Errata

Title & Document Type: **6920B Meter Calibrator Operating Manual**

Manual Part Number: **06920-90001**

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Agilent Technologies

METER CALIBRATOR
MODEL 6920B
SERIAL NUMBER PREFIX 6D

January, 1967
HP Part No. 06920-9[illegible]01

SECTION I
GENERAL INFORMATION

1-1 DESCRIPTION

1-2 The Model 6920B is a feedback-regulated power source particularly suited for calibration of meters. Ten continuously variable output ranges are provided, ranging from 1 volt to 1000 volts and from 100μA to 5A full output. All ranges provide either dc or ac at the power-line frequency; however, the 100μA range is not calibrated in ac. Power output capability is from 2.5 watts in the 10A range to 10 watts in the 10, 100, and 1000 volt ranges. The ac output, while having the same waveform as the input power line, is controlled to have the correct average value. The 3 digit output dial is calibrated in terms of the RMS value of a sine wave.

1-3 The 6920B is particularly useful for production-line checking of meters for accuracy and for sticking movements. In addition, the wide range of outputs allows convenient checking of multimeters in the laboratory. Compact construction, through the use of all semiconductor circuitry, allows for easy portability.

1-4 Built-in current and voltage limiting circuits protect the 6920B from short circuit loads in voltage ranges and open-circuit loads in current ranges.

1-5 OPTIONAL EQUIPMENT

1-6 A 0.1 ohm shunt is available to extend the voltage capabilities downward to include 1mV full output, when used in conjunction with the current ranges of the 6920B. When the shunt is used, the source impedance is 0.1 ohm.

1-7 INSTRUMENT IDENTIFICATION

1-8 This manual applies only to the Model 6920B Change sheets will be supplied which include any differences between your instrument and this manual.

1-9 COOLING SYSTEM

1-10 This instrument is convection cooled and requires no maintenance except for occasional dusting. Adequate space should be provided around the unit to allow free circulation of cooling air.

1-11 POWER CABLE

1-12 A 5-foot three conductor power cable is supplied with the instrument terminated in a polarized three-prong male connector recommended by the National Electrical Manufacturers' Association (NEMA). NEMA recommends that the instrument panel and cabinet be grounded. All Hewlett-Packard instruments are equipped with a 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 pin.

1-13 To preserve the protection feature when operating the instrument from a two-prong outlet, use a three-prong to two-prong adaptor and connect the green pigtail on the adaptor to ground.

Table 1-1. Specifications

INPUT:
105-125Vac, single phase, 58-62Hz.

OUTPUT: AC or DC

.01	- 1V	to 5A
.1V	- 10V	to 1A
1V	- 100V	to 100mA
10V	- 1000V	to 10mA
1μA	- 100μA*	to 500V
10μA	- 1mA	to 500V
100μA	- 10mA	to 500V
1mA	- 100mA	to 50V
10mA	- 1A	to 5V
100mA	- 5A	to .5V

*dc only

TOTAL OUTPUT DISTORTION:
Equal to the input waveshape distortion plus 3%.

LINE REGULATION:
The accuracy specifications will be met with line voltages from 105 to 125Vac.

OUTPUT IMPEDANCE:
DC - 1 volt range: Less than 0.0005 ohms.
Other ranges: Accuracy specification is met with any load within the listed output capability.

AC - 1 volt range: Less than 0.001 ohms.
100μA range: Greater than 500 megohms.
Other ranges: Accuracy specification is met with any load within the listed output capability.

On 10Vac range - minimum load resistance 5 ohms
100Vac range - minimum load resistance 500 ohms
1000Vac range - minimum load resistance 50K ohms

Power factor of load 0.9 to 1.0 in ac ranges.

OPERATING TEMPERATURE:
0° to 50°C.
Accuracy specification met at 25 ± 10°C after 1 hour warm-up in static environment.

DC ACCURACY:
0.2% of output ±1 digit.

AC ACCURACY:
0.4% of output ±1 digit.

OVERLOAD PROTECTION:
May be shorted in voltage ranges and open-circuited in current ranges without damage.

GROUNDING:
In voltage ranges, the negative terminal is grounded.
In current ranges, both terminals are off-ground; load must be floating.

SECTION II
INSTALLATION

2-1 INCOMING INSPECTION

2-2 The instrument should be unpacked and inspected both mechanically and electrically upon receipt. Observe packing method and retain packing materials until unit has been inspected. Mechanical inspection involves checking for signs of physical damage such as scratched panel surfaces, broken knobs, etc. If damage is present, file a claim with the carrier. The electrical inspection involves checking the instrument against its specifications. Section V includes a performance check which is an in-cabinet check to verify proper instrument operation. It is recommended as an incoming inspection test. Refer to the warranty page if there is any electrical malfunction.

2-3 INSTALLATION

2-4 The meter calibrator is a portable instrument requiring no permanent installation. It is only necessary to connect the power cable supplied with the instrument to the power input and the instrument is ready for operation.

2-5 This instrument is air cooled. Sufficient space to permit free flow of cooling air around the instrument should be considered when installing. It should not be used in an area where the temperature exceeds 50°C (122°F). For rated accuracy, the temperature should be between 15°C and 35°C (59°F to 95°F).

2-6 POWER REQUIREMENTS

2-7 The 6920A operates on 115 volts 60Hz. The average input current with the output fully loaded is 1 ampere.

2-8 REPACKAGING FOR SHIPMENT

2-9 The following list is a general guide for repackaging an instrument for shipment. If you have any questions, contact your authorized Harrison Laboratories sales office.

a. Use the original container designed for the instrument. If a new container is required, a foam pack and container can be ordered from Harrison Laboratories. The stock number is given in the table of replaceable parts under "Miscellaneous."

b. Wrap the instrument in heavy paper or plastic before placing it in the shipping carton.

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

d. Use heavy cardboard carton or wooden box to house the instrument and use heavy tape or metal bands to seal the container.

e. Mark the packing box with "Fragile--Delicate Instrument," etc.

NOTE

If the instrument is to be shipped to Harrison Laboratories for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair to be accomplished. In any correspondence, be sure to identify the instrument by model number and serial number.

OPERATION

SECTION III
OPERATION

3-1 INTRODUCTION

3-2 The 6920B is ready to use as received from the factory. For maximum accuracy, allow one hour after turning on to allow the internal temperature to stabilize.

3-3 Figure 3-1 describes the operating controls and indicators.

3-4 OPERATING CONTROLS

3-5 OUTPUT SWITCH

3-6 This disconnects the output terminals when it is in the center "OFF" position. It should be "OFF" when changing loads, changing the range or function switch setting and when turning on the instrument. This insures that any voltage transients which may occur at these times do not damage the load or the operator.

3-7 When all other settings are made and the load connected, the output switch can be tipped to either the "ON TEST" or the "ON HOLD" position. In either case power is now being fed into the load. The switch will return to "OFF" from the "ON TEST" position as soon as figure pressure is removed. It will remain in the "ON HOLD" position until manually returned to "OFF."

3-8 Always return the output switch to "OFF" before removing the load. This is particularly important in the current ranges where dangerous voltages will exist if the load is removed with the output still "ON."

3-9 This switch is also used to reset the overvoltage protection circuit. See Paragraph 3-28.

3-10 OUTPUT TERMINALS

3-11 The device to be calibrated is connected to the output terminals. In dc the Red (HI) terminal is positive (conventional current flow out of the red terminal).

3-12 In all voltage ranges the Black (LO) terminal is connected to the chassis and to earth ground through the three-wire power cord.

NOTE

In all current ranges the black terminal is connected to a point in the circuit which is as much as 1 volt off ground potential, depending on the output dial setting. Do not shunt the LO terminal to earth ground with the device being calibrated. Inaccurate results may be obtained or the load could be damaged. There should be no problem of this kind with non-electronic or battery-powered current meters. If line-operated instruments are to be calibrated, see Paragraph 3-29.

3-13 FUNCTION SWITCH

CAUTION

Do not turn FUNCTION SELECTOR when OUTPUT SWITCH is on.

3-14 The Function Switch is the input line switch for the meter calibrator. In the "OFF" position, input power is off. In "ac", alternating current will be delivered to the output terminals, while in "dc", direct current is available.

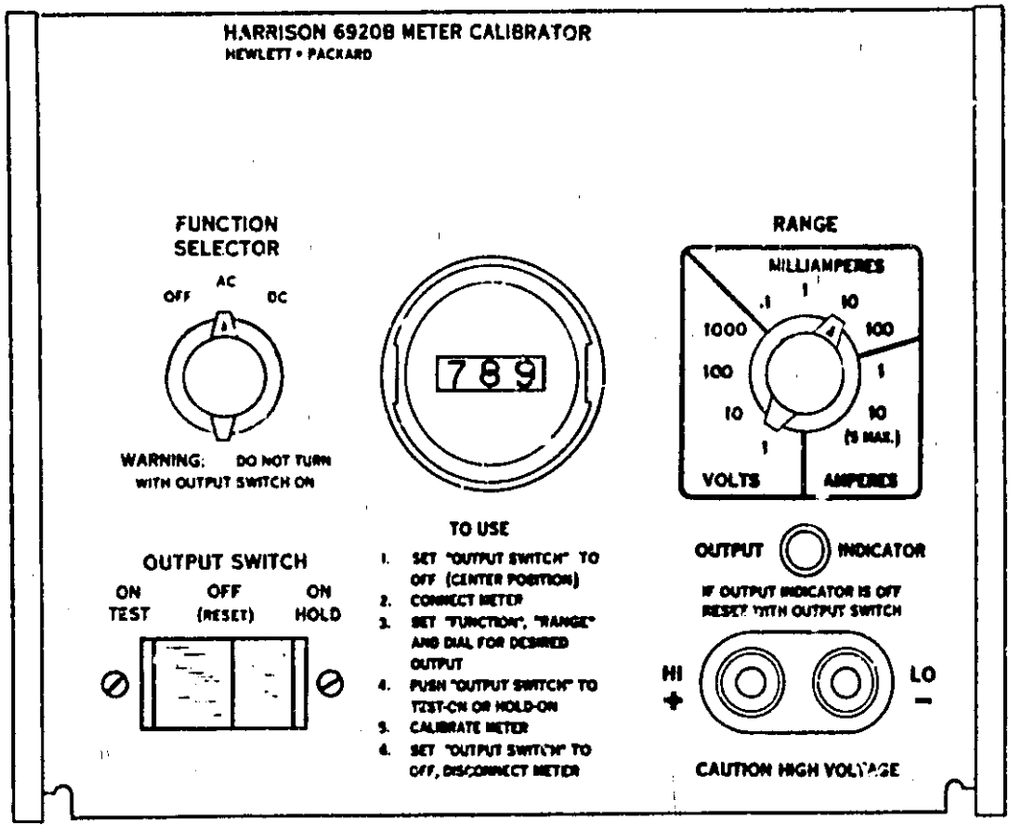
3-15 RANGE SWITCH

3-16 The range switch selects the current or voltage range appropriate to the meter being tested. The range indicated by the switch is the output dial fully clockwise, to (1)000.

3-17 OUTPUT DIAL

3-18 The three-digit, ten turn output dial allows continuous adjustment of the calibrator output within any range.

3-19 To determine the correct decimal point placement, consider the decimal point to be immediately to the left of the left-hand digit, then multiply this number by the range switch setting. For example: 123 on the 10mA range is .123 x 10mA = 1.23mA.



1. Function Selector: Provides line power to meter calibrator when in "AC" or "DC" position. Selects AC or DC at the output terminals.

2. Power Indicator: Lights when instrument is turned on and AC source provided. Not lit if fuse is blown or missing.

3. Output Dial: Allows calibrated adjustment of output over the range selected.

4. Range Switch: Selects the voltage or current available with the output dial at its maximum setting - (1)000.

5. Output Indicator: Lit when power is being delivered at output terminals. Extinguished if over voltage protection circuit trips or output switch is off.

6. Output Terminals: Connector for meter being calibrated. LO (-) terminal is connected to chassis ground in all voltage ranges. In current ranges the ground is inside the circuit and neither terminal should be grounded (see Paragraph 3-29).

7. Output Switch: Open-circuits output terminals when in Off (reset) position. In this position the over-voltage protection circuit is also reset. In either "On" position power is delivered to the output. "On Test" will return "Off" as soon as finger pressure is removed. "On Lock" will remain on until manually returned to "Off."

NOTE

Although the output dial can be mechanically positioned to or near 000, it is not calibrated below 020.

3-20 OUTPUT INDICATOR

3-21 The output indicator is lit when the meter calibrator is delivering power to the output terminals. The light is out if the output switch is in the "OFF" position. It also will be off when the over-voltage protection circuit is activated, which will occur if the load is removed in any of the current ranges.

