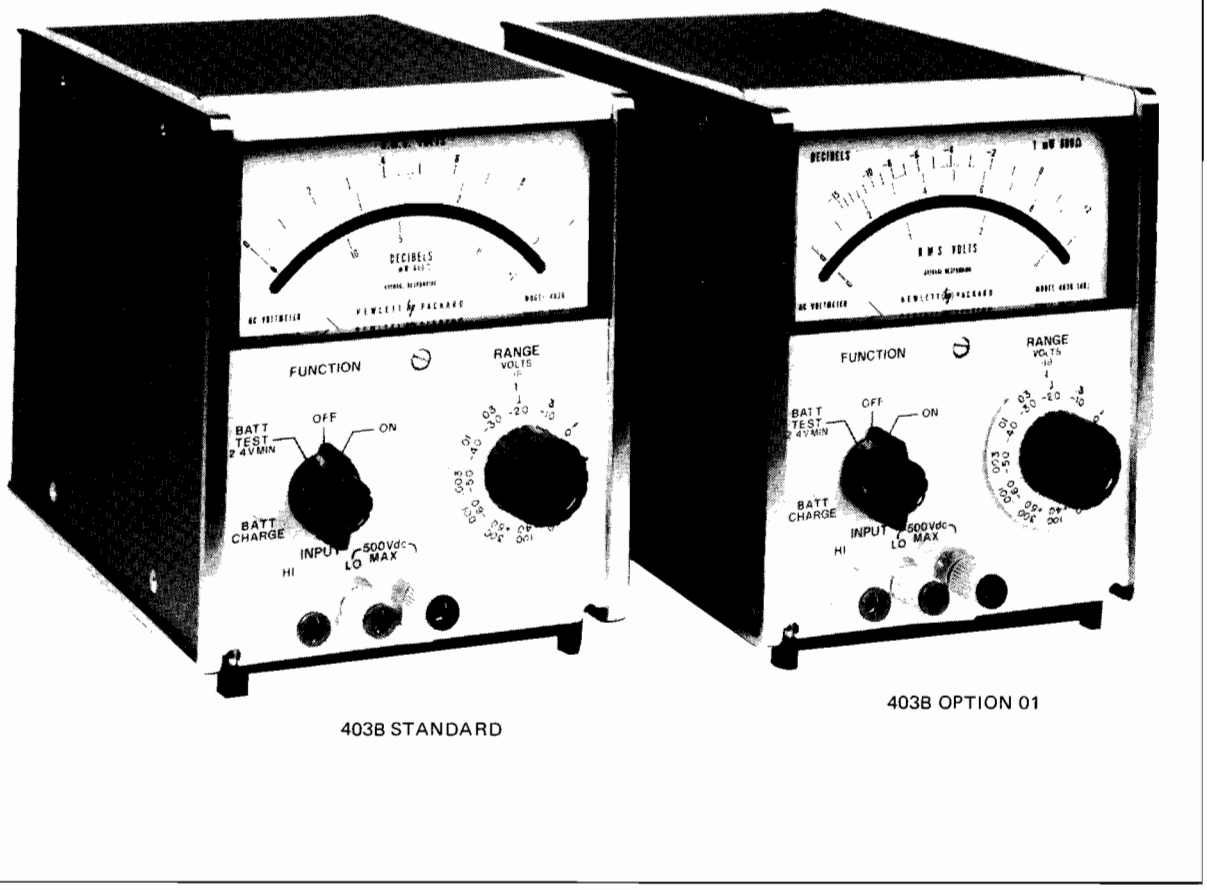


Figure 1-1. Model 403B AC Voltmeter.

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. An additional Operating and Service Manual is available by ordering Option 910, Part Number 00403-90013.

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.

Range:
0.001 to 300 volts rms full scale (12 ranges) in a 1, 3, 10 sequence.

Frequency Range:
5 Hz to 2 MHz

Accuracy:
% of Full Scale.

Model 403B Accuracy Specification

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%

Model 403B Option 01 Accuracy Specification

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

*On the 300 V range, accuracy is not specified above 100 kHz.

Meter:
Individually calibrated, taut band. Responds to average value of input waveform and is calibrated in the rms value of a sine wave.

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.

Overload Protection:
Fuse protected:

DC Isolation:
Signal ground may be ± 500 V dc maximum from external chassis.

Residual Noise:
With 100 kΩ shielded load across the input terminals noise is less than 3% of full scale for battery operation and less than 8% of full scale for ac line operation.

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 230 V ± 10% 48 to 440 Hz, < 3 watts).

Temperature Range:
- 20°C to + 50°C.

Dimensions:
5 - 1/8 in. wide, 6 - 3/32 in. high, 8 in. deep.

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.

Accessory Furnished:
Detachable power cord.

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: ± 3% Input Capacity: 15 pF ± 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 ± 1% at 1 kHz	Resistance / Max. Current / Accuracy < 50 milliohms / 1 amp rms, 1.5 amp peak / ± 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

For operator protection while using the 403B in battery operation. The shorting strap between LO and chassis ground (⏚) must be removed and chassis ground (⏚) must be tied to earth ground.

2-6. INSTALLATION.

2-7. The -hp- Model 403B is fully transistorized; therefore no special cooling is requried. 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).

CAUTION

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 35 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 450 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.

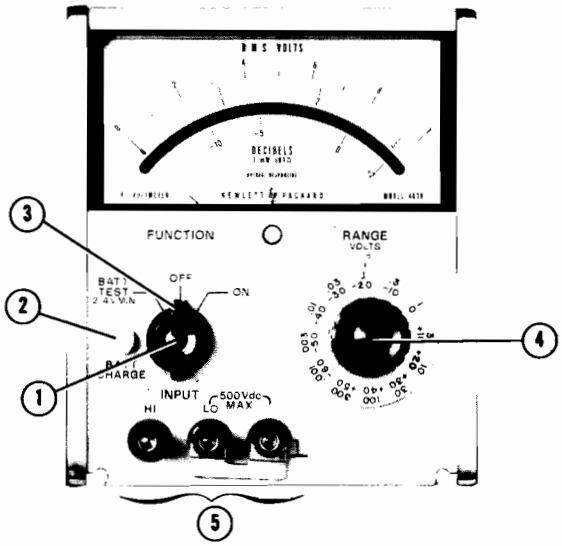
3-15. If measurements are made from a high-impedance source, hum pick-up can affect the meter indication because of high impedance of both the source and voltmeter. Shielded leads will reduce pick-up although they will cause an increase in the capacity shunted across the source, with the possibility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

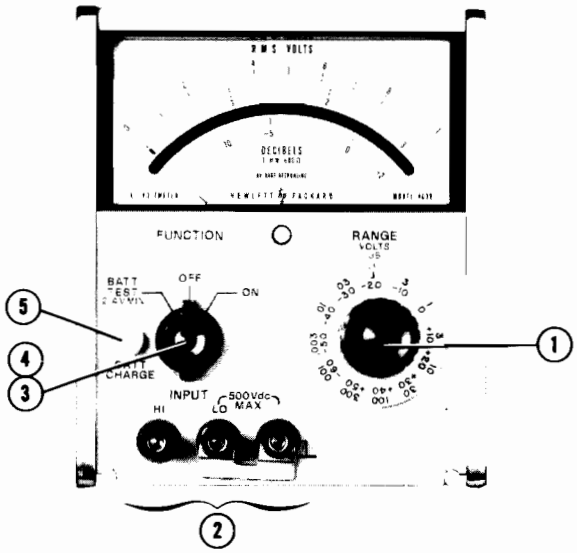
3-18. WAVEFORM ERRORS.

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 volt-



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 V dc 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.



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 the voltages to be measured to the HI and LO input terminals.

NOTE

The black terminal marked ⏚ is connected to chassis ground. For voltage measurements at chassis ground connect the LO terminal to the black chassis terminal. The maximum difference of potential between LO and ⏚ is ± 500 V dc only.

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 recharging. 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.

WARNING

For operator protection while using the 403B in battery operation. The shorting strap between LO and chassis ground (⏚) must be removed and chassis ground (⏚) must be tied to earth ground.

Figure 3-2. Voltage Measurements.

age 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.

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
Funcamental + 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.

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 milliwatt 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:

+ 1 (dB - scale indication)
+30 (range switch position)
+31 (level in dB as indicated by meter)
+ 8 (correction for 90 - ohm impedance)
+39 dBm

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:

+ 1 (dB-scale indication)
+30 (range switch position)
+31 (level in dB as indicated by meter)
- 12.5 (correction for 10,000-ohm impedance)
+18.5 dBm

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.

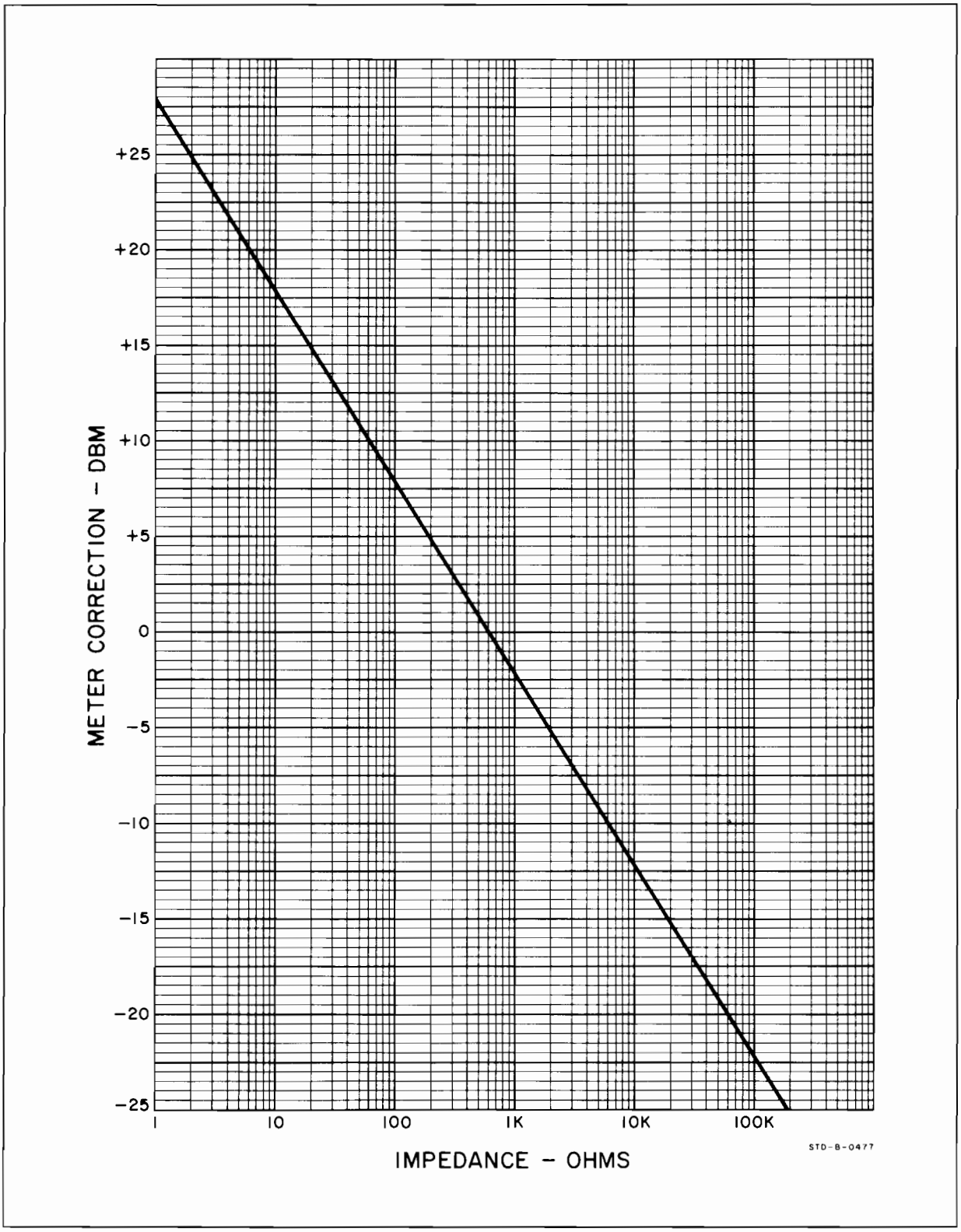


Figure 3-3. Model 403B Impedance Correction Graph.

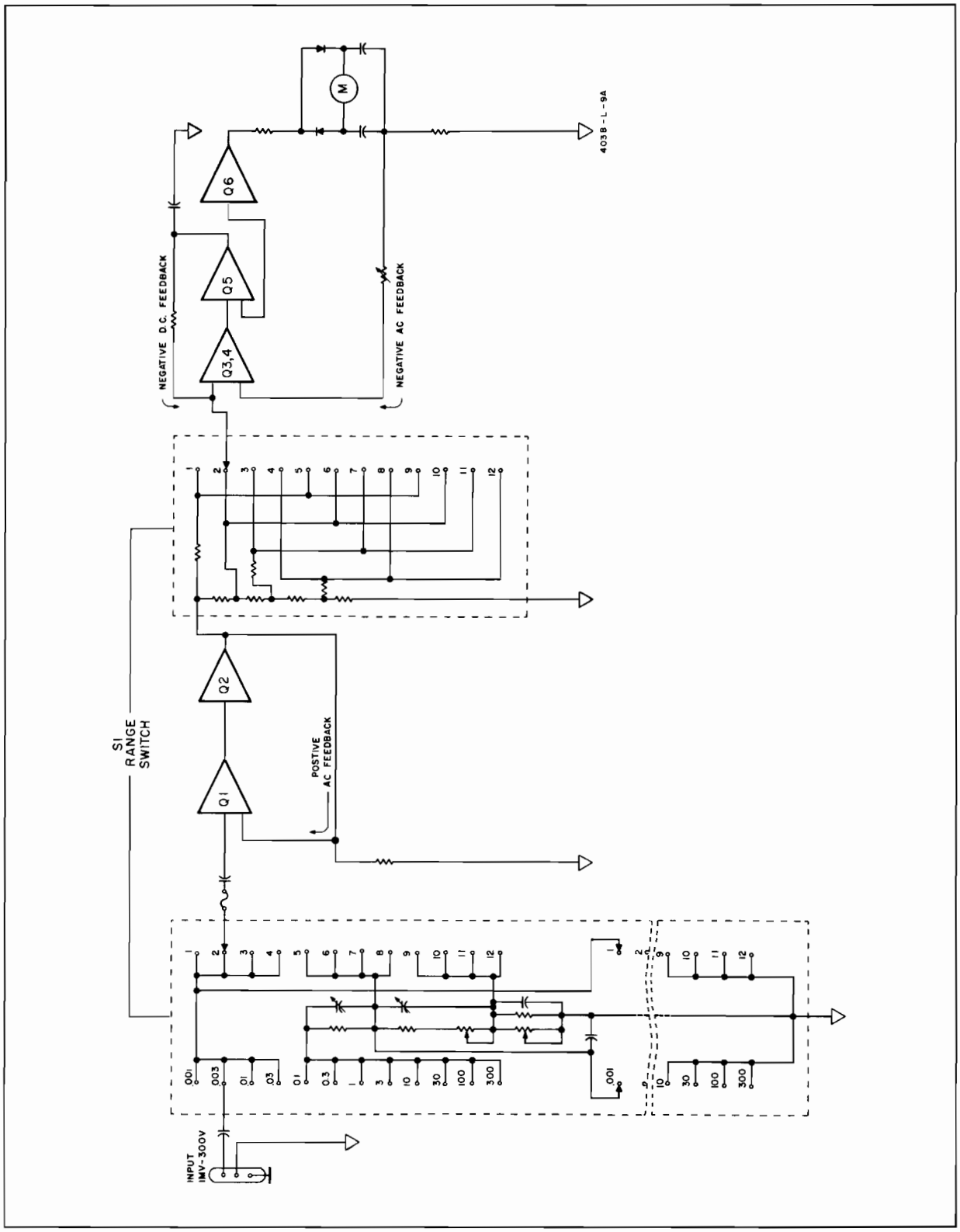


Figure 4-1. Model 403B Functional Block Diagram.

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_1 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.

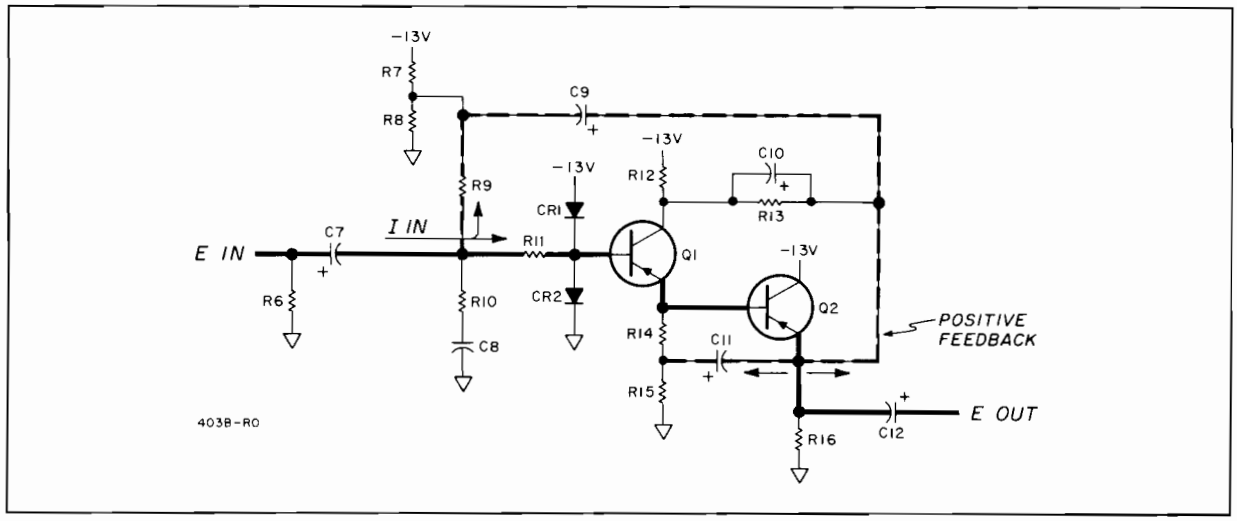


Figure 4-2. Input Amplifier.

