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# **400F/FL AC VOLTMETER**

**OPERATING AND SERVICE MANUAL**



**HEWLETT  PACKARD**





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# OPERATING AND SERVICE MANUAL

(HP PART NO. 00400-90005)

## MODEL 400F/FL AC VOLTMETER

SERIALS PREFIXED: 734-

Appendix C, Manual Backdating Changes,  
adapts this manual to serials prefixed 617-.

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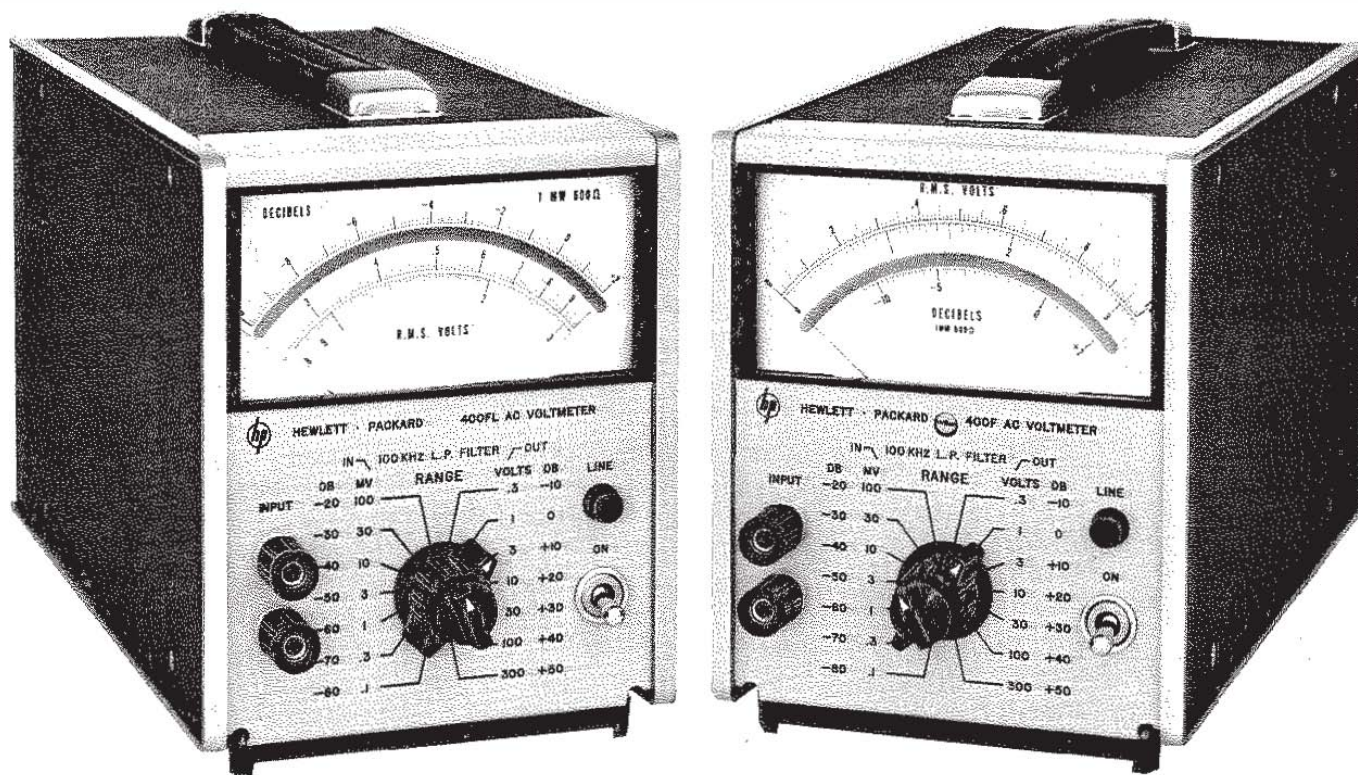


Figure 1-1. Model 400F/FL AC Voltmeter

Table 1-1. Specifications

| -hp- Model 400F/FL                                                                                                                                                                                                                                                                                             | -hp- Model 400F/FL                                                                                                                                                                           |              |            |                      |             |              |             |             |              |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|------------|----------------------|-------------|--------------|-------------|-------------|--------------|--|
| Voltage Range: 100 $\mu$ V to 300 V full scale, 14 ranges in 1, 3, 10 sequence.                                                                                                                                                                                                                                | Recovery From Overload: < 2 seconds for 80 dB overload.                                                                                                                                      |              |            |                      |             |              |             |             |              |  |
| Frequency Range: 20 Hz to 4 MHz.                                                                                                                                                                                                                                                                               | AC Power: 115 or 230 volts $\pm$ 10%, 50 to 1000 Hz, 5 watts.                                                                                                                                |              |            |                      |             |              |             |             |              |  |
| Calibration: Responds to absolute average value of applied signal, calibrated in rms volts.                                                                                                                                                                                                                    | External Battery Operation: Terminals are provided on rear panel; positive and negative voltages between 35 V and 55 V are required. Current drain from each voltage is approximately 45 mA. |              |            |                      |             |              |             |             |              |  |
| Noise Referred to Input: (1000 ohm termination)                                                                                                                                                                                                                                                                |                                                                                                                                                                                              |              |            |                      |             |              |             |             |              |  |
| <table><tr><td>RANGE</td><td>Filter In</td><td>Filter Out</td></tr><tr><td>300 <math>\mu</math> V to 300 V</td><td>&lt; 5 <math>\mu</math> V</td><td>&lt; 30 <math>\mu</math> V</td></tr><tr><td>100 <math>\mu</math> V</td><td>&lt; 5 <math>\mu</math> V</td><td>&lt; 15 <math>\mu</math> V</td></tr></table> | RANGE                                                                                                                                                                                        | Filter In    | Filter Out | 300 $\mu$ V to 300 V | < 5 $\mu$ V | < 30 $\mu$ V | 100 $\mu$ V | < 5 $\mu$ V | < 15 $\mu$ V |  |
| RANGE                                                                                                                                                                                                                                                                                                          | Filter In                                                                                                                                                                                    | Filter Out   |            |                      |             |              |             |             |              |  |
| 300 $\mu$ V to 300 V                                                                                                                                                                                                                                                                                           | < 5 $\mu$ V                                                                                                                                                                                  | < 30 $\mu$ V |            |                      |             |              |             |             |              |  |
| 100 $\mu$ V                                                                                                                                                                                                                                                                                                    | < 5 $\mu$ V                                                                                                                                                                                  | < 15 $\mu$ V |            |                      |             |              |             |             |              |  |
| Input Impedance: 10 megohms shunted by 25 pF on the 100 $\mu$ V - 300 mV ranges and 10 megohms shunted by 10 pF on the 1 V - 300 V ranges.                                                                                                                                                                     | Temperature Range: 0 to +55°C.                                                                                                                                                               |              |            |                      |             |              |             |             |              |  |
| Amplifier AC Output: 1 V rms open circuit for full scale meter indication; output impedance 600 ohms, 20 Hz to 4 MHz.                                                                                                                                                                                          | Weight:                                                                                                                                                                                      |              |            |                      |             |              |             |             |              |  |
|                                                                                                                                                                                                                                                                                                                | Net: 6 lbs. (2,7 kg).                                                                                                                                                                        |              |            |                      |             |              |             |             |              |  |
|                                                                                                                                                                                                                                                                                                                | Shipping: 9 lbs. (4 kg).                                                                                                                                                                     |              |            |                      |             |              |             |             |              |  |
| Meter Response: <0.7 seconds after application of signal.                                                                                                                                                                                                                                                      | Dimensions: 6-1/2" high, 5-1/8" wide, 11" deep (165, 1 x 130, 2 x 279, 4 mm).                                                                                                                |              |            |                      |             |              |             |             |              |  |



## SECTION I

### GENERAL INFORMATION

#### 1-1. DESCRIPTION.

1-2. The -hp- Models 400F and 400FL are versatile ac voltmeters and dB meters. Both models can be used as wideband amplifiers. The Model 400F is primarily intended for voltage measurements, whereas the Model 400FL is primarily a dB meter. However, both meters indicate both volts and dB. The 400F has a linear ac scale with a logarithmic dB scale underneath, and the 400FL has a linear dB scale with a logarithmic ac scale underneath. Since the difference in scales is the only difference between the two instruments, this manual will use the term 400F/FL in reference to both instruments.

1-3. Figure 1-1 shows both the Model 400F and the Model 400FL. Table 1-1 is a list of specifications.

#### 1-4. OPTION (400F ONLY).

1-5. Option 01 is a standard -hp- Model 400F AC Voltmeter which has a dB scale that reads from -15

to +2 instead of from -12 to +2. The dB scale is placed at the top of the meter face for better resolution.

#### 1-6. INSTRUMENT AND MANUAL IDENTIFICATION.

1-7. Hewlett-Packard instruments are identified by a two-section, eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and the Model 400F/FL described in this manual.

1-8. If a letter prefixes the serial number, the instrument was manufactured outside the United States.

#### 1-9. BACKDATING INFORMATION.

1-10. Appendix C contains backdating information that adapts this manual to instruments with serials prefixed 617.

Table 1-1. Specifications (Cont'd)

| MODEL 400F                                 |              |              |                  |                 |              |       |
|--------------------------------------------|--------------|--------------|------------------|-----------------|--------------|-------|
| Accuracy: $\pm$ (% Full Scale + % Reading) |              |              |                  |                 |              |       |
| 300 $\mu$ V TO 300 V RANGES                |              |              |                  |                 |              |       |
| Frequency                                  | 20 Hz        | 40 Hz        | 100 Hz           | 1 MHz           | 2 MHz        | 4 MHz |
|                                            | $\pm(2 + 2)$ | $\pm(1 + 1)$ | $\pm(1/2 + 1/2)$ | $\pm(1 + 1)$    | $\pm(2 + 2)$ |       |
| 100 $\mu$ V RANGE                          |              |              |                  |                 |              |       |
| Frequency                                  | 30 Hz        | 60 Hz        | 100 kHz          | 500 kHz         |              |       |
|                                            | $\pm(2 + 2)$ | $\pm(1 + 1)$ | $\pm 1$          | $\pm 0$<br>$-7$ |              |       |

| MODEL 400FL                 |         |         |         |                 |         |       |
|-----------------------------|---------|---------|---------|-----------------|---------|-------|
| Accuracy: $\pm$ % Reading   |         |         |         |                 |         |       |
| 300 $\mu$ V TO 300 V RANGES |         |         |         |                 |         |       |
| Frequency                   | 20 Hz   | 40 Hz   | 100 Hz  | 1 MHz           | 2 MHz   | 4 MHz |
|                             | $\pm 4$ | $\pm 2$ | $\pm 1$ | $\pm 2$         | $\pm 4$ |       |
| 100 $\mu$ V RANGE           |         |         |         |                 |         |       |
| Frequency                   | 30 Hz   | 60 Hz   | 100 kHz | 500 kHz         |         |       |
|                             | $\pm 4$ | $\pm 2$ | $\pm 1$ | $\pm 0$<br>$-8$ |         |       |

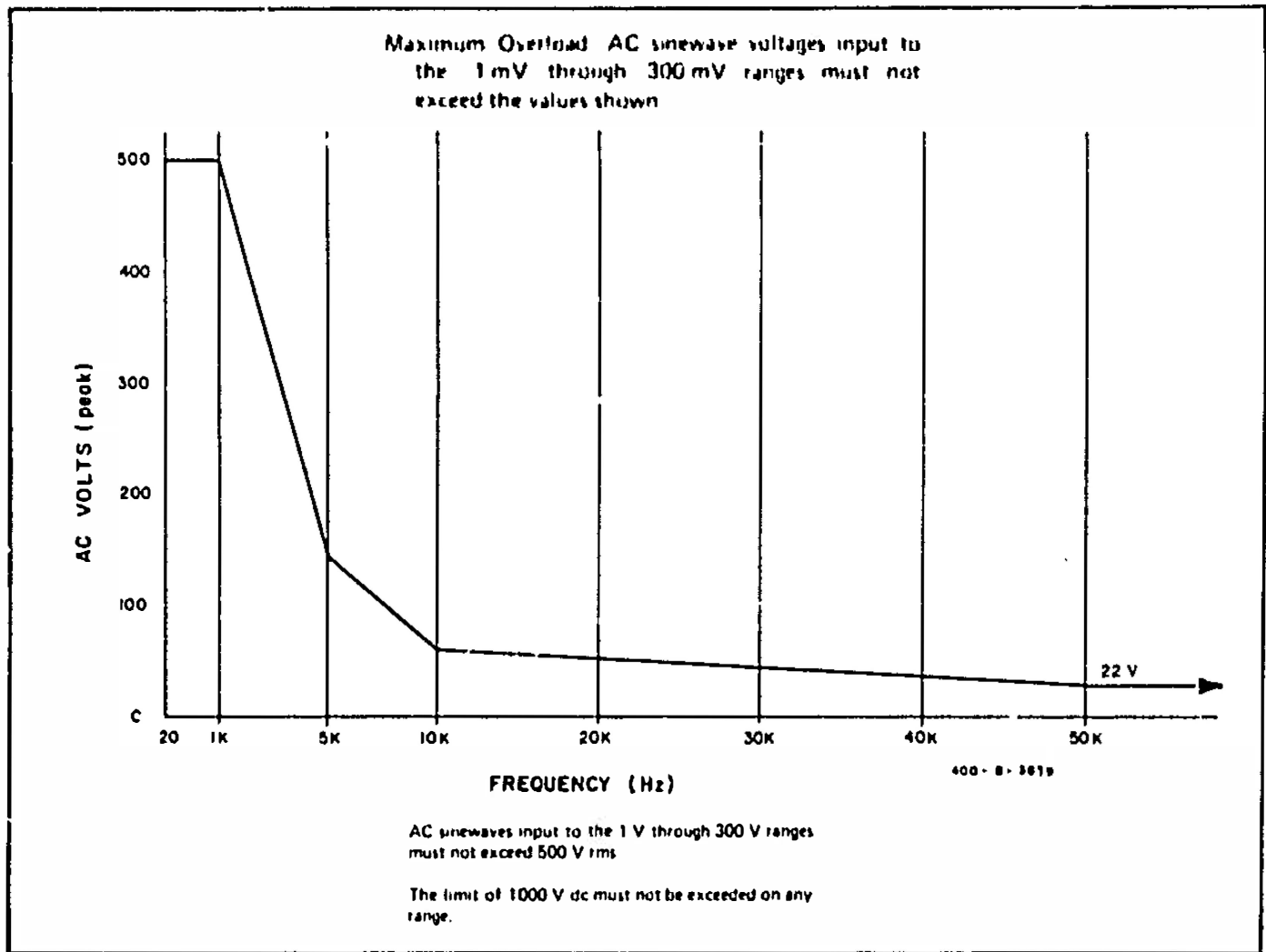


Table 1-2. Performance Characteristics.

## SECTION II INSTALLATION

### 2-1. INTRODUCTION.

2-2. This section contains information and instructions necessary for the installation and shipping of the Model 400F and 400FL voltmeters. Included are initial inspection procedures, power and grounding requirements, installation information, and instructions for repackaging for shipment.

### 2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be physically free of marks or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also check for supplied accessories, and test the electrical performance of the instrument using the procedure outlined in Paragraph 5-5. If there is damage or deficiency, see the warranty on the inside front cover of this manual.

### 2-5. POWER REQUIREMENTS.

2-6. The Model 400F/FL can be operated from any source of 115 or 230 volts at 50 to 1000 cycles or from two 35 to 55 volt batteries connected to the rear panel BATTERY terminals. The 115/230 V slide switch on the rear panel selects the desired line voltage. Power dissipation is 5 watts maximum.

### 2-7. GROUNDING REQUIREMENTS.

2-8. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. All Hewlett-Packard instruments are equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground wire.

2-9. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

### 2-10. INSTALLATION.

2-11. The Model 400F/FL is fully transistorized; therefore, no special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 55°C (131°F) or the relative humidity exceeds 95%.

### 2-12. BENCH MOUNTING.

2-13. The Model 400F/FL is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument.

### 2-14. RACK MOUNTING.

2-15. The Model 400F/FL may be rack mounted by

using an adapter frame (-hp- Part No. 5060-0797). The adapter frame is a rack frame that accepts any combination of submodular units. It can be rack mounted only. For additional information, address inquiries to your -hp- Sales and Service Office. (See Appendix B for office locations.)

### 2-16. COMBINATION MOUNTING.

2-17. The Model 400F/FL may be mounted in combination with other submodular units by using a Combining Case (-hp- Model 1051A or 1052A). The Combining Case is a full-module unit which accepts various combinations of submodular units. Being a full-module unit, it can be bench or rack mounted and is analogous to any full-module instrument.

### 2-18. REPACKAGING FOR SHIPMENT.

2-19. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-20 if the original container is to be used; 2-21 if it is not. If you have any questions, contact your local -hp- Sales and Service Office. (See Appendix B for office locations.)

#### NOTE

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

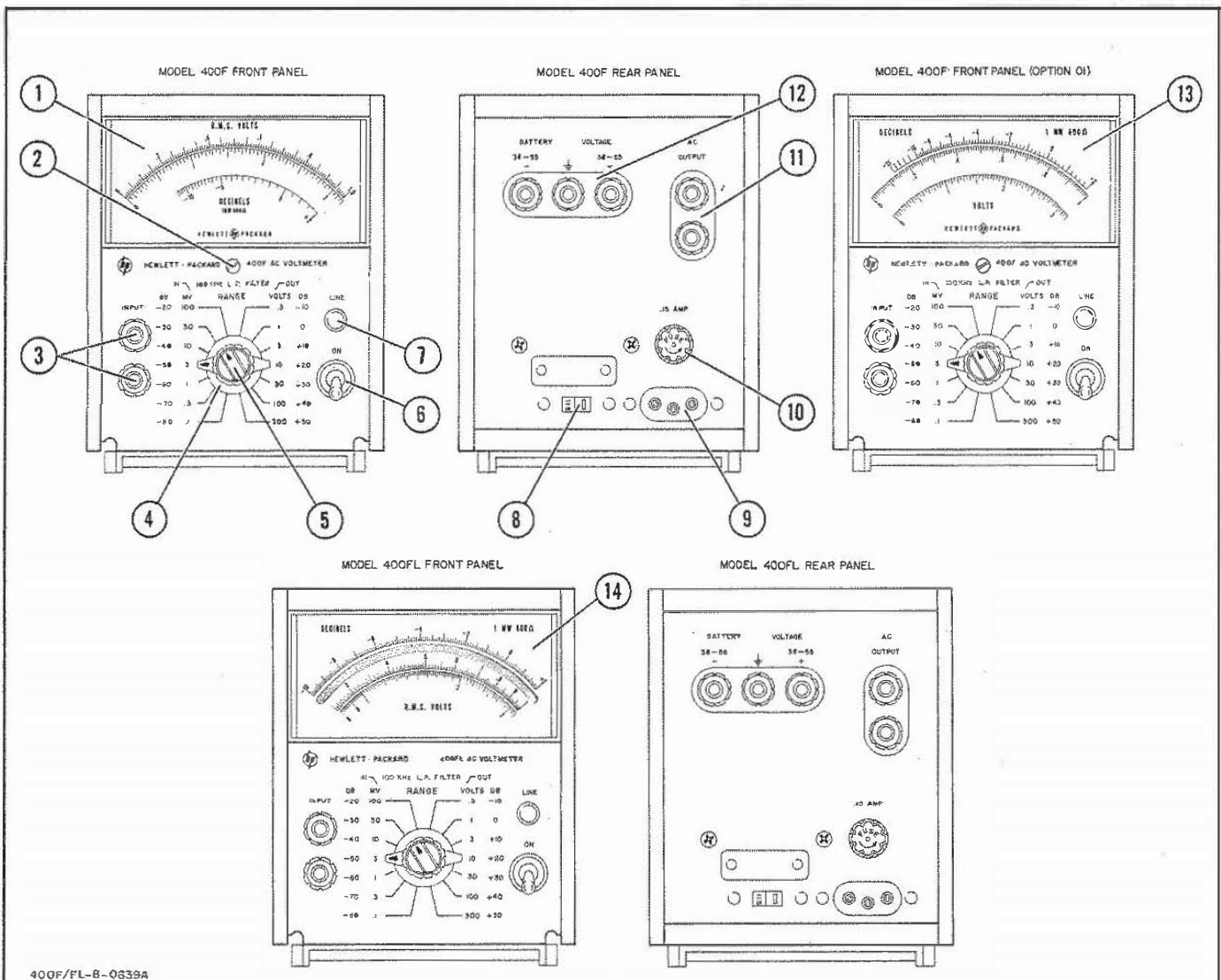
2-20. If original container is to be used, proceed as follows:

- 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.
- b. Ensure that container is well sealed with strong tape or metal bands.

2-21. If original container is not to be used, proceed as follows:

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





400F/FL-B-0539A

- ① **400F Scale:** Indicates magnitude of applied signal in volts and dBm.
- ② **Mechanical Zero Adjust:** Provides a mechanical meter zero adjustment.
- ③ **INPUT Terminals:** Connects signal to be measured to 400F/FL.
- ④ **RANGE Selector (S1):** Selects full scale reading of meter. DBm reading on scale adds algebraically to dB setting of RANGE selector.
- ⑥ **100 KHz LP FILTER Switch (S2):** Switches 100 KHz filter either in or out of circuit.
- ⑦ **Line ON Toggle Switch (S3):** Applies primary power.
- ⑦ **LINE Indicator Lamp:** Indicates application of primary power.
- ⑧ **115/230 Volt Slide Switch (S4):** Selects 115 or 230 volts ac for line operation.
- ⑨ **Primary Power Connector:** Line voltage is applied through this connector.
- ⑩ **FUSE:** Protects instrument against current overload.
- ⑪ **AC OUTPUT:** Ac amplifier output. Output impedance is 600  $\Omega$ .
- ⑫ **BATTERY VOLTAGE Terminals:** 400F/FL may be powered by connecting two 35 to 55 volt batteries to these terminals.
- ⑬ **400F Scale, Option 01:** The dBm scale is placed uppermost for greater resolution.
- ⑭ **400FL Scale:** Indicates magnitude of applied signal in volts and dBm. DBm scale is linear, and voltage scales are logarithmic. This arrangement allows better resolution for dB reading. 0 dBm = 1 mW in 600  $\Omega$ .

Figure 3-1. Location of Controls and Indicators



## SECTION III OPERATING INSTRUCTIONS

### 3-1. INTRODUCTION.

3-2. This section contains instructions and information necessary for the operation of the 400F/FL AC Voltmeters. Included is identification of controls, indicators and connectors, turn on procedures, and operating instructions.

### 3-3. CONTROLS, INDICATORS AND CONNECTORS.

3-4. Each control, indicator, and connector on the 400F/FL is identified and described in Figure 3-1.

### 3-5. METER MECHANICAL ZERO ADJUSTMENT (400F ONLY).

3-6. The mechanical zero adjustment is located in the center of the instrument front panel. If the meter pointer does not indicate zero after the instrument has been off at least one minute, mechanically zero the meter, following the steps outlined below.