3-22 If the output light is not on and output power is desired, move the output switch to the "OFF (RESET)" position. Check the load to be sure that it is within the voltage capabilities of the 6920B, then return the output switch to "ON."

TABLE 3-1

Range	Maximum Output	Meter Resistance
1 volt DC	5 amperes	---
10 volts DC	1 ampere	---
100 volts DC	100ma	---
1000 volts DC	10ma	---
100μa DC	500 volts	---
1ma DC	500 volts	---
10ma DC	500 volts	---
100ma DC	50 volts	---
1 ampere DC	5 volts	---
10 amperes DC	5 amperes/0.5 volts	---
1 volt AC	5 amperes	---
10 volts AC	1 ampere	5 ohms minimum
100 volts AC	100ma	500 ohms minimum
1000 volts AC	10ma	50K ohms minimum
100μa AC	Not Calibrated	---
1ma AC	500 volts	---
10ma AC	500 volts	---
100ma AC	50 volts	---
1 ampere AC	5 volts	---
10 amperes AC	5 amperes/0.5 volts	---

3-23 GENERAL OPERATING PROCEDURE

3-24 A brief procedure for using the Model 6920B meter calibrator, printed on the front panel, is also shown in Figure 3-1.

3-25 OVERLOAD

3-26 The load should be within the current capability of the voltage range with which it is being used. If excessive current is drawn the output voltage will begin to fall, approaching zero for large overloads. Table 3-1 lists the output capabilities of the 6920B in the various ranges.

NOTE

In the 1 volt, 5 amp range, it is very important to minimize the length of load leads and check the method of connection to the output terminals. Contact and lead resistance amounting to only 0.1 ohm would drop 0.5 volt at 5 amperes, leaving only 0.5 volt available at the load.

3-27 In current ranges, it should be recalled that an open circuit is the maximum load condition and that a short circuit is minimum load. When testing current meters, the OUTPUT switch should be returned to "OFF" before removing the meter under test. If this is not done, the output voltage will momentarily exceed the full voltage capability of the current range in use, to as much as 1500 volts in the lowest three current ranges.

3-28 If a current meter is inadvertently removed with the output "ON", an over-voltage protection circuit will turn the error amplifier off - preventing further high-voltage operation. When this occurs, the OUTPUT INDICATOR light ceases to glow brightly and becomes very dim, indicating to the operator that the protection circuit has tripped. The protection circuit can also be activated when changing ranges or turning on the meter calibrator

with the output switch "ON." The over-voltage protection is reset when the OUTPUT switch is placed in the "OFF (RESET)" position.

NOTE

When the over-voltage protection is energized, the output may be as high as 20% of the range switch setting in dc operation or 30% of range setting in ac, regardless of the setting of the output dial. To avoid the possibility of overloading a meter, always return the output switch "OFF" before changing ranges.

3-29 GROUNDING

3-30 With panel meters, multimeters, battery operated instruments and clip-on current meters which have no connection with earth ground, no grounding difficulties should be encountered in either the voltage or current ranges.

3-31 When calibrating line-operated meters which may have resistance and capacitance to earth ground and may generate currents between earth ground and the negative lead, some precautions are necessary in grounding. In voltage ranges the best procedure is to break any connection with earth ground in the meter being tested (as shown in Figure 3-2), the ground connection being made through the negative terminal of the 6920B.

3-32 Line operated current meters, with the exception of clip-on models, require special care in grounding to avoid inaccurate measurements. Two quick tests, illustrated in Figure 3-3, will show where problems exist.

a. Remove any connection between the low or (-) meter terminal and ground. Ground the (+) or high terminal. The meter should read zero within the desired accuracy.

b. Again with the (-) or LO meter terminal ungrounded, connect the (+), high, terminal to a +1 volt source, with respect to ground, ac for ac meters, dc for dc meters. The 1 volt range of the 6920B works well for this. To avoid possible damage to the meter, bring the voltage up slowly from zero until 1 volt is reached. If the meter still reads zero within the desired accuracy limits, no problem will be encountered in calibration if the LO (-) terminal is left ungrounded.

3-33 The above tests are accurate as long as the full-current voltage drop across the meter is small compared with 1 volt. Any guard shields present in the meter should be connected to the (-), LO, terminal but not to ground.

3-34 If the tests in 3-32 show that problems do exist, Figure 3-4 shows a way of curing the problem. A (+1) amplifier such as the DY-2460A Solid State dc amplifier with DY-2461A-M4 plus-one gain plug-in is used to isolate the low-side terminal of the meter from the LO (-) terminal of the 6920B.

GROUNDING CONSIDERATIONS

I. VOLTAGE RANGES

CAUTION:
DO NOT GROUND EITHER OUTPUT TERMINAL OF THE CALIBRATOR UNDER ANY CIRCUMSTANCES.

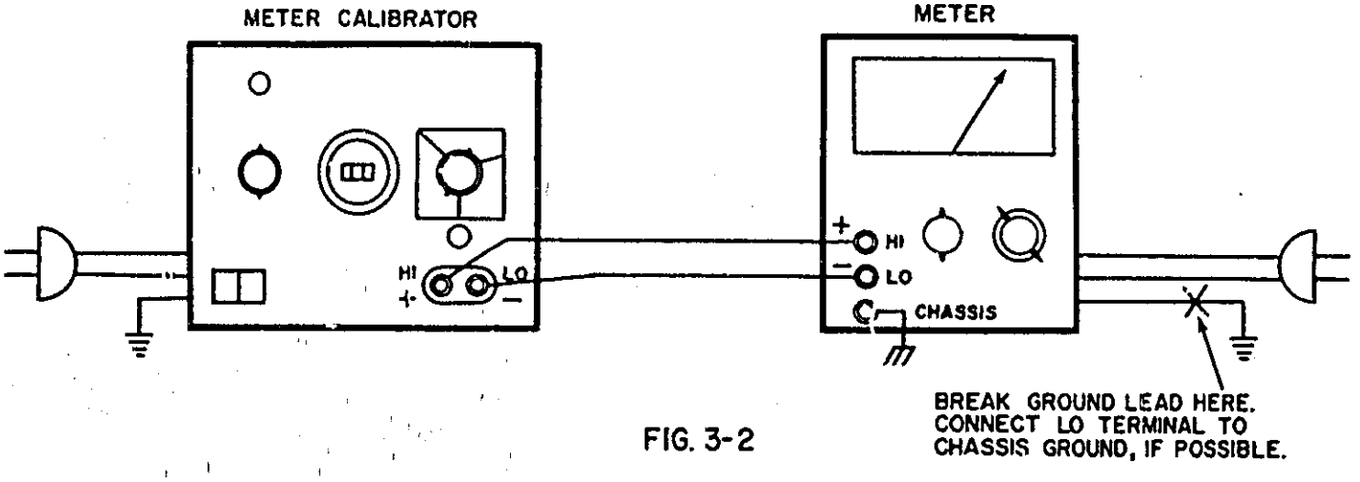
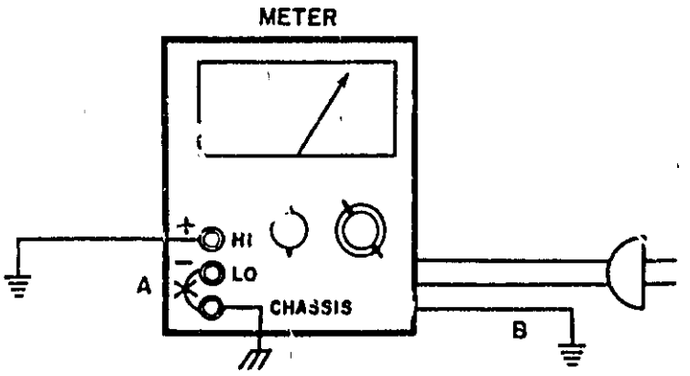


FIG. 3-2

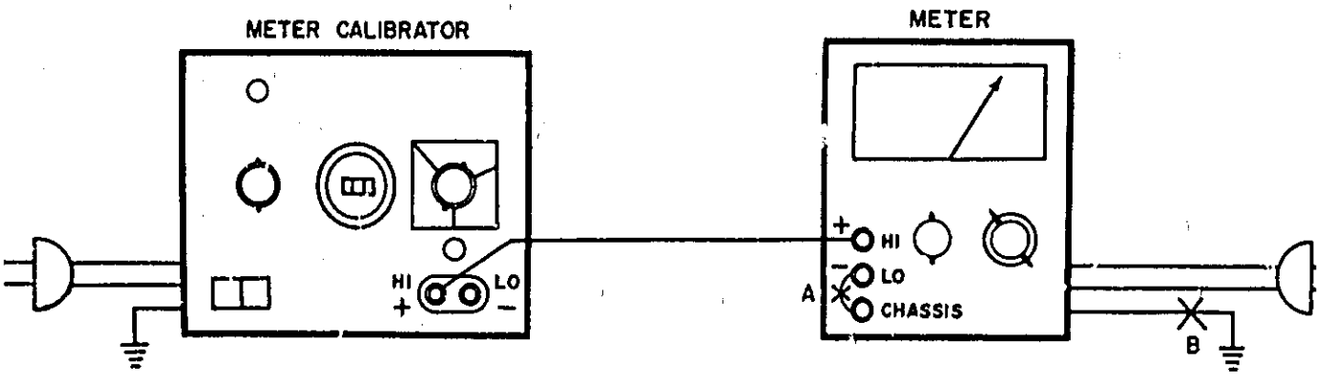
II. TESTING CURRENT METERS FOR GROUND PROBLEMS

A)



DISCONNECT LO TERMINAL FROM CHASSIS GROUND AT A, OR IF THIS CANNOT BE DONE BREAK EXTERNAL GROUND LEAD AT B.

B)



BREAK AT A, OR IF NOT POSSIBLE BREAK LEAD AT B.

FIG. 3-3

3-35 CALIBRATING TRUE RMS AC METERS

3-36 In ac ranges the output waveform of the 6920B will be the same as that of the input power line, which will not be perfectly sinusoidal. The ac reference of the meter calibrator insures that the average value of the output will remain correct regardless of line distortion. The output dial is calibrated in terms of the sinusoidal RMS equivalent of the average value of the output. Thus, any ac meter which is average-sensing, RMS calibrated will be correctly calibrated. Meters of this type include multimeters and most electronic and digital voltmeters.

3-37 For true-reading RMS meters an error will exist as a function of the line distortion. Table 3-2 shows the possible error in terms of second, third and fourth harmonic content of the line.

3-38 If greater accuracy is needed for true RMS meters, an external sine wave oscillator capable of supplying 60Hz, 15 volts ± 10% at 2mA, can be used to supply the signal to the ac reference regulator. To do this, refer to Figure 3-5. Move slide switch S1 on rear panel to EXTERNAL. Connect a pair of shielded leads from the 15 volt ac source to the points shown, the low side going to A1 and the high side going to A2.