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 5-9) 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 form 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 Figure 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 therfore 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.

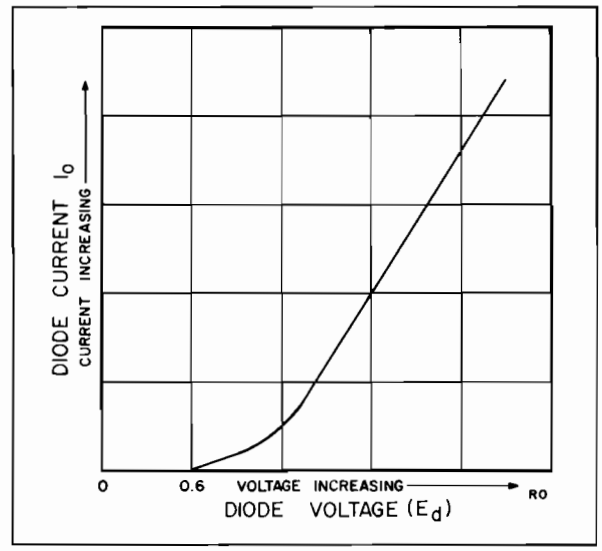


Figure 4-3. Diode Current Vs Diode Voltage.

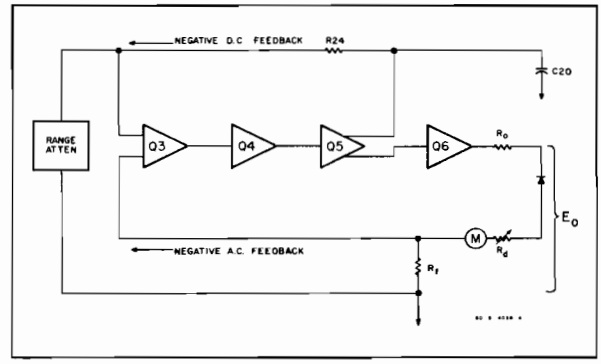


Figure 4-4. Fixed Amplfiier Block Diagram.

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 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.

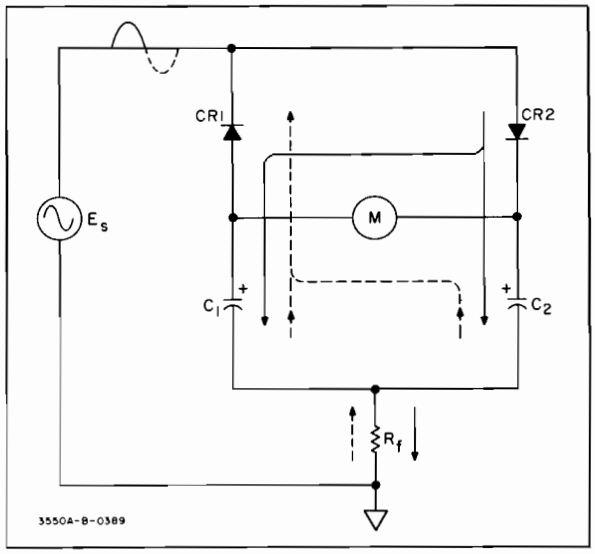


Figure 4-5. Meter Rectifier, Simplified Diagram.

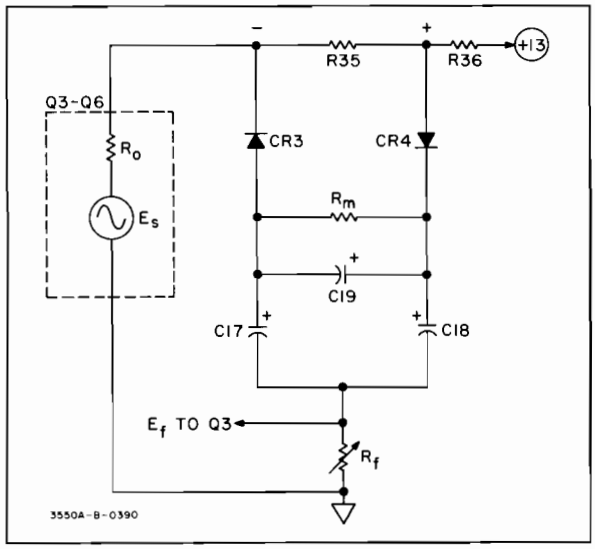


Figure 4-6. Meter Rectifier Circuit.

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.

CAUTION

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.

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 5-9 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.

CAUTION

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 5-9 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.

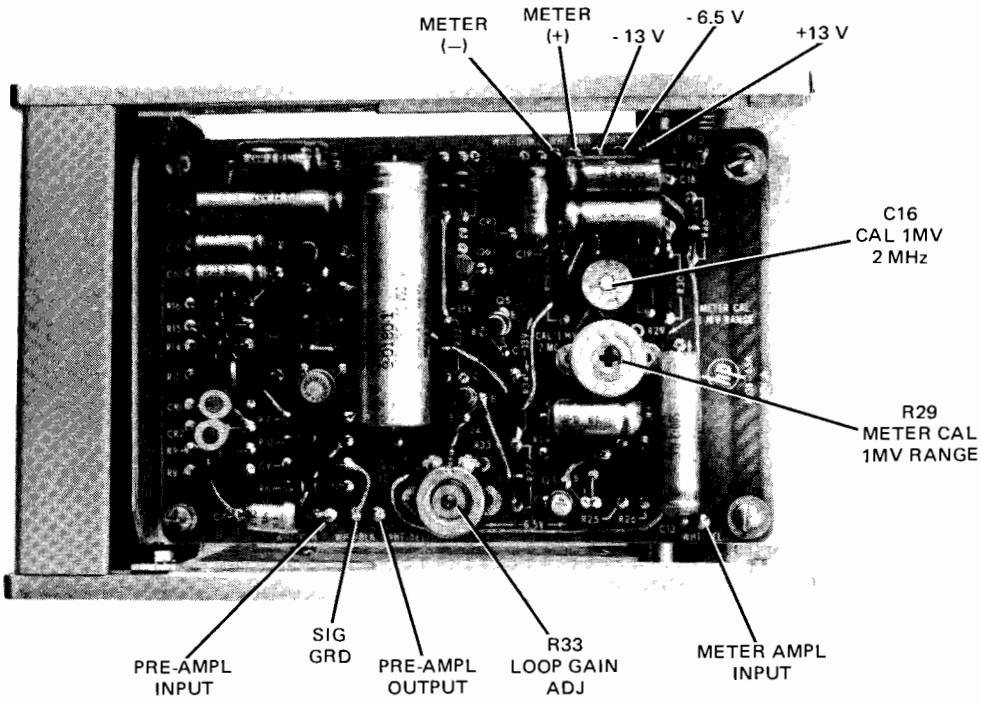


Figure 5-1. Model 403B Top View.

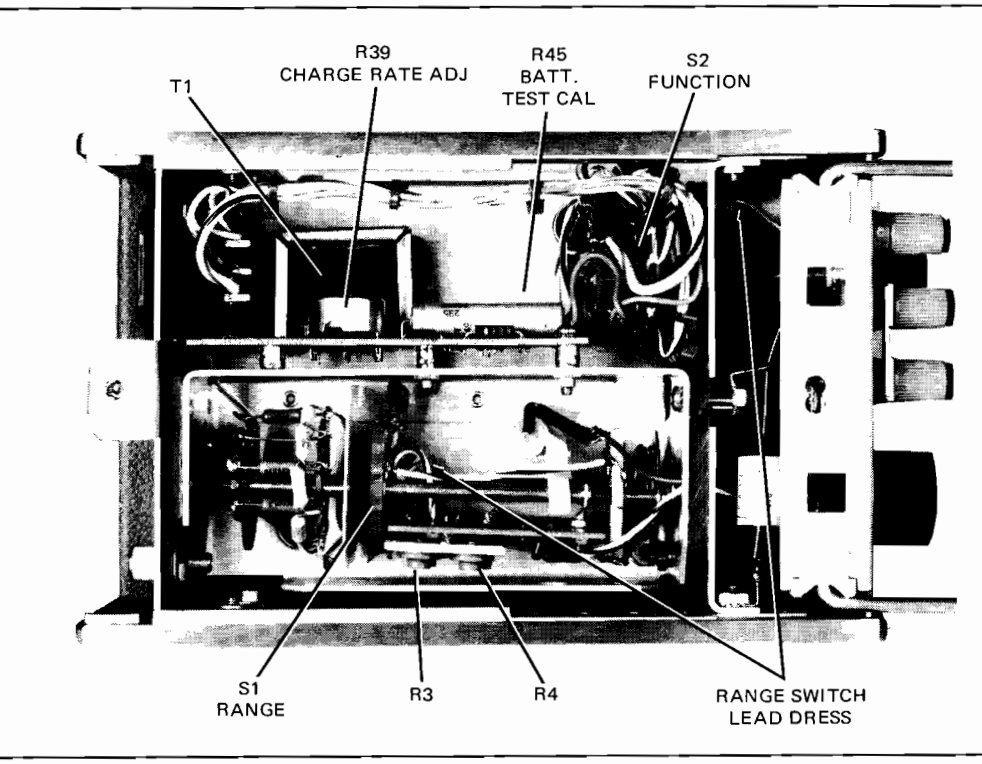


Figure 5-2. Model 403B Bottom View.

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 5-33 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.

NOTE

Whenever it becomes necessary to perform repair on the 403B the position of the leads to and from the range switch should be noted. After repair the leads should be placed in the same position. Lead dress (position) will have the most affect at frequencies above 100 kHz on the 100 V range. Refer to Figure 5-2 for appropriate lead position.

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.

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 3465A Digital 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 or 745A/746A 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

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°.

5-10. PERFORMANCE CHECKS.

5-11. The performance checks are in-cabinet tests that compare the 403B with its specifications. These precedures 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.

Table 5-2. Calibration Check Table.

Voltmeter Calibrator Output (400 Hz rms)	Model 403B Indication (V rms)	
	Minimum	Maximum
300 V	294 V	306 V
100 V	98 V	102 V
30 V	29.4 V	30.6 V
10 V	9.8 V	10.2 V
3 V	2.94 V	3.06 V
1 V	0.98 V	1.02 V
0.3 V	0.294 V	0.306 V
0.1 V	0.098 V	0.102 V
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

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.

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 400 Hz.

j. Connect on 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 19.4 V and 20.6 V.

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 10 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 100 K ohm - shielded load. The 403B meter deflection on any range should be less than 3% of full scale in battery operation and less than 8% of full scale in ac line 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:

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

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 capacitance 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.

NOTE

The following test requires an ac voltmeter that is capable of making floating ac measurements. This requirement can be met by using an -hp-3465A in the battery operated mode.

d. Set the 403B line voltage to 115 volts. Place the ac voltmeter (-hp- 3465A) in the battery operating mode. Using a short pair of twisted clips leads, connect the input of the ac voltmeter to the positive terminal of BT1 and the negative terminal of BT4; the ripple voltage should not exceed 1.5 mV rms.

e. Set 403B FUNCTION switch to OFF; disconnect ac power source and set FUNCTION switch to ON.

CAUTION

DC Voltmeter must be isolated from 403B ground.

f. Connect volts probe of a DC Voltmeter to the red wire connected to the battery BT1; connect common lead of the dc voltmeter to the violet wire connected to battery BT4.

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 of 1/10 the voltage indicated on the 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).

5-23. Overload Check.

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

CAUTION

The 15 KΩ 10W resistor must be connected as shown in Figure 5-3 to prevent damage to voltmeter calibrator.

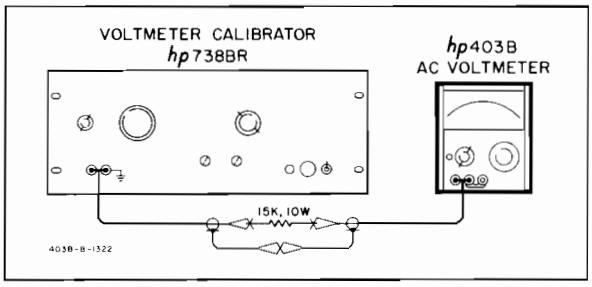


Figure 5-3. Overload Check Setup.

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).

5-24. Calibration and Tracking.

a. Disconnect the 403B from the ac power source. (The following procedure should be performed with battery operation. When using battery operation the chassis should be connected to earth ground).

b. Connect the 403B as shown in Figure 5-4 (Position A).

NOTE

The 200 K 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.

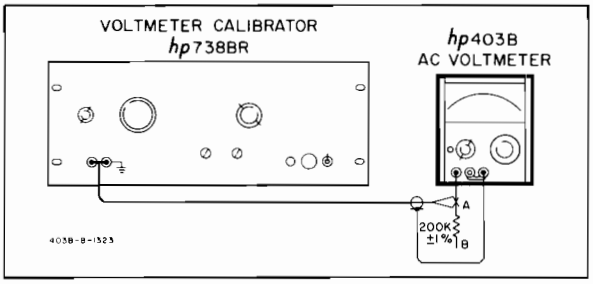


Figure 5-4. Performance Check Setup.

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.

i. Adjust R4 (see Figure 5-2) for a full-scale indication on the 403B meter.

j. Check calibration on the 0.003, 0.01, and 0.03 volt ranges; accuracy should be within ± 2.0% of full scale on all ranges.

k. Set Voltmeter Calibrator for 1.0 volt. Rotate 403B FUNCTION switch to 1.0 volt.

l. Check 403B meter tracking at 0.1 volt increments. Variation should be less than ± 2% of full scale.

5-25. High Frequency Response.

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

b. Set oscillator (-hp- Model 652A) to 10 mV rms range at 400 Hz.

c. Adjust OUTPUT AMPLITUDE control for reading of 9.4 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 9.4 mV ± 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 (refer to Paragraph 5-42 for C15 selection).

NOTE

The frequency roll-off must start between 2 MHz and 3 MHz. If the roll-off is extended beyond 3 MHz, the frequency response will not be flat across the 5 Hz to 2 MHz band.

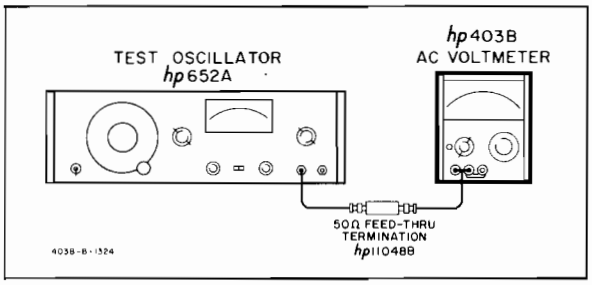


Figure 5-5. Frequency Response Setup.

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 9 mV ± 00.2 mV (± 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.

i. Set the 652A Oscillator for 400 Hz and 0.1 RANGE.

j. Adjust the OUTPUT AMPLITUDE control for an indication of 0.96 of full scale on the 403B meter.

k. Readjust the 652A OUTPUT AMPLITUDE control for a convenient reference on the 652A meter.

l. Change the 652A frequency to 300 kHz while maintaining reference on meter.

m. Adjust C3 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.

b. 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 m, 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 evaluation 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	Recharge Batteries
Noise indication on known quiet source	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 230 V position when using 115 V
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

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 100 K 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	CR3, CR4 bad R35 wrong value
2) Meter reads above some but below other divisions	Diodes CR3, CR4 bad Meter M1 bad
Low frequency response bad	C1, 7, 12, 13, 18-20
400E reads more than 1.5 volts on overload	CR1 or CR2 bad
Excessive Charging Rate R39 No Effect	Bad CR9, Q7

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.

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. Refer to Paragraph 5-39 for replacement of germanium transistor.

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.

5-39. Germanium Transistor Replacement (applies to Serial Numbers 949-10635 and below).

5-40. The germanium transistors used in 403B's (Serial Numbers 949-10635 and below) are no longer available for replacement. When it becomes necessary to replace the germanium transistors (Q2, Q3, Q5 are type 2N2189, Q1 is type 2N852), it is recommended that the replacement be with silicon transistors. The following procedure describes the modifications necessary to replace the germanium transistors with silicon transistors.

a. If either Q1 or Q2 fails, they must be replaced as a pair. The silicon replacement for both transistors is -hp- Part Number 1853-0020. Other modifications necessary are:

1. Change R7 to a 34 kΩ 1% 1/8 watt metal film resistor, -hp- Part Number 0698-4493.

2. Change R13 to a 22 kΩ 10% 1/2 watt resistor, -hp- Part Number 0687-2231.

3. Completely recalibrate the instrument.

b. If either Q3 or Q5 fails, they must be replaced as a pair. The silicon replacement for both transistors is -hp- Part Number 1853-0020. The replacement of R35 with 294 Ω 1% 1/8 watt metal film resistor is the only modification necessary. Completely recalibrate the instrument.