- a. Turn instrument power off, and allow at least one minute for meter pointer to stabilize.
- b. Rotate zero adjustment screw clockwise until pointer is left of zero and moving upscale.
- c. Continue rotating screw clockwise until pointer is at zero. Stop when pointer is exactly on zero. If pointer overshoots, repeat step b.
- d. When pointer is exactly over zero, rotate adjustment screw slightly counterclockwise to relieve tension on pointer suspension. If pointer moves to the left, repeat whole procedure, but make counterclockwise rotation less.

### 3-7. TURN ON PROCEDURES.

- a. If line voltage is used, ensure that the 115-230 vac switch (located on the rear panel) is in the correct position. Turn the line ON toggle switch to the ON position. The LINE lamp will glow, indicating that line power is applied.
- b. If batteries are used, connect two 35 to 55 volt batteries as shown in Figure 3-2. The line ON switch is not in the circuit when batteries are used, therefore an external DPST switch should be used to provide a means for disconnecting the batteries when the instrument is not in use.

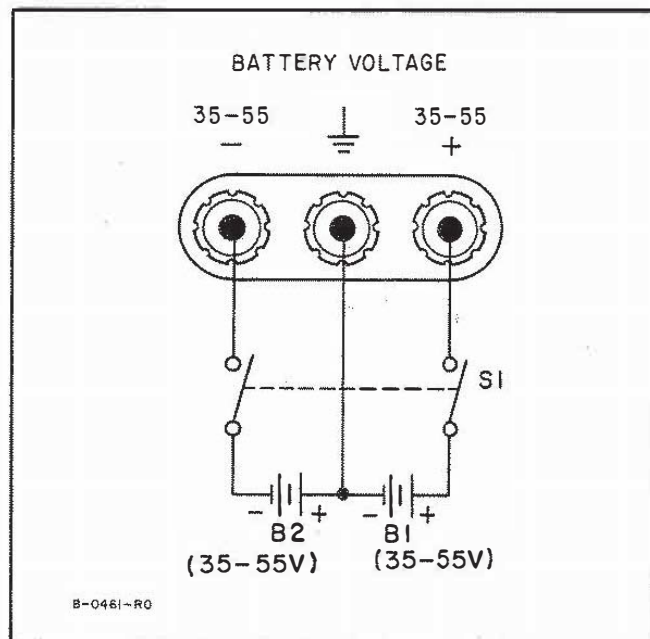


Figure 3-2. External Battery Connection

### 3-8. AC VOLTAGE MEASUREMENTS.

#### NOTE

Since the 400F/FL is average responding and rms calibrated, any distortion will affect the accuracy of the measurement. Table 3-1 shows the errors caused by distortions.

Table 3-1. Effect of Distortion on Average Responding Meter

| HARMONIC                                                         | % DISTORTION | % ERROR<br>(* Fundamental) |                  |
|------------------------------------------------------------------|--------------|----------------------------|------------------|
|                                                                  |              | MAX.<br>POSITIVE           | MAX.<br>NEGATIVE |
| Any even                                                         | 0.1          | 0.000                      |                  |
|                                                                  | 0.5          | 0.001                      |                  |
|                                                                  | 1.0          | 0.005                      |                  |
|                                                                  | 2.0          | 0.020                      |                  |
| Third                                                            | 0.1          | 0.033                      | 0.033            |
|                                                                  | 0.5          | 0.168                      | 0.167            |
|                                                                  | 1.0          | 0.338                      | 0.328            |
|                                                                  | 2.0          | 0.687                      | 0.667            |
| Fifth                                                            | 0.1          | 0.020                      | 0.020            |
|                                                                  | 0.5          | 0.101                      | 0.099            |
|                                                                  | 1.0          | 0.205                      | 0.195            |
|                                                                  | 2.0          | 0.420                      | 0.380            |
| *Depends on phase relationship between harmonic and fundamental. |              |                            |                  |

- a. Perform the steps listed under Paragraphs 3-5 and 3-7.
- b. Set the meter RANGE switch to the approximate range of the voltage to be measured.

### CAUTION

DO NOT APPLY MORE THAN 600 VOLTS TO INPUT. DO NOT OVERLOAD THE .1 MV THROUGH .3 VOLT RANGES WITH MORE THAN 300 VOLTS AT FREQUENCIES BELOW 300 kHz OR WITH MORE THAN 64 VOLTS AT FREQUENCIES ABOVE 300 kHz. IF ANY OF THESE OVERLOADS ARE EXCEEDED, THE INSTRUMENT MAY BE DAMAGED.

- c. If the signal to be measured is a frequency less than 100 kHz, the 100 kHz L. P. FILTER may be switched in to filter out all frequency components above 100 kHz.
- d. Connect the signal to be measured to the INPUT terminals. The RMS voltage amplitude of the input will be indicated on the meter.

### 3-9. DB MEASUREMENTS.

- a. Perform the steps listed under Paragraphs 3-5 and 3-7.
- b. The dB measurement is equal to the algebraic sum of the meter indication and the RANGE setting. For example: if the RANGE setting is +20 dB, and the meter reading is -3 dB, the actual dB measurement is +17 dB.
- c. The dB scale of the 400F/FL is calibrated in dBm. 0 dBm is equivalent to 1 milliwatt dissipated by a 600 ohm load. Therefore, all measurements in dBm must be made across a total impedance of 600 ohms. Measurements across all other impedances will be in dB, but not in dBm.
- d. A reading in dB may be converted to dBm by using the Impedance Correction Graph (Figure 3-3). For example: to convert a 40 dB reading across 100 ohms to dBm, locate the 100 ohm load impedance on the bottom of the graph. Follow the impedance line to the heavy black line, and read the meter correction at that point. The correction for 100 ohms is +7.5 dBm, and the corrected reading is +47.5 dBm.

### 3-10. WIDE BAND AC AMPLIFIER.

### CAUTION

EXTREME CARE SHOULD BE TAKEN TO AVOID COMMON GROUND PATHS BETWEEN THE INPUT AND OUTPUT SIGNALS. BECAUSE OF THE HIGH GAIN OF THE INSTRUMENT ON THE MORE SENSITIVE RANGES (80 DB ON .1 MV RANGE, ETC.), COMMON GROUND PATHS CAN CAUSE OSCILLATIONS AT HIGHER FREQUENCIES.

- a. Perform the steps listed in Paragraphs 3-5 and 3-7.
- b. Set the meter RANGE switch to the approximate range of the input signal.
- c. When signals of frequencies less than 100 kHz are being amplified, the 100 kHz, L. P. FILTER may be switched in to reduce high frequency noise and lessen the possibility of oscillations.
- d. Connect the input signal to the INPUT terminals.
- e. Table 3-2 shows the gain factor for each range of the 400F/FL into an open circuit.

Table 3-2. AC Amplifier Gain Factors

| RANGE | GAIN   | RANGE  | GAIN   |
|-------|--------|--------|--------|
| 300 V | -50 dB | 100 mV | +20 dB |
| 100 V | -40 dB | 30 mV  | +30 dB |
| 30 V  | -30 dB | 10 mV  | +40 dB |
| 10 V  | -20 dB | 3 mV   | +50 dB |
| 3 V   | -10 dB | 1 mV   | +60 dB |
| 1 V   | 0 dB   | .3 mV  | +70 dB |
| .3 V  | +10 dB | .1 mV  | +80 dB |

### 3-11. 400F WITH OPTION 01.

3-12. Operating procedures for the 400F with Option 01 are the same as the operating procedures for the standard 400F. The only difference between the two models is the scale layout. The 400F with Option 01 has a dB scale which reads from -15 to +2, instead of from -12 to +2. The dB scale is placed at the top of the meter face for better resolution.



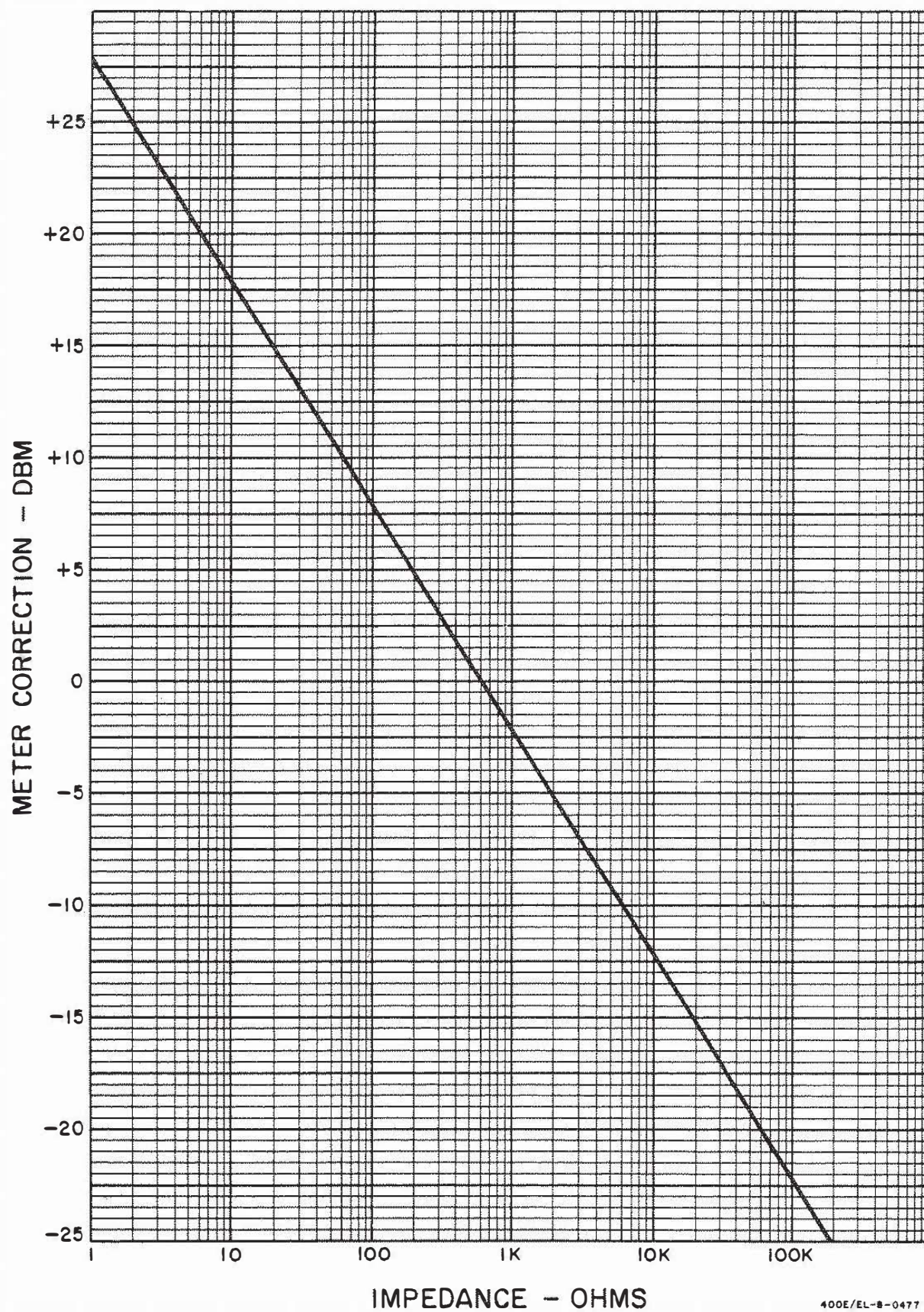


Figure 3-3. Impedance Correction Graph

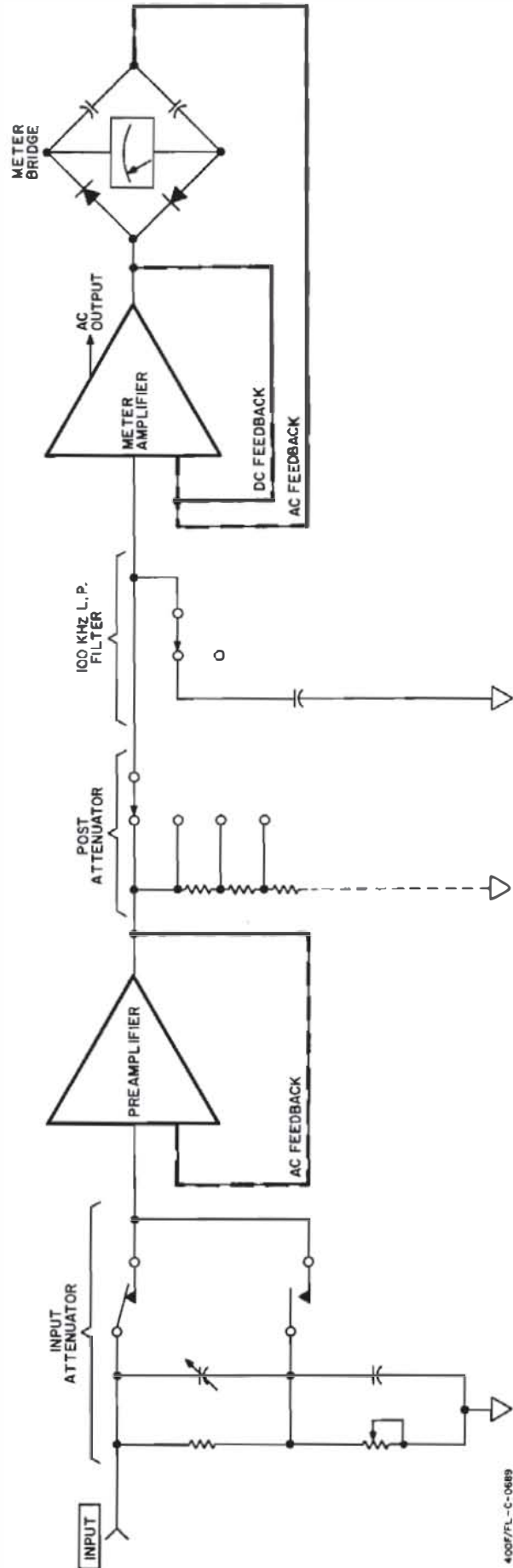


Figure 4-1. Functional Circuit Diagram



## SECTION IV

### THEORY OF OPERATION

#### 4-1. GENERAL.

4-2. The 400F/FL is a solid state, average responding, rms calibrated ac voltmeter. It may also be used as a wide band ac amplifier, with switchable gain and switchable bandwidth. Refer to Figure 4-1 for a functional circuit diagram of the instrument.

#### 4-3. BLOCK DIAGRAM DESCRIPTION.

4-4. The voltage to be measured is applied to the input attenuator, where it is either attenuated by 60 db, or coupled directly to the preamplifier. The preamplifier provides 10 db of gain for the input signal and applies it to the post attenuator. The signal goes from the post attenuator to the 100 KHz LOW PASS filter, which may be switched in to limit the bandwidth to signals from 20 Hz to 100 KHz. The meter amplifier then amplifies the signal, couples it to the meter bridge, and supplies a signal to the AC OUTPUT terminal. The meter bridge rectifies the ac signal and applies it to meter M1, which indicates the rms value of the input voltage. The meter bridge also provides the ac feedback to the meter amplifier.

#### 4-5. SCHEMATIC THEORY.

4-6. Refer to Figure 6-1 for the following discussion.

#### 4-7. INPUT ATTENUATOR.

4-8. The input attenuator consists of an rc voltage divider and two reed relays. On the .1 mv through .3 v ranges, reed relay A1K1 is energized by -26 v from wafer (A) of the RANGE switch, S1, routing the input signal directly to the preamplifier. On all other ranges, the -26 v is applied to relay A1K2. When A1K2 is closed, the input signal is attenuated 60 db by the rc divider and coupled to the preamplifier.

#### 4-9. PREAMPLIFIER.

4-10. The preamplifier is a three stage ac amplifier that amplifies the signal from the input attenuator by 10 db. It also functions as an impedance matcher to match the high impedance of the input attenuator to the much lower impedance of the post attenuator.

4-11. Capacitor A2C5 blocks dc transients and couples the ac signal to the preamplifier. The input signal is limited to 5.4 volts peak-to-peak by diodes A2CR2 and A2CR4, which are biased at +2.7 v and -2.7 v respectively, by zener diodes A2CR1 and A2CR5. A field effect transistor, A2Q1, is used as the input stage of the preamplifier because of its low noise characteristics and high input impedance. The signal is taken from the drain of A2Q1 and is further amplified by A2Q2 and A2Q3.

4-12. Feedback from the emitter of A2Q2 bootstraps the value of A2R9, the drain load of A2Q1. Feedback from the source of A2Q1 bootstraps the input impedance of the preamplifier and keeps it at a high level over all ranges of inputs. Gain stability and linearity of the preamplifier are maintained by feedback from the collector of A2Q2 and the emitter of A2Q3. A2R6 provides a bias adjustment for the field effect transistor, A2Q1.

#### 4-13. POST ATTENUATOR.

4-14. The post attenuator is a precision resistive voltage divider that operates as a function of the RANGE switch. On the two lowest voltage ranges, the signal from the preamplifier is applied through two resistors (S1R1 and S1R15) to the 100 KHz LP FILTER and receives no attenuation. Six precision resistive divider circuits provide signal attenuation in progressive steps of 10 db for the twelve higher ranges.

#### 4-15. 100 KHz LOW PASS FILTER.

4-16. The 100 KHz LP FILTER is a 0.01  $\mu$ f capacitor (S2C1) which may be switched into or out of the circuit by switch S2. When the filter is in the circuit, the bandwidth of the instrument is from 20 Hz to 100 KHz. If the filter is switched out of the circuit, the bandwidth is increased to 4 MHz. Refer to Figure 4-2 for a graph of the filter attenuation characteristics.

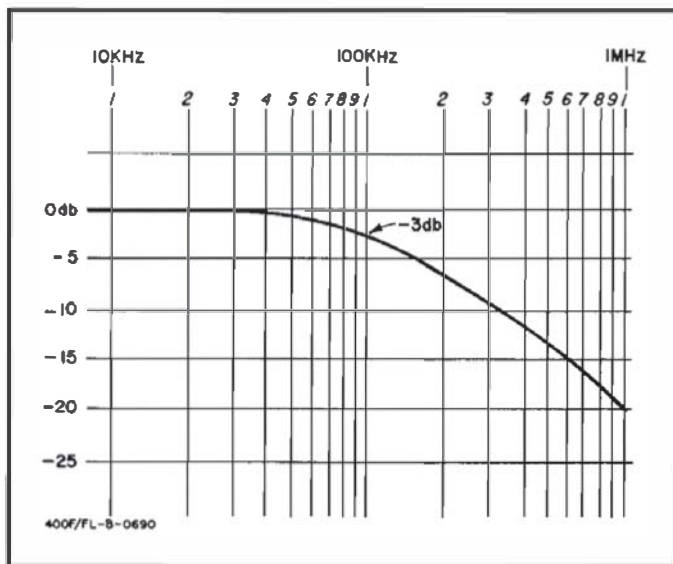


Figure 4-2. Filter Attenuation Characteristics



#### 4-17. METER AMPLIFIER.

4-18. The meter amplifier is a four stage, direct coupled voltage and power amplifier. The first stage is a differential amplifier, A2Q10 and A2Q12, which amplifies the difference between the input signal and the feedback signal on the base of A2Q12, the feedback summing junction. The three other stages of amplification are provided by A2Q11, A2Q13, and A2Q15.

4-19. AC feedback from the meter bridge to the feedback summing junction is adjustable at 4 MHz (A2C36) and 400 Hz (A2R62) on the 30 mv range. On the .1 mv range, A2R64, A2R76, and A2R68 are switched into the circuit to increase the gain of the amplifier by 10 db and to allow a 400 Hz gain adjustment to be made.

4-20. DC feedback from the collector of A2Q15 to the feedback summing junction is adjustable at 20 Hz (A2R59) on the 30 mv range. A2R58 is switched into the circuit on the .1 mv range to provide a feedback adjustment at 30 Hz. These adjustments provide overall amplifier gain stability for the entire voltage and frequency range of the instrument.

4-21. A2Q14 isolates the AC OUTPUT circuit from the meter amplifier and the meter bridge. It is an

independent current source which will supply a signal to the OUTPUT terminal that is identical to the signal applied to the meter bridge. That is, for a 1 v rms signal for full scale meter deflection, A2Q14 will provide a 1 v rms signal at the AC OUTPUT terminal.

#### 4-22. METER BRIDGE.

4-23. Refer to Figure 4-3 for a simplified diagram of the metering circuit.

4-24. The meter bridge is a full wave rectifier that converts the ac signal from the meter amplifier into dc. It supplies current to drive the meter and provides an ac feedback signal to the meter amplifier.

4-25. Transistor A2Q16 provides a large output impedance for the meter amplifier, and is the current drive source for the meter bridge circuit. The collector output of A2Q16 is applied to the meter bridge, and is rectified by diodes A2CR22 and A2CR23. The ac components of the bridge signal are coupled into the feedback loop by capacitors A2C38 and A2C39. A2Q17 bootstraps the resistance of A2R69 to a high value, so that current is driven through the bridge, keeping the meter circuit response linear to large variations in signal amplitude.