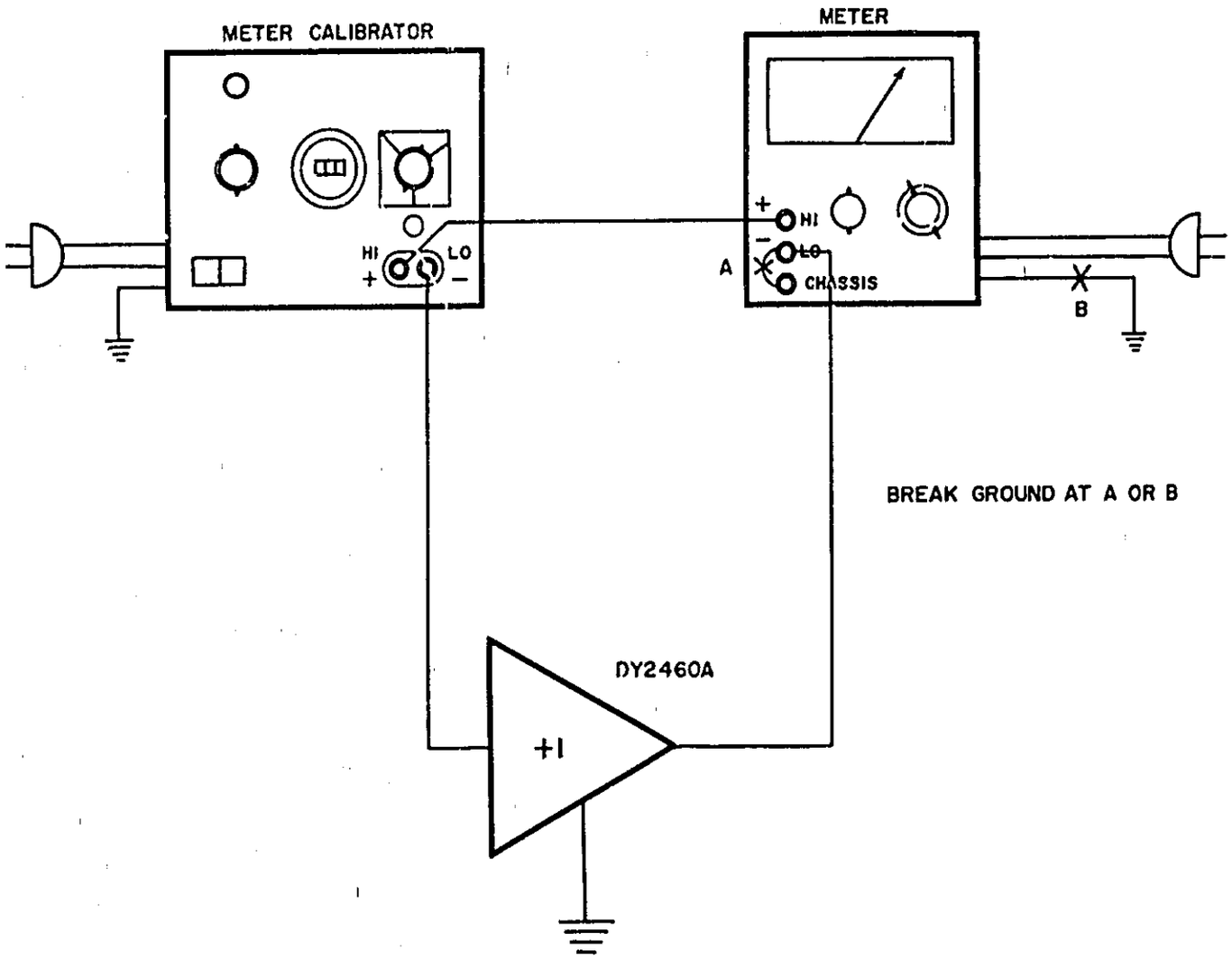


FIG. 3-4 ELIMINATING GROUND PROBLEMS WITH +I AMPLIFIER

% HARMONIC	% ERROR AVERAGE-SENSING RMS CALIBRATED METER	% ERROR TRUE RMS METER
0	0	0
1% Second	0	-0% to +0.02%
2% Second	0	-0% to +0.02%
5% Second	0	-0% to +0.12%
10% Second	0	-0% to +0.50%
20% Second	0	-0.07% to +1.98%
1% Third	0	-0.65% to +0.69%
2% Third	0	-0.65% to +0.69%
5% Third	0	-1.54% to +1.79%
10% Third	0	-3.14% to +3.53%

TABLE 3-2 OUTPUT ERROR DUE TO LINE WAVEFORM DISTORTION

NOTE

The calibrator should never be operated without the 15 volt ac being present as damage to the inverter may result.

3-39 EFFECTS OF RAPID LINE VOLTAGE CHANGES

3-40 In order to prevent distortion of the ac waveform in the ac reference circuit, the ac reference feedback loop has been made slow compared with 60Hz. Hence, sudden changes in line voltage will not be immediately corrected, producing a momentary shift in the ac output. If a particularly noisy line is causing excessive instability of the ac output, an external oscillator capable of supplying 60Hz, 15 volt ± 10% at 2mA, can be used to replace the line-derived ac input normally used. See Paragraph 3-38 and Figure 3-5 for instructions on this procedure.

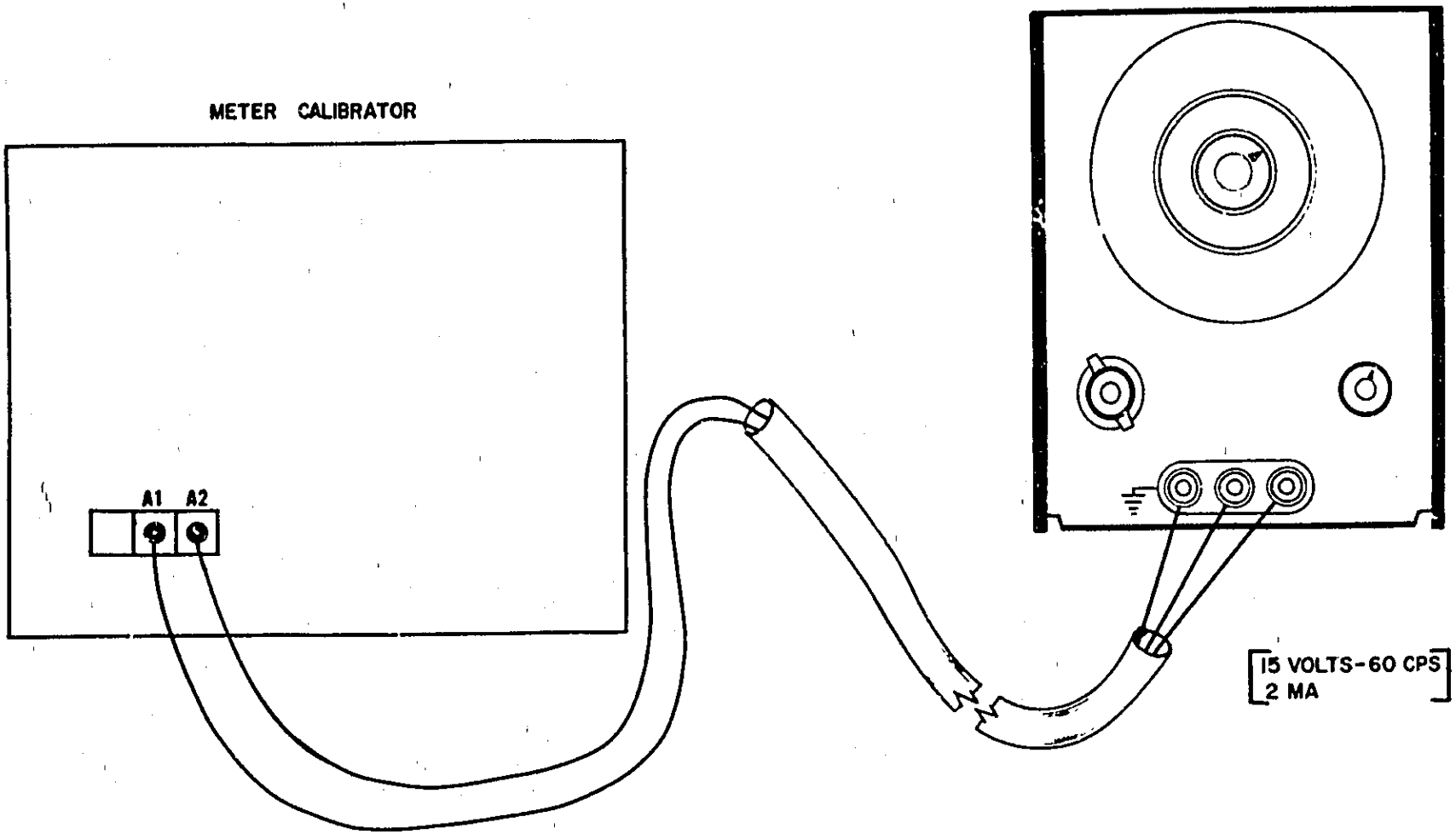


FIG. 3-5
USE OF EXTERNAL OSCILLATOR
TO OPERATE AC REFERENCE

THEORY

SECTION IV
PRINCIPLES OF OPERATION

4-1 INTRODUCTION

4-2 The 6920B is a multiple-range ac/dc power supply which is suitable for the calibration of voltage and current meters. An inverter circuit is used following a dc series regulator transistor. This provides ac which is fed to a transformer. The various secondary windings provide current up to 5 amps and voltage to 1000 volts. The square wave output is rectified and filtered and supplied to the output terminals.

4-3 A closed-loop feedback system controls the output by comparing a reference voltage, set by the output dial, with a suitable measure of the output. The voltage difference is amplified and operates the series regulator transistor.

4-4 AC operation is similar with the exception that an ac reference is used. The rectifiers are bypassed at the secondary of the output transformer and a synchronous demodulator, in the error amplifier, keyed at the inverter frequency is used to maintain negative feedback during both halves of the inverter cycle.

4-5 Auxiliary circuits include a protective current limit, an over-voltage trip circuit, and an amplifier to maintain the inverter transformer in a state of dc balance. An output indicator lamp is used to show the state of the over-voltage trip.

4-6 BLOCK DIAGRAM

4-7 Figure 4-1 shows an over-all block diagram of the Model 6920B. The output signal is sampled by the range divider to obtain a signal which is 1 volt for full output. In the voltage ranges this is a voltage divider, for exaple 1000:1 in the 1000 volt range. In current ranges it is a series monitoring resistor; for example, 1000 ohms in the 1mA range. The range resistor configurations are shown in Figure 4-2. This signal is fed back to the input amplifier where it is compared with a variable reference voltage, set by means of the output which operates R4.

4-8 The output of the error amplifier is delivered to the synchronous demodulator. In dc this demodulator is by passed, its function being taken by the output power rectifiers. In ac, the demodulator reverses the amplifier polarity whenever the inverte switches.

4-9 The demodulator feeds a signal to the power regulator. Here the error signal is further amplified and used to control a series regulator power amplifier.

4-10 INVERTER

4-11 The output of the series regulator is applied to an inverter consisting of transistors Q14 and Q15, which is driven synchronously with the ac power line. In the dc mode of operation this produces a square wave signal which is suitable for applying to the output transformer.

4-12 In ac, because the ac reference, the synchronous demodulator and the inverter are all synchronized with the ac power line, the signal applied to the inverter appears as a full-wave rectified sinusoidal waveform. After passing through the inverter the desired sine wave is obtained on the transformer primary.

4-13 OUTPUT TRANSFORMER

4-14 The output transformer changes the power on its primary to one of four impedance levels which are associated with its four secondary windings; these levels correspond to 1000V at 10mA, 100V at 100mA, 10V at 1A and 2V at .5A.

4-15 FUNCTION SWITCH

4-16 This switch selects whether the transformer output is to be rectified or not. In the ac mode of operation the output rectifiers are bypassed. It also selects the ac or dc reference, bypasses the synchronous demodulator in dc and changes the feedback loop equalizers.

4-17 RANGE SWITCH

4-18 The range switch selects the output windings appropriate to the selected output voltage or current range. In addition, it selects the proper divider or series resistor, in current ranges, to provide the 1 volt/full-output sample of the output signal. In Figure 4-2 the range resistor configuration for each of the ten ranges is shown.