5-41. Factory Selected Components.

5-42. C15, 2 MHz Pad for C16. Refer to Paragraph 5-25(e), to determine if value of C15 needs to be changed. If the frequency roll off described in Step e starts before 2 MHz, the value of C15 must be decreased. If the frequency roll off does not start between 2 MHz and 3 MHz the value of C15 must be increased. The range of C15 is: 100 pF through 200 pF.

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	Amplifier (Common emitter)	Readjust R33	5-25 Steps a thru g
Q5	Amplifier (Common collector)	Readjust R33	5-25 Steps a thru g
Q6	Amplifies signal (Common base)	Readjust R33	5-25 Steps a thru g
Q7	Charging Current Regulation	Readjust R39	5-20 Steps a and b
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	Zener Diode	Readjust R39	5-29 Steps a and b
CR10	Isolation Diode	Check battery charge current	5-20 Steps a and b

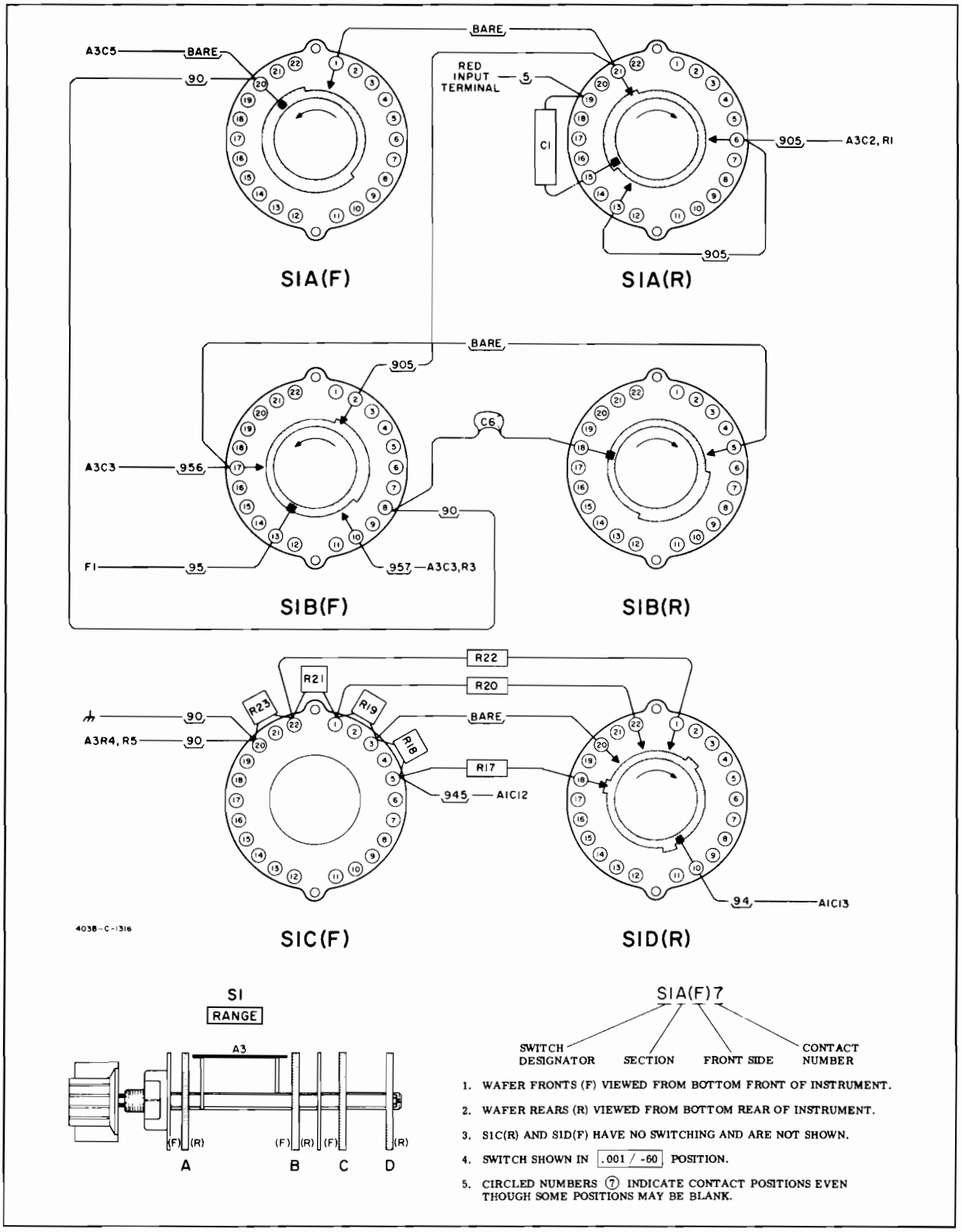


Figure 5-6. Range Switch Detail.

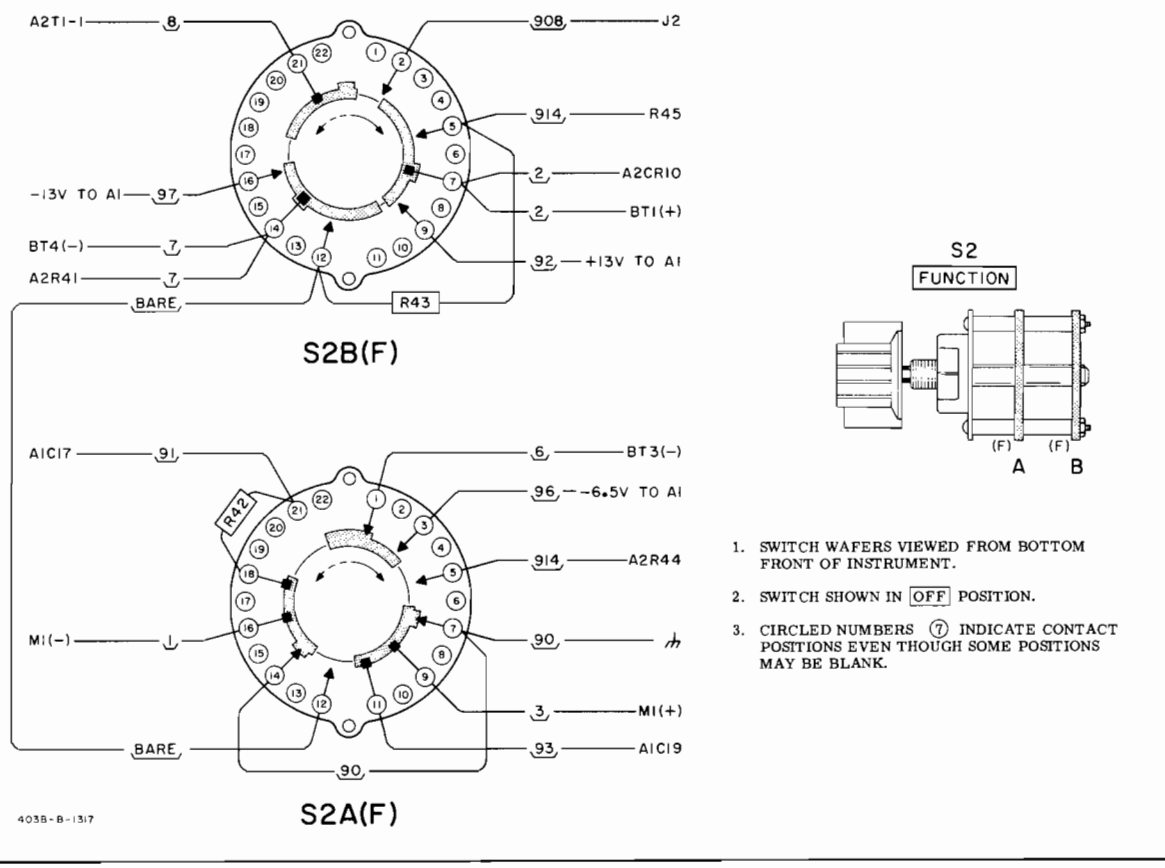


Figure 5-7. Function Switch Detail.

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 ± 10% SHOULD BE ALLOWED WHEN MEASURING THESE VOLTAGES.
5. ⊥ DENOTES CHASSIS GROUND.

   ▽ 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.

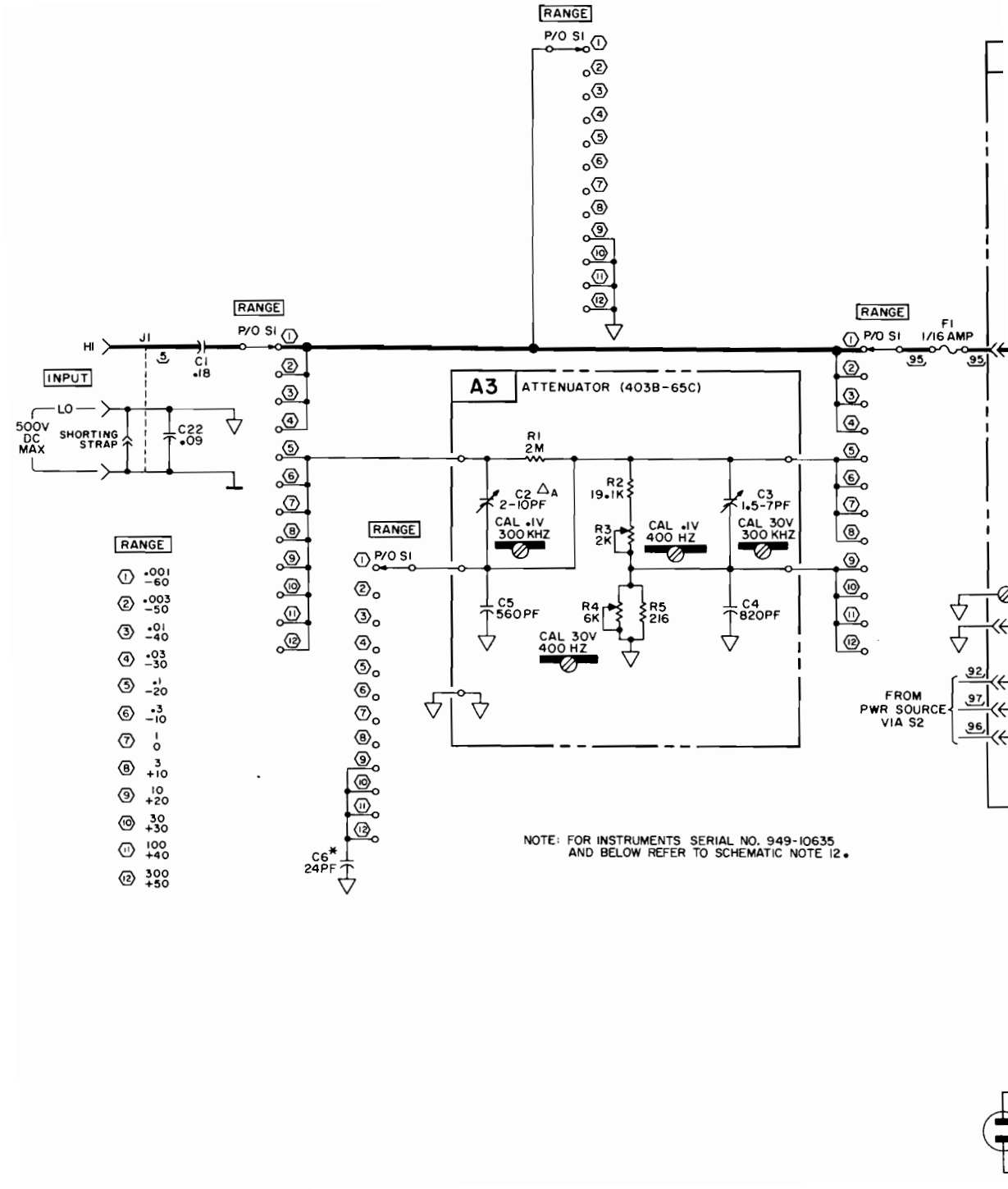
   ——————— DENOTES MAIN SIGNAL PATH.
8. ▭ DENOTES FRONT PANEL MARKING.

   ⊘ 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.)
10. Δ_A DENOTES COMPONENT CHANGE. REFER TO ITEM A IN BACKDATING TABLE.
11. BEFORE ADJUSTING R39 REFER TO PARAGRAPH 3-8, 4-27, 4-28, 4-29 and 5-20.
12. FOR INSTRUMENTS SERIAL NUMBER 949-10635 AND BELOW Q1, Q2, Q3, AND Q5 ARE GERMANIUM TRANSISTORS. Q4 AND Q6 ARE 2N706A. FOR SERIAL NUMBER 949-10635 AND BELOW, THE VOLTAGES SHOWN ON THE SCHEMATIC DO NOT APPLY. WHEN THE Q1 THROUGH Q5 WERE CHANGED TO Si, L1 WAS ADDED TO Q6 EMITTER. FOR VOLTAGES WITH GERMANIUM TRANSISTOR REFER TO TABLE BELOW.

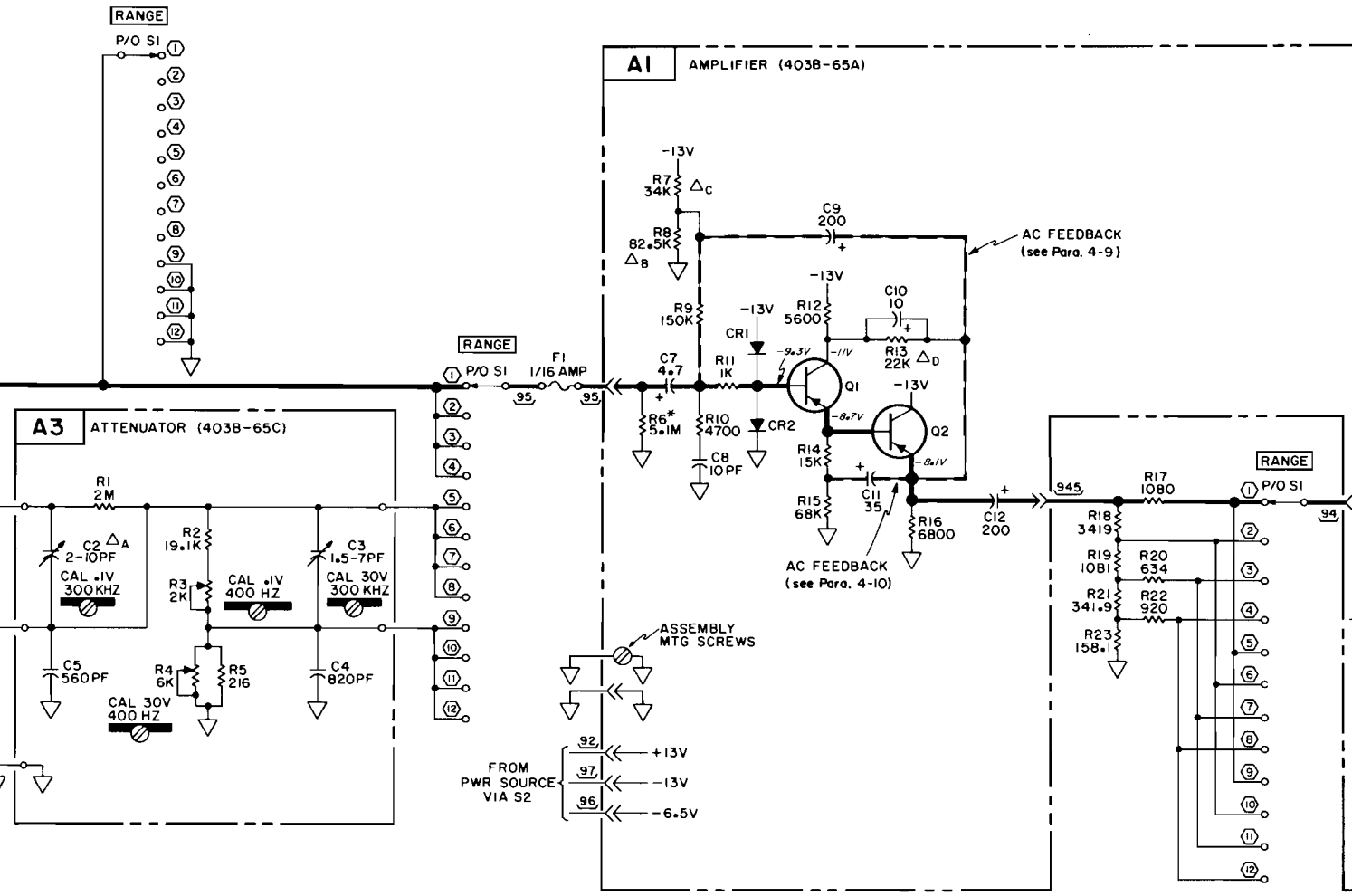
Voltages for Germanium Transistors.
Applies to S/N 949-10635 and below.