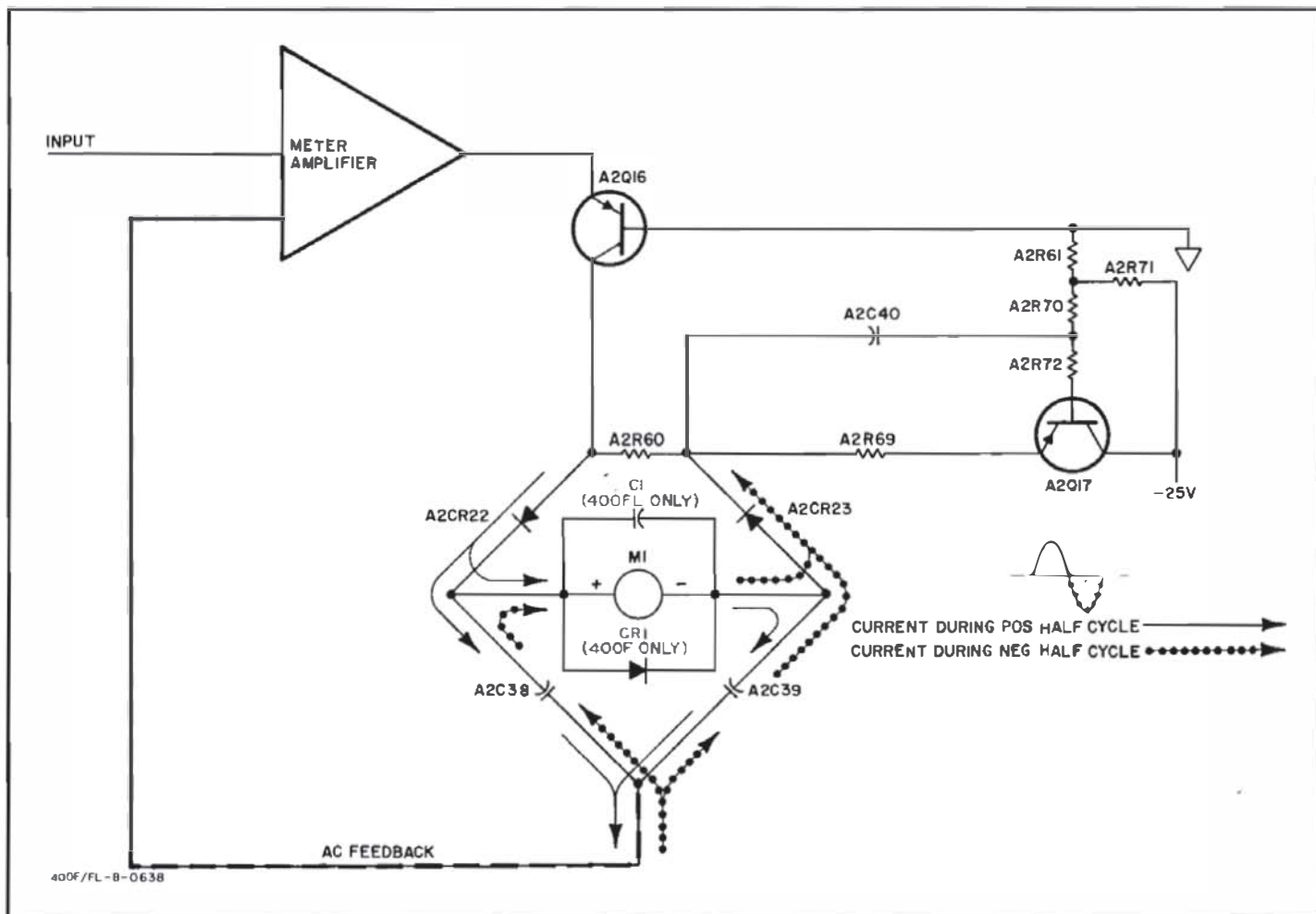


Figure 4-3. Simplified Diagram of Metering Circuit

4-26. The meter, M1, is a current driven device that utilizes a taut-band movement. It responds to the average value of the rectified meter amplifier output, which is proportional to the rms value of the sinusoidal signal being measured. The meter indicates the rms value of the input voltage and the power level in dbm for resistive loads of 600 ohms. Measurements across loads other than 600 ohms will be indicated in db, but not dbm. The meter is protected from circuit overloads by diode CR1 (400F) and capacitor C1 (400FL).

#### 4-27. POWER SUPPLY.

4-28. The power supply provides both a positive and negative 26 v regulated output. It may be operated by external batteries (+35 v to 55 v and -35 v to 55 v) or line power (115 v or 230 v, 50 Hz to 1000 Hz).

4-29. The line input is converted to dc by a diode rectifier network consisting of A2CR6 through A2CR9. The positive output of the rectifier is applied to series regulator A2Q4, which regulates the +26 v supply. Control transistor A2Q6 has a constant emitter reference voltage supplied by zener diode A2CR12. Capacitor A2C16 couples any change in the +26 v output to the base of A2Q6, which will supply a signal proportional to the change in output voltage to A2Q5. A2Q5 will then amplify the signal and couple it to the base of the regulator A2Q4, causing it to regulate the output by either increasing or decreasing conduction.

4-30. The -26 v supply is regulated in the same manner, the only difference being that the control transistor A2Q7 is referenced to the +26 v output, instead of the zener diode.

Table 5-1. Test Equipment

| INSTRUMENT TYPE                         | REQUIRED CHARACTERISTICS                                                                             | USE                                                       | RECOMMENDED MODEL                                                                                                                 |
|-----------------------------------------|------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| AC Voltmeter Calibrator                 | Accuracy: 0.2% at 400 Hz<br>Range: 30 mv to 1 v                                                      | Performance Checks and Calibration                        | -hp- Model 738BR Voltmeter Calibrator                                                                                             |
| Test Oscillator                         | Output: 30 mv to 1 v<br>Frequency Range: 20 Hz to 4 MHz<br>Distortion: <1%<br>Flatness: $\pm 0.25\%$ | Performance Checks and Calibration                        | -hp- Model 652A Test Oscillator<br>or<br>Combination -hp- Model 739AR Frequency Response Test Set and -hp- Model 200SR Oscillator |
| AC/DC Voltmeter/Ohmmeter                | Volts Accuracy: 2%<br>Ohms Accuracy: 5%                                                              | Troubleshooting                                           | -hp- Model 427A Voltmeter                                                                                                         |
| Resistor                                | Fxd, 100 K $\Omega \pm 1\%$                                                                          | Performance Checks                                        | -hp- Part No. 0757-0465                                                                                                           |
| Crystal Socket (with terminals shorted) | Size: 1/2 inch                                                                                       | Performance Checks and Calibration (Shorting Test Points) | -hp- Part No. 1200-0028                                                                                                           |

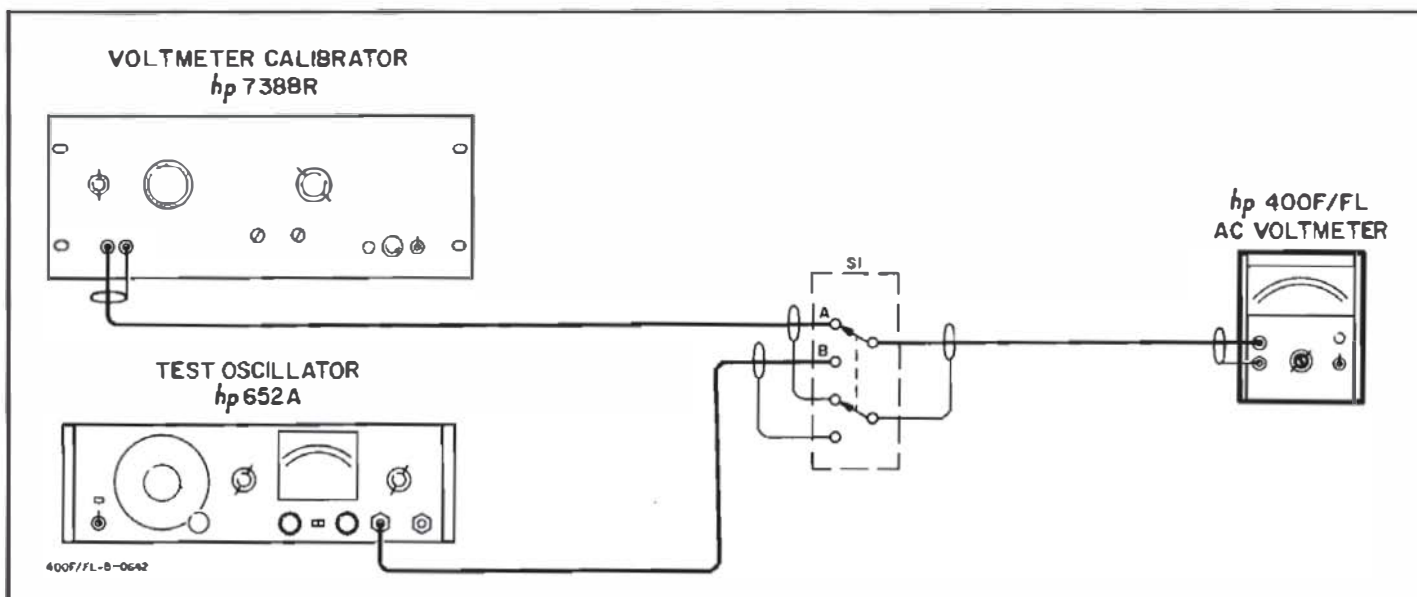


Figure 5-1. Accuracy and Frequency Response Check Setup

## SECTION V

### MAINTENANCE

#### 5-1. INTRODUCTION.

5-2. This section contains maintenance and service information for the Model 400F/FL AC Voltmeter. Included are Performance Checks, Alignment and Calibration Procedures, and Troubleshooting Procedures.

#### 5-3. TEST EQUIPMENT REQUIRED.

5-4. The equipment required to properly maintain the 400F/FL is listed in Table 5-1. The table lists the type of equipment to be used, the specification requirements, and the recommended commercially available test equipment.

#### NOTE (400F only)

Before beginning the Performance Tests, mechanically zero the meter according to the procedures in Paragraph 3-7.

#### 5-5. PERFORMANCE CHECKS.

5-6. The following Performance Checks compare the 400F/FL with its accuracy specifications (Table 1-1). These checks may be used for incoming inspection, periodic maintenance, and for specification checks after a repair. A highly accurate and stable voltage reference that is variable from 20 Hz to 4 MHz is required. The -hp- 738BR Voltmeter Calibrator produces a 400 Hz signal that is within less than 0.2% of the indicated output. The -hp- 652A Test Oscillator can be referenced to the output of the 738BR and can be adjusted to within 0.25% of the set reference voltage from 20 Hz to 4 MHz.

5-7. If the -hp- 652A Test Oscillator is not available, the 739AR Frequency Response Test Set and 200SR Oscillator combination may be used. This combination can be adjusted to within 0.5% of a set voltage reference from 20 Hz to 4 MHz. (The -hp- 739AR, -hp- 200SR, and -hp- 738BR are available in a rack mounted configuration designated -hp- K02-738BR VTVM Calibration System.)

5-8. The following procedures specify the use of the -hp- 652A and the -hp- 738BR. If the K02-738BR calibration system is used, follow the same general procedures.

5-9. Figure 5-1 shows the test setup for using the -hp- 652A and -hp- 738BR combination. Figure 5-2 shows the test setup for using the K02-738BR VTVM Calibration System.

#### NOTE

The 0.1 mv range of the 400F/FL may be checked for accuracy by

verification of the additional 10 db of gain that is provided by the meter amplifier on that range. In order to verify the gain, the top cover of the instrument must be removed to gain access to TP1 through TP4.

#### 5-10. TOP COVER REMOVAL.

5-11. To remove or replace the top cover, follow the procedures outlined in Paragraph 5-21.

#### 5-12. ACCURACY AND FREQUENCY RESPONSE CHECKS.

5-13. The accuracy and frequency response checks compare the 400F/FL with its accuracy specifications over the entire frequency range.

- a. Connect the voltmeter calibrator and the Test Oscillator to the 400F/FL as shown in Figure 5-1. An external switch (S1) may be used to facilitate switching from one test instrument to the other.
- b. Set 400F/FL RANGE switch to 30 mv, and set 100 KHz FILTER switch to OUT. Set switch S1 to Position A.
- c. Adjust voltmeter calibrator for a 30 mv rms output at 400 Hz.
- d. Observe the 400F/FL meter indication. If the meter indication is not within the tolerances listed in Table 5-2 (400F) or Table 5-3 (400FL), perform the Meter Calibration (Paragraph 5-28).
- e. Set 400F/FL RANGE switch to 100 mv. The meter should indicate 30 mv.
- f. Short TP1 to TP4, and short TP2 to TP3. (A shorting device, such as a crystal socket with its terminals shorted together, should be used to avoid pickup of noise.) The meter indication should be the same as the indication in step d of this paragraph ( $\pm 3$  mv). This verifies the additional 10 db of gain that is provided by the meter amplifier on the 0.1 mv range.
- g. Set 400F/FL RANGE switch to 1 volt, and disconnect shorts between test points.
- h. Adjust voltmeter calibrator for a 1 volt output at 400 Hz. Observe the 400F/FL meter indication. If the meter indication is not within the tolerances listed in Table 5-2 (400F) or Table 5-3 (400FL), perform the Meter Calibration (Paragraph 5-28).
- i. Set switch S1 to Position B, and set 400F/FL RANGE switch to 30 mv.



Table 5-2. Full Scale Calibration Tolerances (400F)

| 30 MV RANGE |                  |      | 100 MV RANGE<br>(0.1 mv Range Check) |                  |      | 1 VOLT RANGE |                  |      |
|-------------|------------------|------|--------------------------------------|------------------|------|--------------|------------------|------|
| FREQ.       | METER INDICATION |      | FREQ.                                | METER INDICATION |      | FREQ.        | METER INDICATION |      |
|             | MIN.             | MAX. |                                      | MIN.             | MAX. |              | MIN.             | MAX. |
| 20          | 28.8             | 31.2 | 20                                   | 96               | 104  | 20           | 0.96             | 1.04 |
| 40          | 29.4             | 30.6 | 40                                   | 98               | 102  | 40           | 0.98             | 1.02 |
| 400         | 29.7             | 30.3 | 400                                  | 99               | 101  | 400          | 0.99             | 1.01 |
| 1000        | 29.7             | 30.3 | 1000                                 | 99               | 101  | 1000         | 0.99             | 1.01 |
| 10 K        | 29.7             | 30.3 | 10 K                                 | 99               | 101  | 10 K         | 0.99             | 1.01 |
| 100 K       | 29.7             | 30.3 | 100 K                                | 99               | 101  | 100 K        | 0.99             | 1.01 |
| 1 M         | 29.7             | 30.3 | 1 M                                  | 99               | 101  | 1 M          | 0.99             | 1.01 |
| 2 M         | 29.4             | 30.6 | 2 M                                  | 98               | 102  | 2 M          | 0.98             | 1.02 |
| 4 M         | 28.8             | 31.2 | 4 M                                  | 96               | 104  | 4 M          | 0.96             | 1.04 |

Table 5-3. Full Scale Calibration Tolerances (400FL)

| 30 MV RANGE |                  |      | 100 MV RANGE<br>(0.1 mv Range Check) |                  |      | 1 VOLT RANGE |                  |      |
|-------------|------------------|------|--------------------------------------|------------------|------|--------------|------------------|------|
| FREQ.       | METER INDICATION |      | FREQ.                                | METER INDICATION |      | FREQ.        | METER INDICATION |      |
|             | MIN.             | MAX. |                                      | MIN.             | MAX. |              | MIN.             | MAX. |
| 20          | 28.5             | 31.5 | 20                                   | 95               | 105  | 20           | 0.95             | 1.05 |
| 40          | 29.4             | 30.6 | 40                                   | 98               | 102  | 40           | 0.98             | 1.02 |
| 400         | 29.7             | 30.3 | 400                                  | 99               | 101  | 400          | 0.99             | 1.01 |
| 1000        | 29.7             | 30.3 | 1000                                 | 99               | 101  | 1000         | 0.99             | 1.01 |
| 10 K        | 29.7             | 30.3 | 10 K                                 | 99               | 101  | 10 K         | 0.99             | 1.01 |
| 100 K       | 29.7             | 30.3 | 100 K                                | 99               | 101  | 100 K        | 0.99             | 1.01 |
| 1 M         | 29.7             | 30.3 | 1 M                                  | 99               | 101  | 1 M          | 0.99             | 1.01 |
| 2 M         | 29.4             | 30.6 | 2 M                                  | 98               | 102  | 2 M          | 0.98             | 1.02 |
| 4 M         | 28.5             | 31.5 | 4 M                                  | 95               | 105  | 4 M          | 0.95             | 1.05 |

- j. Adjust test oscillator set for a 30 mv output at 400 Hz, using as a reference the 400F/FL meter indication obtained in step d of this paragraph. Set a reference on meter of test oscillator and use amplitude control to maintain the set reference whenever frequency of oscillator is varied.
- k. Repeat step d of this paragraph for each frequency listed in Table 5-2 (400F) or Table 5-3 (400FL).
- m. Perform steps e and f of this paragraph, maintaining the output amplitude of the test oscillator at 30 mv.
- n. Repeat step d of this paragraph for each frequency listed in Table 5-2 (400F) or Table 5-3 (400FL).
- o. Set 400F/FL RANGE switch to 1 volt, and disconnect shorts between test points.

- p. Adjust test oscillator for a 1 volt output at 400 Hz using as a reference the 400F/FL meter indication obtained in step h of this paragraph.
- q. Repeat step d of this paragraph for each frequency listed in Table 5-2 or Table 5-3.

#### 5-14. RANGE TRACKING CHECK.

5-15. After verifying the 400F/FL full scale calibration with the accuracy and frequency response tests, check the range tracking of the instrument with the following procedures. Use the test setup shown in Figure 5-1 for the range tracking check.

- a. Set switch S1 to Position A.
- b. Set 400F/FL RANGE switch to 30 mv.
- c. Adjust test oscillator for a 400F/FL meter indication of 30 mv at 400 Hz.

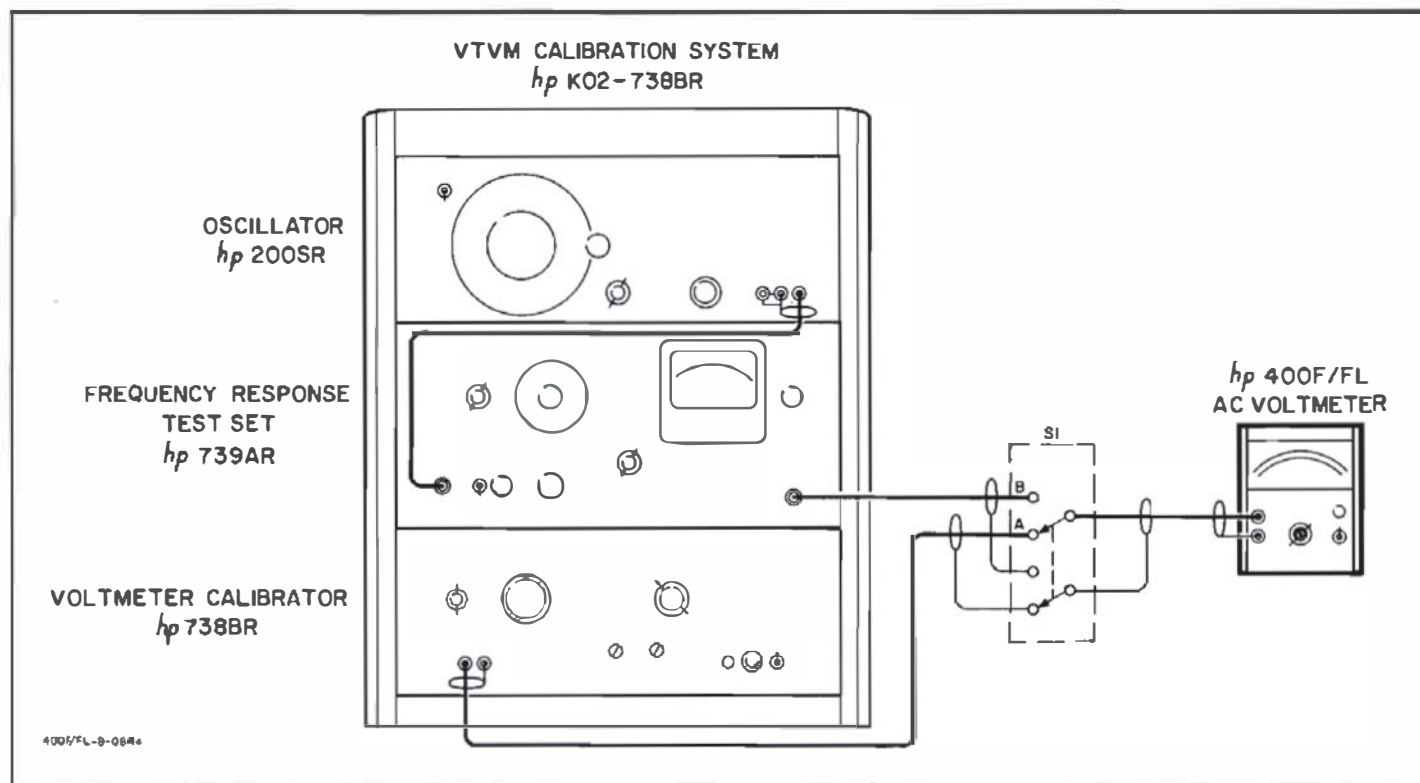


Figure 5-2. Alternate Accuracy and Frequency Response Check Setup

- d. Set 400F/FL RANGE switch to 100 mv.
  - 1) 400F should indicate 30 mv  $\pm 2\%$ .
  - 2) 400FL should indicate 30 mv  $\pm 1\%$ .
- e. Set 400F/FL RANGE switch to 0.3 volts.
  - 1) 400F should indicate 30 mv  $\pm 5\%$ .
  - 2) 400FL cannot be checked with a 1/10 scale input.
- f. Adjust test oscillator for a 400F/FL meter indication of 30 mv at 1 MHz.
- g. Set 400F/FL RANGE switch to 100 mv.
  - 1) 400F should indicate 30 mv  $\pm 2\%$ .
  - 2) 400FL should indicate 30 mv  $\pm 1\%$ .
- h. Set 400F/FL RANGE switch to 0.3 volts.
  - 1) 400F should indicate 30 mv  $\pm 5\%$ .
  - 2) 400F/FL cannot be checked with a 1/10 scale input.

**5-16. INPUT IMPEDANCE CHECK.****5-17. INPUT RESISTANCE CHECK.**

- a. Connect the 50  $\Omega$  output of the test oscillator to 400F/FL.
- b. Set 400F/FL RANGE switch to 1 volt.
- c. Set test oscillator output for full scale deflection of 400F/FL.
- d. Connect a 100 K  $\Omega$  resistor between test oscillator and 400F/FL as shown in Figure 5-3.

- e. 400F/FL meter indication should not drop more than one small scale division from full scale. This verifies an input resistance of 10 M  $\Omega$ .

**5-18. INPUT CAPACITY CHECK.**

- a. Connect test oscillator and a 100 K  $\Omega$  resistor to 400F/FL as shown in Figure 5-3. Connect the resistor lead directly to the GR connector.
- b. Set 400F/FL RANGE switch to 1 volt.
- c. Set test oscillator output for full scale deflection of 400F/FL meter at 400 Hz.
- d. Increase frequency of test oscillator until 400F/FL indication drops to 0.707 volts. This should occur at a frequency of 150 KHz or greater, verifying an input capacity of 10 pf or less on the 1 volt range.
- e. Set 400F/FL RANGE switch to 300 mv.
- f. Set frequency response test set output for full scale deflection of 400F/FL meter at 400 Hz.
- g. Increase frequency of test oscillator until 400F/FL indication drops to 212 mv. This should occur at a frequency of 60 KHz or greater, verifying an input capacity of 25 pf or less on the 300 mv range.