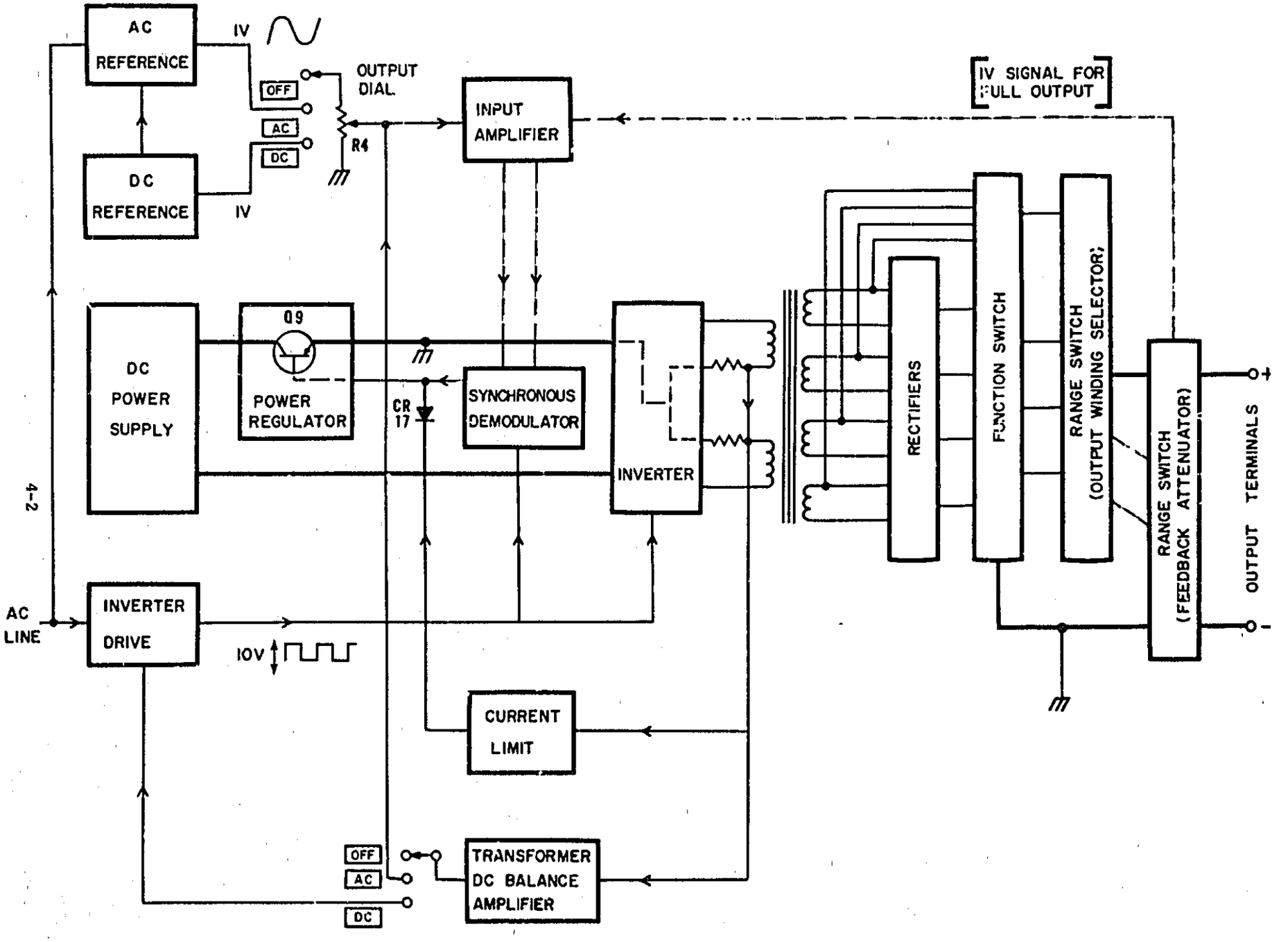


FIG. 4-1
FUNCTIONAL BLOCK DIAGRAM

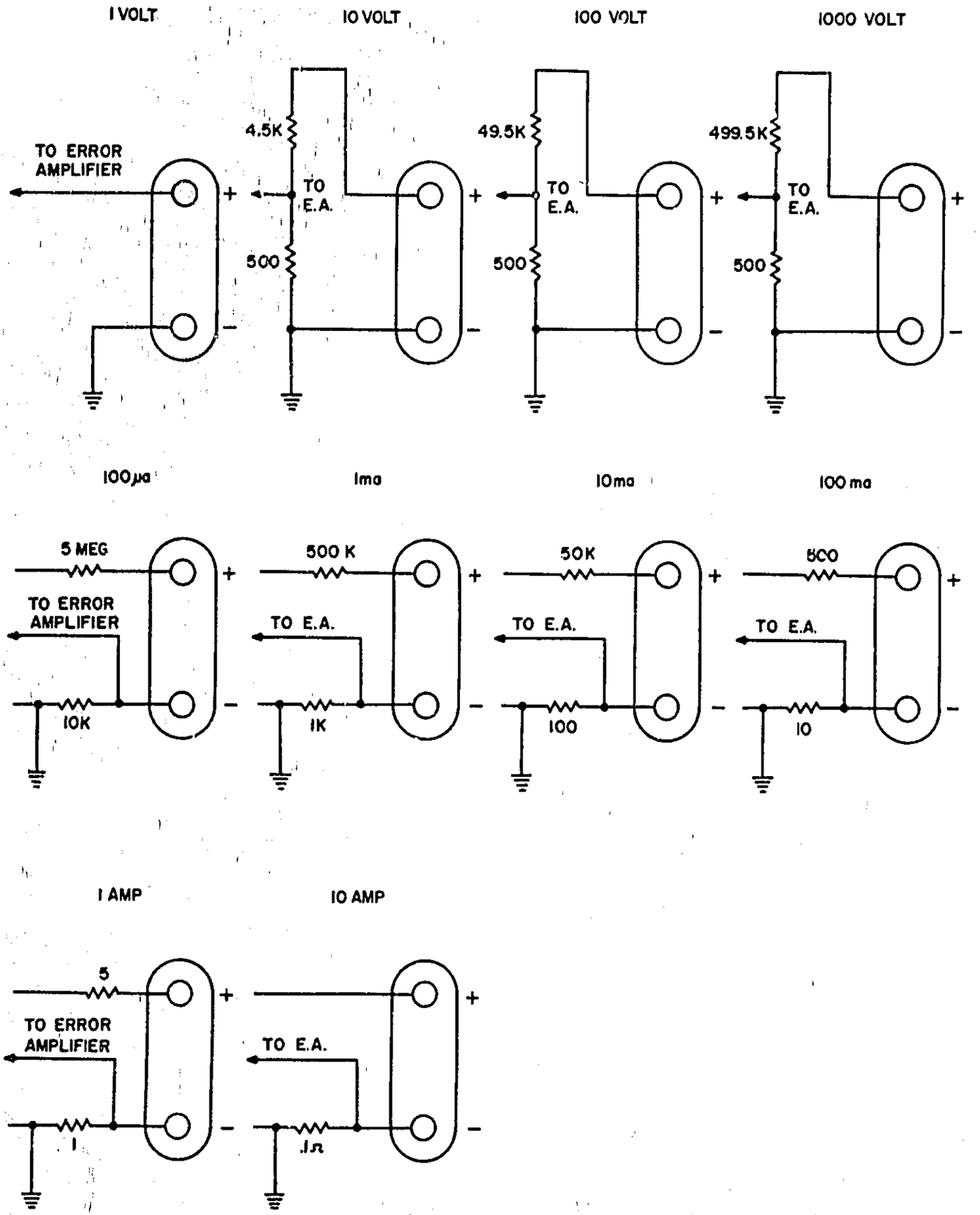


FIG. 4-2
RANGE RESISTOR CONFIGURATION

4-19 DC REFERENCE

4-20 A 6.2 volt temperature compensated reference diode is used as the dc reference. Circuitry is used to minimize the current changes through this diode with changes in the input line. The reference circuit also supplies +12.6 volts and -9.4 volts to operate the low-level error amplifiers.

4-21 AC REFERENCE

4-22 The ac reference voltage is obtained by taking an ac signal derived from the ac line and controlling its amplitude with a photo-resistor. The ac so obtained is accurately converted to dc, proportional to the average ac. This signal is compared with the dc reference. A dc amplifier consisting of transistors Q1, Q3 and Q5 amplifies the error and drives an incandescent lamp which affects the photo-resistor in such a way as to restore the ac reference to the desired value. A block diagram of this circuit appears in Figure 4-3.

4-23 Ac to dc conversion is accomplished by an ac-coupled feedback amplifier containing diodes CR30 and CR31 which drive its feedback network. This configuration has the advantage that changes in diode resistance with voltage and temperature have little effect on the accuracy of the ac to dc conversion process.

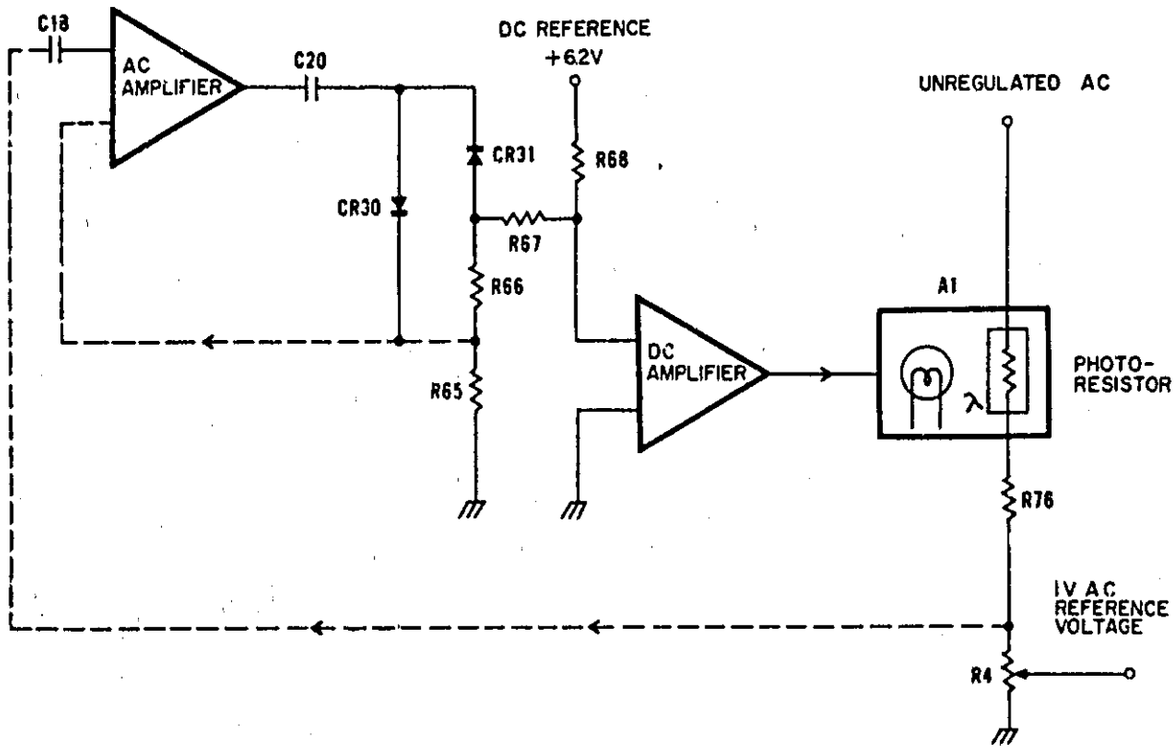


FIG. 4-3
AC REFERENCE

4-24 BALANCE AMPLIFIER

4-25 An amplifier consisting of Q30 and Q31 is connected to sense the average dc in the transformer primary by means of resistors R46 and R47 as shown in Figure 4-4. If a dc unbalance exists, the amplifier output is used to make correction in the circuit to balance the primary current. In the dc mode of operation the timing of the inverter is changed in such a way as to make the "ON" time of one of the two inverter transistors slightly longer with respect to the other. In ac, the balance amplifier output changes the dc level of the ac reference signal which has the effect of balancing the transformer dc.

4-26 INVERTER

4-27 The inverter consists of transistors Q14 and Q15 which are driven as switches to apply the output of the series regulator alternately to each half of the output transformer primary. This allows use of a transformer to step up the voltage or current for the output.

4-28 INVERTER DRIVER

4-29 A signal obtained from the ac line is used to synchronize the switching of the inverter driver. This signal is applied at the bases of Q26 and Q27. Speed-up networks R87 and C25 and R89 and C26 make the transition from one state to the other more rapid. Transistors Q26 and Q27 drive transistors Q28 and Q29 which in turn drive the inverter transistors.

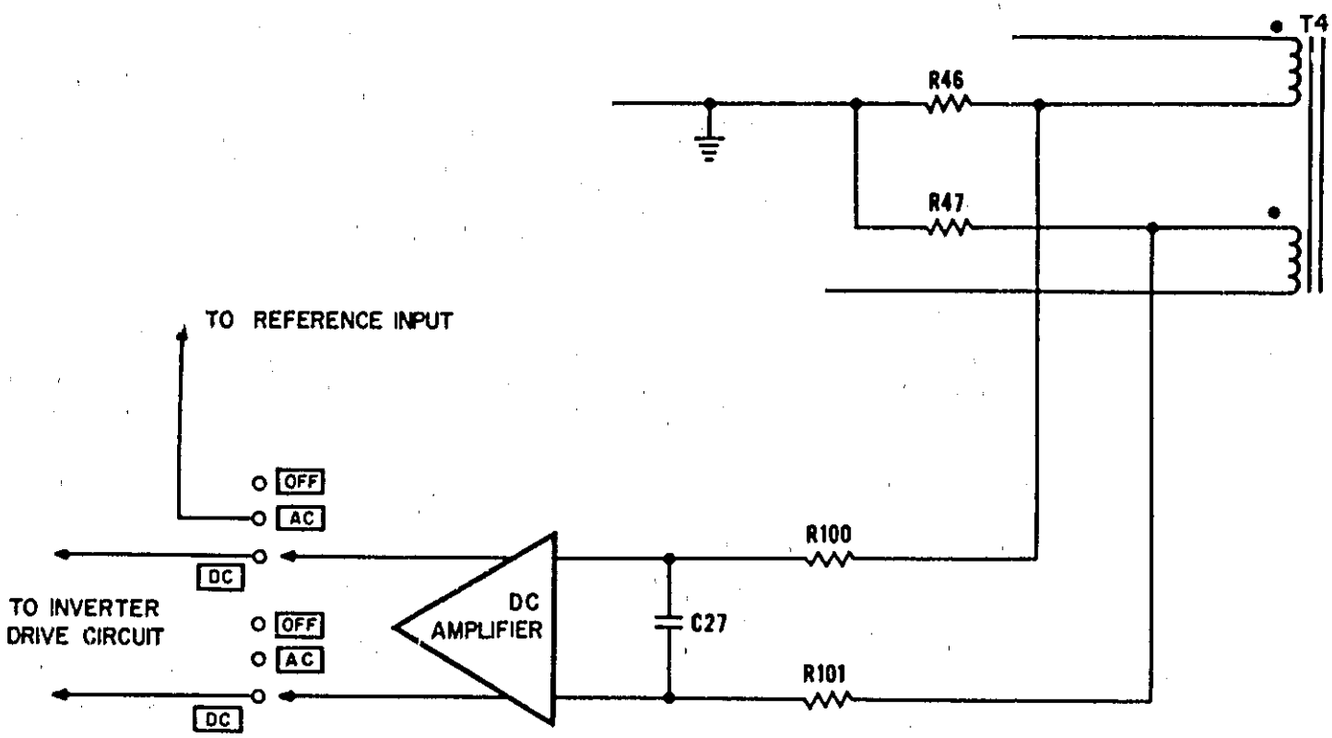


FIG. 4-4
TRANSFORMER DC BALANCE AMPLIFIER

MAINTENANCE

SECTION V
MAINTENANCE

5-1 INTRODUCTION

5-2 This section contains maintenance and service information for the 6920B. The section includes recommended test equipment, performance checks, replacement, repair, and adjustment procedures and troubleshooting charts.