	Collector	Base	Emitter	Test Conditions
Q1	- 8.7 V/- 9.5 V	- 8.3 V/- 9 V	- 8.2 V/- 8.9 V	Range — 300 V INPUT — Shorted Function — ON All voltage referenced to circuit common. All voltages are DC.
Q2	- Supply	- 8.2 V/- 8.9 V	- 8 V/- 8.7 V	
Q3	- 4.5 V	.- .3 V	- .03 V	
Q4	- .9 V	- 4.5 V	- 5 V	
Q5	- 4.8 V	- .9 V	- .6 V	
Q6	+5 V	0 V	- .6 V	

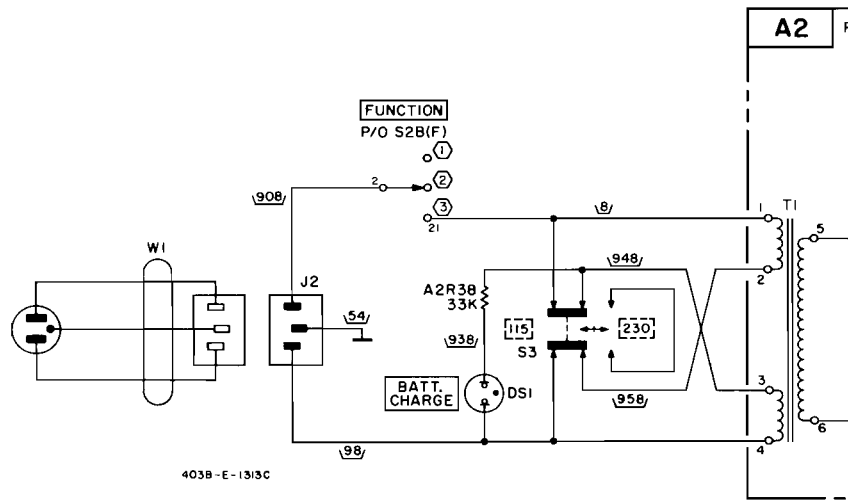
The voltages in the table above are for instruments with germanium transistors. The actual voltages on Q1 and Q2 will vary depending on the battery charge. The table for Q1 and Q2 is set-up to read: Minimum charge/Maximum charge, where Minimum charge = Typical voltages with the battery reading 2.4 V in battery test and Maximum charge = Typical voltages with the battery reading 2.6 V in battery test.



NOTE: FOR INSTRUMENTS SERIAL NO. 949-10635 AND BELOW REFER TO SCHEMATIC NOTE 12.



NOTE: FOR INSTRUMENTS SERIAL NO. 949-10635 AND BELOW REFER TO SCHEMATIC NOTE 12.



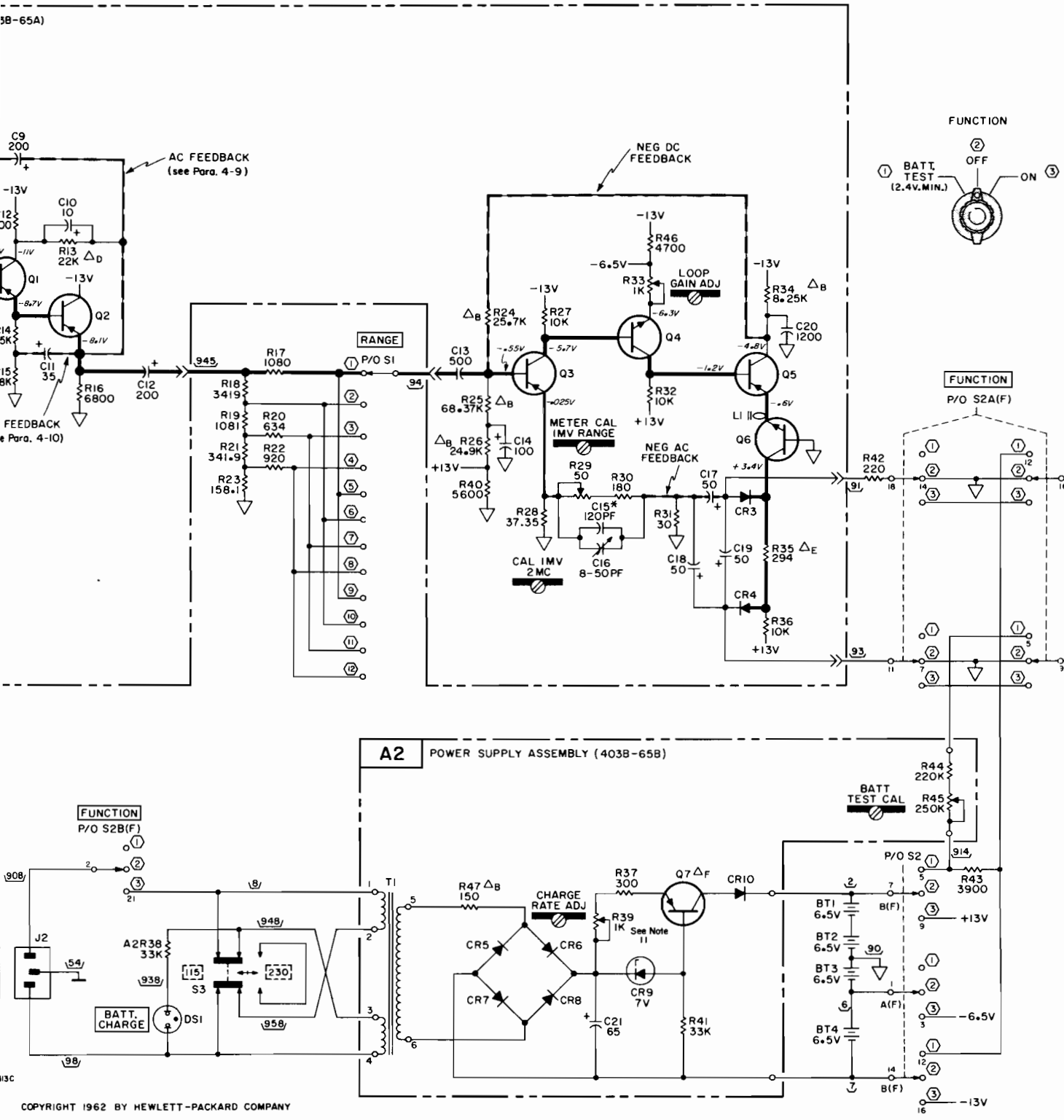


Figure 5-8. Schematic Diagr

PERFORMANCE TEST CARD

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

Tests Performed by _____

Date _____

Description	Par.	Check
1. Calibration	5-12	
A. Range Accuracy		
300 V		_____ Full scale ± 2%
100 V		_____ Full scale ± 2%
30 V		_____ Full scale ± 2%
10 V		_____ Full scale ± 2%
3 V		_____ Full scale ± 2%
1 V		_____ Full scale ± 2%
0.3 V		_____ Full scale ± 2%
0.1 V		_____ Full scale ± 2%
0.03 V		_____ Full scale ± 2%
0.01 V		_____ Full scale ± 2%
0.003 V		_____ Full scale ± 2%
0.001 V		_____ Full scale ± 2%
2. High Frequency Response	5-14	
A. 0.001 Range		
500 kHz		_____ 0.94 Full scale ± 2%
1 MHz		_____ 0.94 Full scale ± 2%
2 MHz		_____ 0.94 Full scale ± 5%
B. 0.003 Range		
500 kHz		_____ 0.94 Full scale ± 2%
1 MHz		_____ 0.94 Full scale ± 2%
2 MHz		_____ 0.94 Full scale ± 5%
C. 0.01 Range		
500 kHz		_____ 0.94 Full scale ± 2%
1 MHz		_____ 0.94 Full scale ± 2%
2 MHz		_____ 0.94 Full scale ± 5%
D. 0.03 Range		
500 kHz		_____ 0.94 Full scale ± 2%
1 MHz		_____ 0.94 Full scale ± 2%
2 MHz		_____ 0.94 Full scale ± 5%

PERFORMANCE TEST CARD (Cont'd)

Description	Par.	Check
2. High Frequency Response (Cont'd)	5-14	
E. 0.1 Range		
500 kHz		_____ 0.94 Full scale ± 2%
1 MHz		_____ 0.94 Full scale ± 2%
2 MHz		_____ 0.94 Full scale ± 5%
F. 3 V Range		
500 kHz		_____ 0.94 Full scale ± 2%
1 MHz		_____ 0.94 Full scale ± 2%
2 MHz		_____ 0.94 Full scale ± 5%
G. 10 V Range		
300 kHz		_____ 0.94 Full scale ± 2%
3. Low Frequency Response	5-15	
A. 0.001 Range		
10 cps		_____ 0.94 Full scale ± 2%
B. 0.003 Range		
10 cps		_____ 0.94 Full scale ± 2%
C. 0.01 Range		
10 Hz		_____ 0.94 Full scale ± 2%
D. 0.03 Range		
10 Hz		_____ 0.94 Full scale ± 2%
E. 0.1 Range		
10 cps		_____ 0.94 Full scale ± 2%
F. 3 Range		
10 cps		_____ 0.94 Full scale ± 2%
4. Noise Check	5-16	
A. Battery Operation		_____ < 3% Deflection
B. AC Operation		_____ < 8% Deflection
5. Input Resistance	5-17	_____ 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 alphameric order of their reference designators and indicates the description, -hp- part number of each part, together with any applicable notes, and provides the following:

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

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

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

d. Manufacturer's part number.

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
Al . . . . . aluminum
A . . . . . ampere(s)
Au . . . . . gold

C . . . . . capacitor
cer . . . . . ceramic
coef . . . . . coefficient
com . . . . . common
comp . . . . . composition
conn . . . . . connection

dep . . . . . deposited
DPDT . . . . . double-pole double-throw
DPST . . . . . double-pole single-throw

elect . . . . . electrolytic
encap . . . . . encapsulated

F . . . . . farad(s)
FET . . . . . field effect transistor
fxd . . . . . fixed

GaAs . . . . . gallium arsenide
GHz . . . . . gigahertz = 10^{+9} hertz
gd . . . . . guard(ed)
Ge . . . . . germanium
gnd . . . . . ground(ed)

H . . . . . henry(ies)
Hg . . . . . mercury

Hz . . . . . hertz (cycle(s) per second)

ID . . . . . inside diameter
impg . . . . . impregnated
incd . . . . . incandescent
ins . . . . . insulation(ed)

kΩ . . . . . kilohm(s) = 10^{+3} ohms
kHz . . . . . kilohertz = 10^{+3} hertz

L . . . . . inductor
lin . . . . . linear taper
log . . . . . logarithmic taper

mA . . . . . milliampere(s) = 10^{-3} amperes
MHz . . . . . megahertz = 10^{+6} hertz
MΩ . . . . . megohm(s) - 10^{+6} ohms
met flm . . . . . metal film
mfr . . . . . manufacturer
ms . . . . . millisecond
mtg . . . . . mounting
mV . . . . . millivolt(s) = 10^{-3} volts
μF . . . . . microfarad(s)
μs . . . . . microsecond(s)
μV . . . . . microvolt(s) = 10^{-6} volts
my . . . . . Mylar®

nA . . . . . nanoampere(s) = 10^{-9} amperes
NC . . . . . normally closed
Ne . . . . . neon
NO . . . . . normally open

NPO . . . . . negative positive zero (zero temperature coefficient)
ns . . . . . nanosecond(s) = 10^{-9} seconds
nsr . . . . . 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 coeffient, 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
vdcw . . . . . direct current working voltage

W . . . . . watt(s)
w/ . . . . . with
wiv . . . . . 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}

STD-B-2734

DESIGNATORS

A . . . . . assembly
B . . . . . motor
BT . . . . . battery
C . . . . . capacitor
CR . . . . . diode
DL . . . . . delay line
DS . . . . . lamp
E . . . . . misc electronic part
F . . . . . fuse

FL . . . . . filter
HR . . . . . heater
IC . . . . . integrated circuit
J . . . . . jack
K . . . . . relay
L . . . . . inductor
M . . . . . meter
MP . . . . . mechanical part
P . . . . . plug

Q . . . . . transistor
QCR . . . . . transistor-diode
R . . . . . resistor
RT . . . . . thermistor
S . . . . . switch
T . . . . . transformer
TB . . . . . terminal board
TC . . . . . thermocouple
TP . . . . . test point

TS . . . . . terminal strip
U . . . . . microcircuit
V . . . . . vacuum tube, neon bulb,photocell, etc.
W . . . . . cable
X . . . . . socket
XDS . . . . . lampholder
XF . . . . . fuseholder
Y . . . . . crystal
Z . . . . . network

Table 6-1. Replaceable Parts

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1	4038-65A		ASSEMBLY, PRINTED CIRCUIT: INCLUDES, C7 THRU C20, CR1 THRU CR4, Q1 THRU Q6, R6 THRU R16, R24 THRU R36, R40, R46		
A2	4038-658		ASSEMBLY, RESISTOR BOARD: INCLUDES, C21, CR5 THRU CR10, T1, Q7, R37 THRU R39, R41, R44, R45, R47		
A3	4038-65C		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	6.0 V/225B
C1	0170-0033	1	C: FXD 0.18 UF +-10% 600 WVDC	09134	TYPE 27
C2	0121-0421		C: VAR TEFLON 2-10 pF	28480	0121-0421
	0130-0003		C: VAR CER 1.5-7 pF FOR S/N 0986A20320 AND BELOW	33095	53-707-002-CV11A070
C3	0130-0003	2	C: VAR CER 1.5-7 pF	33095	53-707-002-CV11A070
C4	0140-0151	1	C: FXD MICA 820 pF +-2% 300 WVDC	04062	DM15F821G
C5	0140-0178	1	C. FXD MICA 560 pF +-2% 300 WVDC	04062	CM15F561G
*C6	0160-0196		C: FXD MICA 24 pF 300 WVDC +-5%	28480	0160-0196
C7	0180-0100	1	C: FXD ELECT 4.7 UF +-10% 35 WVDC	56289	150D475X903582-DYS
C8	0160-0205	1	C: FXD MICA 10 pF +-5% 500 WVDC	04062	DM15C220J
C9	0180-0060	1	C: FXD ELECT 200 UF +100% -10% 3 WVDC	56289	30D116A1
C10	0180-0059	1	C: FXD ELECT 10 UF 10 WVDC	56289	30D182A1
C11	0180-0064	1	C: FXD ELECT 35 UF +100% -10% 3 WVDC	56289	30D122A1
C12	0180-0104	1	C: FXD ELECT 200 UF 15 WVDC	56289	30D174A1
C13	0180-0063	1	C: FXD ELECT 500 UF +100% -10% 3 WVDC	56289	30D120A1
C14	0180-0039	1	C: FXD ELECT 100 UF 12 WVDC	56289	30D154A1
*C15	0160-2205		C: FXD MICA 120 pF 300 WVDC +-5%	28480	0160-2205
C16	0130-0017	1	C: VAR CER 8-50 pF 500 WVDC	72982	557-019-U2 PO34R
C17, C18	0180-0058	2	C: FXD ELECT 50 UF +100% -10% 25 WVDC	56289	30D186A1
C19	0180-0033	1	C: FXD ELECT 50 UF 6 WVDC	56289	30D133A1
C20	0180-0150	1	C: FXD ELCT 1200 UF 10 WVDC	56289	TYPE 34D
C21	0180-0149	1	C: FXD ELECT 65 UF 60 WVDC	56289	TYPE 30D
C22	0160-4316		C: FXD .09 UF APPLIES TO S/N 0986A0854 AND ABOVE	28480	0160-4316
CR1, CR2	1901-0044	2	DIODE: SI 20 mA/ +1 V 10 mA/ -10 V/ 50 WIV	73293	HD
CR3, CR4	1901-0518		DIODE HOT CARRIER, RECOMMENDED REPLACEMENT FOR ALL INSTRUMENTS	28480	1901-0518
CR5 THRU CR8	1901-0025	5	DIODE: SI 100 mA 100 WIV 2 pF	03877	SG-817
CR9	1902-0074	1	DIODE: BREAKDOWN 7.15 V +-5% 400 mW	07910	CE 35664
CR10	1901-0025		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			TERMINALS: THREE FEMALE		
			APPLIES TO S/N 0986A18911 AND ABOVE		
	1510-0091	2	BINDING POST GRY/RED	28480	1510-0091
	1510-0540	1	BINDING POST GRY/BLK WITH GROUNDING STRAP	28480	1510-0540
			APPLIES TO S/N 0986A08541 TO 0986A18770		
	1510-0091	2	BINDING POST GRY/RED	28480	1510-0091
	1510-0107	1	BINDING POST GRY/BLK WITHOUT GROUNDING STRAP	28480	1510-0107
			APPLIES TO S/N 0986A08540 AND BELOW		
	1510-0008	1	ASSEMBLY BINDING POST: RED	28480	1510-0008
	1510-0009	1	ASSEMBLY BINDING POST: BLACK	28480	1510-0009
	5060-0626	1	ASSEMBLY BINDING POST: BLACK WITH STRAP	28480	5060-0626
	0340-0090	1	INSULATOR: 8.P. DOUBLE KEYED	28480	0340-0090
	0340-0086	1	INSULATOR: 8.P. DOU8LE WITHOUT KEY	28480	0340-0086
J2	1251-2357	1	CONNECTOR: AC POWER	82389	EAC-301
L1	9170-0016	1	FERRITE BEAD. APPLIES TO S/N 949-10635 AND ABOVE	02114	56-590-65A1/3B
M1	1120-0315	1	METER: 0-100 UA DC	28480	1120-0315
	1120-0316	1	METER: 0-100 UF DC DB SCALE (OPTION 01)	28480	1120-0316
Q1, Q2, Q3, Q5	1853-0020	4	TSTR: SI PNP . APPLIES TO S/N 949-10636 AND ABOVE. FOR S/N 949-10635 AND 8ELOW REFER TO PARAGRAPH 5-39.	28480	1853-0020
Q4, Q6	1854-0071	2	TSTR: SI NPN. APPLIES TO S/N 949-10636 AND ABOVE RECOMMENDED REPLACEMENT FOR ALL SERIAL NUMBERS.	28480	1854-0071
Q7	1853-0016	1	TSTR: PNP 2N3638. RECOMMENDED REPLACEMENT FOR ALL SERIAL NUMBERS.	28480	1853-0016
R1	0727-0287	1	R: FXD COMP 2M +-1% 1/2 W	19701	DC 1/2 CR5
R2	0727-0443	1	R: FXD COMP 19.1 K +-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 +-1/2% 1/2 W	19701	DC 1/2 AR5
*R6	0686-5155	1	R. FXD COMP 5.1 M OHM +-5%	01121	EB5155