**5-19. ALIGNMENT AND CALIBRATION PROCEDURES.**

5-20. The Alignment and Calibration Procedures should be performed only if it has been determined by the Performance Checks that the 400F/FL is not within

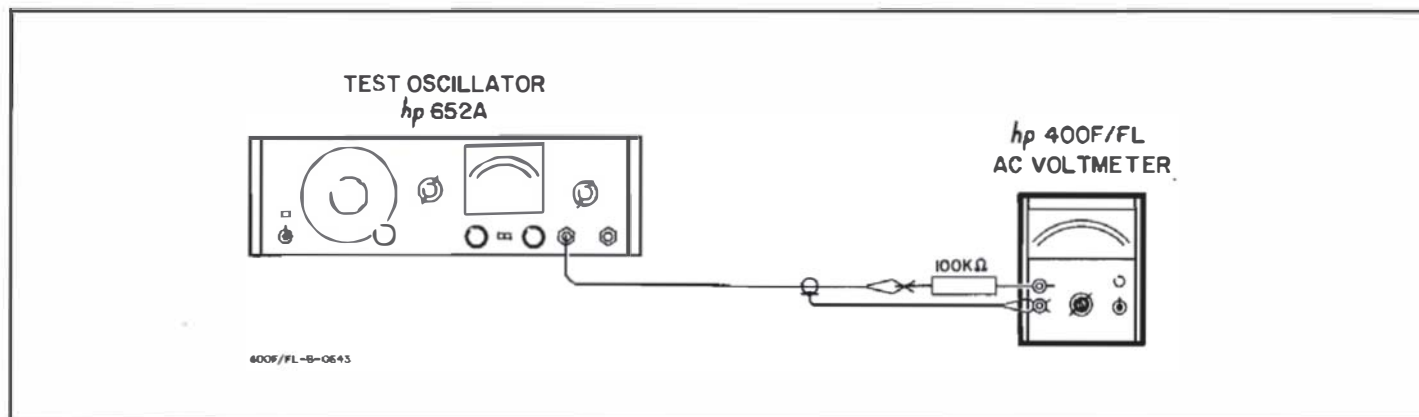


Figure 5-3. Input Impedance Check Setup

specifications. The following procedures specify the use of an -hp- 738BR Voltmeter Calibrator and an -hp- 652A Test Oscillator. However, an -hp- K02-738BR VTVM Calibration System may be substituted by following the same general procedures. If the instrument cannot be properly adjusted, refer to Paragraph 5-39, Troubleshooting Procedures. Refer to Figure 5-4 for the location of internal adjustments.

#### 5-21. COVER REMOVAL AND REPLACEMENT.

5-22. Removal of the top cover exposes circuit areas for routine checks and adjustments. Removal of the bottom and side covers exposes circuit areas for operations such as soldering and component replacement.

#### 5-23. TOP OR BOTTOM COVERS.

- Remove screw at rear of cover. Slide cover about 1 inch to rear, and lift it off.
- To replace cover, reverse the removal procedure.

#### 5-24. SIDE COVER.

5-25. Remove the four screws from side cover, and lift it off.

#### 5-26. METER MECHANICAL ZERO ADJUSTMENT.

5-27. Refer to Paragraph 3-5 for the meter mechanical zero adjustment procedures.

#### 5-28. METER CALIBRATION.

5-29. The following procedures are used to adjust the gain of the meter amplifier on two voltage ranges at five different frequencies. Proper gain adjustments will assure accurate meter indications over the entire voltage and frequency range of the instrument. Use the test setup shown in Figure 5-1 for the meter calibration.

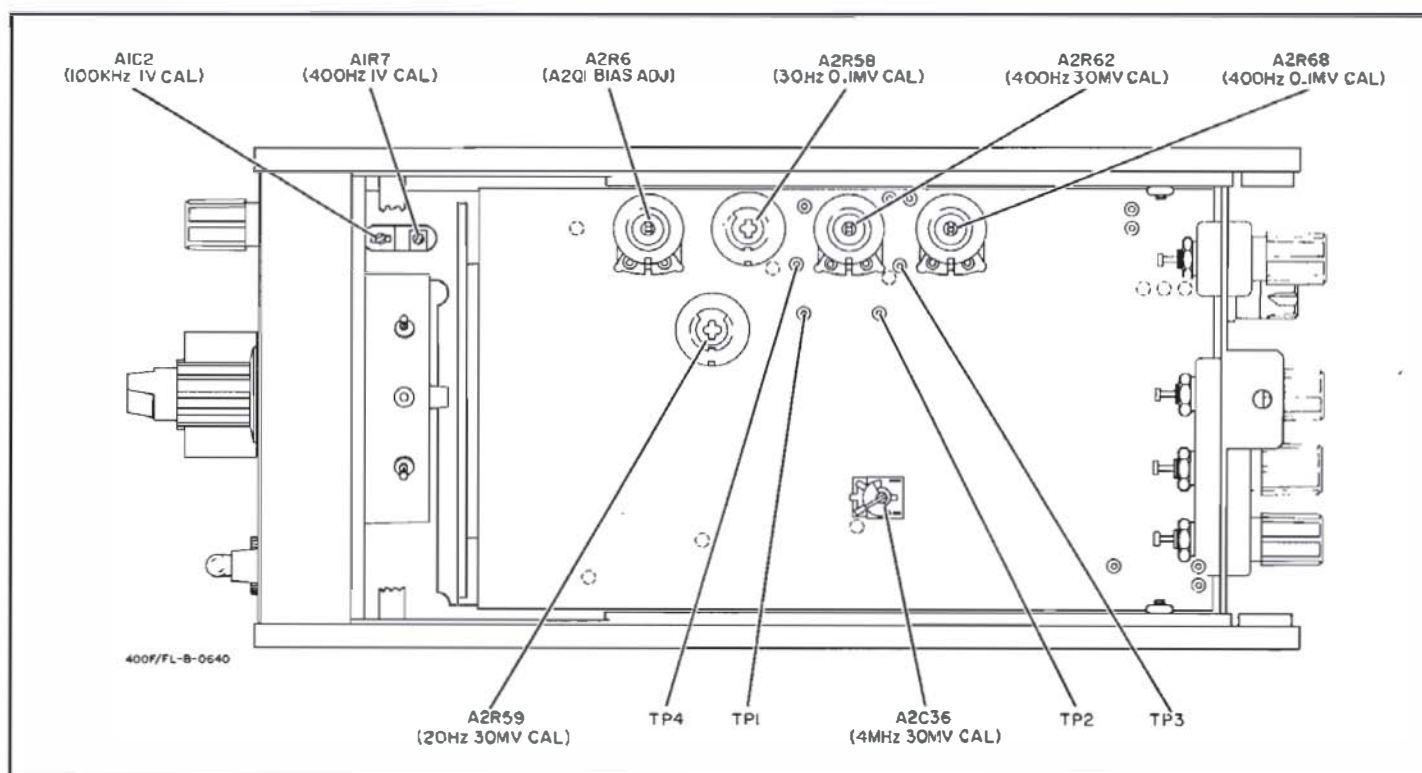


Figure 5-4. Location of Internal Adjustments

**5-30. METER CALIBRATION, 30 MV RANGE.**

- a. Set switch S1 to Position A.
- b. Set 400F/FL RANGE switch to 30 mv, and set 100 KHz L. P. FILTER switch to OUT.
- c. Set voltmeter calibrator for 30 mv output at 400 Hz.
- d. Adjust A2R62 for a 400F/FL meter indication of 30 mv.
- e. Set switch S1 to Position B.
- f. Adjust test oscillator for a 400F/FL meter indication of 30 mv at 400 Hz. Set a reference on meter of test oscillator and use amplitude control to maintain reference whenever frequency of oscillator is changed.
- g. Set test oscillator to 20 Hz, maintaining amplitude at 30 mv.
- h. Adjust A2R59 for a 400F/FL meter indication of 30mv.
- i. Set test oscillator to 4 MHz, maintaining amplitude at 30 mv.
- j. Adjust A2C36 for a 400F/FL meter indication of 30 mv.

**5-31. METER CALIBRATION, 0.1 MV RANGE.****NOTE**

The 0.1 mv range meter calibration is performed on a higher range. This is done by shorting test points which provide the amplifier with the additional 10 db of gain that normally is switched in only on the 0.1 mv range.

- a. Set switch S1 to Position B.
- b. Set 400F/FL RANGE switch to 30 mv, and set 100 KHz L. P. FILTER switch to OUT.
- c. Adjust test oscillator for a 400F/FL meter indication of 30 mv at 400 Hz.
- d. Set 400F/FL RANGE switch to 100 mv.
- e. Short TP1 to TP4 and short TP2 to TP3. (This increases the gain of the meter amplifier by 10 db, as if the instrument were on the 0.1 mv range.)
- f. Adjust A2R68 for a 400F/FL meter indication of 30 mv. (Although the 400F/FL RANGE switch is in the 100 mv position, the instrument effectively is still on the 30 mv range.)
- g. Set test oscillator to 30 Hz, maintaining amplitude at 30 mv.
- h. Adjust A2R58 for a 400F/FL meter indication of 30 mv.

**5-32. ATTENUATOR ALIGNMENT.**

5-33. The following procedures are used to properly align the input attenuator of the 400F/FL at both high

and low frequencies. Use the test setup shown in Figure 5-1 for the attenuator alignment.

- a. Set switch S1 to Position A.
- b. Set 400F/FL RANGE switch to 1 volt, and set 100 KHz L. P. FILTER switch to OUT.
- c. Adjust voltmeter calibrator for a 1 volt output at 400 Hz.
- d. Adjust A1R7 for a 400F/FL meter indication of 1 volt.
- e. Set switch S1 to position B.
- f. Set test oscillator for a 400F/FL meter indication of 1 volt at 400 Hz.
- g. Set test oscillator to 100 KHz, maintaining the amplitude at 1 volt.
- h. Adjust A1C2 for a 400F/FL meter indication of 1 volt. If more than a 1% adjustment is needed, repeat the 400 Hz adjustment.

**5-34. A2Q1 BIAS ADJUSTMENT.**

5-35. A2R6 provides a bias adjustment for field effect transistor A2Q1.

- a. Monitor voltage at junction between A2R5 and A2R3 with a dc voltmeter.
- b. Adjust A2R6 for a -6 v indication at the junction.

**5-36. REPLACEMENT OF A2C37\*.**

5-37. The value of A2C37 is individually selected to compensate for varying circuit parameters within the instrument. Certain Model 400F/FL instruments may not have a capacitor in this location.

5-38. If an instrument cannot be properly calibrated on the 30 mv range at 4 MHz, A2C37 should be changed. Increase the value of A2C37 if the instrument meter indication is high and cannot be adjusted low enough. Decrease the value of A2C37 if the instrument meter indication is low and cannot be adjusted high enough.

**5-39. TROUBLESHOOTING PROCEDURE.**

5-40. If the 400F/FL is operating improperly, it either needs to be calibrated or has a circuit that is malfunctioning. Troubleshoot the instrument only after it has been determined that the malfunction cannot be corrected by performing the Alignment and Calibration Procedures in Paragraph 5-19.

5-41. When a malfunction occurs, remove power from the 400F/FL and visually inspect for loose or broken wires and connectors. Also check for overheated or loose components and similar conditions that could be a source of trouble.

5-42. The checks outlined in this section were not designed to measure all circuit parameters, but to localize the malfunction. Therefore, it is probable that additional checks and measurements will be required to completely isolate the faulty component.



Table 5-4. Troubleshooting Guide

| MALFUNCTION INDICATION                                                                                | PROBABLE TROUBLE                                                         |
|-------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Instrument will not operate on line voltage, and LINE ON lamp will not light.                         | Fuse F1 open.                                                            |
| Instrument will not uprange above 0.3 volt, but works on 0.3 volt range and below.                    | Relay A2K1 stuck closed, or A2K2 stuck open.                             |
| Instrument will not downrange below 1 volt, but works on 1 volt range and above.                      | Relay A2K1 stuck open, or A2K2 stuck closed.                             |
| Voltage at A2R8 cannot be properly adjusted.                                                          | Impedance Converter Circuit (A2Q1, A2Q2 and A2Q3).                       |
| No voltage at A2L1.                                                                                   | Jumper wire #1 broken.                                                   |
| Power supply output unregulated.                                                                      | A2Q6, A2Q7 or Zener diode A2CR12.                                        |
| No ac output.                                                                                         | A2R33 shorted.                                                           |
| Instrument operates improperly with inputs above 100 kHz, but works with inputs of lower frequencies. | Filter switch S2.                                                        |
| Instrument will not operate properly on 0.1 mv range.                                                 | Range switch S1, wafer D.                                                |
| Meter deflection on all ranges with no input.                                                         | A2Q15, A2Q16, A2Q17.<br>A2C38, A2C39, A2C40.                             |
| Meter remains at zero with any input on any range.                                                    | Diode A2CR1 shorted (400F only), or capacitor A2C1 shorted (400FL only). |

5-43. Refer to Table 5-4 for a list of possible malfunctions and their probable causes.

**NOTE**

All the voltage measurements in this section should be made with the 400F/FL input shorted and the RANGE switch set to 1 volt.

**5-44. POWER SUPPLY.**

5-45. Measure the power supply outputs at jumper wires #1 and #2 for +26 v and -26 v respectively. If both outputs are incorrect, first check the components in the +26 v section of the power supply, because the control transistor in the -26 v supply is referenced to the +26 v output. Consequently, if the +26 v becomes unregulated, the -26 v will also be unregulated. Refer to Table 5-5 for a list of check point voltages in the power supply.

Table 5-5. Power Supply Voltages

| CHECK POINT  | VOLTAGE           |
|--------------|-------------------|
| Emitter Q4   | +26.0 v $\pm$ 1 v |
| Collector Q4 | +41.5 v $\pm$ 5 v |
| Collector Q6 | +27.5 v $\pm$ 1 v |
| Emitter Q8   | -26.0 v $\pm$ 1 v |
| Emitter Q9   | -43.5 v $\pm$ 5 v |

**5-46. AMPLIFIERS.**

5-47. Both the preamplifier and the meter amplifier are internally dc coupled. If the dc voltages anywhere in the amplifiers are incorrect, the amplifiers will not operate properly. Measure the dc voltages in the amplifiers at the check points listed in Tables 5-6 and 5-7.

Table 5-6. Preamplifier Voltages

| CHECK POINT  | VOLTAGE             |
|--------------|---------------------|
| Source Q1    | - 2.3 v $\pm$ 0.5 v |
| Drain Q1     | -17.0 v $\pm$ 2.0 v |
| Collector Q2 | - 7.5 v $\pm$ 0.5 v |
| Collector Q3 | -21.4 v $\pm$ 1.0 v |

Table 5-7. Meter Amplifier Voltages

| CHECK POINT   | VOLTAGE              |
|---------------|----------------------|
| Emitter Q10   | - 0.64 v $\pm$ 0.1 v |
| Collector Q10 | + 9.20 v $\pm$ 1.0 v |
| Collector Q11 | + 0.97 v $\pm$ 0.2 v |
| Collector Q12 | +22.00 v $\pm$ 1.0 v |
| Collector Q13 | +11.00 v $\pm$ 0.5 v |
| Collector Q15 | + 2.30 v $\pm$ 0.5 v |

**5-48. METER BRIDGE.**

5-49. Measure the dc voltages on the transistors in the meter bridge and compare the readings with those given in Table 5-8. Also measure the voltages at the meter terminals. The meter should be floating at approximately -9 volts  $\pm$  1 volt with respect to circuit ground.

Table 5-8. Meter Bridge Voltages

| CHECK POINT   | VOLTAGE         |
|---------------|-----------------|
| Collector Q16 | - 9 v $\pm$ 1 v |
| Base Q17      | -17 v $\pm$ 1 v |

**5-50. ETCHED CIRCUIT BOARD REPAIR.**

5-51. The Model 400F/FL uses plated-through, double-sided, etched circuit boards. To prevent damage to

the circuit board and components, observe the following rules when soldering:

- a. Use a low-heat (25 to 50 watts) soldering iron with a small tip (1/16" to 3/32" diameter).
- b. To remove a component, clip a heat sink (long nose pliers, commercial heat sink tweezers etc.) on the component lead as close to the component as possible. Place the soldering iron directly on the component lead, and pull up on the lead. If a component is obviously damaged or faulty, clip the leads close to the component and then remove the leads from the board.



EXCESSIVE OR PROLONGED HEAT  
CAN LIFT THE CIRCUIT FOIL

FROM THE BOARD OR CAUSE  
DAMAGE TO COMPONENTS.

- c. Clean the component lead holes by heating the solder in the hole, quickly removing the soldering iron, and inserting a pointed, non-metallic object such as a toothpick.
- d. To mount a new component, shape the leads and insert them in the holes. Clip a heat sink on the component, heat with the soldering iron, and add solder as necessary to obtain a good electrical connection.
- e. Clip excess leads off after soldering and clean excess flux from the connection and adjoining area, using type TF Freon (-hp- Part No. 8500-0232).



## SECTION VI

### SCHEMATICS

#### 6-1. INTRODUCTION.

6-2. This section contains the schematic and component location diagrams for the Model 400F/FL. Figure 6-1 shows a flattened view of the RANGE switch and part of the internal wiring data. Figure 6-2 shows

the component location on the A1 and A2 printed circuit boards, and the location of the internal adjustments. Figure 6-3 is the schematic diagram of the 400F/FL. Main signal paths and feedback paths are identified. (Refer to the notes on the schematic diagram.)



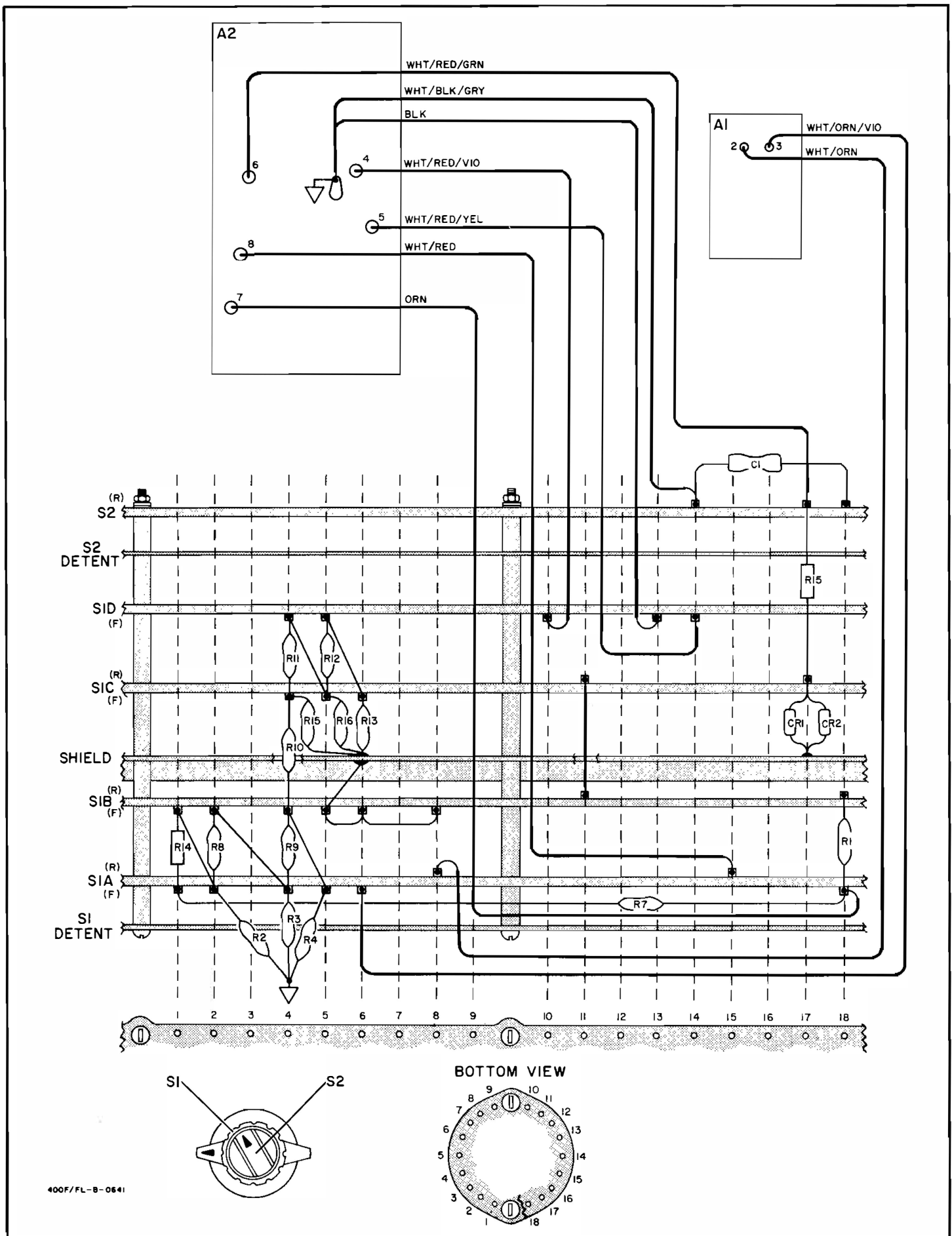
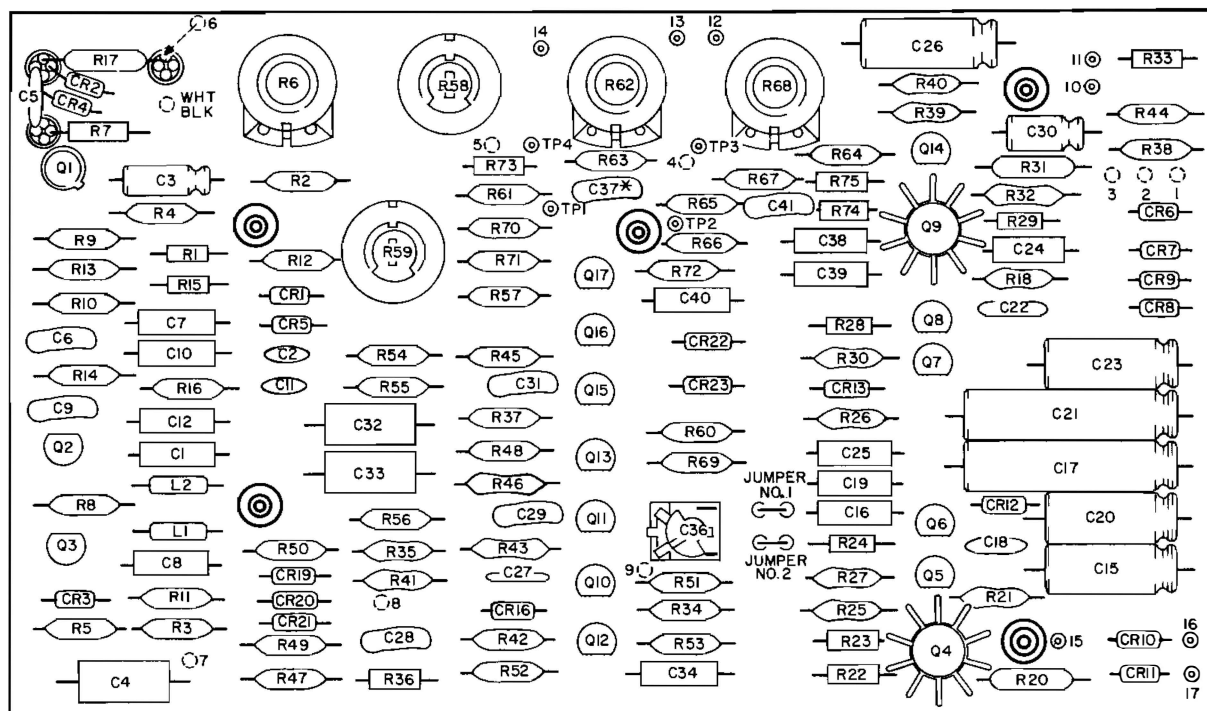
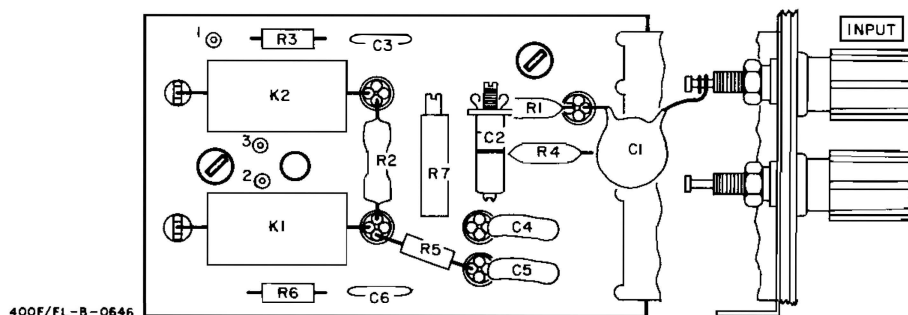