5-3 TEST EQUIPMENT

5-4 Table 5-1 lists recommended test equipment to be used in performance checks and adjustments.

Table 5-1. Test Equipment Required

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	SUGGESTED TEST EQUIPMENT
AC Voltmeter	Accuracy of ±1% 90 to 130 volts. Expanded scale.	Measure Input Line Voltage	Triplett Model 420M
Variable Transformer	100-130 volt ranges. 5 amp current capacity.	Change ac Input Voltage	Superior Type Q116U
Oscilloscope	200μV/cm sensitivity. Differential Input.	Measure ripple Transient response	HP Model 130C
Differential Voltmeter AC/DC	1mV resolution. Ranges 1V to 1000V.	Measure output accuracy	HP Model 741A
Shunt Resistors	.05% Accuracy 10K 1K 100 ohms 10 ohms .1 watt 1 ohm 1 watt 0.1 ohm 2.5 watts (NOTE: The total load resistance connected to the output terminals, including leads to the load resistor, should be 0.1 ohms in order to limit the current to a maximum of 5 amperes.)	Measure output current	General Radio 500-S 500-4 500-D 500-R Leeds & Northrop 4020-B 4221-B
Digital Voltmeter		Measure dc voltage and isolate ground loops	HP Model 3460B
Two Resistance Decades	1% accuracy. 10 ohms to 100K per step.	Select value of calibration resistors	Precise Model 465

5-5 PERFORMANCE CHECKS

5-6 The performance check procedures are used to check the 6920B against its specifications. All checks are made from the front panel. Thus, the procedures are useful as incoming or outgoing quality control, periodic maintenance, or after repair checks. The calibration interval for this instrument is 3 to 6 months, depending on the frequency of use.

5-7 Refer to the instructions printed on the front panel for general operating procedures.

5-8 GENERAL CHECK

a. Turn OUTPUT switch "OFF."

b. Pilot should light when FUNCTION switch is at "AC" or "DC."

c. Set output dial to (1)000.

d. With "RANGE" in any of the four voltage ranges, yellow "OUTPUT INDICATOR" should light when the "OUTPUT" switch is turned "ON."

e. With output terminals shorted and "RANGE" in any of the six current ranges, the yellow "OUTPUT INDICATOR" should light when the "OUTPUT" switch is turned "ON." On the 10 amp range, the output dial should be set at 500.

5-9 VOLTAGE CALIBRATION CHECK

a. Allow unit to warm-up one hour.

b. Connect equipment as shown in Figure 5-1.

c. Switch FUNCTION to dc and RANGE to 1 volt.

d. Set voltmeter range to 1 volt dc.

e. Set output dial to (1)000.

f. Voltmeter should indicate 1.000V ± 0.003V.

g. Set output dial to 100.

h. Voltmeter should indicate 0.100V ± 0.0012V.

i. Similarly, check the remaining three dc VOLTAGE ranges and the four ac VOLTAGE ranges, referring to Table 5-2 for dial settings and tolerances.

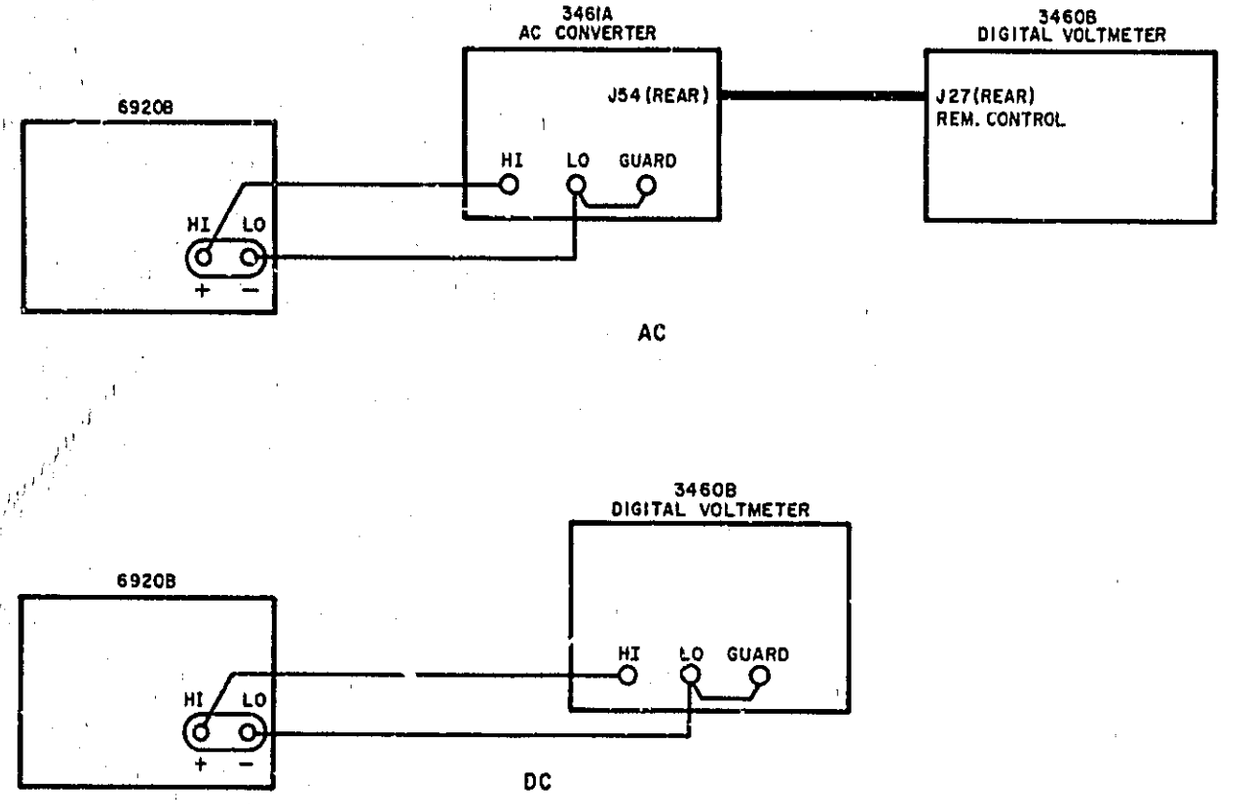


Figure 5-1. Checking Voltage Calibration

Table 5-2. Voltage and Current Calibration Check

RANGE	SETTING	OUTPUT	% ERROR DC	% ERROR AC
1V	(1)000 100	1.000V 0.100V	±3mV ±1.2mV	±5mV ±1.4mV

Table 5-2. Voltage and Current Calibration Check (Continued)

RANGE	SETTING	OUTPUT	% ERROR DC	% ERROR AC
10V	(1)000	10.000V	±30mV	±50mV
	100	1.00V	±12mV	±14mV
100V	(1)000	100.00V	±300mV	±500mV
	100	10.0V	120mV	140mV
1000V	(1)000	1000.V		±5V
	100	100.V		±1.4V
100µA	(1)000	100.0µA	±0.3µA	---
	100	10.0µA	±0.12µA	---
1mA	(1)000	1.000mA	±3µA	±5µA
	100	100.µA	±1.2µA	±1.4µA
10mA	(1)000	10.00mA	±30µA	±50µA
	100	1.00mA	±12µA	±14µA
100mA	(1)000	100.0mA	±300µA	±500µA
	100	10.0mA	±120µA	±140µA
1 ampere	(1)000	1.000 ampere	±3mA	±5mA
	100	0.100 ampere	±1.2mA	±1.4mA
10 amperes	500*	5.00 amperes	±20mA	±30mA
	100	1.00 ampere	±12mA	±14mA

In all current ranges, when using the monitoring resistor values shown in Figure 5-2, the equivalent voltage tolerance will be as shown in the 1 volt range. *Except ±2mV dc, ±3mV ac.

5-10 If the line voltage is rapidly fluctuating, some instability may be noted in the ac ranges if an ac meter with rapid response is used. These fluctuations are normal and are due to the slow speed of the feedback loop controlling the ac reference.

5-11 CURRENT CALIBRATION CHECK

a. Allow unit to warm-up 1 hour.

b. Connect equipment as shown in Figure 5-2.

c. With OUTPUT switch "OFF", switch FUNCTION to dc and RANGE to 100µA.

d. Connect a 10K ohm ±.05% resistor across the output terminals as in Figure 5-2.

e. With OUTPUT "ON" check calibration at (1)000 and 100 on the dial, referring to Table 5-2 for tolerances.

f. Check the remaining current ranges, using monitoring resistors as shown in Figure 5-2 and referring to the tolerances in Table 5-2.

NOTE

Do not operate the 6920B in any current range with the OUTPUT "ON" without a suitable resistor across the output terminals, as dangerous voltages can occur.

5-12 REFERENCE REGULATOR CHECK

a. Connect a variable Auto-Transformer and Line Voltage Meter ahead of the ac input of the 6920B.

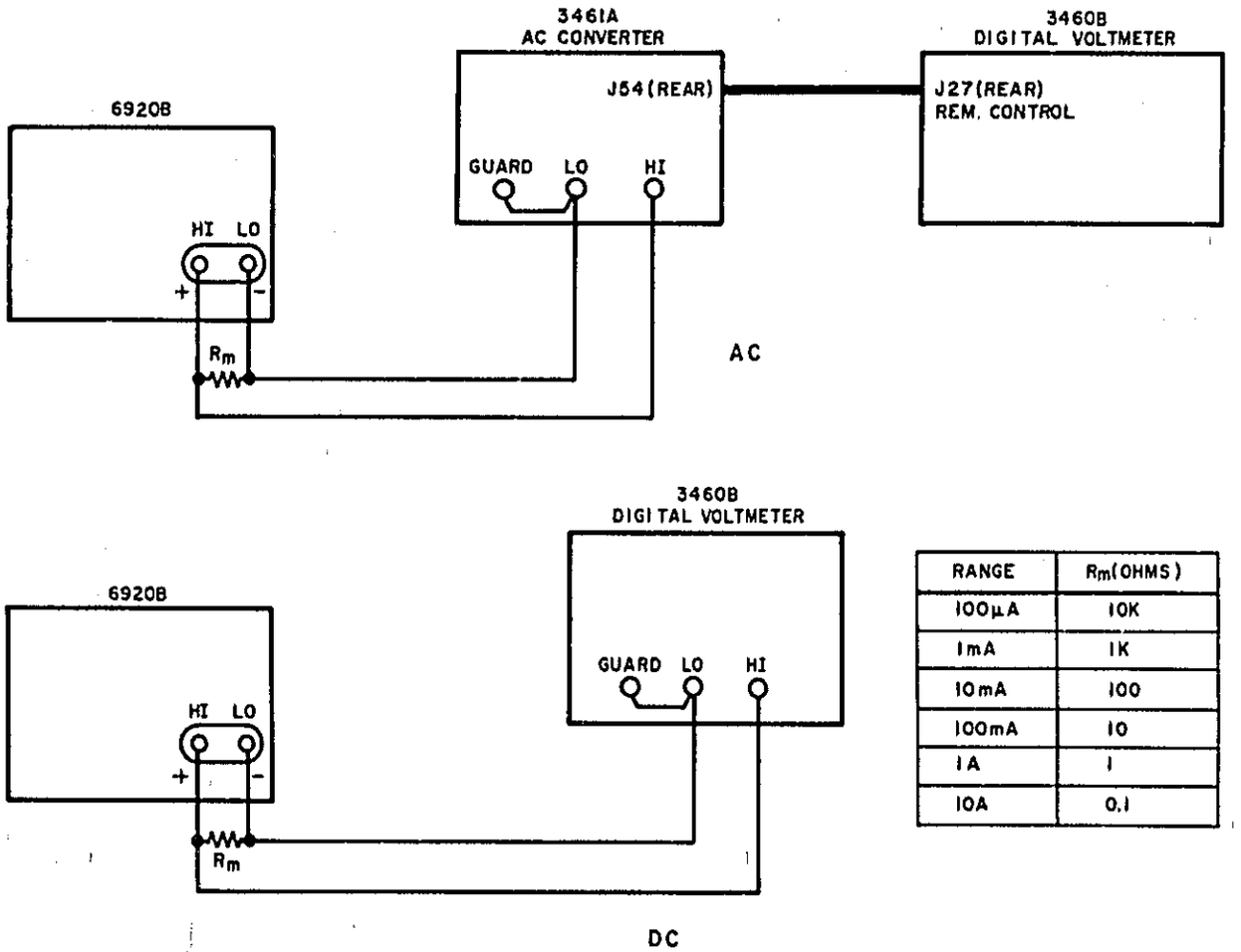
b. Connect power equipment as for the 1 volt calibration check.