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

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
R7	0698-4493	1	R: FXD FLM 34 K +-1% 1/8 W FOR S/N 949-10636 AND ABOVE	24546	C4-1/8-T0-3402-F
	0758-0051	1	R: FXD COMP 43 K +-5% 1/2 W FOR S/N 949-10635 AND BELOW. REFER TO PARAGRAPH 5-39.	27167	C5-1/4-T0-4302-J
R8	0757-0774	1	R: FXD MET FLM 82.5 K 1%. DIRECTLY REPLACES 82 K FXD COMP USED IN OLDER INSTRUMENTS.	24546	C5-1/4-T0-8252-F
R9	06B7-1541	1	R: FXD COMP 150 K +-10% 1/2W	01121	EB 1541
R10	0687-4721	2	R: FXD COMP 4.7 K +-10% 1/2 W	01121	EB 4721
R11	0693-1021	1	R: FXD COMP 1 K +-10% 1/2 W	01121	HB 1021
R12	0687-5621	2	R: FXD COMP 5.6 K +-10% 1/2 W	01121	EB 5621
R13	0687-2231	1	R: FXD COMP 22 K 10% 1/2 W. APPLIES TO S/N 0986A15246 AND ABOVE FOR 403B AND 0986A15346 AND ABOVE FOR 403B OPTION 01.	01121	EB 2231
	0687-1221	1	R: FXD COMP 1.2 K 10% 1/2 W. APPLIES TO S/N 0986A15245 AND BELOW FOR 403B AND S/N 986A15345 AND BELOW FOR 403B OPTION 01. REFER TO PARAGRAPH 5-39.	01121	EB 1221
R14	06B7-1531	1	R: FXD COMP 15 K +-10% 1/2 W	01121	EB 1531
R15	0687-6831	1	R: FXD COMP 68 K +-10% 1/2 W	01121	EB 6831
R16	0687-6821	1	R: FXD COMP 6.8 K +-10% 1/2 W	01121	EB 6821
R17	0727-0103	1	R: FXD CATBON FLM 1080 OHM +-1% 1/2 W	19701	DC 1/2 CR5
[1]R18	0698-8301	1	R: FXD MET FLM 3419 OHM	19701	MF52C1/4-T2-3419R-C
[1]R19	0698-8302	1	R: FXD MET FLM 1081 OHM	19701	MF52C1/4-T2-1081R-C
R20	0727-0084	1	R: FXD CARBON FLM 634 OHM +-1% 1/2 W	19701	DC 1/2 CR5
[1]R21	0698-8303	1	R: FXD MET FLM 341.9 OHM		
R22	0727-0096	1	R: FXD CARBON FLM 920 OHM +-1% 1/2 W	19701	DC 1/2 CR5
[1]R23	0698-8582	1	R: FXD MET FLM 158.1 OHM	24546	NC60
R24	0757-0112	1	R: FXD MET FLM 25.7 K 1%. DIRECTLY REPLACES 27 K 5% USED IN OLDER INSTRUMENTS.	19701	MF52C1/4-T0-2572-F
R25	0698-4201	1	R: FXD MET FLM 68.37 K 1%. DIRECTLY REPLACES 68 K 5% USED IN OLDER INSTRUMENTS.	GM 005	CCA
R26	0698-3217	1	R: FXD MET FLM 24.9 K 1%. DIRECTLY REPLACES 24 K 5% USED IN OLDER INSTRUMENTS.	16299	C5-1/4-T0-2491-F
R27	0687-1031	2	R: FXD COMP 10K +-10% 1/2 W	01121	EB 1031
R28	0727-0017	1	R: FXD CARBON FLM 37.35 OHM +-1/2% 1/2 W	19701	DC1/2 CR5
R29	2100-0240	1	R: VAR WW 50 OHM +-20% 1 W	11236	SERIES 110
R30	0727-0050	1	R: FXD CARBON FLM 180 OHM +-1% 1/2 W	19701	DC 1/2 CR5
[1]R31	0698-8306	1	R: FXD MET FLM 30 OHM	19701	MF52C1/4-T2-30R0-C
R32	0687-1031		R: FXD COMP 10 K +-10% 1/2 W	01121	DB 1031
R33	2100-0154	1	R: VAR COMP 1K +-30% 3/10 W	11237	UPE70 C5
R34	0698-5866	1	R: FXD MET FLM 8.25 K 1%. DIRECTLY REPLACES 8.2 K 5% USED IN OLDER INSTRUMENTS.	24546	NE60
R35	0698-4448	1	R: FXD MET FLM 294 OHM. APPLIES TO S/N 0986A08391 THRU 0986A08590 AND 0986A018591 AND ABOVE. RECOMMENDED REPLACEMENT FOR ALL SERIAL NUMBERS.	16299	C4-1/8-T0-294R-F
	0687-3911	1	R: FXD COMP 390 OHM. APPLIES TO S/N 0986A08390 AND BELOW.	01121	EB 3911
R36	0687-1031		R: FXD COMP 10 K +-10% 1/2 W	01121	EB 1031
R37	0687-3015	1	R: FXD COMP 300 OHM +-5% 1/2 W	01121	EB 3015
R38	0687-3331	2	R: FXD COMP 33 K +-10% 1/2 W	01121	EB 3331
R39	2100-0391	1	R: VAR WW 1 K +-20% 1.25 W	11236	SERIES 110
R40	0687-5621		R: FXD COMP 5.6 K +-10% 1/2 W	01121	EB 5621
R41	0687-3331		R: FXD COMP 33 K +-10% 1/2 W	01121	EB 3331
R42	0687-2211	1	R: FXD COMP 220 OHM +-10% 1/2 W	01121	EB 2211
R43	0687-3921	1	R: FXD COMP 3.9 K +-10% 1/2 W	01121	EB 3921
R44	0687-2241	1	R: FXD COMP 220 K +-10% 1/2 W	01121	EB 2241
R45	2100-0144	1	R: VAR COMP 250 K +-30% 0.2 W	11237	UPE70
R46	0687-4721		R: FXD COMP 4.7 K +-10% 1/2 W	01121	EB 4721
R47	0757-0715	1	R: FXD MET FLM 150 OHM 1%. DIRECTLY REPLACES 150 OHM 5% USED IN OLDER INSTRUMENTS.	24546	C5-1/4-T0-151-F
S1	403B-19W	1	ASSEMBLY RANGE SWITCH: 3 SECT 12 POSITIONS; INCLUDES C1, C6, A3, AND R17 THRU R23. NOTE WHEN ORDERING THE RANGE SWITCH FOR INSTRUMENT HAVING A METAL SHAFT THROUGH THE FRONT PANEL, THE FOLLOWING PARTS MUST BE ORDERED TO MAKE THE NEW SI COMPATIBLE: SHAFT, BAKELITE 403B-37, COUPLER 5020-0237.	28480	403B-19W
S2	403B-19A	1	ASSEMBLY FUNCTION SWITCH 2 SECT 3 POS INCLUDES: R42 AND R43	28480	403B-19A
	7123-0101	1	WASHER FLUORESCENT INDICATOR FOR USE WITH FUNCTION SWITCH KNOB	28480	7123-0101
S3	3101-1234	1	SWITCH-SLIDE: DPDT 115-230 V	82389	11A-1242A
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		
	00403-90013	1	OPERATING AND SERVICE MANUAL	28480	00403-90013

[1]FOR SERIAL NUMBER 0986A07651 AND BELOW R18, R19, R21, R23, AND R31 ARE WIRE WOUND RESISTORS. IF ONE OF THE ABOVE RESISTORS MUST BE CHANGED THEY ALL MUST BE CHANGED TO THE METAL FILM RESISTORS. FOR EASE IN ORDERING, ORDER KIT 00403-69502. THE KIT CONTAINS ALL 5 RESISTORS.

Table 6-2. Mechanical Parts.

Number On Illustration	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	00403-00206
8	Meter, 0-100 μA dc (403B) or Meter, 0-100 μA 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	00403-00205
24	Side frame 6 x 8 sub-module	5060-0702
25	Switch shield: All applications	00403-00602
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	Nuts, plastic	2950-0144
44	Spring washer	3050-0593
45	Hinge	5040-0700
46	Stand, third mod, tilt	1490-0031
47	Foot assembly, third mod.	5060-0727
48	Bakelite shaft for range switch	403B-37
49	Assembly, dial	403B-99
50	Assembly, binding post: black w/strap Assembly, binding post: red/grey Assembly, binding post: red/grey	See J1, Table 6-1
51	Meter trim, third mod.	5020-6852
52	Battery, nickel cadmium, 6.25 V nom. 225 mAh	See BT1, 2, 3, 4, Table 6-1
53	Assembly, resistor board	See A3, Table 6-1

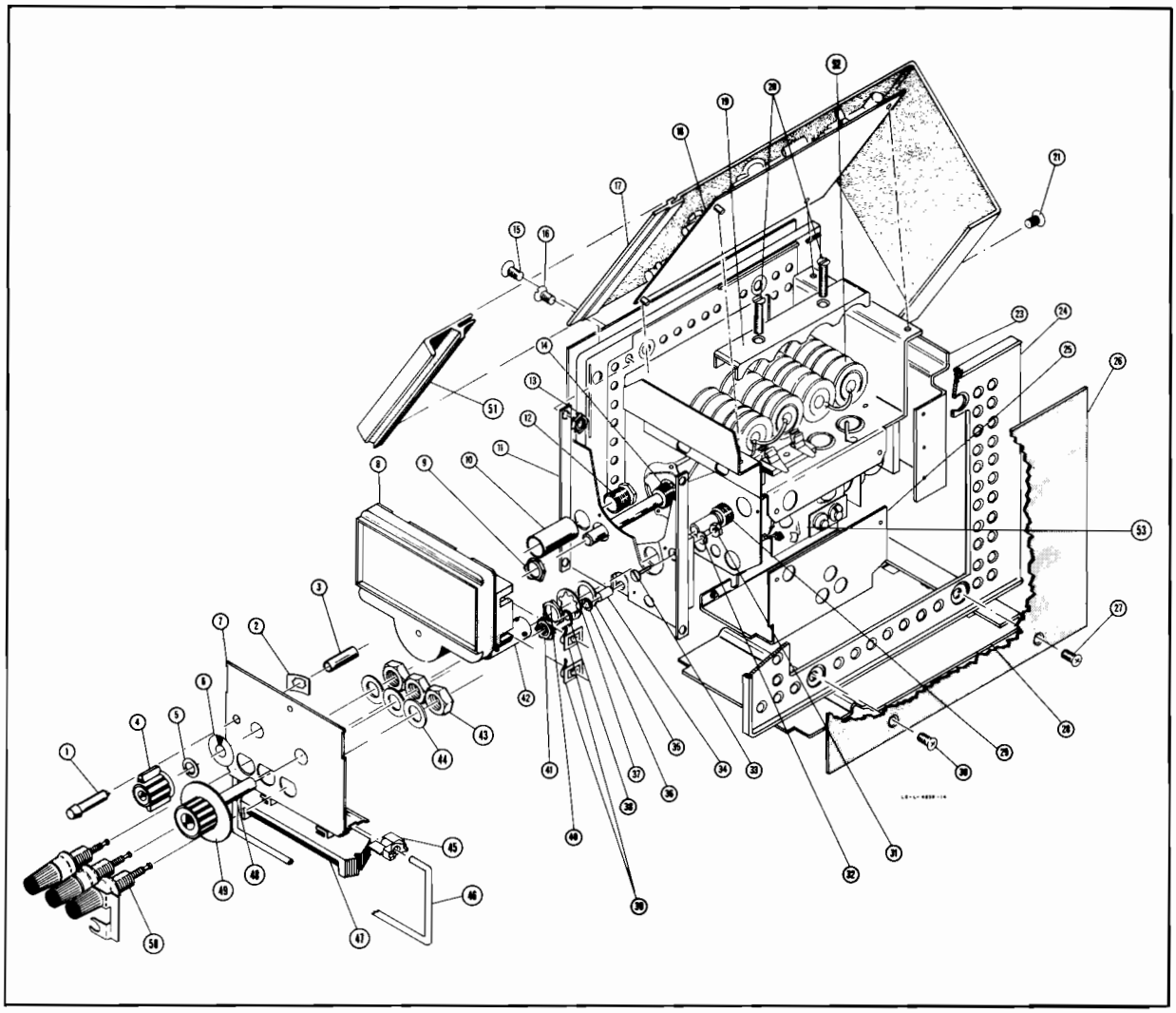


Figure 6-1. Mechanical Parts.

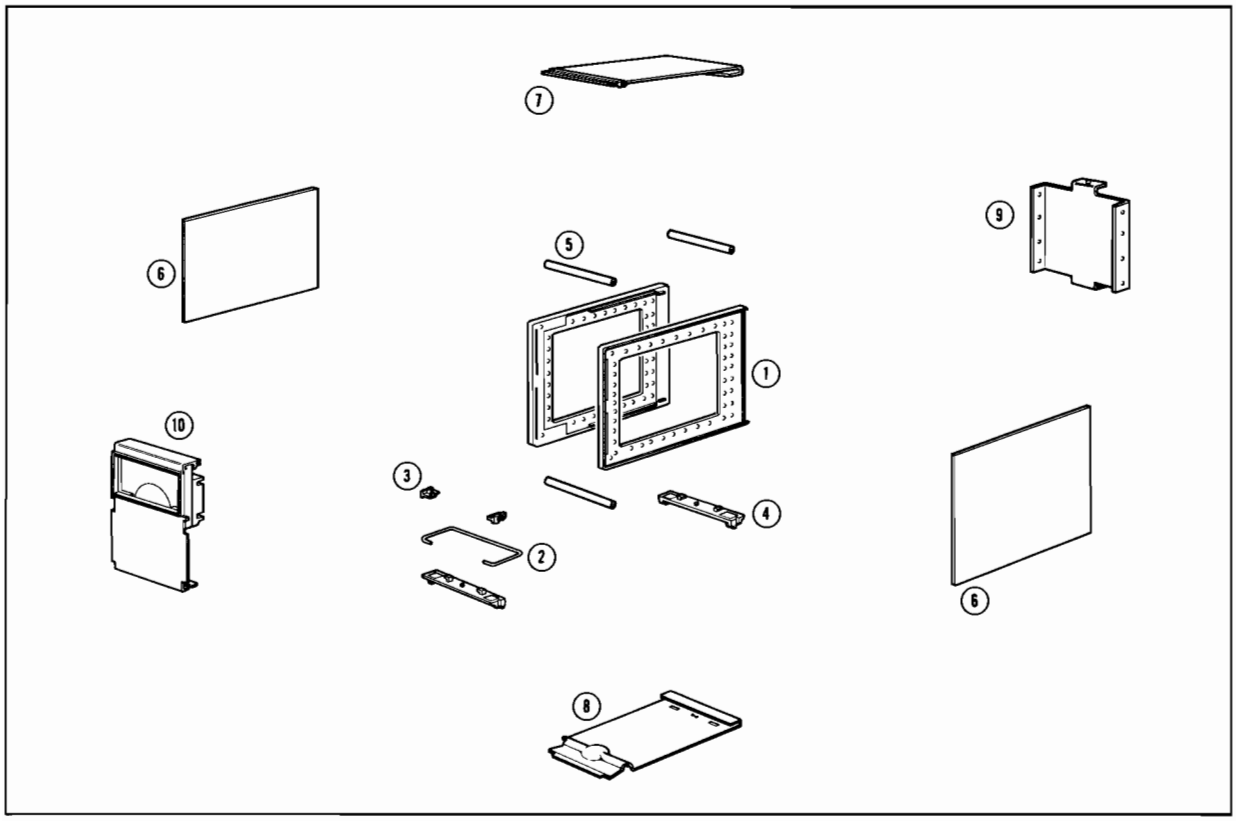


Figure 6-2. Cabinet Parts.

Table 6-3. Cabinet Parts.

Item Number	-hp- 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	
	5000-0702	Cover: Side	For Blue Instruments
7	5060-8547	Cover Assembly: Top	
	5060-0705	Cover Assembly: Top	For Blue Instruments
8	5000-8569	Cover Assembly: Bottom	
	5000-5388	Cover Assembly: Bottom	For Blue Instruments
9	00403-00205	Panel: Rear	All applications
10	00403-00206	Panel: Front (See Figure 6-1)	All applications. For instruments S/N 0986A08480 and below, the input connector J1 must be changed to: 1510-0091(2), 1510-0540(1) and C22 must be added between input Lo and chassis.