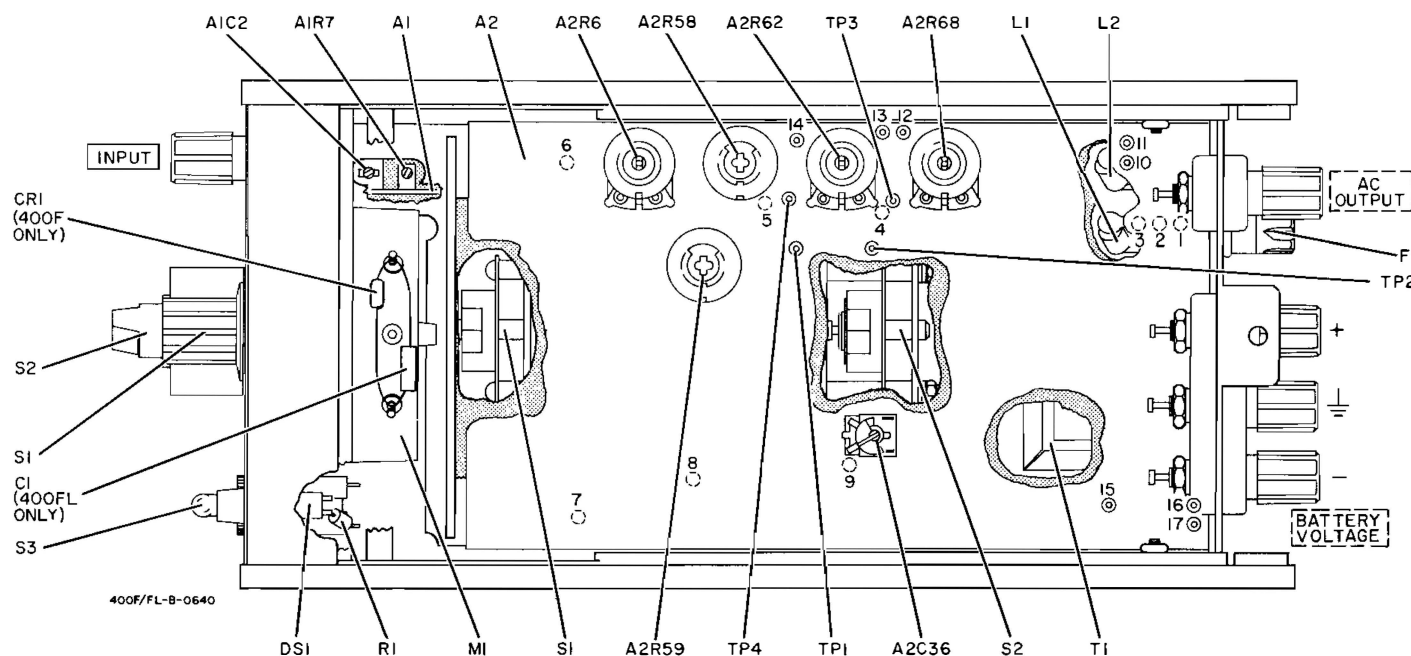
Figure 6-1. Model 400F/FL Range Switch and p/o Internal Wiring Data



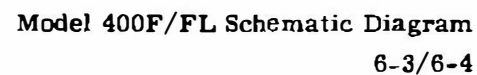
A2 BOARD (-hp- Part No. 00400-66504)



A1 BOARD (-hp- Part No. 00400-66505)









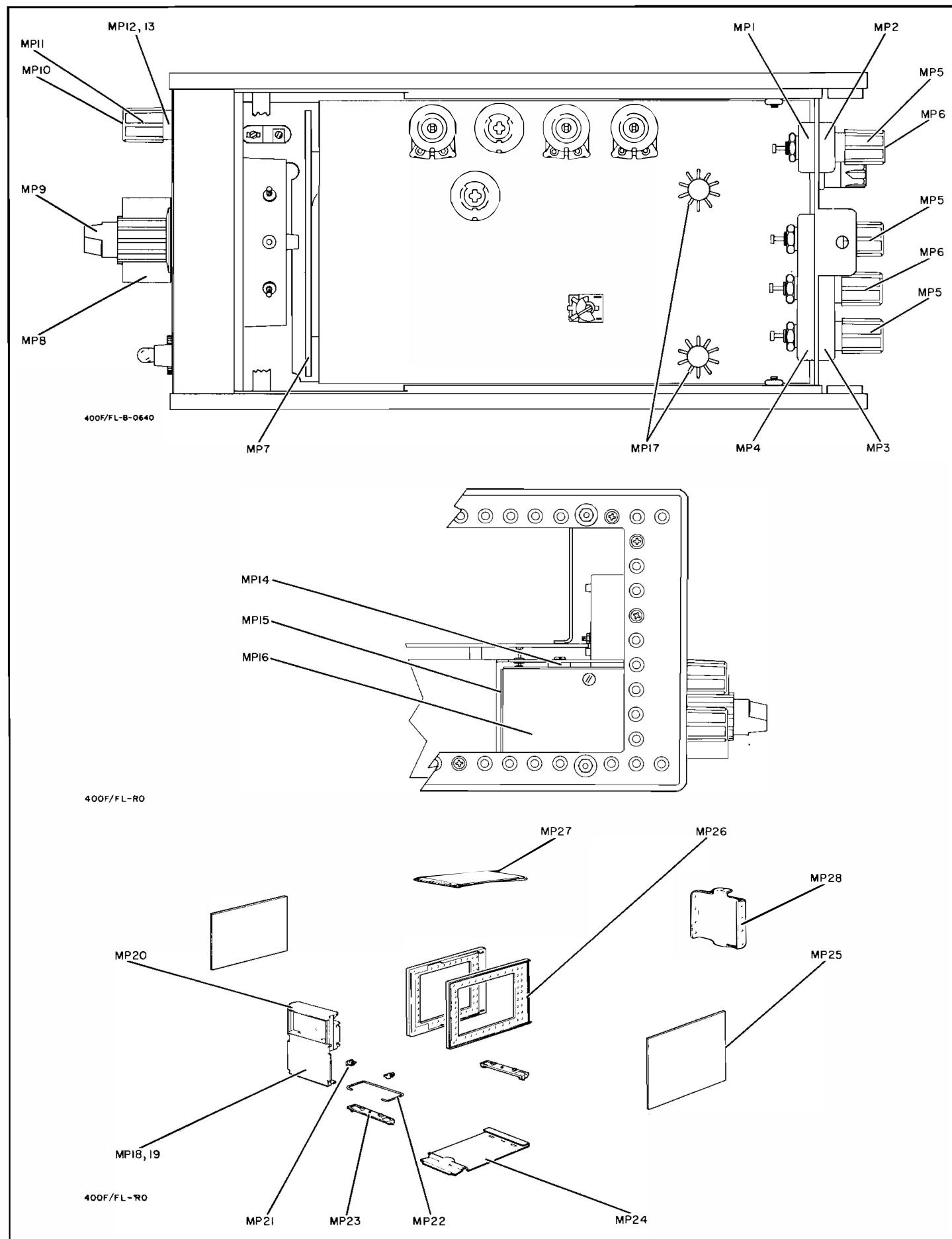


Figure 7-1. Location of Important Mechanical Parts



## SECTION VII

### REPLACEABLE PARTS

#### 7-1. INTRODUCTION.

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

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

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

#### 7-4. ORDERING INFORMATION.

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

#### 7-6. NONLISTED PARTS.

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

- a. Instrument model number.
- b. Instrument serial number.
- c. Description of the part.
- d. Function and location of the part.

#### REFERENCE DESIGNATORS

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

#### ABBREVIATIONS

|                                                                                                                                                                                                                                                       |                            |                                                             |                                                                                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|-------------------------------------------------------------|----------------------------------------------------------------------------------|
| a = amperes                                                                                                                                                                                                                                           | elect = electrolytic       | mtg = mounting                                              | rot = rotary                                                                     |
| bp = bandpass                                                                                                                                                                                                                                         | encap = encapsulated       | my = mylar                                                  | rms = root-mean-square                                                           |
| bwa = backward wave oscillator                                                                                                                                                                                                                        | f = farads                 | NC = normally closed                                        | rmo = rack mount only                                                            |
| c = carbon                                                                                                                                                                                                                                            | fxd = fixed                | Ne = neon                                                   | s-b = slow-blow                                                                  |
| cer = ceramic                                                                                                                                                                                                                                         | Ge = germanium             | NO = normally open                                          | Se = selenium                                                                    |
| cmo = cabinet mount only                                                                                                                                                                                                                              | grd = ground (ed)          | NPO = negative positive zero (zero temperature coefficient) | sect = section(s)                                                                |
| coef = coefficient                                                                                                                                                                                                                                    | h = henries                | nsr = not separately replaceable                            | Si = silicon                                                                     |
| com = common                                                                                                                                                                                                                                          | Hg = mercury               | obd = order by description                                  | sil = silver                                                                     |
| comp = composition                                                                                                                                                                                                                                    | impd = impregnated         | p = peak                                                    | sl = slide                                                                       |
| conn = connection                                                                                                                                                                                                                                     | incd = incandescent        | pc = printed circuit board                                  | td = time delay                                                                  |
| crt = cathode-ray tube                                                                                                                                                                                                                                | ins = insulation (ed)      | pf = picofarads = $10^{-12}$ farads                         | TiO <sub>2</sub> = titanium dioxide                                              |
| dep = deposited                                                                                                                                                                                                                                       | K = kilo = 1000            | pp = peak to peak                                           | tog = toggle                                                                     |
| EIA = Tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications; tubes and transistors selected for best performance will be supplied if ordered by stock numbers. | lin = linear taper         | piv = peak inverse voltage                                  | tol = tolerance                                                                  |
|                                                                                                                                                                                                                                                       | log = logarithmic taper    | pos = position (s)                                          | trim = trimmer                                                                   |
|                                                                                                                                                                                                                                                       | m = milli = $10^{-3}$      | poly = polystyrene                                          | twr = traveling wave tube                                                        |
|                                                                                                                                                                                                                                                       | M = megohms                | pot = potentiometer                                         | var = variable                                                                   |
|                                                                                                                                                                                                                                                       | ma = milliamperes          | rect = rectifier                                            | w/ = with                                                                        |
|                                                                                                                                                                                                                                                       | $\mu$ = micro = $10^{-6}$  |                                                             | W = watts                                                                        |
|                                                                                                                                                                                                                                                       | minat = miniature          |                                                             | ww = wirewound                                                                   |
|                                                                                                                                                                                                                                                       | mfgl = metal film on glass |                                                             | w/o = without                                                                    |
|                                                                                                                                                                                                                                                       | mfr = manufacturer         |                                                             | * = optimum value selected at factory, average value shown (part may be omitted) |

Table 7-1. Replaceable Parts

| REFERENCE DESIGNATOR | -hp- PART NO. |  | TQ | DESCRIPTION                                                                                                                                                                                        | MFR.  | MFR. PART NO.     |
|----------------------|---------------|--|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------------------|
| A1                   | 00400-66505   |  | 1  | Assembly: board etched circuit includes<br>C1 through C6<br>K1 through K2<br>R1 through R7                                                                                                         | 28480 | 00400-66505       |
| A1C1                 | 0150-0012     |  | 1  | C: fxd cer 0.01 $\mu$ f $\pm$ 20% 1000 vdcw                                                                                                                                                        | 56289 | 29C214A3          |
| A1C2                 | 0132-0003     |  | 1  | C: var trimmer 0.7 to 3.0 pf                                                                                                                                                                       | 72982 | 535-016-4R        |
| A1C3                 | 0150-0093     |  | 2  | C: fxd 0.01 $\mu$ f +80% -20% 100 vdcw                                                                                                                                                             | 91418 | TA obd            |
| A1C4                 | 0140-0179     |  | 1  | C: fxd mica 1000 pf $\pm$ 2%                                                                                                                                                                       | 04062 | RDM19F102G3C      |
| A1C5                 | 0140-0156     |  | 1  | C: fxd mica 1500 pf $\pm$ 2%                                                                                                                                                                       | 04062 | RDM19F152G3C      |
| A1C6                 | 0150-0093     |  |    | C: fxd 0.01 $\mu$ f +80% -20% 100 vdcw                                                                                                                                                             | 91418 | TA obd            |
| A1K1                 | 0490-0195     |  | 1  | Relay: reed high voltage                                                                                                                                                                           | 28480 | 0490-0195         |
| A1K2                 | 0490-0196     |  | 1  | Relay: reed low voltage                                                                                                                                                                            | 28480 | 0490-0196         |
| A1R1                 | 0757-0346     |  | 2  | R: fxd prec met film 10 ohms $\pm$ 1% 1/8 w                                                                                                                                                        | 91637 | MFF1/8 T-O obd    |
| A1R2                 | 0698-4128     |  | 1  | R: fxd prec met film 10 meg $\pm$ 0.25%                                                                                                                                                            | 03888 | PME 70-T-2        |
| A1R3                 | 0684-2211     |  | 2  | R: fxd comp 220 ohms $\pm$ 10% 1/4 w                                                                                                                                                               | 01121 | CB-2211           |
| A1R4                 | 0698-4475     |  | 1  | R: fxd prec met film 9.76 K $\pm$ 1% 1/8 w                                                                                                                                                         | 91637 | MFF1/8 T-O obd    |
| A1R5                 | 0683-0625     |  | 1  | R: fxd comp 6.2 ohms $\pm$ 5% 1/4 w                                                                                                                                                                | 01121 | CB-62G5           |
| A1R6                 | 0684-2211     |  |    | R: fxd comp 220 ohms $\pm$ 10% 1/4 w                                                                                                                                                               | 01121 | CB-2211           |
| A1R7                 | 2100-1799     |  | 1  | R: var ww 500 ohms $\pm$ 10% 1 w                                                                                                                                                                   | 02660 | 2600 Series       |
| A2                   | 00400-66504   |  | 1  | Assembly: board etched circuit includes<br>C1 through C12 CR19 through CR23<br>C15 through C34 L1, L2<br>C36 through C41 Q1 through Q17<br>CR1 through CR12 R1 through R18<br>CR16 R20 through R75 | 28480 | 00400-66504       |
| A2C1                 | 0180-0100     |  | 10 | C: fxd Ta 4.7 $\mu$ f $\pm$ 10% 35 vdcw                                                                                                                                                            | 56289 | 1500475X9035B2    |
| A2C2                 | 0150-0122     |  | 3  | C: fxd 0.002 $\mu$ f $\pm$ 20% 500 vdcw                                                                                                                                                            | 72982 | 801-000-Y55-202M  |
| A2C3                 | 0180-0119     |  | 1  | C: fxd Al elect 1 $\mu$ f +75% -10% 25 vdcw                                                                                                                                                        | 56289 | 30D105G025BA2-DSM |
| A2C4                 | 0180-0137     |  | 2  | C: fxd Ta elect 100 $\mu$ f $\pm$ 20% 10 vdcw                                                                                                                                                      | 56289 | 150D107X0010R2    |
| A2C5                 | 0150-0084     |  | 1  | C: fxd cer 0.1 $\mu$ f +80% -20% 50 vdcw                                                                                                                                                           | 56289 | 33C41 obd         |
| A2C6                 | 0160-2024     |  | 1  | C: fxd 75 pf $\pm$ 5% 500 vdcw                                                                                                                                                                     | 28480 | 0160-2024         |
| A2C7                 | 0180-0106     |  |    | C: fxd Ta elect 60 $\mu$ f $\pm$ 20% 6 vdcw                                                                                                                                                        | 56289 | 150D606X0006B2    |
| A2C8                 | 0180-0100     |  |    | C: fxd Ta 4.7 $\mu$ f $\pm$ 10% 35 vdcw                                                                                                                                                            | 56289 | 1500475X9035B2    |
| A2C9                 | 0140-0198     |  | 1  | C: fxd mica 200 pf $\pm$ 5% 300 vdcw                                                                                                                                                               | 04062 | RDM15F201J3C      |
| A2C10                | 0180-0100     |  |    | C: fxd Ta 4.7 $\mu$ f $\pm$ 10% 35 vdcw                                                                                                                                                            | 56289 | 1500475X9035B2    |
| A2C11                | 0150-0122     |  |    | C: fxd 0.002 $\mu$ f $\pm$ 20% 500 vdcw                                                                                                                                                            | 72982 | 801-000-Y55-202M  |
| A2C12                | 0180-0100     |  |    | C: fxd Ta 4.7 $\mu$ f $\pm$ 10% 35 vdcw                                                                                                                                                            | 56289 | 1500475X9035B2    |
| A2C13, A2C14         |               |  |    | Not Assigned                                                                                                                                                                                       |       |                   |
| A2C15                | 0180-0061     |  | 3  | C: fxd Al elect 100 $\mu$ f +75% -10% 15 vdcw                                                                                                                                                      | 56289 | 30D107G015DC2-DSM |
| A2C16                | 0180-0100     |  |    | C: fxd Ta 4.7 $\mu$ f $\pm$ 10% 35 vdcw                                                                                                                                                            | 56289 | 1500475X9035B2    |
| A2C17                | 0180-1819     |  | 2  | C: fxd Al elect 100 $\mu$ f +75% -10% 50 vdcw                                                                                                                                                      | 56289 | 30D107G050DH2-DSM |
| A2C18                | 0150-0024     |  | 2  | C: fxd cer 0.02 $\mu$ f +80% -20% 600 vdcw                                                                                                                                                         | 72982 | 841-000-25U-203Z  |
| A2C19                | 0180-0100     |  |    | C: fxd Ta 4.7 $\mu$ f $\pm$ 10% 35 vdcw                                                                                                                                                            | 56289 | 1500475X9035B2    |
| A2C20                | 0180-0061     |  |    | C: fxd Al elect 100 $\mu$ f +75% -10% 15 vdcw                                                                                                                                                      | 56289 | 30D107G015DC2-DSM |
| A2C21                | 0180-1819     |  |    | C: fxd Al elect 100 $\mu$ f +75% -10% 50 vdcw                                                                                                                                                      | 56289 | 30D107G050DH2-DSM |
| A2C22                | 0150-0024     |  |    | C: fxd cer 0.02 $\mu$ f +80% -20% 600 vdcw                                                                                                                                                         | 72982 | 841-000-25U-203Z  |
| A2C23                | 0180-0061     |  |    | C: fxd Al elect 100 $\mu$ f +75% -10% 15 vdcw                                                                                                                                                      | 56289 | 30D107G015DC2-DSM |
| A2C24, A2C25         | 0180-0100     |  |    | C: fxd Ta 4.7 $\mu$ f $\pm$ 10% 35 vdcw                                                                                                                                                            | 56289 | 1500475X9035B2    |
| A2C26                | 0180-0058     |  | 1  | C: fxd Al elect 50 $\mu$ f +75% -10% 25 vdcw                                                                                                                                                       | 56289 | 30D506G025CC2-DSM |