c. Output dial to (1)000.

d. Set the input line voltage to 105Vac and record the output voltage.

e. Raise the line voltage to 125Vac and again record the output voltage.

f. Repeat the measurements in the ac mode with FUNCTION at ac, recording the ac output at



RANGE	Rm(OHMS)
100µA	10K
1mA	1K
10mA	100
100mA	10
1A	1
10A	0.1

Figure 5-2. Checking Current Calibration

105V and 125Vac line.

g. The measurements obtained should be within ±3mV of 1.000 volt in dc and ±5mV of 1.000 volt in ac.

5-13 TROUBLESHOOTING

5-14 Components within Hewlett-Packard power supplies are conservatively operated to provide maximum reliability. In spite of this, parts within a supply may fail. Usually the instrument must be immediately repaired with a minimum of "down time" and a systematic approach as outlined in succeeding paragraphs can greatly simplify and speed up the repair.

5-15 TROUBLE ANALYSIS

5-16 General. Before attempting to troubleshoot this instrument, ensure that the fault is with the instrument and not with an associated circuit. The performance checks (Paragraph 5-5) enable this to be determined without having to remove the instrument from the cabinet.

5-17 Once it is determined that the power supply is at fault, check for obvious troubles such as open fuse, a defective power cable, or an input power failure. Next, remove the covers (each held by four retaining screws) and inspect for open connections, charred components, etc. If the trouble source cannot be detected by visual inspection, follow the detailed procedure outlined in succeeding paragraphs. Once the defective component has been located (by means of visual inspection or trouble analysis) correct it and re-conduct the performance checks. If a component is replaced, refer to the adjustment and calibration paragraphs in this section.

5-18 A good understanding of the principles of operation is a helpful aid in troubleshooting, and it is recommended that the reader review Section IV of the manual before attempting to troubleshoot the unit in detail. Once the principles of operation are understood, logical application of this knowledge used in conjunction with Tables 5-3 through 5-5,

will isolate a fault to a component or small group of components. Table 5-3 includes remedies for troubles that are common in both the ac and dc outputs. Table 5-4 is for ac output and 5-5 for dc output.

5-19 If Tables 5-3 through 5-5 do not include the correct symptom or cause of trouble, systematically perform all the troubleshooting procedures included in Paragraphs 5-20 through 5-44.

Table 5-3. AC and DC Output Troubleshooting

SYMPTOM	PROBABLE CAUSE	REMEDY (REFER TO PARAGRAPH)
1. Poor regulation	1a. Loose or improper internal sensing connections between HI (+) and R110, and LO (-) and R109	
	1b. Incorrect reference voltages	1b. Paragraph 5-23 and 5-28
2. Low Output Voltage. Refer to waveforms on schematic diagram at rear of manual	2a. Low reference voltages	2a. Paragraph 5-23 and 5-28
	2b. Low impedance or shunt path on the secondary of T4	2b. Check for shorted components
	2c. Excessive voltage (IR) drops in the external load leads caused by insufficient load lead thickness	
	2d. Output resistor R110 through R125	2d. Replace, if defective
3. Fuse blows	3a. CR1 or CR2 shorted	3a. Replace, if defective
	3b. Primary or secondary of T1 or T3 shorted	3b. Replace, if defective
4. Erratic Output	4a. Reference circuit potentiometers R1 or R69 noisy	4a. Replace, if defective
	4b. Front panel potentiometer R4 noisy	4b. Replace, if defective

Table 5-4. AC Output Troubleshooting

SYMPTOM	PROBABLE CAUSE	REMEDY (REFER TO PARAGRAPH)
1. Distortion of Output Waveform. Refer to the waveforms on the schematic diagram at the rear of the manual	1a. Distortion of output waveform in the AC Reference Circuit	1a. Paragraph 5-28
	1b. Balance Amplifier improperly adjusted	1b. Paragraph 5-43
	1c. Inverter Drive Circuit improperly adjusted	1c. Paragraph 5-36
	1d. Defective Inverter Circuit	1d. Paragraph 5-38
2. Oscillations	2a. Open sensing connections in the Error Amplifier	2a. Paragraph 5-33
	2b. Leaky capacitors in the Error Amplifier	2b. Paragraph 5-33

Table 5-4. AC Output Troubleshooting (Continued)

SYMPTOM	PROBABLE CAUSE	REMEDY (REFER TO PARAGRAPH)
2. Oscillations	2c. Defective RC networks R25/C11 or R31/C7 in Series Regulator Circuit	2c. Replace, if defective
3. Loss of AC output in Constant Voltage and Constant Current modes	3a. Loss of AC reference voltage at base of Q1B	3a. Paragraph 5-28
	3b. Loss of inverter drive output	3b. Paragraph 5-36
	3c. Open front panel decadial potentiometer R4	3c. Replace, if defective
	3d. Improper connections on FUNCTION SELECTOR and RANGE switches S1 and S2	
4. Loss of AC output in Constant Current mode only	4a. Resistor R121 through R125 open	4a. Replace, if defective
	4b. Improper monitoring or load connections on the monitoring resistors R114 through R120	
	4c. Resistors R114 through R120 not grounded internally or LO (-) output terminal is grounded. This shorts resistors R114 through R120	

Table 5-5. DC Output Troubleshooting

SYMPTOM	PROBABLE CAUSE	REMEDY (REFER TO)
1. Unbalanced DC ripple. Refer to the waveforms on the schematic diagram at the rear of the manual	1a. Misaligned Balance Circuit	1a. Paragraph 5-43
	1b. Defective Inverter Drive Circuit	1b. Paragraph 5-36
	1c. Shorted or open rectifier diodes on the secondary of inverter transformer T4	1c. Replace, if defective
	1d. Defective connections on FUNCTION SELECTOR or RANGE switch S1 or S2	
2. Loss of DC output in Constant Voltage and Constant Current modes	2a. Loss of DC reference voltage on the base of Q1B	2a. Paragraph 5-23
	2b. Loss of inverter drive output	2b. Paragraph 5-36
	2c. Open front panel decadial potentiometer R4	2c. Replace, if defective
	2d. Improper connections on FUNCTION SELECTOR and RANGE switches S1 and S2	
	2e. Open or shorted output rectifiers CR44 through CR53 and Q33, Q34	2e. Replace, if defective
3. Loss of DC output in Constant Current mode only	3a. Resistors R121 and/or R125 open	3a. Replace, if defective
	3b. Improper connections on monitoring resistors R114 through R120	
	3c. Resistors R114 through R120 not grounded internally or LO (-) output terminal is grounded. This shorts resistors R114 through R120	

5-20 Output Resistance. The first basic step in trouble shooting the instrument is to disconnect the AC power, turn the OUTPUT switch to the OFF position, attach an ohmmeter to the output terminals, and measure the following resistances:

RANGE Switch Position (AC or DC)	Resistance (±.1%)
1V	500 ohms
10V	5 K
100V	50 K
1000V	500 K

5-21 The next resistance measurement checks should be made from chassis ground to the negative output with the OUTPUT switch in the OFF position.

RANGE Switch Position (AC or DC)	Resistance (±.1%)
.1 ma	10 K
1 ma	1 K
10 ma	100 ohms
100 ma	10 ohms
1 a	1 ohm
10 a	.1 ohm

5-22 These readings will help insure the accuracy of the calibration assuming that they are correct. If these readings are incorrect, insure that the ground and the HI (positive) connections are being made properly, before replacing any resistors. Typical causes of trouble in this region are either open resistors or a wiring error associated with RANGE switch S2.

5-23 DC Reference. The output of the DC reference supply will be excessive when either transistor Q16 or Q17 is shorted. The higher than normal reference voltages will cause troubles in other circuits of the meter calibrator.

5-24 Since the DC reference supplies all of the circuitry in the meter calibrator, it should be thoroughly checked for the following outputs:

DC VOLTAGE +12.6V +6.2V -6.2V

5-25 Also, a very important output from this circuit is the one volt DC reference which is applied to the base of Q1B in the error amplifier. This voltage is measured from the LO (-) terminal to terminal E4 on FUNCTION switch S1. The ripple on this one volt DC is approximately 1 mv RMS. The one volt is applied to the base via FUNCTION switch S1.

5-26 The one volt reference should be measured in the following manner:

1. Turn the output indicator dial to 100.
2. Turn FUNCTION SELECTOR switch S1 to the DC position.
3. Remove the output power by turning the OUTPUT switch to OFF.
4. The voltage then may be measured at the base of Q1B and will be between 0.7 and 1 Vdc.

5-27 Some of the causes of trouble in the DC reference circuit are as follows:

1. Shorted or open transistors.
2. Defective switching in the area at the base of Q1B.
3. Resistors R1 or R2 open.
4. Zener diode VR4, VR5, or VR6 shorted or open.

5-28 AC Reference. Before attempting to trouble-shoot the AC reference, insure that the DC reference is providing the proper voltages required by the AC reference for proper transistor biasing. Refer to Paragraph 5-23.

5-29 Next, a voltage measurement should be made to insure VR7 is maintaining the proper potential of 15 volts DC at Raysistor A1. Then check the 15 volt AC supplied to Raysistor A1 from transformer T1.

5-30 The final output from the AC reference circuit is a one volt sine wave measured from chassis ground to terminal E7 on FUNCTION SELECTOR S1. This is applied to the base of Q1B via S1 (E7) and should be measured as follows:

1. Turn the output indicator dial to 100.
2. Turn FUNCTION SELECTOR switch S1 to the AC position.
3. Remove the output power by turning the OUTPUT switch to OFF.
4. Measure 1Vac reference between the base of Q1B and chassis ground.

5-31 The stability of the reference circuit is dependent upon the stability of the AC line, which is normal for this type circuit. It can be improved by use of an external oscillator as described in Paragraph 3-38.

5-32 One of the common problems generally found in the AC reference is the loss of one volt AC. It may be caused by the following failures:

1. Raysistor A1 open.
2. No DC reference.
3. R68 or R69 open. (Poor calibration may result if reference adjustment R69 is erratic.)

5-33 DC Power Supply (Series Regulator, Demodulator and Error Amplifier). The output of the series regulator (measured from chassis ground to the positive end of C6) vaires from zero to maximum output and the waveform is dependent upon the output voltage selected by FUNCTION SELECTOR S1. The DC output contains approximately 10mV ripple and the ac output is a 60 Hz rectified sine wave at 0 to 16V p-p.

5-34 If the series regulator Q9 shorts, the output is turned on full and the supply is not protected, except for the ac fuses, which blow because of the excessive current.

5-35 To troubleshoot the dc power supply (series regulator, demodulator, and error amplifier) proceed as follows:

1. Disable the current limit circuit by removing the lead from the emitter of Q13. If the symptom is eliminated, the trouble is in the current limit circuit. If the symptom remains, reconnect the emitter lead and proceed to step 2.
2. Remove silicon controlled rectifier CR3.
3. By turning the transistors on or off, troubles in the dc power supply can be isolated to a particular stage. To turn a transistor on or off, either short emitter-collector or remove the transistor that is feeding it. Begin at the series regulator Q9, then error amplifier driver Q4, differential amplifiers Q1,Q2,Q3, demodulator Q5,Q6, and drivers Q10,Q11.