CODE LIST OF MANUFACTURERS

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

Code No.	Manufacturer	Address
00000	U. S. A Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N. Y.
00287	Cemco, Inc.	Danielson, Conn.
00334	Humidial	Colton, Calif.
00348	Mictron, Co., Inc.	Valley Stream, N. Y.
00373	Garlock Inc.	Cherry Hill, N. J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp. Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N. J.
00809	Croven, Ltd.	Whitby, Ontario, Canada
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Co., Pickens Div.	Pickens, S. C.
00866	Goe Engineering Co.	City of Industry, Cal.
00891	Carl E. Holmes Corp.	Los Angeles, Cal.
00929	Microlab Inc.	Livingston, N. J.
01002	General Electric Co., Capacitor Dept.	Hudson Falls, N. Y.
01009	Aiden Products Co.	Brockton, Mass.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Cal.
01281	TRW Semiconductors, Inc.	Lawndale, Cal.
01295	Texas Instruments, Inc., Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co	Alliance, Ohio
01538	Small Parts Inc.	Los Angeles, Cal.
01589	Pacific Relays, Inc.	Van Nuys, Cal.
01670	Gudebrod Bros. Silk Co.	New York, N. Y.
01930	Amerock Corp.	Rockford, Ill.
01960	Pulse Engineering Co	Santa Clara, Cal.
02114	Ferroxcube Corp. of Americ a	Saugerties, N. Y.
02116	Wheelock Signals, Inc.	Long Branch, N. J.
02286	Cole Rubber and Plastics Inc	Sunnyvale, Cal.
02660	Amphenol-Borg Electronics Corp.	Broadview, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Division	Somerville, N. J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins EngineeringCo.	San Fernando, Cal.
02875	Hudson Tool & Die	Newark, N. J.
03296	Nylon Molding Corp.	Springfield, N. J.
03508	G. E. Semiconductor Prod. Dept.	Syracuse, N. Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	Compton, Calif.
03818	Parker Seal Co.	Los Angeles, Cal.
03877	Transitron Electric Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N. J.
03954	Singer Co., Diehl Div., Finderne Plant	Sumerville, N. J.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taruus Corp.	Lambertville, N. J.
04062	Arco Electronic Inc.	Great Neck, N. Y.
04217	Essex Wire	Los Angeles, Cal.
04222	Hi-Q Division of Aerovox.	Myrtle Beach, S. C.
04354	Precision Paper Tube Co.	Wheeling, Ill
04404	Palo Alto Division of Hewlett-Packard Co.	Palo Alto, Cal.
04651	Sylvania Electric Products, Microwave Device Div.	Mountain View, Cal.
04673	Dakota Engr. Inc.	Culver City, Cal.
04713	Motorola Inc. Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Div.	Culver City, Cal.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire Co.	Redwood City, Cal.
04811	Precision Coil Spring Co.	El Monte, Cal.
04870	P. M. Motor Company	Westchester, Ill
04919	Component Mfg. Service Co.	W. Bridgewater, Mass.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Cal.
05277	Westinghouse Electric Corp. Semiconductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Cal.
05397	Union Carbine Corp., Elect. Div.	New York, N. Y.
05574	Viking Ind. Inc.	Canoga Park, Cal.
05593	Icore Electro-Plastics Inc.	Sunnyvale, Cal.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N. Y.
05729	Metro-Tel Corp.	Westbury, N. Y.
05783	Stewart Engineering Co.	Santa Cruz, Cal.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	Bassick Co., Div. of Stewart Warner Corp.	Bridgeport, Conn.
06090	Raychem Corp.	Redwood City, Cal.
06175	Bausch and Lomb Optical Co.	Rochester, N. Y.
06402	E. T. A. Products Co. of America	Chicago, Ill.
06540	Amatom Electronic Hardware Co., Inc.	New Rochelle, N. Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N. H.
06666	General Devices Co., Inc.	Indianapolis, Ind.
06751	Components Inc., Ariz. Div.	Phoenix, Arizona
06812	Torrington Mfg. Co., West Div.	Van Nuys, Cal.
06980	Varian Assoc. Etmac Div.	San Carlos, Cal.
07088	Kelvin Electric Co.	Van Nuys, Cal.
07126	Digitran Co.	Pasadena, Cal.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp., Electronic Tube Div.	Elmira, N. Y.
07149	Filmohm Corp.	New York, N. Y.
07233	Cinch-Graphik Co.	City of Industry, Cal.
07256	Silicon Transistor Corp.	Carle Place, N. Y.
07261	Avnet Corp.	Culver City, Cal.
07263	Fairchild Camera & Inst. Corp., Semiconductor Div.	Mountain View, Cal.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	Birtcher Corp, The	Monterey Park, Cal.
07397	Sylvania Elect. Prod. Inc., Mt. View Operations	Mountain View, Cal.
07700	Technical Wire Products Inc.	Cranford, N. J.
07829	Bodine Elect. Co.	Chicago, Ill.
07910	Continental Device Corp.	Hawthorne, Cal.
07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, Cal.
07980	Hewlett-Packard Co., New Jersey Division	Rockaway, N. J.
08145	U. S. Engineering Co.	Los Angeles, Cal.
08289	Blinn, Delbert Co.	Pomona, Cal.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08524	Deutsch Fastener Corp.	Los Angeles, Cal.
08664	Bristol Co., The	Waterbury, Conn.
08717	Sloan Company	Sun Valley, Cal.
08718	ITT Cannon Electric Inc., Phoenix Div.	Phoenix, Arizona
08727	National Radio Lab. inc.	Paramus, N. J.
08792	CBS Electronics Semiconductor Operations, Div. of CBS Inc	Lowell, Mass.
08806	General Electric Co., Miniature Lamp Dept.	Cleveland, Ohio
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays Div.	Costa Mesa, Cal.
09097	Electronic Enclosures Inc.	Los Angeles, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Tech. Ind. Inc. Atohm Elect.	Burbank, Cal.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09353	C & K Components Inc.	Newton, Mass.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
09795	Pennsylvania Florocarbon.	Clifton Heights, Penn.
09922	Burndy Corp	Norwalk, Conn.
10214	General Transistor Western Corp.	Los Angeles, Cal.
10411	Ti-Tal, Inc.	Berkeley, Cal.
10646	Carborundum Co.	Niagara Falls, N. Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Cal.
11242	Bay State Electronics Corp.	Waltham, Mass.
11312	Teledyne Inc., Microwave Div.	Palo Alto, Cal.
11314	National Seal	Downey, Cal.
11453	Precision Connector Corp.	Jamaica, N. Y.
11534	Duncan Electronics Inc.	Costa Mesa, Cal.
11711	General Instrument Corp., Semiconductor Division Products Group	Newark, N. J.
11717	Imperial Electronic, Inc.	Buena Park, Cal.
11870	Melabs, Inc.	Palo Alto, Cal.
12136	Philadelphia Handle Co.	Camden, N. J.
12361	Grove Mfg. Co., Inc.	Shady Grove, Pa.
12574	Gulton Ind. Inc., Data System Div.	Albuquerque, N. M.
12697	Clarostat Mfg. Co.	Dover, N. H.
12728	Elmar Filter Corp	W. Haven, Conn.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12881	Metex Electronics Corp.	Clark, N. J.
12930	Delta Semiconductor Inc.	Newport Beach, Cal.
12954	Dickson Electronics Corp.	Scottsdale, Arizona
13019	Airco Supply Co., Inc.	Witchita, Kansas
13061	Wilco Products	Detroit, Mich.
13103	Thermolloy	Dallas, Texas
13327	Solitron Devices Inc.	Tappan, N. Y.
13396	Telefunken (GmbH)	Hanover, Germany
13835	Midland-Wright Div. of Pacific Industries, Inc.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Cal.
14193	Calif. Resistor Corp	Santa Monica, Cal.
14298	American Components, Inc.	Conshohocken, Pa.
14433	ITT Semiconductor, a Div. of Int. Telephone and Telegraph Corporation	West Palm Beach, Fla.
14493	Hewlett-Packard Company.	Loveland, Colo.
14655	Cornell Dublier Electric Corp	Newark, N. J.
14674	Corning Glass Works	Corning, N. Y.
14752	Electro Cube Inc.	San Gabriel, Cal.
14960	Williams Mfg. Co.	San Jose, Cal.
15106	The Sphere Co., Inc.	Little Falls, N. J.
15203	Webster Electronics Co.	New York, N. Y.
15287	Scionics Corp.	Northridge, Cal.
15291	Adjustable Bushing Co.	N. Hollywood, Cal.
15558	Micron Electronics.	Garden City, Long Island, N. Y.
15566	Amprobe Inst. Corp.	Lynbrook, N. Y.
15631	Cabletronics	Costa Mesa, Cal.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Cal.
15801	Fenwal Elect. Inc.	Framingham, Mass.
15818	Amelco Inc.	Mountain View, Cal.
16037	Spruce Pine Mica Co.	Spruce Pine, N. C.
16179	Omni-Spectra Inc.	Detroit, Ill.
16352	Computer Diode Corp.	Lodi, N. J.
16554	Electroid Co.	Union, N. J.
16585	Boots Aircraft Nut Corp.	Pasadena, Cal.
16688	Ideal Prec. Meter Co., Inc., De Jur Meter Div.	Brooklyn, N. Y.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
17109	Thermonetics Inc.	Canoga Park, Cal.
17474	Tranex Company	Mountain View, Cal.
17675	Hamlin Metal Products Corp.	Akron, Ohio
17745	Angstrohm Prec. Inc.	No. Hollywood, Cal.
17856	Siliconix Inc.	Sunnyvale, Cal.
17870	McGraw-Edison Co.	Manchester, N. H.
18042	Power Design Pacific Inc.	Palo Alto, Cal.
18083	Clevite Corp. Semiconductor Div.	Palo Alto, Cal.
18324	Signetics Corp.	Sunnyvale, Cal.
18476	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
18486	TRW Elect. Comp. Div.	Des Plaines, Ill.
18565	Chomerics	Plainville, Mass.
18583	Curtis Instrument, Inc.	Mt. Kisco, N. Y.
18612	Vishay Instruments Inc.	Malvern, Pa.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
18911	Durant Mfg. Co.	Milwaukee, Wis.
19315	The Bendix Corp., Navigation & Control Div.	Teterboro, N. J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison	West Orange, N. J.
19589	Concoa	Baldwin Park, Cal.

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
19644	LRC Electronics	Horseheads, N.Y.
19701	Electra Mfg. Co.	Independence, Kansas
20183	General Atronics Corp.	Philadelphia, Pa.
21226	Executone, Inc.	Long Island City, N.Y.
21355	Fafnir Bearing Co., The	New Britian, Conn.
21520	Fansteel Metallurgical Corp.	N. Chicago, Ill.
23020	General Reed Co.	Metuchen, N.J.
23042	Texscan Corp.	Indianapolis, Ind.
23783	British Radio Electronics Ltd.	Washington, D.C.
24455	G.E. Lamp Division, Nela Park,	Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
24681	Memcor Inc., Comp. Div.	Huntington, Ind.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobert File Co. of America, Inc.	Carlstadt, N.J.
26851	Compac/Hollister Co.	Hollister, Cal.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Cal.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
30817	Instrument Specialties Co., Inc.	Little Falls, N.J.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Coil Products, Ltd.	Hawkesbury, Ontario, Canada
36287	Cunningham, W.H. & Hill, Ltd.	Toronto, Ontario, Canada
37942	P.R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
40931	Honeywell Inc.	Minneapolis, Minn.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
46384	Penn Eng. & Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer & Inst. Co.	Southampton, Pa.
49956	Microwave & Power Tube Div.	Waltham, Mass.
52090	Rowan Controller Co.	Westminster, Md.
52983	HP Co., Med. Elec. Div.	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Raytheon Co. Commercial Apparatus & System Div.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
58474	Superior Elect. Co.	Bristol, Conn.
59446	Telex Corp.	Tulsa, Okla.
59730	Thomas & Betts Co.	Elizabeth, N.J.
60741	Triplett Electrical Inst. Co.	Bluffton, Ohio
61775	Union Switch and Signal Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Inc. Weston-Newark.	Newark, N.J.
66295	Wittek Mfg. Co.	Chicago, Ill.
66346	Minnesota Mining & Mfg. Co. Revere Mincom Div.	St. Paul, Minn.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control	New York, N.Y.
70318	Allmetal Screw Product Co., Inc.	Garden City, N.Y.
70417	Amplex, Div. of Chrysler Corp.	Detroit, Mich.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	Union City, N.J.
70674	ADC Products Inc.	Minneapolis, Minn.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electric Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71034	Bliley Electric Co., Inc.	Erie, Pa.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincey, Mass.
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionics Corp.	Cambridge, Mass.
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Cardwell Condenser Corp.	Lindenhurst, L.I., N.Y.
71400	Bussmann Mfg. Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71447	Calif. Spring Co., Inc.	Pico-Rivera, Cal.
71450	CTS Corp.	Elkhart, Ind.
71468	ITT Cannon Electric Inc.	Los Angeles, Cal.
71471	Cinema, Div. Aerovox Corp.	Burbank, Cal.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	Cornish Wire Co., The	New York, N.Y.
71707	Coto Coil Co., Inc.	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co., Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	Indiana General Corp., Electronics Div.	Keasby, N.J.
72699	General Instrument Corp., Cap Division	Newark, N.J.
72765	Drake Mfg. Co.	Harwood Heights, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72962	Elastic Stop Nut Corp.	Union, N.J.
72964	Robert M. Hadley Co.	Los Angeles, Cal.
72982	Erie Technological Products, Inc.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Inst., Inc.	Fullerton, Cal.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Cal.
73445	Amperex Elect. Co.	Hicksville, L.I., N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73586	Circle F Mfg. Co.	Trenton, N.J.
73682	George K. Garrett Co., Div. MSL Industries, Inc.	Philadelphia, Pa.
73734	Federal Screw Products, Inc.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	General Industries Co., The	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Corp.	San Jose, Cal.
73957	Groove-Pin Corp.	Ridgefield, N.J.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronic Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75263	Keystone Carbon Co., Inc.	St. Marys, Pa.
75378	CTS Knights, Inc.	Sandwich, Ill.
75382	Kulka Electric Corp.	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Cal.
76433	General Instrument Corp., Micamold Division	Newark, N.J.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Cal.
76530	Cinch-Monadnock, Div. of United Carr Fastener Corp.	San Leandro, Cal.
76545	Mueller Electric Co.	Cleveland, Ohio
76703	National Union	Newark, N.J.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	The Bendix Corp., Electrodynamics Div.	N. Hollywood, Cal.
77075	Pacific Metals Co.	San Francisco, Cal.
77221	Phaostran Instrument and Electronic Co.	So. Pasadena, Cal.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine & Foundry Co. Potter & Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77638	General Instrument Corp., Rectifier Division	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Cal.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78277	Sigma	So. Braintree, Mass.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Cal.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	San Gabriel, Cal.
78947	Ucinite Co.	Newtonville, Mass.
79136	Waldes Kohinoor Inc.	Long Island City, N.Y.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80033	Prestole Corp.	Toledo, Ohio
80120	Schnitzer Alloy Products Co.	Elizabeth, N.J.
80131	Electronic Industries Association. Standard tube or semi-conductor device, any manufacturer.	
80207	Unimax Switch, Div. Maxon Electronics Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Inc.	Riverside, Cal.
80411	Arco Div. of Robertshaw Controls Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Label Co.	Monrovia, Cal.
80583	Hammarlund Co., Inc.	Mars Hill, N.C.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
80813	Dimco Gray Co.	Dayton, Ohio
81030	International Inst. Inc.	Orange, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Cal.
81312	Winchester Elec. Div. Litton Ind., Inc.	Oakville, Conn.
81349	Military Specification	
81483	International Rectifier Corp.	El Segundo, Cal.
81541	Airpax Electronics, Inc.	Cambridge, Maryland
81860	Barry Controls, Div. Barry Wright Corp.	Watertown, Mass.
82042	Carter Precision Electric Co.	Skokie, Ill.
82047	Sperti Faraday Inc., Copper Hewitt Electric Div.	Hoboken, N.J.
82116	Electric Regulator Corp.	Norwalk, Conn.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Fairchild Camera & Inst. Corp., Space & Defense Systems Div.	Paramus, N.J.
82209	Magurie Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod., Inc. Electronic Tube Division	Emporium, Pa.
82376	Astron Corp.	East Newark, Harrison, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals & Controls Inc., Spencer Products	Attleboro, Mass.
82768	Phillips-Advance Control Co.	Joliet, Ill.
82866	Research Products Corp.	Madison, Wis.
82877	Rolton Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Cal.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	General Instrument Corp., Capacitor Div.	Darlington, S.C.
83148	ITT Wire and Cable Div.	Los Angeles, Cal.
83186	Victory Eng. Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83324	Rosan Inc.	Newport Beach, Cal.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83332	Tech Labs	Palisades Park, N.J.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83740	Union Carbide Corp., Consumer Prod. Div.	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
83942	Aeronautical Inst. & Radio Co.	Lodi, N.J
84171	Arco Electronics Inc.	Great Neck, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Cal.
84411	TRW Capacitor Div.	Ogallala, Neb.