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

| REFERENCE DESIGNATOR  | -hp- PART NO. |    | T Q | DESCRIPTION                                               | MFR.  | MFR. PART NO.    |
|-----------------------|---------------|----|-----|-----------------------------------------------------------|-------|------------------|
| A2C27                 | 0150-0122     |    |     | C: fxd 0.002 $\mu$ f $\pm 20\%$ 500 vdcw                  | 72982 | 801-000-Y55-202M |
| A2C28                 | 0140-0195     | 1  |     | C: fxd 130 pf mica $\pm 5\%$ 300 vdcw                     | 04062 | RDM15F131J3C     |
| A2C29                 | 0140-0190     | 1  |     | C: fxd mica 39 pf $\pm 5\%$                               | 04062 | RDM15E390J3C     |
| A2C30                 | 0180-0224     | 1  |     | C: fxd Al elect 10 $\mu$ f 15 vdcw                        | 56289 | 30D106G015BA4    |
| A2C31                 | 0140-0208     | 1  |     | C: fxd mica 680 pf $\pm 5\%$ 300 vdcw                     | 04062 | RDM15F681J3C     |
| A2C32, A2C33          | 0180-0137     |    |     | C: fxd Ta elect 100 $\mu$ f $\pm 20\%$ 10 vdcw            | 56289 | 150D107X0010R2   |
| A2C34                 | 0180-0100     |    |     | C: fxd Ta 4.7 $\mu$ f $\pm 10\%$ 35 vdcw                  | 56289 | 1500475X9035B2   |
| A2C35                 |               |    |     | Not Assigned                                              |       |                  |
| A2C36                 | 0121-0127     | 1  |     | C: var 1.7 to 11 pf single section                        | 74970 | 189-5-5          |
| A2C37*                | 0160-0205     | 1  |     | C: fxd mica 10 pf $\pm 5\%$ 500 vdcw                      | 56289 | 73P73P223016     |
| A2C38, A2C39          | 0180-0393     | 2  |     | C: fxd Ta 39 $\mu$ f $\pm 10\%$ 10 vdcw                   | 56289 | 150D396X9010B2   |
| A2C40                 | 0180-0100     |    |     | C: fxd Ta 4.7 $\mu$ f $\pm 10\%$ 35 vdcw                  | 56289 | 1500475X9035B2   |
| A2C41                 | 0140-0149     | 1  |     | C: fxd mica 470 pf $\pm 5\%$ 300 vdcw                     | 04062 | DM15F471J        |
| A2CR1                 | 1902-0022     | 2  |     | Diode: breakdown 2.67 v $\pm 10\%$ 4 mw                   | 07910 | CD35540          |
| A2CR2                 | 1901-0044     | 2  |     | Diode: Si 50 ma at +1 v 10 na reverse current 50 wiv 2 pf | 07910 | obd              |
| A2CR3                 | 1901-0040     | 10 |     | Diode: Si 30 ma at +10 v piv 12 pf 2 ns                   | 07910 | CD6319 obd       |
| A2CR4                 | 1901-0044     |    |     | Diode: Si 50 ma at +1 v 10 na reverse current 50 wiv 2 pf | 07910 | obd              |
| A2CR5                 | 1902-0022     |    |     | Diode: breakdown 2.67 v $\pm 10\%$ 4 mw                   | 07910 | CD35540          |
| A2CR6 through A2CR11  | 1901-0033     | 6  |     | Diode: Si 100 ma at 1 v 180 wiv 1N485B                    | 93332 | D6238 obd        |
| A2CR12                | 1901-0040     |    |     | Diode: Si 30 ma at +10 v piv 12 pf 2 ns                   | 07910 | CD6319 obd       |
| A2CR13                | 1902-3125     | 1  |     | Diode: Si 6.98 v $\pm 2\%$ 400 mw                         | 07263 | obd              |
| A2CR14, A2CR15        |               |    |     | Not Assigned                                              |       |                  |
| A2CR16                | 1901-0040     |    |     | Diode: Si 30 ma at +10 v piv 12 pf 2 ns                   | 07910 | CD6319 obd       |
| A2CR17, A2CR18        |               |    |     | Not Assigned                                              |       |                  |
| A2CR19 through A2CR21 | 1901-0040     |    |     | Diode: Si 30 ma at +10 v piv 12 pf 2 ns                   | 07910 | CD6319 obd       |
| A2CR22, A2CR23        | 1901-0027     | 2  |     | Diode: Si 1N4392                                          | 73293 | obd              |
| A2L1, A2L2            | 9140-0047     | 2  |     | Inductor: fxd 20 $\mu$ h $\pm 10\%$                       | 99848 | H 51074020       |
| A2Q1                  | 1855-0029     | 1  |     | Transistor: FET P channel                                 | 61637 | F5035            |
| A2Q2                  | 1854-0215     | 7  |     | Transistor: Si NPN 2N3904                                 | 04713 | 2N3904           |
| A2Q3                  | 1853-0036     | 7  |     | Transistor: Si PNP 2N3906                                 | 04713 | 2N2906           |
| A2Q4                  | 1854-0039     | 2  |     | Transistor: Si NPN 2N3052                                 | 86684 | 2N3053           |
| A2Q5, A2Q6            | 1854-0215     |    |     | Transistor: Si NPN 2N3904                                 | 04713 | 2N3904           |
| A2Q7, A2Q8            | 1853-0036     | 6  |     | Transistor: Si PNP 2N3906                                 | 04713 | 2N3906           |
| A2Q9                  | 1854-0039     |    |     | Transistor: Si NPN 2N3053                                 | 86684 | 2N3053           |
| A2Q10                 | 1854-0215     |    |     | Transistor: Si NPN 2N3904                                 | 04713 | 2N3904           |
| A2Q11                 | 1853-0036     |    |     | Transistor: Si PNP 2N3906                                 | 04713 | 2N3906           |
| A2Q12 through A2Q14   | 1854-0215     |    |     | Transistor: Si NPN 2N3904                                 | 04713 | 2N3904           |
| A2Q15 through A2Q17   | 1853-0036     |    |     | Transistor: Si PNP 2N3906                                 | 04713 | 2N3906           |
| A2R1                  | 0698-4121     | 5  |     | R: fxd prec comp 11.3 K $\pm 1\%$ 1/8 w                   | 75042 | CEA T-O obd      |
| A2R2                  | 0757-0474     | 4  |     | R: fxd prec met flm 243 K $\pm 1\%$ 1/8 w                 | 91637 | MFF-1/8 T-O obd  |
| A2R3                  | 0757-0434     | 12 |     | R: fxd prec met flm 3.65 K $\pm 1\%$ 1/8 w                | 91637 | MFF-1/8 T-O obd  |
| A2R4                  | 0698-3178     | 2  |     | R: fxd prec met flm 487 ohms $\pm 1\%$ 1/8 w              | 91637 | MFF-1/8 T-O obd  |
| A2R5                  | 0698-4196     | 5  |     | R: fxd prec met flm 1.07 K $\pm 1\%$ 1/8 w                | 91637 | MFF-1/8 T-O obd  |
| A2R6                  | 2100-0095     | 1  |     | R: var comp lin 100 K $\pm 30\%$ 0.10 w                   | 71450 | UPE 70RE (hp)    |
| A2R7                  | 0686-2265     | 1  |     | R: fxd comp 22 meg $\pm 5\%$ 1/2 w                        | 01121 | EB-2265          |
| A2R8                  | 0757-0410     | 1  |     | R: fxd prec met flm 301 ohms $\pm 1\%$ 1/8 w              | 91637 | MFF-1/8 T-O obd  |

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

| REFERENCE DESIGNATOR | -hp- PART NO. |   | T Q | DESCRIPTION                                   | MFR.  | MFR. PART NO.   |
|----------------------|---------------|---|-----|-----------------------------------------------|-------|-----------------|
| A2R9                 | 0757-0434     |   |     | R: fxd prec met flm 3.65 K $\pm 1\%$ 1/8 w    | 91637 | MFF-1/8 T-O obd |
| A2R10                | 0698-3510     | 2 |     | R: fxd prec met flm 453 ohms $\pm 1\%$ 1/8 w  | 91637 | MFF-1/8 T-O obd |
| A2R11                | 0698-4457     | 1 |     | R: fxd prec met flm 576 ohms $\pm 1\%$ 1/8 w  | 91637 | MFF-1/8 T-O obd |
| A2R12                | 0757-0474     |   |     | R: fxd met flm 243 K $\pm 1\%$ 1/8 w          | 91637 | MFF-1/8 T-O obd |
| A2R13                | 0757-0434     |   |     | R: fxd prec met flm 3.65 K $\pm 1\%$ 1/8 w    | 91637 | MFF-1/8 T-O obd |
| A2R14                | 0698-4396     | 2 |     | R: fxd prec met flm 80.6 ohms $\pm 1\%$ 1/8 w | 91637 | MFF-1/8 T-O obd |
| A2R15                | 0698-4121     |   |     | R: fxd prec met flm 11.3 K $\pm 1\%$ 1/8 w    | 75042 | CEA T-O obd     |
| A2R16                | 0757-0428     | 1 |     | R: fxd prec met flm 1.62 K $\pm 1\%$ 1/8 w    | 75042 | CEA T-O obd     |
| A2R17                | 0757-0808     | 1 |     | R: fxd prec met flm 301 ohms $\pm 1\%$ 1/2 w  | 75042 | CEC T-O obd     |
| A2R18                | 0757-0401     | 5 |     | R: fxd prec met flm 100 ohms $\pm 1\%$ 1/8 w  | 75042 | CEA T-O obd     |
| A2R19                |               |   |     | Not Assigned                                  |       |                 |
| A2R20                | 0757-0794     | 2 |     | R: fxd prec met flm 68.1 ohms $\pm 1\%$ 1/2 w | 91637 | MFF-1/2 T-O obd |
| A2R21                | 0698-4196     |   |     | R: fxd prec met flm 1.07 K $\pm 1\%$ 1/8 w    | 91637 | MFF-1/8 T-O obd |
| A2R22, A2R23         | 0757-0434     |   |     | R: fxd prec met flm 3.65 K $\pm 1\%$ 1/8 w    | 91637 | MFF-1/8 T-O obd |
| A2R24                | 0757-0290     | 2 |     | R: fxd prec met flm 6.19 K $\pm 1\%$ 1/8 w    | 91637 | MFF-1/8 T-O obd |
| A2R25                | 0698-4121     |   |     | R: fxd prec met flm 11.3 K $\pm 1\%$ 1/8 w    | 75042 | CEA T-O obd     |
| A2R26                | 0757-0447     | 1 |     | R: fxd prec met flm 16.2 K $\pm 1\%$ 1/8 w    | 75042 | CEA T-O obd     |
| A2R27                | 0698-3155     | 1 |     | R: fxd prec met flm 4.64 K $\pm 1\%$ 1/8 w    | 91637 | MFF-1/8 T-O obd |
| A2R28, A2R29         | 0757-0434     |   |     | R: fxd prec met flm 3.65 K $\pm 1\%$ 1/8 w    | 91637 | MFF-1/8 T-O obd |
| A2R30                | 0698-3156     | 4 |     | R: fxd prec met flm 14.7 K $\pm 1\%$ 1/8 w    | 75042 | CEA T-O obd     |
| A2R31                | 0757-0794     |   |     | R: fxd prec met flm 68.1 ohms $\pm 1\%$ 1/2 w | 91637 | MFF-1/2 T-O obd |
| A2R32                | 0698-4196     |   |     | R: fxd prec met flm 1.07 K $\pm 1\%$ 1/8 w    | 91637 | MFF-1/8 T-O obd |
| A2R33                | 0757-0474     |   |     | R: fxd met flm 243 K $\pm 1\%$ 1/8 w          | 91637 | MFF-1/8 T-O obd |
| A2R34                | 0757-0401     |   |     | R: fxd met flm 100 ohms $\pm 1\%$ 1/8 w       | 75042 | CEA T-O obd     |
| A2R35, A2R36         | 0757-0434     |   |     | R: fxd prec met flm 3.65 K $\pm 1\%$ 1/8 w    | 91637 | MFF-1/8 T-O obd |
| A2R37                | 0757-0438     | 1 |     | R: fxd prec met flm 5.11 K $\pm 1\%$ 1/8 w    | 75042 | CEA T-O obd     |
| A2R38                | 0698-3156     |   |     | R: fxd prec met flm 14.7 K $\pm 1\%$ 1/8 w    | 75042 | CEA T-O obd     |
| A2R39                | 0698-3510     |   |     | R: fxd prec met flm 453 ohms $\pm 1\%$ 1/8 w  | 91637 | MFF-1/8 T-O obd |
| A2R40                | 0698-3438     | 2 |     | R: fxd prec met flm 147 ohms $\pm 1\%$ 1/8 w  | 91637 | MFF-1/8 T-O obd |
| A2R41                | 0698-4196     |   |     | R: fxd prec met flm 1.07 K $\pm 1\%$ 1/8 w    | 91637 | MFF-1/8 T-O obd |
| A2R42                | 0757-0401     |   |     | R: fxd prec met flm 100 ohms $\pm 1\%$ 1/8 w  | 75042 | CEA T-O obd     |
| A2R43                | 0757-0408     | 1 |     | R: fxd prec met flm 243 ohms $\pm 1\%$ 1/8 w  | 75042 | CEA T-O obd     |
| A2R44                | 0698-3156     |   |     | R: fxd prec met flm 14.7 K $\pm 1\%$ 1/8 w    | 75042 | CEA T-O obd     |
| A2R45                | 0757-0277     | 1 |     | R: fxd prec met flm 49.9 ohms $\pm 1\%$ 1/8 w | 91637 | MFF-1/2 T-2     |
| A2R46                | 0757-0441     | 1 |     | R: fxd prec met flm 8.25 K $\pm 1\%$ 1/8 w    | 75042 | CEA T-O obd     |
| A2R47                | 0698-3157     | 2 |     | R: fxd prec met flm 19.6 K $\pm 1\%$ 1/8 w    | 75042 | CEA T-O obd     |
| A2R48                | 0757-0401     |   |     | R: fxd prec met flm 100 ohms $\pm 1\%$ 1/8 w  | 75042 | CEA T-O obd     |
| A2R49                | 0698-3156     |   |     | R: fxd prec met flm 14.7 K $\pm 1\%$ 1/8 w    | 75042 | CEA T-O obd     |
| A2R50                | 0757-0434     |   |     | R: fxd prec met flm 3.65 K $\pm 1\%$ 1/8 w    | 91637 | MFF-1/8 T-O obd |
| A2R51                | 0698-4121     |   |     | R: fxd met flm 11.3 K $\pm 1\%$ 1/8 w         | 75042 | CEA T-O obd     |
| A2R52                | 0757-0444     | 1 |     | R: fxd prec met flm 12.1 K $\pm 1\%$ 1/8 w    | 75042 | CEA T-O obd     |
| A2R53                | 0698-4121     |   |     | R: fxd met flm 11.3 K $\pm 1\%$ 1/8 w         | 75042 | CEA T-O obd     |
| A2R54                | 0757-0401     |   |     | R: fxd prec met flm 100 ohms $\pm 1\%$ 1/8 w  | 75042 | CEA T-O obd     |
| A2R55                | 0698-3438     |   |     | R: fxd prec met flm 147 ohms $\pm 1\%$ 1/8 w  | 91637 | MFF-1/8 T-O obd |
| A2R56                | 0698-3450     | 2 |     | R: fxd prec met flm 42.2 K $\pm 1\%$ 1/8 w    | 91637 | MFF-1/8 T-O obd |
| A2R57                | 0757-0408     | 1 |     | R: fxd prec met flm 243 ohms $\pm 1\%$ 1/8 w  | 91637 | MFF-1/8 T-O obd |
| A2R58, A2R59         | 2100-0290     | 2 |     | R: var prec ww 100 ohms $\pm 2\%$ 1-1/2 w     | 11237 | 110 obd         |
| A2R60                | 0698-4396     |   |     | R: fxd prec met flm 80.6 ohms $\pm 1\%$ 1/8 w | 91637 | MFF-1/8 T-O obd |
| A2R61                | 0698-3157     |   |     | R: fxd prec met flm 19.6 K $\pm 1\%$ 1/8 w    | 75042 | CEA T-O obd     |
| A2R62                | 2100-0240     | 1 |     | R: var ww 50 ohms $\pm 20\%$ 1-1/2 w          | 11237 | 110 obd         |
| A2R63                | 0757-0161     | 1 |     | R: fxd prec 604 ohms $\pm 1\%$ 1/8 w          | 28480 | 0757-0161       |
| A2R64                | 0698-3434     | 1 |     | R: fxd 34.8 ohms $\pm 1\%$ 1/8 w              | 75042 | CEA T-O obd     |
| A2R65                | 0757-0381     | 1 |     | R: fxd prec met flm 15 ohms $\pm 1\%$ 1/8 w   | 91637 | MFF-1/8 T-O obd |
| A2R66                | 0757-0384     | 1 |     | R: fxd prec met flm 20 ohms $\pm 1\%$ 1/8 w   | 91637 | MFF-1/8 T-O obd |



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

| REFERENCE DESIGNATOR | -hp- PART NO. | TQ | DESCRIPTION                                                    | MFR.  | MFR. PART NO.      |
|----------------------|---------------|----|----------------------------------------------------------------|-------|--------------------|
| A2R67                | 0757-0346     | 1  | R: fxd prec met flm 10 ohms $\pm 1\%$ 1/8 w                    | 91637 | MFF-1/8 T-O obd    |
| A2R68                | 2100-0277     |    | R: var comp lin 100 ohms $\pm 2\%$ 0.3 w                       | 71450 | Type UPE65 CV      |
| A2R69                | 0698-4196     |    | R: fxd prec met flm 1.07 K $\pm 1\%$ 1/8 w                     | 91637 | MFF-1/8 T-O obd    |
| A2R70                | 0698-3450     |    | R: fxd met flm 42.2 K $\pm 1\%$ 1/8 w                          | 91637 | MFF-1/8 T-O obd    |
| A2R71                | 0757-0290     |    | R: fxd prec met flm 6.19 K $\pm 1\%$ 1/8 w                     | 91637 | MFF-1/8 T-O obd    |
| A2R72                | 0698-3178     | 2  | R: fxd prec met flm 487 ohms $\pm 1\%$ 1/8 w                   | 91637 | MFF-1/8 T-O obd    |
| A2R73                | 0757-0474     |    | R: fxd prec met flm 243 K $\pm 1\%$ 1/8 w                      | 91637 | MFF-1/8 T-O obd    |
| A2R74, A2R75         | 0757-0434     |    | R: fxd prec met flm 3.65 K $\pm 1\%$ 1/8 w (400FL Only, A2R75) | 91637 | MFF-1/8 T-O obd    |
| C1                   | 0180-0106     |    | C: fxd Ta 60 $\mu$ f $\pm 20\%$ 6 vdcw (400FL Only)            | 56289 | 150D606X006B2      |
| CR1                  | 1901-0040     |    | Diode: Si (400F Only) 30 ma at +10 v piv 12 pf 2 ns            | 07910 | CD6319 obd         |
| DS1                  | 1450-0048     | 1  | Lamp: pilot A165 red transparent                               | 72765 | 599-124            |
| F1                   | 2110-0017     | 1  | Fuse: 0.15 amp slow-blow 115/230 v                             | 75915 | 313.150            |
| J1 through J3        | 1251-0148     | 1  | See MP5, MP6, MP10, and MP11                                   | 87930 | H-1061-2           |
| J4                   |               |    | Connector: ac power cord receptacle                            |       |                    |
| L1, L2               |               |    | Inductor: fxd 2.5 mh $\pm 10\%$                                |       |                    |
| M1                   |               |    | Meter: linear (400F Only)                                      |       |                    |
| M1                   |               |    | Meter: log (400FL Only)                                        |       |                    |
| M1                   | 1120-1273     | 1  | Meter: linear (400F Only, Option 01)                           | 28480 | 1120-1273          |
| MP1                  | 0340-0090     | 1  | Insulator: 2 hole BP with locating key                         | 28480 | 0340-0090          |
| MP2                  | 0340-0086     | 1  | Insulator: 2 hole without locating key                         | 28480 | 0340-0086          |
| MP3                  | 0340-0087     | 1  | Insulator: 3 hole BP in line                                   | 28480 | 0340-0087          |
| MP4                  | 0340-0091     | 1  | Insulator: 3 hole BP with locating key                         | 28480 | 0340-0091          |
| MP5                  | 1510-0010     | 3  | Binding Post Ass'y: red battery voltage and ac output          | 28480 | 1510-0010          |
| MP6                  | 1510-0011     | 2  | Binding Post Ass'y: black rear panel                           | 28480 | 1510-0011          |
| MP7                  | 00400-00605   | 1  | Shield: meter                                                  | 28480 | 00400-00605        |
| MP8                  | 0370-0113     | 1  | Knob: bar with one arrow part of S1 black                      | 28480 | 0370-0113          |
| MP9                  | 0370-0115     | 1  | Knob: bar red with pointer part of S2                          | 28480 | 0370-0115          |
| MP10                 | 1510-0035     | 1  | Binding Post Ass'y: black INPUT                                | 28480 | 1510-0035          |
| MP11                 | 1510-0036     | 1  | Binding Post Ass'y: red INPUT                                  | 28480 | 1510-0036          |
| MP12                 | 0340-0099     | 2  | Insulator: binding post (single)                               | 28480 | 0340-0099          |
| MP13                 | 0340-0100     | 1  | Insulator: binding post (single)                               | 28480 | 0340-0100          |
| MP14                 | 0340-0109     | 6  | Insulator: nylon threaded                                      | 02768 | 212-160402-00-0101 |
| MP15                 | 00400-05502   | 1  | Can: shield                                                    | 28480 | 00400-05502        |
| MP16                 | 00400-04102   | 1  | Cover: attenuator                                              | 28480 | 00400-04102        |
| MP17                 | 1205-0033     | 2  | Semiconductor: heat dissipator                                 | 05820 | NF-207             |
| MP18                 | 00400-00207   | 1  | Panel: front (400FL Only)                                      | 28480 | 00400-00207        |
| MP19                 | 00400-00208   | 1  | Panel: front (400F Only)                                       | 28480 | 00400-00208        |
| MP20                 | 5020-0704     | 1  | Trim: meter third mod                                          | 28480 | 5020-0704          |
| MP21                 | 5040-0700     | 2  | Hinge                                                          | 28480 | 5040-0700          |
| MP22                 | 1490-0031     | 1  | Stand: 1/3 mod tilt                                            | 91260 | obd                |
| MP23                 | 5060-0727     | 2  | Foot Ass'y: 1/3 mod                                            | 28480 | 5060-0727          |
| MP24                 | 5000-0711     | 1  | Cover Ass'y: bottom 5 x 11 sm                                  | 28480 | 5000-0711          |
| MP25                 | 5000-0703     | 2  | Cover Ass'y: side 6 x 11 sm                                    | 28480 | 5000-0703          |
| MP26                 | 5060-0703     | 2  | Frame: sub mod 6 x 11                                          | 28480 | 5060-0703          |
| MP27                 | 5060-0709     | 1  | Cover Ass'y: top 5 x 11 sm                                     | 28480 | 5060-0709          |
| MP28                 | 00400-00206   | 1  | Panel: rear                                                    | 28480 | 00400-00206        |
| R1                   | 0687-3331     | 1  | R: fxd comp 33 K $\pm 10\%$ 1/2 w                              | 01121 | EB-3331            |
| S1                   | 00400-61903   | 1  | Switch Assembly: range includes C1 CR1, CR2 R1 through R15     | 28480 | 00400-61903        |
| S1C1                 | 0160-0207     | 1  | C: fxd mylar 0.01 $\mu$ f $\pm 5\%$ 200 v                      | 56289 | 192P10352          |
| S1CR1, S1CR2         | 1901-0040     |    | Diode: Si 30 ma at +10 v piv 12 pf 2 ns                        | 07910 | CD6319 obd         |

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

| REFERENCE DESIGNATOR | -hp- PART NO. |  | TQ | DESCRIPTION                                          | MFR.  | MFR. PART NO. |
|----------------------|---------------|--|----|------------------------------------------------------|-------|---------------|
| S1R1                 | 0757-0167     |  | 1  | R: fxd prec 143 ohms $\pm 1\%$ 1/4 w                 | 19701 | MF6C T-O obd  |
| S1R2 through S1R6    | 0698-4118     |  | 5  | R: fxd met flm prec 277.48 ohms $\pm 0.1\%$ 1/4 w    | 75042 | CEB T-3 obd   |
| S1R7 through S1R12   | 0698-4119     |  | 6  | R: fxd met flm prec 410.26 ohms $\pm 0.1\%$ 1/4 w    | 75042 | CEB T-3 obd   |
| S1R13                | 0698-4117     |  | 1  | R: fxd met flm prec 189.72 ohms $\pm 0.1\%$ 1/4 w    | 75042 | CEB T-3 obd   |
| S1R14, S1R15         | 0687-1501     |  | 2  | R: fxd comp 150 ohms $\pm 10\%$ 1/2 w                | 28480 | 0687-1501     |
| S2                   |               |  |    | P/o RANGE switch assembly S1                         |       |               |
| S3                   | 3101-0036     |  | 1  | Switch: toggle SPST On-None-Off 3 amps 25 v          | 88140 | 8928K61       |
| S4                   | 3101-0033     |  | 1  | Switch: slide DPDT 115/230 v                         | 42190 | 4633 obd      |
| T1                   | 9100-1321     |  | 1  | Transformer                                          | 28480 | 9100-1321     |
| TP1 through TP4      | 0360-0435     |  | 4  | Terminal: board silver plated brass                  | 12284 | 1012-3        |
| W1                   | 00400-61602   |  | 1  | Cable 1 : power                                      | 28480 | 00400-61602   |
| W2                   | 00400-61603   |  | 1  | Cable 2 : meter                                      | 28480 | 00400-61603   |
| XF1                  | 1400-0084     |  | 1  | Holder: fuse extractor post type                     | 75915 | 342014        |
|                      |               |  |    | <u>MISCELLANEOUS</u>                                 |       |               |
|                      | 8120-0078     |  | 1  | Cord: set power smooth black extra limp 7.5 ft. long | 70903 | KH-4147       |
|                      | 00400-90003   |  | 1  | Manual: operating and service                        | 28480 | 00400-90003   |