5-36 Inverter Drive Circuit. The output of the inverter drive circuit is checked by observing the potential at the collectors of Q28 and Q29. The output waveform should be a 10 volt peak-to-peak square wave at a frequency of 60 Hz as illustrated on the schematic diagram at the rear of the manual. An unbalance in the inverter drive output will result in a reduced output. If the output waveform is distorted (unbalanced), resistors R78 and R86 should be adjusted for equal balancing with the OUTPUT switch in the OFF position and the FUNCTION SELECTOR in either AC or DC.

5-37 Common problems within this circuit are shorted or open transistors, low gain transistors, or input transformer T1 either opening or shorting. This transformer provides the drive which is necessary to generate the square wave.

5-38 Inverter. If the previous troubleshooting procedures have been made and all have checked satisfactorily, with still an indication of trouble in the output, next check the inverter circuitry. The inverter drive signal is applied to the bases of Q14 and Q15. The signal is a 10 volt peak-to-peak 60 cycle square wave as illustrated on the schematic diagram at the rear of the manual.

5-39 Normal ac and dc output waveforms of the inverter circuit are illustrated on the schematic diagram at the rear of the manual.

5-40 Loss of the inverter drive output will not enable the inverter circuit to operate properly. If either Q14 or Q15 is shorted and is drawing excessive current (this current may be monitored by the voltage drop across R46 or R47 which is typically 0.25 volts for each resistor) the output may still occur dependent upon the position of S1 and S2. However, if either Q14 or Q15 is shorted the voltage dropped across R46 or R47 will exceed .25 volts and be unbalanced.

5-41. A simple check to insure that the inverter transistors are not shorted is to measure from chassis ground to the emitters of Q14 and Q15. The resistance should be approximately 20 ohms. Excessive unbalance may be caused by either open or shorted secondaries or open or shorted components.

5-42 Current Limit Circuit. The 6920B has the capability of operating without the current limit circuit should it open. However, it is a protective circuit and should be thoroughly checked out. Typical problems occuring within the circuitry are:

1. The loss of current input signal as derived from junctions R46 and R47, the resistors located in the inverter circuitry.
2. Another cause of an inoperative current limit circuit may be the loss of the -6.2 volts DC.

5-43 Balance Amplifier. The signals that drive the balance amplifier are derived from the inverter circuit and, therefore, must be the correct value to insure proper output. To check this circuit, the following procedure should be used:

1. Turn the FUNCTION SELECTOR switch to AC.
2. Turn the RANGE switch to 1 volt.
3. Set the OUTPUT switch to ON HOLD.
4. Monitor the current between test points 11 and 12 with a milliammeter.
5. Adjust R99 for equal current splitting.

Problems occuring on the secondary side of transformer T4 may result in the balance amplifier not operating properly; that is, not being able to balance the current between Q14 and Q15.

5-44 Typical problems occuring in this circuit are the loss of sensing signals derived from the inverter circuit and the loss of dc reference.

5-45 ADJUSTMENT AND CALIBRATION

NOTE

Before performing any adjustments or calibrations turn-on the meter calibrator and allow a one hour warmup.

NOTE

All of the adjustment and calibration procedures in the following paragraph are valid for 50Hz as well as 60Hz operation. The sequence of adjustments (by paragraph number) is, as follows: 5-52, 5-50, 5-49, 5-51.

5-46 INVERTER PHASING

A. Set controls on meter calibrator as follows:

FUNCTION SELECTOR – AC
RANGE switch – 1V
OUTPUT SWITCH – ON HOLD

B. Connect series combination of switch (initially closed) and load resistance across output terminals. Load resistance should be 0.2Ω, 5 watts.

C. Connect oscilloscope across output terminals and set R99 (inside calibrator) to about mid-range.

D. Adjust output dial to obtain 1Vac, 60Hz, waveshape on oscilloscope.

E. Adjust potentiometers R78 and R86 to remove any spikes or notches on ac waveshape.

F. Open and close external switch (in series with load) several times so that load is removed and then reapplied.

G. Adjust R99, if necessary, to remove any notches or distortions that occur when switch is operated.

5-47 BALANCE AMPLIFIER

A. Set controls on meter calibrator as follows:

FUNCTION SELECTOR	-	AC
RANGE switch	-	1-volt
OUTPUT SWITCH	-	ON HOLD

B. Connect DC voltmeter between test points 11 and 12. (DC voltmeter should have at least 5mv 5mv resolution at zero.)

C. Adjust R99 for 0 ± 5mv indication on DC voltmeter.

5-48 DIAL PHASING (AC Zero)

A. Set controls on meter calibrator as follows:

FUNCTION SELECTOR	-	AC
RANGE switch	-	1-volt
OUTPUT SWITCH	-	ON HOLD
Dial	-	010

B. Connect AC voltmeter with 10 mv range and 2% accuracy across front panel output terminals. AC voltmeter indication should be 10 ± 0.25 mv.

C. If AC voltmeter indication is incorrect, loosen the two Allen-head setscrews that are recessed in the knob of the dial, gently push the knob inward to disengage the knob gear from the dial gear, and rotate the knob as necessary to obtain a 10 ± 0.25 mv indication (dial remains at 010). Gently pull the knob forward to engage the gears and then tighten the setscrews.

5-49 AC CALIBRATION

A. Set controls on meter calibrator as follows:

FUNCTION SELECTOR	-	AC
RANGE switch	-	1-volt
OUTPUT SWITCH	-	ON HOLD
Dial	-	(1)000

B. Connect AC voltmeter with 1-volt range and 0.1% accuracy across front panel output terminals.

C. Adjust R69 for 1 ± 0.001 volt indication on AC voltmeter.

5-50 DC ZERO

A. Set controls on meter calibrator as follows:

FUNCTION SELECTOR	-	DC
RANGE switch	-	1-volt
OUTPUT SWITCH	-	ON HOLD
Dial	-	010

B. Connect DC voltmeter with 10 mv range and 2% accuracy across front panel output terminals.

C. Adjust R7 for 10 ± 0.25 mv indication on DC voltmeter.

5-51 DC CALIBRATION

A. Set controls on meter calibrator as follows:

FUNCTION SELECTOR	-	DC
RANGE switch	-	1-volt
OUTPUT SWITCH	-	ON HOLD
Dial	-	(1)000

B. Connect DC voltmeter with 1-volt range and 0.05% accuracy across front panel output terminals.

C. Adjust R1 for 1 ± 0.0005 volt indication on DC voltmeter.

5-52 0.1 MA DC ZERO

A. Set controls on meter calibrator as follows:

FUNCTION SELECTOR	-	DC
RANGE switch	-	0.1 ma
OUTPUT SWITCH	-	OFF

Dial - 010

B. Connect DC ammeter with 1μa range and 5% accuracy across front panel output terminals.

Set OUTPUT SWITCH to ON HOLD.

C. Adjust R22 for 1 ± 0.05μa indication on DC DC ammeter.

PARTS LIST

SECTION VI
REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering replacement parts. Table 6-4 lists parts in alphanumeric order by reference designators and provides the following information:

a. Reference Designators. Refer to Table 6-1.

b. Description. Refer to Table 6-2 for abbreviations.

c. Total Quantity (TQ). Given only the first time the part number is listed except in instruments containing many sub-modular assemblies, in which case the TQ appears the first time the part number is listed in each assembly.

d. Manufacturer's Part Number or Type.

e. Manufacturer's Federal Supply Code Number. Refer to Table 6-3 for manufacturer's name and address.

f. Hewlett-Packard Part Number.

g. Recommended Spare Parts Quantity (RS) for complete maintenance of one instrument during one year of isolated service.

h. Parts not identified by a reference designator are listed at the end of Table 6-4 under Mechanical and/or Miscellaneous. The former consists of parts belonging to and grouped by individual assemblies; the latter consists of all parts not immediately associated with an assembly.

6-3 ORDERING INFORMATION

6-4 To order a replacement part, address order or inquiry to your local Hewlett-Packard sales office (see lists at rear of this manual for addresses). Specify the following information for each part: Model, complete serial number, and any Option or special modification (J) numbers of the instrument; Hewlett-Packard part number; circuit reference designator; and description. To order a part not listed in Table 6-4, give a complete description of the part, its function, and its location.

Table 6-1. Reference Designators

A	= assembly	E	= miscellaneous electronic part
B	= blower (fan)	F	= fuse
C	= capacitor	J	= jack, jumper
CB	= circuit breaker	K	= relay
CR	= diode	L	= inductor
DS	= device, signaling (lamp)	M	= meter
P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
Q	= transistor	VR	= zener diode
R	= resistor	X	= socket
S	= switch	Z	= integrated circuit or network
T	= transformer		
TB	= terminal block		
TS	= thermal switch		

Table 6-1. Reference Designators (Continued)

Table 6-2. Description Abbreviations

A	= ampere	mfr	= manufacturer
ac	= alternating current	mod.	= modified or modified
assy.	= assembly	mtg	= mounting
bd	= board	n	= nano = 10^{-9}
bkt	= bracket	NC	= normally closed
°C	= degree Centigrade	NO	= normally open
cd	= card	NP	= nickel-plated
coef	= coefficient	Ω	= ohm
comp	= composition	obd	= order by description
CRT	= cathode-ray tube	OD	= outside diameter
CT	= center-tapped	p	= pico = 10^{-12}
dc	= direct current	P.C.	= printed circuit
DPDT	= double pole, double throw	pot.	= potentiometer
DPST	= double pole, single throw	p-p	= peak-to-peak
elect	= electrolytic	ppm	= parts per million
encap	= encapsulated	pvr	= peak reverse voltage
F	= farad	rect	= rectifier
°F	= degree Farenheit	rms	= root mean square
fxd	= fixed	Si	= silicon
Ge	= germanium	SPDT	= single pole, double throw
H	= Henry	SPST	= single pole, single throw
Hz	= Hertz	SS	= small signal
IC	= integrated circuit	T	= slow-blow
ID	= inside diameter	tan.	= tantalum
incnd	= incandescent	Ti	= titanium
k	= kilo = 10^{3}	V	= volt
m	= milli = 10^{-3}	var	= variable
M	= mega = 10^{6}	ww	= wirewound
μ	= micro = 10^{-6}	W	= Watt
met.	= metal		