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
94870	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A. B. Boyd Co.	San Francisco, Cal.
85474	R. M. Bracamonte & Co.	San Francisco, Cal.
85660	Koiled Kords, Inc.	Hamden, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86174	Fafnir Bearing Co.	Los Angeles, Calif.
86197	Clifton Precision Products Co., Inc.	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, Electronic Comp. & Devices Division	Harrison, N.J.
86928	Seastrom Mfg. Co.	Glendale, Cal.
87034	Marco Industries	Anaheim, Cal.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Cal.
87664	Van Waters & Rogers Inc.	San Francisco, Cal.
87930	Tower Mfg. Corp.	Providence, R.I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Cal.
89473	G. E. Distributing Corp.	Schenectady, N.Y.
89479	Security Co.	Detroit, Mich.
89665	United Transformer Co.	Chicago, Ill.
90030	United Shoe Machinery Corp.	Beverly, Mass.
90179	U.S. Rubber Co., Consumer Ind. & Plastics Prod. Div.	Passaic, N.J.
90365	Belleville Speciality Tool Mfg., Inc.	Belleville, Ill.
90763	United Carr Fastener Corp.	Chicago, Ill.
90970	Bearing Engineering Co.	San Francisco, Cal.
91146	ITT Cannon Elect. Inc., Salem Div.	Salem, Mass.
91260	Connor Spring Mfg. Co.	San Francisco, Cal.
91345	Miller Dial & Nameplate Co.	El Monte, Cal.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Willow Grove, Pa.
91673	Epiphone Inc.	New York, N.Y.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Cal.
91886	Malco Mfg., Inc.	Chicago, Ill.
91929	Honeywell Inc., Micro Switch Division	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Cal.
92180	Tru-Connector Corp.	Peabody, Mass.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92607	Tensolite Insulated Wire Co., Inc.	Tarrytown, N.Y.
92702	IMC Magnetics Corp.	Westbury, L.I., N.Y.
92966	Hudson Lamp Co.	Kearney, N.J.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins & Myers Inc.	Pallisades Park, N.J.
93410	Stemco Controls, Div. of Essex Wire Corp.	Mansfield, Ohio
93632	Waters Mfg. Co.	Culver City, Cal.
93929	G.V. Controls	Livingston, N.J.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Co., Comp. Div., Ind. Comp. Operations	Quincy, Mass.
94148	Scientific Electronics Products, Inc.	Loveland, Colo.
94154	Wagner Elect. Corp., Tung-Sol Div.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Patterson, N.J.
94222	South Chester Corp.	Chester, Pa.
94330	Wire Cloth Products, Inc.	Bellwood, Ill.
94375	Automatic Metal Products Co.	Brooklyn, N.Y.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
94696	Magnecraft Electric Co.	Chicago, Ill.
95023	George A. Philbrick Researchers, Inc.	Boston, Mass.
95146	Alco Elect. Mfg. Co.	Lawrence, Mass.
95236	Allies Products Corp.	Diania, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	Long Island, N.Y.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordos Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Rolling Meadows, Ill.
95566	Arnold Engineering Co.	Marengo, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95984	Siemon Mfg. Co.	Wayne, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Microwave Assoc., West, Inc.	Sunnyvale, Cal.
96095	Hi-Q Div. of Aerovox Corp.	Olean, N.Y.
96256	Thordarson-Meissner Inc.	Mt. Carmel, Ill.
96296	Solar Mfg. Co.	Los Angeles, Cal.
96396	Microswitch, Div. of Minn.-Honeywell	Freeport, Ill.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Cal.
96508	Xcelite, Inc.	Orchard Park, N.Y.
96733	San Fernando Elec. Mfg. Co.	San Fernando, Cal.
96881	Thomson Ind. Inc.	Long Island, N.Y.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic & Precision Mfg.	Englewood, N.J.
97979	Reon Resistor Corp.	Yonkers, N.Y.
97983	Litton System Inc., Adler-Westrex Commun. Div.	New Rochelle, N.Y.
98141	R-Tronics, Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Cal.
98220	Hewlett-Packard Co., Medical Elec. Div.	Pasadena, Cal.
98278	Microdot, Inc.	So. Pasadena, Cal.
98291	Sealectro Corp.	Mamaronech, N.Y.
98376	Zero Mfg. Co.	Burbank, Cal.
98410	Etc Inc.	Cleveland, Ohio
98731	General Mills Inc., Electronics Div.	Minneapolis, Minn.
98734	Paeco Division of Hewlett-Packard Co.	Palo Alto, Cal.
98821	North Hills Electronics, Inc.	Glen Cove, N.Y.
98978	International Electronic Research Corp.	Burbank, Cal.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Cal.
99378	Atlee Corp.	Winchester, Mass.
99515	Marshall Ind., Capacitor Div.	Monrovia, Cal.
99707	Control Switch Division, Controls Co. of America	El Segundo, Cal.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99928	Branson Corp.	Whippany, N.J.
99934	Rembrandt, Inc.	Boston, Mass.
99942	Hoffman Electronics Corp., Semiconductor Division	El Monte, Cal.
99957	Technology-Instrument Corp. of California	Newbury Park, Cal.

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 Comp. Co.	Van Nuys, Cal.
000CS	Hewlett-Packard Co., Colorado Springs Div.	Colorado Springs, Colorado
000MM	Rubber Eng. & Development	Hayward, Cal.
000NN	A "N" D Mfg. Co.	San Jose, Cal.
000QQ	Cooltron	Oakland, Cal.
000WW	California Eastern Lab	Burlington, Cal.
000YY	S.K. Smith Co.	Los Angeles, Cal.

SUPPLEMENTAL CODE LIST OF MANUFACTURERS

Code No.	Manufacturer	Address
000LB	Specialty Connector Co.	Indianapolis, Ind.
000LC	Jackson Bros. Ltd.	New York, N.Y.
000LJ	(Relcoa) Relay Co. of America c/o Barnhill Associates	Denver, Colo.
00327	Welwyn International Inc.	Cleveland, Ohio
03911	Clairex Corp.	New York, N.Y.
08988	Skottie Electronics	Archbald, Pennsylvania

SALES OFFICES
Arranged alphabetically by country

ANGOLA
Telectra
Empresa Técnica de Equipamentos Eléctricos, S.A.R.L.
R. Barbosa Rodrigues, 41-I°DT °
Caixa Postal, 6487
Luanda
Tel: 35515/6

ARGENTINA
Hewlett-Packard Argentina S.A
Santa Fe 2035, Martinez
6140 **Buenos Aires**
Tel: 792-1239, 798-6086
Telex: 122443 AR CIGY

Biotron S.A.C.I.y M
Avda. Paseo Colon 221 9 piso
1399 **Buenos Aires**
Tel: 30-4846/1851/8384
34-9356/0460/4551
Telex: (33) 17595 BIO AR

AUSTRALIA

AUSTRALIA CAPITAL TERR.
Hewlett-Packard Australia Pty Ltd.
121 Wollongong Street
Fyshwick, 2609
Tel: 804244
Telex: 62650

NEW SOUTH WALES
Hewlett-Packard Australia Pty. Ltd.
31 Bridge Street
Pymble, 2073
Tel: 4496566
Telex: 21561

QUEENSLAND
Hewlett Packard Australia Pty Ltd
5th Floor
Teachers Union Building
495-499 Boundary Street
Spring Hill, 4000
Tel: 2291544

SOUTH AUSTRALIA
Hewlett-Packard Australia Pty Ltd.
153 Greenhill Road
Parkside, 5063
Tel: 2725911
Telex: 82536

VICTORIA
Hewlett-Packard Australia Pty Ltd
31-41 Joseph Street
Blackburn, 3130
Tel: 89-6351
Telex: 31024 MELB

WESTERN AUSTRALIA
Hewlett-Packard Australia Pty. Ltd.
141 Stirling Highway
Nedlands, 6009
Tel: 3865455
Telex: 93859

AUSTRIA
Hewlett-Packard Ges.m.b.H.
Wehlistrasse 29
P.O. Box 7
A-1205 **Vienna**
Tel: 35-16-21-0
Telex: 13582/135066

Hewlett-Packard Ges.m.b.H
Wehlistrasse, 29
A-1205 **Wien**
Tel: 35-18-21
Telex: 135066

BAHRAIN
Medical Only
Wael Pharmacy
P.O. Box 648
Bahrain
Tel: 54886, 56123
Telex: 8550 WAEL GJ

Al Hamdiya Trading and Contracting
P.O. Box 20074
Manama
Tel: 259978, 259958
Telex: 8895 KALDIA GJ

BANGLADESH
The General Electric Co. of Bangladesh Ltd.
Magnet House 72
Dilkusha Commercial Area
Motijheil, Dacca 2
Tel. 252415, 252419
Telex 734

BELGIUM
Hewlett-Packard Benelux S.A./N.V.
Avenue du Col-Vert, 1, (Groenkraaglaan)
B-1170 **Brussels**
Tel: (02) 660 50 50
Telex 23 494 paloben bru

BRAZIL
Hewlett-Packard do Brasil I.e.C. Ltda.
Alameda Rio Negro, 750
Alphaville
06400 **Barueri** SP
Tel: 429-3222

Hewlett-Packard do Brasil I.e.C. Ltda.
Rua Padre Chagas, 32
90000-**Pôrto Alegre**-RS
Tel: 22-2966, 22-5621

Hewlett-Packard do Brasil I.e.C. Ltda.
Av. Epitacio Pessoa, 4664
22471-**Rio de Janeiro**-RJ
Tel: 286-0237
Telex: 021-21905 HPBR-BR

CANADA

ALBERTA
Hewlett-Packard (Canada) Ltd
11620A - 168th Street
Edmonton T5M 3T9
Tel. (403) 452 3670
TWX: 610-831-2431

Hewlett-Packard (Canada) Ltd.
210, 7220 Fisher St. S.E
Calgary T2H 2H8
Tel (403) 253-2713
TWX: 610-821-6141

BRITISH COLUMBIA
Hewlett-Packard (Canada) Ltd.
10691 Shellbridge Way
Richmond V6X 2W7
Tel: (604) 270-2277
TWX: 610-925-5059

MANITOBA
Hewlett-Packard (Canada) Ltd.
360-550 Century St.
St. James,
Winnipeg R3H 0Y1
Tel: (204) 786-6701
TWX 610-671-3531

NOVA SCOTIA
Hewlett-Packard (Canada) Ltd.
P.O. Box 931
800 Windmill Road
Dartmouth B3B 1L1
Tel: (902) 469-7820
TWX: 610-271-4482

ONTARIO
Hewlett-Packard (Canada) Ltd
1020 Morrison Dr.
Ottawa K2H 8K7
Tel (613) 820-6483
TWX. 610-563-1636

Hewlett-Packard (Canada) Ltd.
6877 Goreway Drive
Mississauga L4V 1M8
Tel: (416) 678-9430
TWX: 610-492-4246

Hewlett-Packard (Canada) Ltd
552 Newbold Street
London N6E 2S5
Tel: (519) 686-9181
TWX 610-352-1201

QUEBEC
Hewlett-Packard (Canada) Ltd.
275 Hymus Blvd.
Pointe Claire H9R 1G7
Tel: (514) 897-4232
TWX. 610-422-3022

FOR CANADIAN AREAS NOT LISTED:
Contact Hewlett-Packard (Canada) Ltd. in Mississauga.

CHILE
Jorge Calcagni y Cia. Ltda
Arturo Burhle 065
Casilla 16475
Correo 9, **Santiago**
Tel: 220222
Telex. JCALCAGNI

COLOMBIA
Instrumentación
Henrik A. Langebaek & Kier S.A.
Carrera 7 No. 48-75
Apartado Aéreo 6287
Bogotá, 1 D.E.
Tel 269-8877
Telex 44400

Instrumentación
H.A. Langebaek & Kier S.A.
Carrera 63 No. 49-A-31
Apartado 54098
Medellin
Tel 304475

COSTA RICA
Científica Costarricense S.A.
Avenida 2, Calle 5
San Pedro de Montes de Oca
Apartado 10159
San José
Tel. 24-38-20, 24-08-19
Telex. 2367 GALGUR CR

CYPRUS
Kypronics
19 Gregorios Xenopoulos Street
P.O. Box 1152
Nicosia
Tel: 45628/29
Telex: 3018

CZECHOSLOVAKIA
Hewlett-Packard
Obchodni zaskupitelstvi v CSSR
Psemny styk
Post. schranka 27
CS 118 01 **Praha** 011
CSSR

Vyvojova a Provozni Zakladna
Vyzkumnych Ustavu v Bechovicich
CSSR-25097 **Bechovice u Prahy**
Tel: 89 93 41
Telex: 12133

Institute of Medical Bionics
Vyskumny Ustav Lekarskej Bioniky
Jedlova 6
CS-88346 **Bratislava-Kramare**
Tel: 44-551
Telex: 93229

DENMARK
Hewlett-Packard A/S
Datavej 52
DK-3460 **Birkerod**
Tel: (02) 81 66 40
Telex: 37409 hpas dk

Hewlett-Packard A/S
Navervej 1
DK-8600 **Silkeborg**
Tel: (06) 82 71 66
Telex 37409 hpas dk

ECUADOR
CYEDE Cia. Ltda.
P.O. Box 6423 CCI
Av. Eloy Alfaro 1749
Quito
Tel: 450-975, 243-052
Telex 2548 CYEDE EO

Medical Only
Hospitalar S.A.
Casilla 3590
Robles 625
Quito
Tel. 545-250

EGYPT
I.E.A.
International Engineering Associates
24 Hussein Hegazi Street
Kasr-el-Aini
Cairo
Tel 23 829
Telex 93830

SAMITRO
Sami Aman Trading Office
18 Abdel Aziz Gawish
Abdine-Cairo
Tel. 24932

EL SALVADOR
IPESA
Bulevar de los Heroes 11-48
Edificio Sarah 1148
San Salvador
Tel 252787

ETHIOPIA
Abdella Abdulmalik
P.O. Box 2635
Addis Ababa
Tel: 11 93 40

FINLAND
Hewlett-Packard Oy
Revontulentie, 7
SF-02100 **Espoo** 10
Tel (90) 455 0211
Telex 121563 hewpa sf

FRANCE
Hewlett-Packard France
Zone d'activites de Courtaboeuf
Avenue des Tropiques
Boite Postale 6
91401 **Orsay**-Cédex
Tel. (1) 907 78 25
TWX 600048F

Hewlett-Packard France
Chemin des Moulles
B.P. 162
69130 **Ecully**
Tel: (78) 33 81 25
TWX. 310617F

Hewlett-Packard France
20, Chemin de La Cépière
31081 **Toulouse**
Le Mirail-Cédex
Tel. (61) 40 11 12

Hewlett-Packard France
Le Ligoures
Place Romée de Villeneuve
13100 **Aix-en-Provence**
Tel: (42) 59 41 02
TWX: 410770F

Hewlett-Packard France
2, Allee de la Bourgonette
35100 **Rennes**
Tel: (99) 51 42 44
TWX 740912F

Hewlett-Packard France
18, rue du Canal de la Marne
67300 **Schiltigheim**
Tel: (88) 83 08 10
TWX 890141F

Hewlett-Packard France
Immeuble péricentre
rue van Gogh
59650 **Villeneuve** D'Ascq
Tel (20) 91 41 25
TWX: 160124F

Hewlett-Packard France
Bâtiment Ampère
Rue de la Commune de Paris
B.P. 300
93153 **Le Blanc Mesnil**-Cédex
Tel (01) 931 88 50
Telex 211032F

Hewlett-Packard France
Av. du Pdt. Kennedy
33700 **Merignac**
Tel. (56) 97 01 81

Hewlett-Packard France
Immeuble Lorraine
Boulevard de France
91035 **Evry**-Cédex
Tel: 077 96 60
Telex 692315F

Hewlett-Packard France
23 Rue Lothaire
57000 **Metz**
Tel: (87) 65 53 50

GERMAN FEDERAL REPUBLIC
Hewlett-Packard GmbH
Vertriebszentrale Frankfurt
Berner Strasse 117
Postfach 560 140
0-6000 **Frankfurt** 56
Tel: (06011) 50041
Telex: 04 13249 hpffm d

Hewlett-Packard GmbH
Technisches Büro Böblingen
Herrenberger Strasse 110
0-7030 **Böblingen**, Württemberg
Tel: (07031) 867-1
Telex. 07265739 bbn

Hewlett-Packard GmbH
Technisches Büro Düsseldorf
Emanuel-Leutze-Str. 1 (Seestern)
0-4000 **Düsseldorf**
Tel: (0211) 5971-1
Telex: 085/86 533 hpdd d

Hewlett-Packard GmbH
Technisches Büro Hamburg
Kapstadtring 5
0-2000 **Hamburg** 60
Tel: (040) 63804-1
Telex. 21 63 032 hphh d

Hewlett-Packard GmbH
Technisches Büro Hannover
Am Grossmarkt 6
0-3000 **Hannover** 91
Tel: (0511) 46 60 01
Telex: 092 3259

Hewlett-Packard GmbH
Technisches Büro Nürnberg
Neumeyerstrasse 90
0-8500 **Nürnberg**
Tel: (0911) 52 20 83
Telex: 0623 860

Hewlett-Packard GmbH
Technisches Büro München
Eschenstrasse 5
D-6021 **Taufkirchen**
Tel. (089) 6117-1
Telex: 0524985

Hewlett-Packard GmbH
Technisches Büro Berlin
Kaithstrasse 2-4
D-1000 **Berlin** 30
Tel: (030) 24 90 86
Telex: 018 3405 hpbln d

GREECE
Kostas Karayannis
8 Omirou Street
Athens 133
Tel: 32 30 303/32/37 731
Telex: 21 59 62 RKAR GR

GUAM
Guam Medical Supply, Inc
Suite C, Airport Plaza
P.O. Box 8947
Tamuning 96911
Tel: 646-4513

GUATEMALA
IPESA
Avenida Reforma 3-48
Zona 9
Guatemala City
Tel: 316627, 314786, 66471-5, ext. 9
Telex: 4192 Teletro Gu

HONG KONG
Hewlett-Packard Hong Kong Ltd.
11th Floor, Four Seas Bldg.
212 Nathan Rd.
Kowloon
Tel: 3-697446 (5 lines)
Telex: 36678 HX

Medical/Analytical Only
Schmidt & Co. (Hong Kong) Ltd.
Wing On Centre, 28th Floor
Connaught Road, C.
Hong Kong
Tel: 5-455644
Telex: 74766 SCHMX HX