# APPENDIX

## CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

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

| Code No. | Manufacturer                                               | Address                  | Code No. | Manufacturer                                                 | Address                        | Code No. | Manufacturer                                                 | Address                 | Code No. | Manufacturer                     | Address               |
|----------|------------------------------------------------------------|--------------------------|----------|--------------------------------------------------------------|--------------------------------|----------|--------------------------------------------------------------|-------------------------|----------|----------------------------------|-----------------------|
| 00589    | U.S.A. Common                                              | Any supplier of U.S.     | 07115    | Corning Glass Works                                          | Bradford, Pa.                  | 26555    | General Radio Co.                                            | West Concord, Mass.     | 73233    | Hughes Products Division of      |                       |
| 00135    | McCoy Electronics                                          | Mount Holly Springs, Pa. |          | Electronic Components Dept.                                  |                                | 26365    | Gries Reproduction Corp.                                     | New Rochelle, N.Y.      |          | Hughes Aircraft Co.              | Newport Beach, Calif. |
| 00213    | Sage Electronics Corp.                                     | Rochester, N. Y.         | 07126    | Digitac Co.                                                  | Pasadena, Calif.               | 26462    | Gabel Film Co. of America, Inc.                              | Carlsbad, N.J.          | 73445    | Amperex Electronic Co., Div. of  | North                 |
| 00334    | Hemond Co.                                                 | Colton, Calif.           | 07137    | Transistor Electronics Corp.                                 | Minneapolis, Minn.             | 26592    | Hamilton Watch Co.                                           | Longwood, Pa.           |          | American Phillips Co., Inc.      | St. Paul, N.Y.        |
| 00335    | Washco Corp.                                               | New York, N.Y.           | 07138    | Westinghouse Electric Corp.                                  |                                | 28480    | Hewlett-Packard Co.                                          | Palo Alto, Calif.       | 73490    | Beckman Medical Corp.            | San Francisco, Calif. |
| 00373    | Garlock Packing Co.                                        |                          |          | Electronic Tube Div.                                         | Elmira, N.Y.                   | 33173    | G.E. Rotorwing Tube Dept.                                    | Glenview, Ill.          | 73506    | Bradley Semiconductor Corp.      | Hamden, Conn.         |
|          | Electronic Products Div.                                   | Camden, N.J.             | 07149    | Filmac Corp.                                                 | New York, N.Y.                 | 35434    | Leetech Inc.                                                 | Chicago, Ill.           | 73559    | Carling Electric, Inc.           | Marlton, Conn.        |
| 00696    | Aerovox Corp.                                              | New Bedford, Mass.       | 07233    | Crutch-Graphic Co.                                           | City of New York, Calif.       | 35196    | Slawny Corp.                                                 | Hamlet, Ontario, Canada | 73682    | George W. Garrett Co., Inc.      | Philadelphia, Pa.     |
| 00779    | Aero, Inc.                                                 | Harrisburg, Pa.          | 07261    | Avnet Corp.                                                  | Los Angeles, Calif.            | 37942    | P.R. Mallory & Co., Inc.                                     | Indianapolis, Ind.      | 73734    | Federal Screw Prod. Co.          | Chicago, Ill.         |
| 00861    | Aircraft Radio Corp.                                       | Bentley, N.J.            | 07280    | Fairchild Semiconductor Corp.                                |                                | 39543    | Mechanical Industries Prod. Co.                              | Akron, Ohio             | 73743    | Fischer Special Mfg. Co.         | Cincinnati, Ohio      |
| 00815    | Nonlinear Engineering Laboratories, Inc.                   | Burlington, Wis.         |          | Mountain View, Calif.                                        |                                | 40920    | Minuteman Precision Ball Bearings, Inc.                      | Chicago, Ill.           | 73793    | The General Industries Co.       | Elyria, Ohio          |
|          |                                                            |                          | 07322    | Minnesota Rubber Co.                                         | Minneapolis, Minn.             | 42190    | Nutcr Co.                                                    | Chicago, Ill.           | 73846    | Gashin Stamping & Tool Co.       | Cosham, Ind.          |
| 00853    | Sergano Electric Company, Drill Division (Capacitors)      | Merion, Ill.             | 07387    | The Blitcher Corp.                                           | Los Angeles, Calif.            | 43990    | C.A. Norren Co.                                              | Englewood, Colo.        | 73899    | JFB Electronics Corp.            | Brooklyn, N.Y.        |
| 00856    | Goe Engineering Co.                                        | Los Angeles, Calif.      | 07700    | Technical White Products                                     | Springfield, N.J.              | 44555    | Omrite Mfg. Co.                                              | Sinkie, Ill.            | 73905    | Jennings Radio Mfg. Co.          | San Jose, Calif.      |
| 00891    | CalE, Holmes Corp.                                         | Los Angeles, Calif.      | 07910    | Continental Device Corp.                                     | Mountain View, Calif.          | 47504    | Polestar Corp.                                               | Cambridge, Mass.        | 74276    | Signalite Inc.                   | Wachter, Mass.        |
| 01121    | Allen Bradley Co.                                          | Milwaukee, Wis.          | 07933    | Rheon Semiconductor Corp.                                    |                                | 48520    | Precision Thermometers and Inst. Co.                         | Philadelphia, Pa.       | 74455    | J.H. Wines and Sons              | Chicago, Ill.         |
| 01255    | Leton Industries, Inc.                                     | Beverly Hills, Calif.    | 07956    | Shockey Semi-Conductor Laboratories                          | Palo Alto, Calif.              | 49556    | Raytheon Company                                             | Lexington, Mass.        | 74461    | Industrial Condenser Corp.       | Danbury, Conn.        |
| 01281    | TRW Semiconductors Inc.                                    | Lawrenceville, Calif.    | 07980    | Boonton Radio Corp.                                          | Boonton, N.J.                  | 52090    | Roman Controller Co.                                         | Baltimore, Md.          | 74868    | R.F. Products Division of Aphon- |                       |
| 01295    | Texas Instruments, Inc.                                    |                          | 08145    | U.S. Engineering Co.                                         | Los Angeles, Calif.            | 61743    | Ward Leonard Electric                                        | St. Louis, Mo.          |          | Borg Electronics Corp.           | Danbury, Conn.        |
|          | Transistor Products Div.                                   | Dallas, Texas            | 08285    | Blum, Delbert Co.                                            | Pomona, Calif.                 | 54294    | Ward Leonard Mfg. Co.                                        | Selma, N.C.             | 74970    | E.F. Johnson Co.                 | Essex, Minn.          |
| 01349    | The Alliance Mfg. Co.                                      | Alliance, Ohio           | 08346    | Burgess Battery Co.                                          | Niagara Falls, Ontario, Canada | 55826    | Simpson Electric Co.                                         | Chicago, Ill.           | 75173    | James, Howard B., Division of    | Philadelphia, Pa.     |
| 01561    | Chassis-Tron Corp.                                         | Indianapolis, Ind.       |          |                                                              |                                | 55933    | Sonolene Corp.                                               | Elmwood, N.Y.           |          | Cinch Mfg. Corp.                 | Chicago, Ill.         |
| 01589    | Pacific Relays, Inc.                                       | Van Nuys, Calif.         | 08717    | Sloan Company                                                | Burbank, Calif.                | 55938    | Sorenson & Co., Inc.                                         | So. Norwalk, Conn.      | 75376    | James Knights Co.                | Sandwich, Ill.        |
| 01930    | Amsco Corp.                                                | Rochester, Ind.          | 08718    | Cannon Electric Co., Phoenix Div.                            | Phoenix, Ariz.                 | 56137    | Spaulding Fibre Co., Inc.                                    | Tonawanda, N.Y.         | 75382    | Kulko Electric Corporation       | Mt. Vernon, N.Y.      |
| 01961    | Pulse Engineering Corp.                                    | Stato Clara, Calif.      | 08792    | CBS Electronics Semiconductor Operations Div. of C.B.S. Inc. | Lowell, Mass.                  | 56289    | Sprague Electric Co.                                         | North Adams, Mass.      | 75818    | Lenz Electric Mfg. Co.           | Chicago, Ill.         |
| 02114    | Fenoscabo Corp. of America                                 | Smyth, N.Y.              | 08804    | Mel-Ram                                                      | Indianapolis, Ind.             | 59445    | Tela, Inc.                                                   | St. Paul, Minn.         | 75915    | Littlelite Inc.                  | Des Plaines, Ill.     |
| 02286    | Cole Mfg. Co.                                              | Palo Alto, Calif.        | 09026    | Babcock Relays, Inc.                                         | Chicago, Ill.                  | 59738    | Thomas & Betts Co.                                           | Elizabethtown, N.J.     | 76005    | Loir Mfg. Co.                    | Elgin, Pa.            |
| 02580    | Amphenol-Rog Electronics Corp.                             | Chicago, Ill.            | 09145    | Texas Capacitor Co.                                          | Houston, Texas                 | 61741    | Thompson Electrical Inc.                                     | Bloomington, Ohio       | 76210    | C.W. Marwedel                    | San Francisco, Calif. |
| 02735    | Radio Corp. of America, Semiconductor and Materials Div.   | Somerville, N.J.         | 09145    | Alatom Electronics                                           | San Valley, Calif.             | 61775    | Union Switchgear & Signal Div. of Westinghouse Air Brake Co. | Swissvale, Pa.          | 76433    | Microfilm Electronic Mfg. Corp.  | Brooklyn, N.Y.        |
|          |                                                            |                          | 09569    | Electro Assemblies, Inc.                                     | Chicago, Ill.                  |          |                                                              |                         | 76487    | James Milne & Co., Inc.          | Walden, Mass.         |
| 02771    | Vocaline Co. of America, Inc.                              | Old Saybrook, Conn.      | 09569    | Mallory Battery Co. of Canada, Ltd.                          | Toronto, Ontario, Canada       | 63139    | Universal Electric Co.                                       | Dowagiac, Mich.         | 76493    | J.W. Muller Co.                  | Los Angeles, Calif.   |
| 02777    | Hopkins Engineering Co.                                    | San Fernando, Calif.     | 09569    | The Bristol Co.                                              | Worcester, Mass.               | 63743    | Ward Leonard Electric Co., Inc.                              | ML Yermac, N.Y.         | 76988    | Menard Mills                     | San Leandro, Calif.   |
| 03580    | G.E. Semiconductor Products Dept.                          | Syracuse, N.Y.           | 10214    | General Transistor Western Corp.                             | Los Angeles, Calif.            | 64599    | Western Electric Co., Inc.                                   | New York, N.Y.          | 76988    | Muller Electric Co.              | Cleveland, Ohio       |
| 03705    | Apex Machine & Tool Co.                                    | Darien, Ohio             |          |                                                              |                                | 65992    | Westonist, Div. of Ampco, Inc.                               | Newark, N.J.            | 76988    | Quincy Electric Co.              | Cleveland, Ohio       |
| 03757    | Elenco Corp.                                               | El Monte, Calif.         | 10411    | Tri-Tel, Inc.                                                | Beltsville, Md.                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 03877    | Transamerica Electronic Corp.                              | Worcester, Mass.         | 10446    | Carbide & Carbon Co.                                         | Niagara Falls, N.Y.            | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 03888    | Pyrostat Resistor Co.                                      | Marlton, N.J.            | 11235    | CTS of Desae, Inc.                                           | Berne, Ind.                    | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 03954    | Air Marine Motors, Inc.                                    | Los Angeles, Calif.      | 11237    | Chicago Telephone of California, Inc.                        | San Francisco, Calif.          | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 04089    | Atow, Nait and Hagenan Elect. Co.                          | Haltford, Conn.          |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 04113    | Tayco Corp.                                                | Lambertville, N.J.       |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 04122    | Elenco Products Co.                                        | New York, N.Y.           |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 04122    | HQ Divisional Airways                                      | Myrtle Beach, S.C.       |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 04299    | Elgin National Watch Co., Electronics Division             | Barabank, Calif.         |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 04358    | Precision Paper Tube Co.                                   | Chicago, Ill.            |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 04401    | Dynac Division of Hewlett-Packard Co.                      | Palo Alto, Calif.        |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 04551    | Sylvania Electric Prods., Inc.                             |                          |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
|          | Electronic Tube Div.                                       | Mountain View, Calif.    |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 04713    | Motorola, Inc., Semiconductor Prod. Div.                   |                          |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
|          |                                                            |                          |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 04732    | Fulton Co., Inc., Western Div.                             | Culver City, Calif.      |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 04773    | Automatic Electric Co.                                     | Northlake, Ill.          |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 04777    | Automatic Electric Sales Corp.                             | Northlake, Ill.          |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 04796    | Sequoyia Wire & Cable Co.                                  | Redwood City, Calif.     |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 04811    | Precision Coil Spring Co.                                  | Elmhurst, Ill.           |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 04870    | P.M. Motor Company                                         | Chicago 46, Ill.         |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 05005    | Twentieth Century Plastics, Inc.                           | Los Angeles, Calif.      |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
|          |                                                            |                          |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 05277    | Westinghouse Electric Corp., Semi-Conductor Dept.          | Youngwood, Pa.           |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 05367    | Ulticon, Inc.                                              | San Mateo, Calif.        |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 05593    | Illuminex Engineering Co.                                  | Sunnyvale, Calif.        |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 05616    | Cosmo Plastic                                              |                          |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
|          | (E.T.A. Electrical Spec. Co.)                              | Cleveland, Ohio          |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 05624    | Barber-Cushman Co.                                         | Rochester, Ill.          |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 05728    | Tello Optical Co.                                          |                          |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
|          |                                                            |                          |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 05729    | Metropolitan Telecommunications Corp., Metro Cap. Division | Brooklyn, N.Y.           |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 05783    | Stewart Engineering Co.                                    | San Francisco, Calif.    |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 05820    | Wakefield Engineering Inc.                                 | Wakefield, Mass.         |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 06004    | The Bassett Co.                                            | Bridgeport, Conn.        |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 06175    | Bausch & Lomb Optical Co.                                  | Rochester, N.Y.          |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 06402    | E.T.A. Products Co. of America                             | Chicago 18, Ill.         |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 06475    | Western Devices, Inc.                                      | Ingleswood, Calif.       |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 06480    | Amulco Electronic Hardware Co., Inc.                       | New Rochelle, N.Y.       |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 06555    | Bande Electrical Instrument Co., Inc.                      | Pennock, N.H.            |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 06751    | U.S. Sensor Division of Instructa Corp. of America         | Phoenix, Arizona         |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 06812    | Toninon Mfg. Co., West Div.                                | Van Nuys, Calif.         |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |
| 07006    | Kahn Electric Co.                                          |                          |          |                                                              |                                | 66285    | Willens Optical Co.                                          | Rochester, N.Y.         | 76988    | Shelton Electric Co.             | Crystal Lake, Ill.    |



# **APPENDIX** **CODE LIST OF MANUFACTURERS (Sheet 2 of 2)**

| Code No. | Manufacturer                                                          | Address               | Code No. | Manufacturer                                      | Address               | Code No. | Manufacturer                                                            | Address                | Code No. | Manufacturer                                           | Address              |
|----------|-----------------------------------------------------------------------|-----------------------|----------|---------------------------------------------------|-----------------------|----------|-------------------------------------------------------------------------|------------------------|----------|--------------------------------------------------------|----------------------|
| 81349    | Military Specification                                                | .....                 | 85474    | R. N. Macomate & Co.                              | San Francisco, Calif. | 93929    | G. V. Controls                                                          | Lynn, Mass., N. J.     | 98226    | Francis L. Mosley                                      | Pasadena, Calif.     |
| 81415    | Wilbur Products, Inc.                                                 | Cleveland, Ohio       | 85660    | Koried Kords, Inc.                                | New Haven, Conn.      | 93983    | Insuline-Van Norman Ind., Inc.                                          | Manchester, N.H.       | 98278    | Nicodol, Inc.                                          | So. Pasadena, Calif. |
| 81453    | Raytheon Mfg. Co., Industrial Components Div., Indus. Tube Operations | Newton, Mass.         | 85911    | Seamless Rubber Co.                               | Chicago, Ill.         | 94137    | General Cable Corp.                                                     | Bayonne, N.J.          | 98191    | Sealecote Corp.                                        | Manassas, N.Y.       |
| 81483    | International Rectifier Corp.                                         | El Segundo, Calif.    | 86197    | Clifton Precision Products                        | Clifton Heights, Pa.  | 94144    | Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation | Quincy, Mass.          | 98405    | Caad Corp.                                             | Redwood City, Calif. |
| 81541    | The Arco Products Co.                                                 | Cambridge, Mass.      | 86579    | Precision Rubber Products Corp.                   | Dayton, Ohio          | 94145    | Raytheon Mfg. Co., Semiconductor Div.,                                  | California Steel Plant | 98771    | General Mills                                          | Minneapolis, Minn.   |
| 81860    | Garry Controls, Inc.                                                  | Watertown, Mass.      | 86684    | Roth Corp. of America, RCA Electron Tube Div.     | Harrison, N.J.        | 94148    | Scientific Radio Products, Inc.                                         | Loveland, Colo.        | 98821    | North Hills Electric Co.                               | Minneapolis, N.Y.    |
| 82042    | Carier Parts Co.                                                      | St. Louis, Ill.       | 87216    | Phillips Corporation (Lansdale Division)          | Lansdale, Pa.         | 94154    | Teng-Sol Electric, Inc.                                                 | Newark, N.J.           | 98925    | Clevite Transistor Prod.                               | Cleveland, Ohio      |
| 82142    | Jellies Electronics Division of                                       | .....                 | 87473    | Western Fiberglass Glass Products Co.             | San Francisco, Calif. | 94197    | Optics-Weight Corp.,                                                    | East Paterson, N.J.    | 98978    | International Electronic                               | Burbank, Calif.      |
| 82170    | Allen B. Dumas Lab., Inc.                                             | Clifton, N.J.         | 87664    | Van Waters & Rogers, Inc.                         | Seattle, Wash.        | 94272    | Seitico Div. OIS, Chester Cold,                                         | Leser, Pa.             | 99109    | Columbia Technical Corp.                               | New York, N.Y.       |
| 82209    | Magnite Industries, Inc.                                              | Greenwich, Conn.      | 87930    | Towm Mfg. Corp.                                   | Providence, R. I.     | 94310    | Tra Dm Prod. Div. of Model Engineering and Mfg. Co.                     | Chicago, Ill.          | 99313    | Varian Associates                                      | Palo Alto, Calif.    |
| 82219    | Sylvania Electric Prod., Inc.                                         | Emporium, Pa.         | 88140    | Cutler-Hammer, Inc.                               | Lincoln, Ill.         | 94330    | Win Cloth Products Inc.                                                 | Chicago, Ill.          | 99515    | Marshall Industries, Electron Products Division        | Pasadena, Calif.     |
| 82376    | Asiron Co.                                                            | East Newark, N.J.     | 88220    | Cauld-National Batteries, Inc.                    | St. Paul, Minn.       | 94682    | Worcester Pressed Aluminum Corp.                                        | Worcester, Mass.       | 99707    | Cambridge Division, Contois Co. of America             | El Segundo, Calif.   |
| 82389    | Switchall, Inc.                                                       | Chicago, Ill.         | 88698    | General Mills, Inc.                               | Buffalo, N.Y.         | 95023    | Philbrick Remanufacturers, Inc.                                         | Boston, Mass.          | 99848    | Delavan Electronics Corp.                              | East Aurora, N.Y.    |
| 82647    | Wetland Controls, Inc., Div. of Texas Instruments, Inc.,              | Spencer, Mass.        | 89231    | Grysser Electric Co.                              | Durham, Calif.        | 95026    | Allison Products Corp.                                                  | Waco, Fla.             | 99934    | Resbands, Inc.                                         | Boston, Mass.        |
| 82866    | Research Products Corp.                                               | Madison, Wis.         | 89462    | Walden Robinson, Inc.                             | Cambridge, Mass.      | 95038    | Continental Connector Corp.                                             | Woodside, N.Y.         | 99942    | Hoffman Semiconductor Div. of Holcom Electronics Corp. | Evanston, Ill.       |
| 82977    | Horton Manufacturing Co., Inc.                                        | Woodstock, N.Y.       | 89635    | Carier Parts Div. of Economy Haler Co.            | Chicago, Ill.         | 95236    | Lecon Electronics, Inc.                                                 | Burbank, Calif.        | 99957    | Technology Instrument Corp. of Calif.                  | Newbury Park, Calif. |
| 82993    | Vectra Electronic Co.                                                 | Glendale, Calif.      | 89665    | United Transformer Co.                            | Chicago, Ill.         | 95265    | National Coil Co.                                                       | Shelton, Conn.         |          |                                                        |                      |
| 83053    | Western Wash Air Mfr. Co.                                             | Los Angeles, Calif.   | 90179    | U.S. Rubber Co., Mechanical Goods Div.            | Pasadena, N.J.        | 95275    | Vivian, Inc.                                                            | Bridgeport, Conn.      |          |                                                        |                      |
| 83058    | Carri Fastener Co.                                                    | Cambridge, Mass.      | 90870    | Bearing Engineering Co.                           | San Francisco, Calif. | 95348    | Cardas Corp.                                                            | Bloomfield, N.J.       |          |                                                        |                      |
| 83086    | New Hampshire Ball Bearing, Inc.                                      | Peterborough, N.H.    | 91260    | Conair Spring Mfg. Co.                            | San Francisco, Calif. | 95349    | Method Mfg. Co.                                                         | Chicago, Ill.          |          |                                                        |                      |
| 83125    | Pyramid Electric Co.                                                  | Dartmouth, S.C.       | 91345    | Miller Dial & Nameplate Co.                       | El Monte, Calif.      | 95712    | Dace Electric Co., Inc.                                                 | Franklin, Ind.         |          |                                                        |                      |
| 83148    | Electro Cords Co.                                                     | Los Angeles, Calif.   | 91418    | Radio Materials Co.                               | Chicago, Ill.         | 95987    | Heckesser Co.                                                           | Chicago, Ill.          |          |                                                        |                      |
| 83186    | Victory Engineering Corp.                                             | Springfield, N.J.     | 91506    | August Brothers, Inc.                             | Alhambra, Mass.       | 96067    | Higgins Laboratories                                                    | Sandyvale, Calif.      |          |                                                        |                      |
| 83258    | Bendix Corp., Arm Bank Div.                                           | Red Bank, N.J.        | 91637    | Dale Electronics, Inc.                            | Columbus, Ohio        | 96085    | Hi-Q Division of Aerovox                                                | Dixon, N.Y.            |          |                                                        |                      |
| 83315    | Hubbell Corp.                                                         | Buffalo, N.Y.         | 91662    | Eico Corp.                                        | Philadelphia, Pa.     | 96256    | Therapysa-Melroe Div. of Wiggins Industries, Inc.                       | Los Angeles, Calif.    |          |                                                        |                      |
| 83330    | Smith, Henson H., Inc.                                                | Brooklyn, N.Y.        | 91727    | Emcor Mfg. Co., Inc.                              | Woburn, Mass.         | 96330    | Solar Manufacturing Co.                                                 | Chicago, Ill.          |          |                                                        |                      |
| 83383    | General Screw Co.                                                     | Chicago, Ill.         | 91827    | KF Development Co.                                | Rehoboth, Calif.      | 96341    | Carlton Screw Co.                                                       | Burlington, Mass.      |          |                                                        |                      |
| 83501    | Gavitt Ruc and Cable Co., Div. of Aerotec Corp.                       | Brookfield, Mass.     | 91929    | Metropolis-Honeywell Modulator Co.                | Freeport, N.J.        | 96501    | Excel Transformer Co.                                                   | Oakland, Calif.        |          |                                                        |                      |
| 83596    | Burroughs Corp.                                                       | Plainsboro, N.J.      | 91961    | Nash-Dash Spring Co.                              | Oakland, Calif.       | 96504    | Industrial Retaining Ring Co.                                           | Irvine, N.J.           |          |                                                        |                      |
| 83740    | Eveready Battery                                                      | New York, N.Y.        | 92180    | Tru-Connector Corp.                               | Peabody, Mass.        | 97539    | Automatic and Precision Mfg. Co.                                        | Yonkers, N.Y.          |          |                                                        |                      |
| 83777    | Model Eng. and Mfg., Inc.                                             | Huntington, Ind.      | 92196    | Universal Metal Prod., Inc.                       | Bassett, Pa.          |          |                                                                         |                        |          |                                                        |                      |
| 83801    | Lloyd Scientific Co.                                                  | Foster, Mo.           | 92367    | Eigen Optical Co., Inc.                           | Rochester, N.Y.       |          |                                                                         |                        |          |                                                        |                      |
| 84171    | Arco Electronics, Inc.                                                | New York, N.Y.        | 92607    | Thasolite Insulated Wire Co.                      | Tariffville, N.Y.     |          |                                                                         |                        |          |                                                        |                      |
| 84198    | A. J. Giesener Co., Inc.                                              | San Francisco, Calif. | 92332    | Sylvania Electric Prod., Inc., Semiconductor Div. | Woburn, Mass.         |          |                                                                         |                        |          |                                                        |                      |
| 84441    | Gand All Electric Mfg. Co.                                            | Dagallo, Mo.          | 93369    | Rubens and Myers, Inc.                            | New York, N.Y.        |          |                                                                         |                        |          |                                                        |                      |
| 84970    | Series Tactian, Inc.                                                  | Bloomington, Ind.     | 93410    | Stevens Mfg. Co., Inc.                            | Wausau, Ohio          |          |                                                                         |                        |          |                                                        |                      |
| 85454    | Boston Molding Company                                                | Boston, Mass.         | 93788    | Horned J. Smith Inc.                              | Portsmouth, N. J.     |          |                                                                         |                        |          |                                                        |                      |
| 85471    | A. B. Boyd Co.                                                        | San Francisco, Calif. |          |                                                   |                       |          |                                                                         |                        |          |                                                        |                      |

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

|       |                                           |                        |
|-------|-------------------------------------------|------------------------|
| J0000 | Winchester Electronics, Inc.              | San Monica, Calif.     |
| 0000F | Meco Tool and Die                         | Los Angeles, Calif.    |
| 0000M | Western Coil Div. of Automatic Ind., Inc. | Redwood City, Calif.   |
| 0000P | Ty-Cor Mfg. Co., Inc.                     | Holliston, Mass.       |
| 0000Z | How Leather Products Corp.                | Newark, N.J.           |
| 0000A | British Radio Electronics Ltd.            | Washington, D.C.       |
| 0000B | ETA                                       | England                |
| 0000C | Indiana General Corp., Elect. Div.        | Indianapolis, Ind.     |
| 0000D | Precision Instrument Components Co.       | Van Nuys, Calif.       |
| 0000M | Rubber Eng. & Development                 | Baywood, Calif.        |
| 0000N | A. W. Manufacturing Co.                   | San Jose 27, Calif.    |
| 0000Q | Control                                   | Oakland, Calif.        |
| 0000S | Control of Elgin Watch Co.                | Burlington, N.Y.       |
| 0000W | California Eastern Lab.                   | Burlington, N.Y.       |
| 0000V | S.K. Smith Co.                            | Los Angeles 45, Calif. |



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# MANUAL BACKDATING CHANGES

Model MODEL 400F/FL

Name AC VOLTMETER

Prefix \_\_\_\_\_

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

| Instrument Serial Prefix | Make Manual Changes |
|--------------------------|---------------------|
| 617-00450 and below      | 1, 2, 3, 4, 6, 8    |
| 617-00451 thru 617-01525 | 2, 3, 4, 6, 8       |
| 734-01526 thru 734-02775 | 3, 4, 6, 8          |
| 912-02776 thru 912-02875 | 4, 5, 6, 8          |
| 912-02876 thru 912-02975 | 5, 6                |
| 912-02976 thru 912-03475 | 6                   |

## CHANGE NO. 1

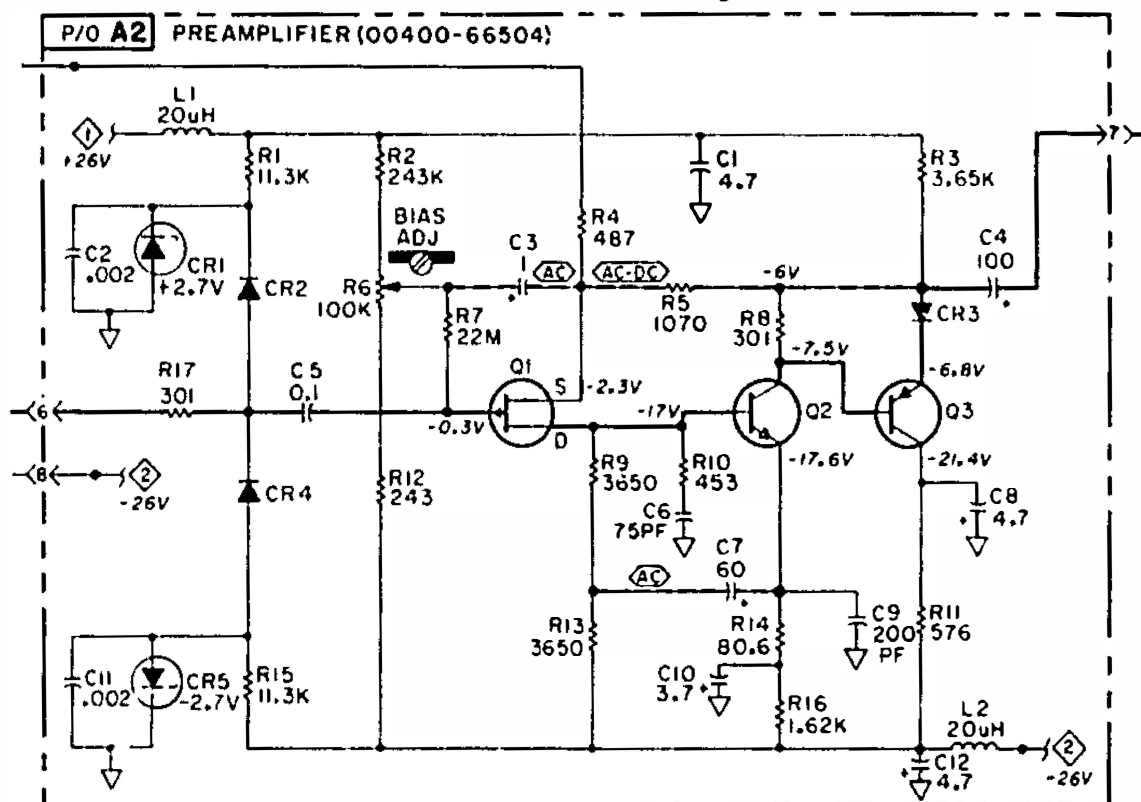
Delete diodes A2CR24 through A2CR28 from Figure 7-2, Figure 7-3, and Table 6-1.

| Instrument Serial Prefix | Make Manual Changes |
|--------------------------|---------------------|
| All                      | 7                   |
|                          |                     |
|                          |                     |
|                          |                     |
|                          |                     |
|                          |                     |

## CHANGE NO. 2

Paragraph 5-30(b), change "+ 6 V" to "- 6 V," Figure 7-3:

Change PREAMPLIFIER schematic to the following:



**Table 6-1:**

Change A2Q1 to 1855-0052 FET P channel.

Change A2Q2 to 1854-0314 Si NPN.

Change A2Q3 to 1853-0036 Si PNP.

**CHANGE NO. 3**

Figure 7-3 and Table 6-1:

A2R33, 0757-0474, R:fxd prec met flm  $243\text{ k}\Omega \pm 1\%$  1/8W

A2R39, 0698-3510, R:fxd prec met flm  $453\text{ }\Omega \pm 1\%$  1/8W

A2R40, 0698-3438, R:fxd prec met flm  $147\text{ }\Omega \pm 1\%$  1/8W

**CHANGE NO. 4**

Figure 7-3 and Table 6-1:

A2R63, 0757-0417, R:fxd prec met flm  $562\text{ }\Omega \pm 1\%$  1/8W

**CHANGE NO. 5**

Figure 7-3 and Table 6-1:

A2R33, 0698-4125, R:fxd prec met flm  $953\text{ }\Omega \pm 1\%$  1/8W

A2R39, 0698-4422, R:fxd prec met flm  $1.27\text{ k}\Omega \pm 1\%$  1/8W

A2R40, 0698-3488, R:fxd prec met flm  $442\text{ }\Omega \pm 1\%$  1/8W

**CHANGE NO. 6**

Table 6-1:

J4, 1251-0148, Connector: ac power cord receptacle, 87930,  
H-1061-2

MP24, 00400-00206, Panel: rear, -hp-  
8120-0078, Cord: power

**CHANGE NO. 7**

The part numbers listed are for brown instruments. The  
part numbers for blue instruments are shown below.

|      |             |                      |
|------|-------------|----------------------|
| MP22 | 00400-64102 | Cover Assy: top      |
| MP25 | 5000-0703   | Cover Assy: side     |
| MP26 | 5000-0711   | Cover Assy: bottom   |
| MP30 | 00400-00207 | Panel: front (400FL) |
|      | 00400-00208 | Panel: front (400F)  |
| MP31 | 5020-0704   | Trim: meter (400FL)  |
|      | 5030-5388   | Trim: meter (400F)   |

**CHANGE NO. 8**

Table 6-1:

A2R63\*, 0698-4468, R:fxd flm  $1.13\text{ k}\Omega \pm 1\%$  1/8W



# MANUAL CHANGES

|                         |             |
|-------------------------|-------------|
| Manual for Model Number | 400F/FL     |
| Manual printed on       | July 1974   |
| Manual Part Number      | 00400-90016 |

Make all ERRATA corrections.

Check the following table for your instrument serial prefix/serial number and make the listed changes to your manual.

► New Item

| Serial Prefix or<br>Serial Number |           | Manual<br>Changes | Serial Prefix or<br>Serial Number |  | Manual<br>Changes |
|-----------------------------------|-----------|-------------------|-----------------------------------|--|-------------------|
| 1212G01321                        | and above | 1                 |                                   |  |                   |
| 1202G01426                        | and above | 1-2               |                                   |  |                   |
| 1202G01591                        | and above | 1-3               |                                   |  |                   |
| 1641G01681                        | and above | 1-4               |                                   |  |                   |

## INDEX OF MANUAL CHANGES

**Page 2**

# MANUAL CHANGE 1

On Table 6-1, change the Table of Replaceable Parts to read:

|          |             |                                         |
|----------|-------------|-----------------------------------------|
| A1C1     | 0160-2902   | C:FXD CER 0.01UF + 20% 1000V            |
| A1C2     | 0132-0003   | C:VAR TRIMMER 3.0PF                     |
| A1C3,6   | 0160-2930   | C:FXD CER 0.01UF +80 -20% 100V          |
| A2C5     | 0160-2914   | C:FXD CER 0.1UF +80 -20% 50V            |
| A2C18,22 | 0160-2897   | C:FXD CER 0.02UF +80 -20% 600V          |
| A2C41    | 0160-2940   | C:FXD MICA 470PF +5% 300V               |
| A2C6     | DELETE      |                                         |
| A2R10    | DELETE      |                                         |
| A2CR22   | 1901-0535   | DIODE HOT CARRIER                       |
| A2Q3     | 1854-0329   | TRANSISTOR SI NPN                       |
| A2R5     | 0698-4125   | R:FXD FILM 953 OHM + 1% 1/8W            |
| A2R60*   | 0757-0392   | VALUE SELECTED AT FACTORY, LOWEST VALUE |
|          |             | 43,2 OHM.                               |
| A2R69    | 0757-1097   | R:FXD FILM 1.2K + 1% 1/8W               |
| MP24     | 00400-10006 | PANEL REAR                              |
| MP30     | 00400-00102 | PANEL FRONT                             |
| MP31     | 5020-7633   | TRIM METER                              |
| MP32     | 5060-0703   | BRACKET: COVER RETAINER                 |
| DS1      | 1450-0419   | LAMP - PILOT                            |
| S3       | 3101-0030   | SWITCH TOGGLE                           |

For Instruments equipped with German "Schuko" Power cable  
change power cord to 8120-1689

# MANUAL CHANGE 2

On Table 6-1, change the Holder Fuse 1400-0084 to the following Components:

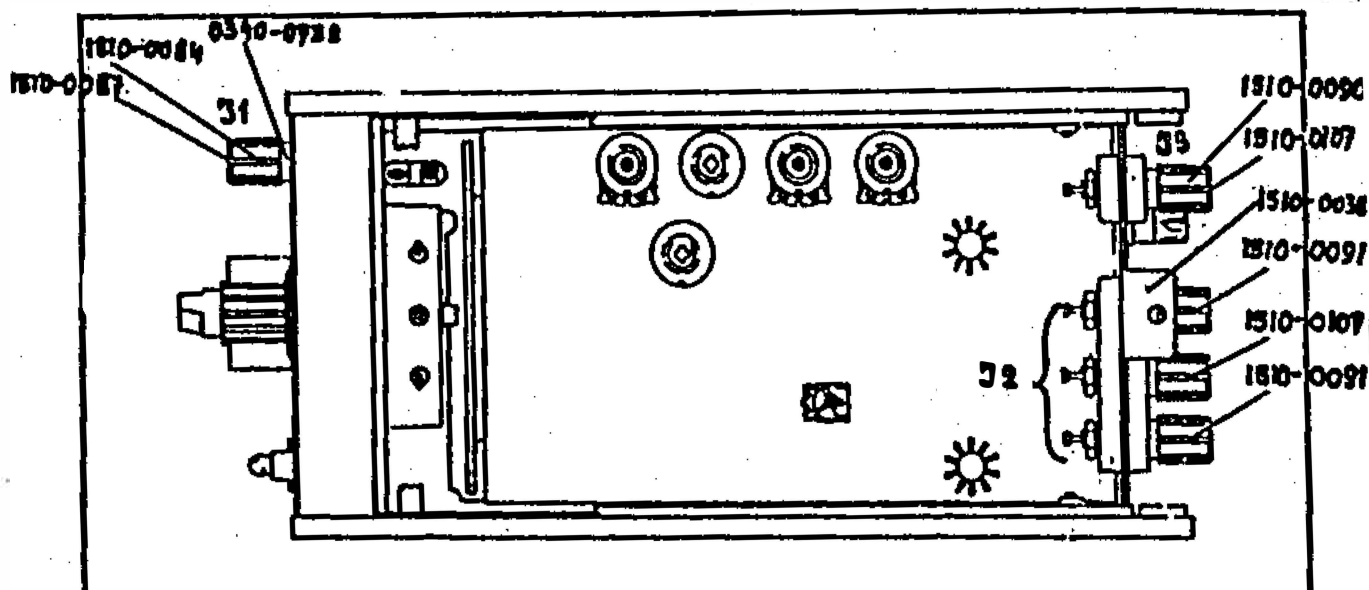
|     |           |                    |
|-----|-----------|--------------------|
| MP5 | 2110-0470 | FUSEHOLDER BODY    |
| MP5 | 1400-0090 | WASHER NEOPRENE    |
| MP5 | 2190-0054 | WASHER LOCK        |
| MP5 | 2110-0467 | NUT HEX (METALLIC) |
| MP5 | 2110-0465 | FUSEHOLDER CAP     |

### MANUAL CHANGE 3

On Table 6-1, change the Table of Replaceable Parts to read:

|                     |             |                        |
|---------------------|-------------|------------------------|
| MP24                | 00400-60212 | PANEL ASSY REAR        |
| MP1,2,3,4,6,7,12,13 | DELETE      |                        |
|                     | 0340-0732   | INSULATOR BINDING POST |
|                     | 1510-0084   | BINDING POST           |
|                     | 1510-0087   | BINDING POST           |
|                     | 1510-0090   | BINDING POST           |
|                     | 1510-0091   | BINDING POST           |
|                     | 1510-0107   | BINDING POST           |
|                     | 2950-0144   | NUT NYLON, 3/8 - 32    |

NOTE: The components listed above can be identified on the diagram shown below:



### MANUAL CHANGE 4

On Table 6-1, change the Table of Replaceable Parts to read:

|      |             |                        |
|------|-------------|------------------------|
| C2   | 0160-4048   | C:FXD .022UF ACROSS J4 |
| S3   | 3101-2147   | SW SPST                |
| S4   | 3101-1740   | SW SLIDE               |
| MP24 | 00400-00246 | PANEL ASSY REAR        |
|      | 1510-0038   | BINDING POST           |



# **MANUAL CHANGES**

MODEL 400F/FL

AC VOLTMETER

Manual Part No. 00400-90016

## ■ New or Revised Item

**CHANGE NO. 1** applies to serial number 0950A-08338 and above for the 400F and serial number 0950A-08286 and above for the 400FL.

Page 6-7, Table 6-1. Add to the replaceable parts the following:

-hp- Part No. 1510-0038, TQ:1, description:BDG post-single (located on rear panel).

-hp- Part No. 7120-4609, TQ:1 description: Warning Label.

**CHANGE NO 2.** applies to serial number 0950A-08726 and above for the 400F and serial number 0950A-08766 and above for the 400FL.

Page 3-0 and 3-1, Figure 3-1 and 3-2. Change  to

Page 6-2, Figure 6-1. Change rear panel drawing to Figure CS1 of change sheet.

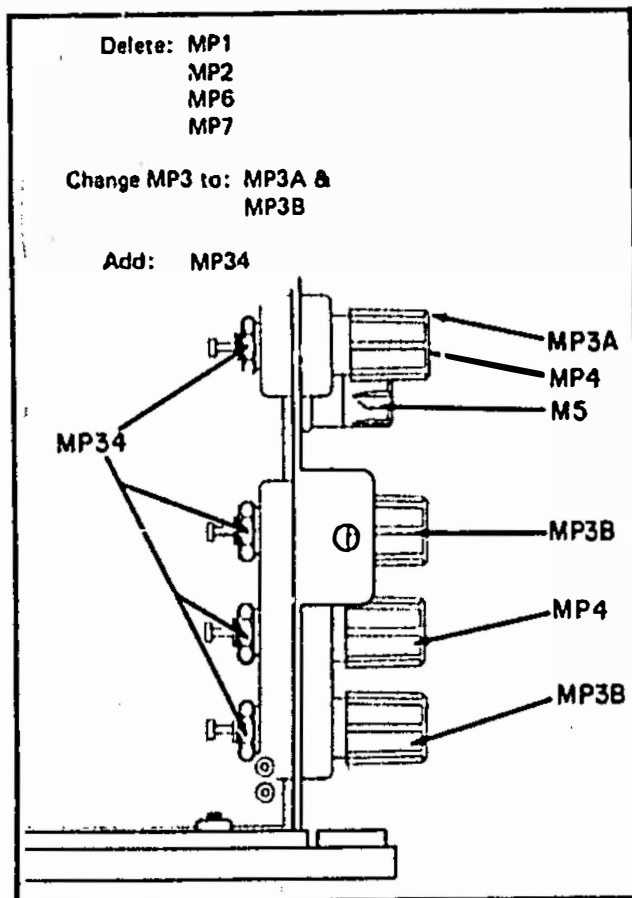


FIGURE CS1

Page 6-6, Table 6-1. Delete the following parts:

|     |           |
|-----|-----------|
| MP1 | 0340-0090 |
| MP2 | 0340-0086 |
| MP6 | 0340-0087 |
| MP7 | 0340-0091 |

Change the part numbers for the following reference designator:

|      | From        | To                 |
|------|-------------|--------------------|
| MP3  | 1510-0010   | MP3A 1510-0090 TQ1 |
|      |             | MP3B 1510-0091 TQ2 |
| MP4  | 1510-0011   | 1510-0107 TQ2      |
| MP12 | 1510-0035   | 1510-0087 TQ1      |
| MP13 | 1510-0036   | 1510-0084 TQ1      |
| MP14 | 0340-0099   | 0340-0732 TQ2      |
| MP15 | 0340-0160   | 0340-0732          |
| MP24 | 00400-00210 | 00400-00212        |

Add: MP34 2950-0144 TQ5

**CHANGE NO. 3** applies to serial number 0950A-09386 and above for the 400F and serial number 0950A-09406 and above for the 400FL.

Page 6-4, Table 6-1. Change part number and description of A2C28 from 130 pF 0140-0195 to 82 pF 0140-0193 and add a star to reference designator.

Page 7-3/7-4, Figure 7-2. On the schematic place a star next to C28 and change the value to 82 pF.

**CHANGE NO. 4** applies to serial numbers 0950A09786 and above for the 400F and serial number 0950A09836 and above for the 400FL.

Page 6-6, Table 6-1. Change the Part Number and Description for MP5 from 1400-0084-Holder:Fuse to 2110-0470-Fuhr-Extr Post and 2110-0465-Cap. Add the following part numbers and description as required hardware:

|           |         |        |
|-----------|---------|--------|
| 2110-0467 | Nut Hex | Qty. 1 |
| 1400-0090 | Washer  | Qty. 1 |
| 2190-0054 | Washer  | Qty. 1 |

**CHANGE NO. 5** applies to serial numbers 0950A10085 and above for the 400F and serial numbers 0950A10036 and above for the 400FL.

Table 6-1 on Pages 6-3, 6-4, 6-5. Change the part numbers for the following reference designators:

|       | <u>From</u> | <u>To</u>   | <u>Description</u>                                   |
|-------|-------------|-------------|------------------------------------------------------|
| A2    | 00400-66504 | 00400-66514 | Same                                                 |
| A2R6  | 2100-0095   | 2100-3214   | R:Var Comp Lin<br>100 k $\Omega$ $\pm$ 10%<br>0.10 W |
| A2R68 | 2100-0277   | 2100-0568   | Res:Var, 100 $\Omega$ $\pm$<br>10% 0.3 W             |

Page 6-4. Add to A2C37\* -hp- part number 0140-0201 the following padding list:

5 pF 500 V 0160-0763  
18 pF 300 V 0160-0366

Page 6-5. Add to A2C83\* -hp- part number 0698-4468 the following padding list:

499 ohm .01 0698-4123  
681 ohm .01 0767-0419

Page 7-3/7-4, Figure 7-2. Change A2 board from -hp- part number 00400-66504 to 00400-66514.

CHANGE NO. 6 applies to serial numbers 0950A10206 and above for the 400F and serial numbers 0950A10176 and above for the 400FL.

Page 6-4. Change A2C38, C39 from -hp- part number 0180-0393 to 0180-2795, C:Fxd Ta 39UF  $\pm$  10% 10 VDC W.

CHANGE NO. 7 applies to all serial numbers.

Page 1-1. Add the following paragraph between 1-3 and 1-4.

Options.

Option 910. An additional Operating and Service Manual part number 00400-90016.