INDIA
Blue Star Ltd.
Sahas
414/2 Vir Savarkar Marg
Prabhadevi
Bombay 400 025
Tel: 45 78 87
Telex: 011-4093

Blue Star Ltd.
Band Box House
Prabhadevi
Bombay 400 025
Tel: 45 73 01
Telex: 011-3751

Blue Star Ltd.
Bhavdeep
Sladium Road
Ahmedabad 380 014
Tel: 43922
Telex: 012-234

Blue Star Ltd.
7 Hare Street
Calcutta 700 001
Tel: 23-0131
Telex: 021-7655

Blue Star Ltd.
Bhandari House
91 Nehru Place
New Delhi 110 024
Tel: 682547
Telex: 031-2463

Blue Star Ltd.
T.C. 7/603 'Poornima'
Maruthankuzhi
Trivandrum 695 013
Tel: 65799
Telex: 0884-259

Blue Star Ltd.
11 Magarath Road
Bangalore 560 025
Tel: 55668
Telex: 0845-430

Blue Star Ltd.
Meenakshi Mandiram
XXXXV/1379-2 Mahatma Gandhi Rd.
Cochin 682 016
Tel: 32069
Telex: 085-514

Blue Star Ltd.
1-1-117/1 Sarojini Devi Road
Secunderabad 500 033
Tel. 70126
Telex: 0155-459

Blue Star Ltd.
133 Kodambakkam High Road
Madras 600 034
Tel: 82057
Telex: 041-379

ICELAND
Medical Only
Eiding Trading Company Inc
Hafnarnvoli - Tryggvagötu
P.O. Box 895
IS-**Reykjavik**
Tel. 1 56 20/1 63 03

INDONESIA
BERCA Indonesia P.T.
P.O. Box 496/Jkt.
Jln. Abdul Muis 62
Jakarta
Tel. 349255, 349886
Telex: 46748 BERSIL IA

BERCA Indonesia P.T.
P.O. Box 174/Sby.
23 Jln. Jemerlo
Surabaya
Tel: 42027

IRELAND
Hewlett-Packard Ltd.
Kestrel House
Clanwilliam Place
Lower Mount Street
Dublin 2, Eire

Hewlett-Packard Ltd.
2C Avongberg Ind. Est.
Long Mile Road
Dublin 12
Tel: 514322/514224
Telex: 30439

Medical Only
Cardiac Services (Ireland) Ltd.
Kilmore Road
Artane
Dublin 5, Eire
Tel: (01) 315820

Medical Only
Cardiac Services Co.
95A Finaghy Rd. South
Belfast BT10 0BY
GB-Northern Ireland
Tel: (0232) 625566
Telex: 747626

ISRAEL
Electronics Engineering Div. of Motorola Israel Ltd.
16, Kremenetski Street
P.O. Box 25016
Tel-Aviv
Tel: 38973
Telex: 33569, 34164

ITALY
Hewlett-Packard Italiana S.p.A.
Via G. Di Vittorio, 9
20063 **Carnuco Sul Naviglio** (MI)
Tel: (2) 903691
Telex: 334632 HEWPACKIT

Hewlett-Packard Italiana S.p.A.
Via Turazza, 14
35100 **Padova**
Tel: (49) 664888
Telex: 430315 HEWPACKI

Hewlett-Packard Italiana S.p.A.
Via G. Armellini 10
I-00143 **Roma**
Tel: (06) 54 69 61
Telex: 610514

Hewlett-Packard Italiana S.p.A.
Corso Giovanni Lanza 94
I-10133 **Torino**
Tel: (011) 659308
Telex: 221079

Hewlett-Packard Italiana S.p.A.
Via Principe Nicola 43 G/C
I-95126 **Catania**
Tel. (095) 37 05 04
Telex: 970291

Hewlett-Packard Italiana S.p.A.
Via Nuova san Rocco A Capadimonte, 62A
80131 **Napoli**
Tel: (081) 710698

Hewlett-Packard Italiana S.p.A.
Via Martin Luther King, 38/111
I-40132 **Bologna**
Tel: (051) 402394
Telex: 511830

JAPAN
Yokogawa-Hewlett-Packard Ltd.
29-21, Takaido-Higashi 3-chome
Suginami-ku, **Tokyo** 168
Tel: 03-331-6111
Telex: 232-2024 YHP Tokyo

Yokogawa-Hewlett-Packard Ltd.
Chuo Bldg., 4th Floor
4-20, Nishinakajima 5-chome
Yodogawa-ku, Osaka-shi
Osaka, 532
Tel: 06-304-6021
Telex: 523-3624

Yokogawa-Hewlett-Packard Ltd.
Sunitomo Samei Nagaya Bldg.
11-2 Shimosasajima-cho,
Nakamura-ku, **Negoya**, 450
Tel: 052 571-5171

Yokogawa-Hewlett-Packard Ltd.
Tangawa Building
2-24-1 Tsuruya-cho
Kanagawa-ku
Yokohama, 221
Tel: 045-312-1252
Telex: 382-3204 YHP YOK

Yokogawa-Hewlett-Packard Ltd.
Mito Mitsui Building
105, 1-chome, San-no-maru
Mito, Ibaragi 310
Tel: 0292-25-7470

Yokogawa-Hewlett-Packard Ltd.
Inoue Building
1348-3, Asahi-cho, 1-chome
Atsugi, Kanagawa 243
Tel: 0462-24-0452

Yokogawa-Hewlett-Packard Ltd.
Kumagaya Asahi
Hachijuni Building
4th Floor
3-4, Tsukuba
Kumagaya, Saitama 360
Tel: 0485-24-6563

JORDAN
Mouasher Cousins Co.
P.O. Box 1387
Amman
Tel: 24907/39907
Telex: SABCO JO 1456

KENYA
ADCOM Ltd., Inc.
P.O. Box 30070
Nairobi
Tel: 331955
Telex: 22639

Medical Only
International Aeradio (E.A.) Ltd.
P.O. Box 19012
Nairobi Airport
Nairobi
Tel: 336055/56
Telex: 22201/22301

Medical Only
International Aeradio (E.A.) Ltd.
P.O. Box 95221
Mombasa

KOREA
Samsung Electronics Co., Ltd.
4759 Shingil-6-Dong
Yeong Deung POU
Seoul
Tel: 833-4122, 4121
Telex: SAMSAN 27364

KUWAIT
Al-Khaldiya Trading & Contracting
P.O. Box 830 Safat
Kuwait
Tel: 42 4910/41 1726
Telex: 2481 Areeg kt

LUXEMBURG
Hewlett-Packard Benelux S.A./N.V.
Avenue du Col-Vert, 1 (Groenkraaglaan)
B-1170 **Brussels**
Tel: (02) 660 5050
Telex: 23 494

MALAYSIA
Hewlett-Packard Sales (Malaysia) Sdn. Bhd.
Suite 2.21/2.22
Bangunan Angkasa Raya
Jalan Ampang
Kuala Lumpur
Tel: 483680, 485653

Protel Engineering
P.O. Box 1917
Lot 259, Satok Road
Kuching, **Sarawak**
Tel: 53544

MEXICO
Hewlett-Packard Mexicana, S.A. de C.V.
Av. Periférico Sur No. 6501
Tepepan, Xochimilco
Mexico 23, D.F.
Tel: 905-676-4600
Telex: 017-74-507

Hewlett-Packard Mexicana, S.A. de C.V.
Rio Volga #600
Col. Del Valle
Monterrey, N.L.
Tel: 78-32-10

MOROCCO
Dolbeau
81 rue Karatchi
Casablanca
Tel: 3041 82
Telex: 23051/22822

Gerep
2, rue d'Agadir
Boite Postal 156
Casablanca
Tel: 272093/5
Telex: 23 739

MOZAMBIQUE
A.N. Goncalves, Ltd.
162, 1° Apt. 14 Av. 0 Luis
Caixa Postal 107
Maputo
Tel: 27091, 27114
Telex: 6-203 NEGON Mo

NETHERLANDS
Hewlett-Packard Benelux N.V.
Van Heuven Goedhartlaan 121
P.O. Box 667
1181KK **Amstelveen**
Tel: (20) 47 20 21
Telex: 13 216

NEW ZEALAND
Hewlett-Packard (N.Z.) Ltd.
4-12 Cruickshank Street
Kilbirnie, Wellington 3
P.O. Box 9443
Courtney Place
Wellington
Tel: 877-199

Hewlett-Packard (N.Z.) Ltd.
P.O. Box 26-189
169 Manukau Road
Epsom, **Auckland**
Tel: 887-159

Analytical/Medical Only
Northrup Instruments & Systems Ltd.
Sturdee House
85-87 Ghuznee Street
P.O. Box 2406
Wellington
Tel. 850-091
Telex: NZ 31291

Northrup Instruments & Systems Ltd.
Eden House, 44 Khyber Pass Rd.
P.O. Box 9682, Newmarket
Auckland 1
Tel: 794-091

Northrup Instruments & Systems Ltd.
Terrace House, 4 Oxford Terrace
P.O. Box 8386
Christchurch
Tel: 64-165

NIGERIA
The Electronics Instrumentations Ltd.
N6B/770 Oyo Road
Oluseun House
P.M.B. 5402
Ibadan
Tel: 461577
Telex: 31231 TEIL NG

The Electronics Instrumentations Ltd.
144 Agege Motor Road, Mushin
P.O. Box 481
Mushin, **Lagos**

NORWAY
Hewlett-Packard Norge A/S
Ostendalen 18
P.O. Box 34
1345 **Osteraas**
Tel: (02) 1711 80
Telex: 16621 hpnas n

Hewlett-Packard Norge A/S
Nygaardsgaten 114
P.O. Box 4210
5013 Nygaardsgaten,
Bergen
Tel: (05) 21 97 33

PANAMA
Electrónico Balboa, S.A.
Aparatado 4929
Panama 5
Calle Samuel Lewis
Edificio "Alfa," No. 2
Ciudad de Panama
Tel: 64-2700
Telex: 3483103 Curundu, Canal Zone

PERU
Compañía Electro Médica S.A.
Los Flamencos 145
San Isidro Casilla 1030
Lima 1
Tel: 41-4325
Telex: Pub. Booth 25424 SISIDRO

PAKISTAN
Mushko & Company Ltd.
Oosman Chambers
Abdullah Haroon Road
Karachi-3
Tel: 511027, 512927
Telex: 2894

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00403-90013

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MANUAL CHANGES

MODEL 403B

AC VOLTMETER

Manual Part Number 00403-90013

▌New or Revised Item

CHANGE NO. 1 applies to serial numbers 0987A21061 and greater.

Page 6-2. Change A1 from -hp- Part Number 403B-65A to 00403-66501.

Page 6-3. Change R33 from -hp- Part Number 2100-0154 to 2100-3211, R:VAR COMP 1 K 10%.

CHANGE NO. 2 applies to serial numbers 0986A20791 and greater.

Page 6-2. Change A2 from -hp- Part Number 403B-65B to 00403-66502.

Page 6-3. Change R45 from -hp- Part Number 2100-0144 to 2100-3213, R:VAR COMP 200 kΩ 10%.

CHANGE NO. 3 applies to serial numbers 0986A20571 and greater.

Page 6-2. Change BT1, 2, 3, 4 from -hp- Part Number 1420-0015 to 1420-0243.

Page 6-4. Change illustration No. 19 from battery holder to Battery Clamps (4 ea.) -hp- Part Number 1400-0689.

Page 6-4, Table 6-2. Add support Battery Holder -hp- Part Number 00403-01201, Hardware Req'd: Bolt -hp- Part Number 2360-0137, and washer -hp- Part number 2190-0918.

Page 6-5, Figure 6-1. Mechanical Parts.

CHANGE NO. 4 applies to serial numbers 0986A20611 and greater.

Page 6-2. Change C*15 from -hp- Part Number 0160-2205 to 0140-0197, C:FXD MICA 180 pF 300 V. Add the following padding list:

140 pF	0140-0217
160 pF	0160-2206
200 pF	0140-0198
240 pF	0140-0199

Page 5-11/5-12, Figure 5-8. Change value of C15* from 120 pF to 180 pF.

CHANGE NO. 5 applies to all serial numbers.

Page 5-5, Paragraph 5-25(m). Change C3 to C2.

CHANGE NO. 6 applies to serial numbers 0986A21831 and greater.

Page 6-2. Change A2CR5-CR8 from -hp- part number 1901-0025 to 1901-0028, Description: Diode Pwr Rect 750 mA 400N DO-29, Mfr. 28480, Mfr. Code 1901-0028.

CHANGE NO. 7 applies to serial numbers 0986A21375 and greater.

Page 5-11/5-12, Figure 5-8. Change the value of R37 from 300 Ω to 200 Ω on the A2 Schematic.

Page 6-2. Change A2Q7 from -hp- part number 1853-0016 to 1853-0012, Description: TSTR:PNP 2N2904A SI to −39 PO = 600 MW, Mfr. 01698, Mfr. Code. 2N2904A.

Page 6-3. Change A2R37 from -hp- part number 0697-3015 to 0696-2015, Description: R:Fxd comp 200 Ω ± 5% 1/2 W CCTC = 0647, Mfr. 01607, Mfr. Code. EB2035.

CHANGE NO. 9 applies to serial numbers 0986A21374 and below.

Page 6-3. Add R37 -hp- part number 0698-3015, Description: R:Fxd comp 300 Ω ± 5% 1/2 W (for replacement in serial number 0986A21374 and below only).

CHANGE NO. 10 applies to all serial numbers.

Page 6-2. Change DS1 from -hp- part numbers 1450-0419 to 1450-0566. Same description, Mfr. 05532, Mfr. Code 2910517.

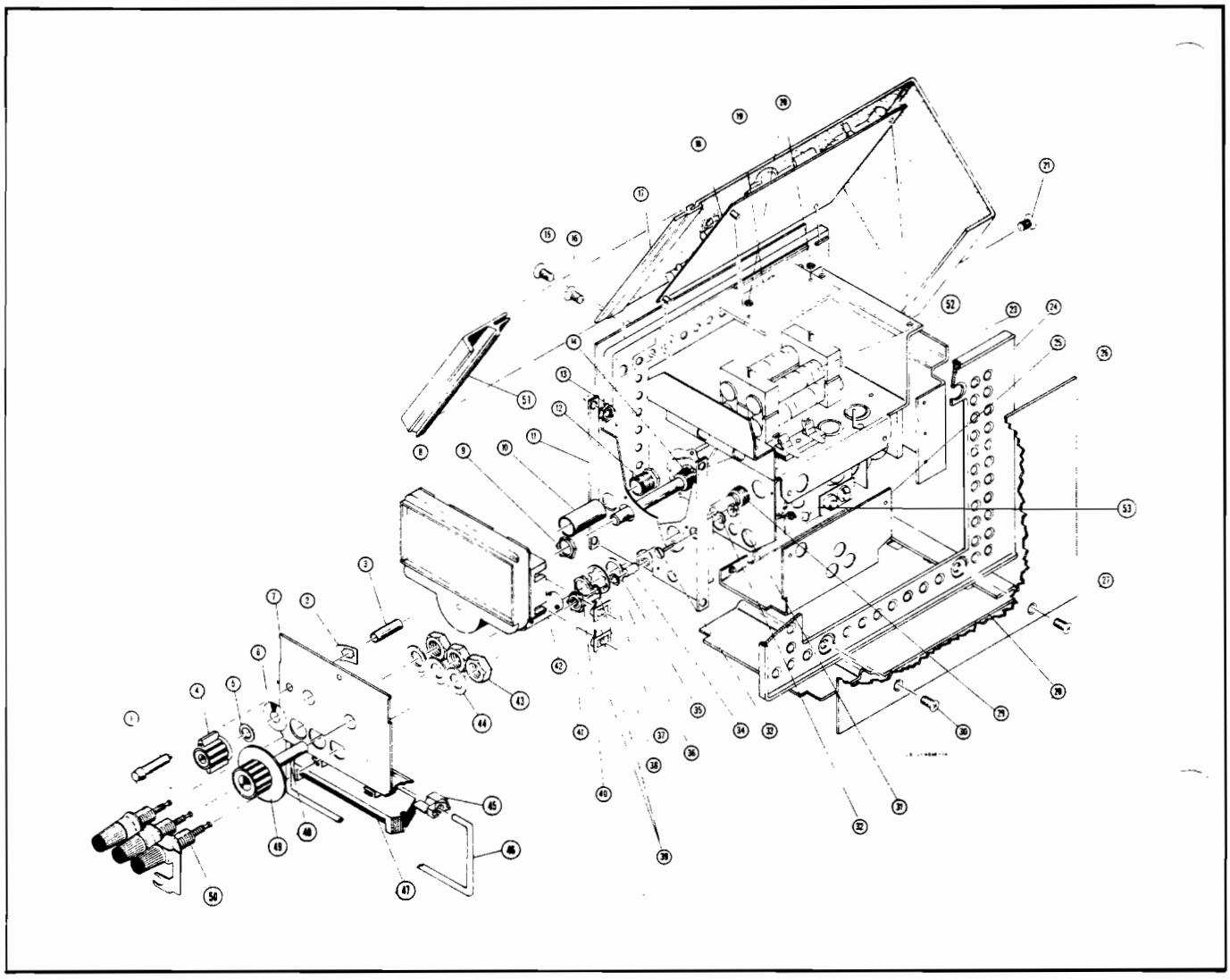

Figure 6-1. Mechanical Parts.