Table 6-3. Code List of Manufacturers

CODE NO.	MANUFACTURER	ADDRESS
00629	EBY Sales Co., Inc.	Jamaica, N.Y.
00656	Aerovox Corp.	New Bedford, Mass.
00853	Sangamo Electric Co. S. Carolina Div.	Pickens, S.C.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Semiconductor-Components Div.	Dallas, Texas
01686	RCL Electronics, Inc.	Manchester, N.H.
01930	Amerock Corp.	Rockford, Ill.
02107	Sparta Mfg. Co.	Dover, Ohio
02114	Ferroxcube Corp.	Saugerties, N.Y.
02606	Fenwal Laboratories	Morton Grove, Ill.
02660	Amphenol Corp.	Broadview, Ill.
02735	Radio Corp. of America, Solid State and Receiving Tube Div.	Somerville, N.J.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03797	Eldema Corp.	Compton, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co. Inc.	Cedar Knolls, N.J.
04009	Arrow, Hart and Hegeman Electric Co.	Hartford, Conn.
04072	ADC Electronics, Inc.	Harbor City, Calif.
04213	Caddell & Burns Mfg. Co. Inc.	Mineola, N.Y.
04404	*Hewlett-Packard Co. Palo Alto Div.	Palo Alto, Calif.
04713	Motorola Semiconductor Prod. Inc.	Phoenix, Arizona
05277	Westinghouse Electric Corp. Semiconductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	Grand Junction, Colo.
05820	Wakefield Engr. Inc.	Wakefield, Mass.
06001	General Elect. Co. Electronic Capacitor & Battery Dept.	Irmo, S.C.
06004	Bassik Div. Stewart-Warner Corp.	Bridgeport, Conn.
06486	IRC Div. of TRW Inc. Semiconductor Plant	Lynn, Mass.
06540	Amatom Electronic Hardware Co. Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co.	Penacook, N.H.
06666	General Devices Co. Inc.	Indianapolis, Ind.
06751	Semcor Div. Components, Inc.	Phoenix, Arizona
06776	Robinson Nugent, Inc.	New Albany, Ind.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07263	Fairchild Camera and Instrument Corp. Semiconductor Div.	Mountain View, Calif.
07387	Birtcher Corp., The	Los Angeles, Calif.
07397	Sylvania Electric Prod. Inc. Sylvania Electronic Systems Western Div.	Mountain View, Calif.
07716	IRC Div. of TRW Inc. Burlington Plant	Burlington, Iowa
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Co. Components Div. Semiconductor Operation	Mountain View, Calif.
08484	Breeze Corporations, Inc.	Union, N.J.
08530	Reliance Mica Corp.	Brooklyn, N.Y.
08717	Sloan Company, The	Sun Valley, Calif.
08730	Vemaline Products Co. Inc.	Wyckoff, N.J.
08806	General Elect. Co. Miniature Lamp Dept.	Cleveland, Ohio
08863	Nylomatic Corp.	Norrisville, Pa.
08919	RCH Supply Co.	Vernon, Calif.
09021	Airco Speer Electronic Components	Bradford, Pa.
09182	*Hewlett-Packard Co. New Jersey Div.	Rockaway, N.J.
09213	General Elect. Co. Semiconductor Prod. Dept.	Buffalo, N.Y.
09214	General Elect. Co. Semiconductor Prod. Dept.	Auburn, N.Y.
09353	C & K Components Inc.	Newton, Mass.
09922	Burndy Corp.	Norwalk, Conn.
[illegible]	Wagner Electric Corp. Tung-Sol Div.	Bloomfield, N.J.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of Cal. Inc.	So. Pasadena, Calif.
11502	IRC Div. of TRW Inc. Boone Plant	Boone, N.C.
11711	General Instrument Corp Rectifier Div.	Newark, N.J.
12136	Philadelphia Handle Co. Inc.	Camden, N.J.
12615	U.S. Terminals, Inc.	Cincinnati, Ohio
12617	Hamlin Inc.	Lake Mills, Wisconsin
12697	Clarostat Mfg. Co. Inc.	Dover, N.H.
13103	Thermalloy Co.	Dallas, Texas
14493	*Hewlett-Packard Co. Loveland Div.	Loveland, Colo.
14655	Cornell-Dubilier Electronics Div. Federal Pacific Electric Co.	Newark, N.J.
14936	General Instrument Corp. Semiconductor Prod. Group	Hicksville, N.Y.
15801	Fenwal Elect.	Framingham, Mass.
16299	Corning Glass Works, Electronic Components Div.	Raleigh, N.C.

*Use Code 28480 assigned to Hewlett-Packard Co., Palo Alto, California

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
16758	Delco Radio Div. of General Motors Corp.	Kokomo, Ind.
17545	Atlantic Semiconductors, Inc.	Asbury Park, N.J.
17803	Fairchild Camera and Instrument Corp Semiconductor Div. Transducer Plant	Mountain View, Calif.
17870	Daven Div. Thomas A. Edison Industries McGraw-Edison Co.	Orange, N.J.
18324	Signetics Corp.	Sunnyvale, Calif.
19315	Bendix Corp. The Navigation and Control Div.	Teterboro, N.J.
19701	Electra/Midland Corp.	Mineral Wells, Texas
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
22229	Union Carbide Corp. Electronics Div.	Mountain View, Calif.
22753	UID Electronics Corp.	Hollywood, Fla.
23936	Pamotor, Inc.	Pampa, Texas
24446	General Electric Co.	Schenectady, N.Y.
24455	General Electric Co. Lamp Div. of Consumer Prod. Group	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
24681	LTV Electrosystems Inc Memcor/Components Operations	Huntington, Ind.
26982	Dynacool Mfg. Co. Inc.	Saugerties, N.Y.
27014	National Semiconductor Corp.	Santa Clara, Calif.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
28875	IMC Magnetics Corp. New Hampshire Div.	Rochester, N.H.
31514	SAE Advance Packaging, Inc.	Santa Ana, Calif.
31827	Budwig Mfg. Co.	Ramona, Calif.
33173	G.E. Co. Tube Dept.	Owensboro, Ky.
35434	Lectrohm, Inc.	Chicago, Ill.
37942	P.R. Mallory & Co. Inc.	Indianapolis, Ind.
42190	Muter Co.	Chicago, Ill.
43334	New Departure-Hyatt Bearings Div. General Motors Corp.	Sandusky, Ohio
44655	Ohmite Manufacturing Co.	Skokie, Ill.
46384	Penn Engr. and Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
49956	Raytheon Co.	Lexington, Mass.
55026	Simpson Electric Co. Div. of American Gage and Machine Co.	Chicago, Ill.
56289	Sprague Electric Co.	North Adams, Mass.
58474	Superior Electric Co.	Bristol, Conn.
58849	Syntron Div. of FMC Corp.	Homer City, Pa.
59730	Thomas and Betts Co.	Philadelphia, Pa.
61637	Union Carbide Corp.	New York, N.Y.
63743	Ward Leonard Electric Co.	Mt. Vernon, N.Y.

CODE NO.	MANUFACTURER	ADDRESS
70563	Amperite Co. Inc.	Union City, N.J.
70901	Beemer Engrg. Co.	Fort Washington, Pa.
70903	Belden Corp.	Chicago, Ill.
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionic Corp.	Cambridge, Mass.
71400	Bussmann Mfg. Div. of McGraw & Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	I.T.T. Cannon Electric Inc.	Los Angeles, Calif.
71590	Globe-Union Inc. Centralab Div.	Milwaukee, Wis.
71700	General Cable Corp. Cornish Wire Co. Div.	Williamstown, Mass.
71707	Coto Coil Co. Inc.	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co. and Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co. Inc.	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N.Y.
72699	General Instrument Corp.	Newark, N.J.
72765	Drake Mfg. Co.	Harwood Heights, Ill.
72962	Elastic Stop Nut Div. of Amerace Esna Corp.	Union, N.J.
72982	Erie Technological Products Inc.	Erie, Pa.
73096	Hart Mfg. Co.	Hartford, Conn.
73138	Beckman Instruments Inc. Helipot Div.	Fullerton, Calif.
73168	Fenwal, Inc.	Ashland, Mass.
73293	Hughes Aircraft Co. Electron Dynamics Div.	Torrance, Calif.
73445	Amperex Electronic Corp.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73734	Federal Screw Products, Inc.	Chicago, Ill.
74193	Heinemann Electric Co.	Trenton, N.J.
74545	Hubbell Harvey Inc.	Bridgeport, Conn.
74868	Amphenol Corp. Amphenol RF Div.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	IRC Div. of TRW, Inc.	Philadelphia, Pa.
75183	*Howard B. Jones Div. of Cinch Mfg. Corp.	New York, N.Y.
75376	Kurz and Kasch, Inc.	Dayton, Ohio
75382	Kilka Electric Corp.	Mt. Vernon, N.Y.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76381	Minnesota Mining and Mfg. Co.	St. Paul, Minn.
76385	Minor Rubber Co. Inc.	Bloomfield, N.J.
76487	James Millen Mfg. Co. Inc.	Malden, Mass.
76493	J.W. Miller Co.	Compton, Calif.

*Use Code 71785 assigned to Cinch Mfg. Co., Chicago, Ill.

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
76530	Cinch	City of Industry, Calif.
76854	Oak Mfg. Co. Div. of Oak Electro/Netics Corp.	Crystal Lake, Ill.
77068	Bendix Corp., Electrodynamics Div.	No. Hollywood, Calif.
77122	Palnut Co.	Mountainside, N. J.
77147	Patton-MacGuyer Co.	Providence, R. I.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine and Foundry Co. Potter and Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N. J.
77764	Resistance Products Co.	Harrisburg, Pa.
76189	Illinois Tool Works Inc. Shakeproof Div.	Elgin, Ill.
78452	Everlock Chicago, Inc.	Chicago, Ill.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78526	Stanwyck Winding Div. San Fernando Electric Mfg. Co. Inc.	Newburyh, N. Y.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78584	Stewart Stamping Corp.	Yonkers, N. Y.
79136	Waldes Kohinoor, Inc.	L. I. C., N. Y.
79307	Whitehead Metals Inc.	New York, N. Y.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Co.	Mt. Kisco, N. Y.
80031	Mepco Div. of Sessions Clock Co.	Morristown, N. J.
80294	Bourns, Inc.	Riverside, Calif.
81042	Howard Industries Div. of Msl Ind. Inc.	Racine, Wisc.
81073	Grayhill, Inc.	La Grange, Ill.
81483	International Rectifier Corp.	El Segundo, Calif.
81751	Columbus Electronics Corp.	Yonkers, N. Y.
82099	Goodyear Sundries & Mechanical Co. Inc.	New York, N. Y.
82142	Airco Speer Electronic Components	Du Bois, Pa.
82219	Sylvania Electric Products Inc. Electronic Tube Div. Receiving Tube Operations	Emporium, Pa.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls Inc. Control Products Group	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Inc.	Woodstock, N. Y.
82993	Vector Electronic Co.	Glendale, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83186	Victory Engineering Corp.	Springfield, N. J.
83298	Bendix Corp. Electric Power Div.	Eatontown, N. J.
83330	Herman H. Smith, Inc.	Brooklyn, N. Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Div. of Amerace Esna Corp.	Brookfield, Mass.
83508	Grant Pulley and Hardware Co.	West Nyack, N. Y.
83594	Burroughs Corp. Electronic Components Div.	Plainfield, N. J.
83835	U. S. Radium Corp.	Morristown, N. J.
83877	Yardeny Laboratories, Inc.	New York, N. Y.
84171	Arco Electronics, Inc.	Great Neck, N. Y.
84411	TRW Capacitor Div.	Ogallala, Neb.
86684	RCA Corp. Electronic Components	Harrison, N. J.
86838	Rummel Fibre Co.	Newark, N. J.
87034	Marco & Oak Industries a Div. of Oak Electro/netics Corp.	Anaheim, Calif.
87216	Philco Corp. Lansdale Div.	Lansdale, Pa.
87585	Stockwell Rubber Co. Inc.	Philadelphia, Pa.
87929	Tower-Olschan Corp.	Bridgeport, Conn.
88140	Cutler-Hammer Inc. Power Distribution and Control Div. Lincoln Plant	Lincoln, Ill.
88245	Litton Precision Products Inc, USECO Div. Litton Industries	Van Nuys, Calif.
90634	Gulton Industries Inc.	Metuchen, N. J.
90763	United-Car Inc.	Chicago, Ill.
91345	Miller Dial and Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Neb.
91662	Elco Corp.	Willow Grove, Pa.
91929	Honeywell Inc. Div. Micro Switch	Freeport, Ill.
92825	Whitso, Inc.	Schiller Pk., Ill.
93332	Sylvania Electric Prod. Inc. Semi-conductor Prod. Div.	Woburn, Mass.
93410	Essex Wire Corp. Stemco Controls Div.	Mansfield, Ohio
94144	Raytheon Co. Components Div. Ind. Components Oper.	Quincy, Mass.
94154	Wagner Electric Corp. Tung-Sol Div.	Livingston, N. J.
94222	Southco Inc.	Lester, Pa.
95263	Leecraft Mfg. Co. Inc.	L. I. C., N. Y.
95354	Methode Mfg. Co.	Rolling Meadows, Ill.
95712	Bendix Corp. Microwave Devices Div.	Franklin, Ind.
95987	Weckesser Co. Inc.	Chicago, Ill.
96791	Amphenol Corp. Amphenol Controls Div.	Janesville, Wis.
97464	Industrial Retaining Ring Co.	Irvington, N. J.
97702	IMC Magnetics Corp. Eastern Div.	Westbury, N. Y.
98291	Sealectro Corp.	Mamaroneck, N. Y.
98410	ETC Inc.	Cleveland, Ohio
98978	International Electronic Research Corp.	Burbank, Calif.
99934	Renbrandt, Inc.	Boston, Mass.

Reference Designator	Description	Quantity	Mfr. Part # or Type	Mfr.	Mfr. Code	℗ Stock No.	RS
A1	Raysistor photo modular	1	CK1112-P	Raytheon	94144	1990-0059	1
C1,5,7,11	fxd, film .01μf 200vdc	4	192P10392	Sprague	56289	0160-0161	1
C2	fxd, film .22μf 80vdc	1	192P2249R8	Sprague	56289	0160-2453	1
C3	fxd, film .033μf 200vdc	1	192P33392	Sprague	56289	0160-0163	1
C4	fxd, elect 1μf 35vdc	1	150D105X9035A2	Sprague	56289	0180-0291	1
C6	fxd, elect 1400μf 30vdc	1	D38303	HLAB	09182	0180-1860	1
C8	fxd, film .0022μf 200vdc	1	192P22292	Sprague	56289	0160-0154	1
C9,18,25,26	fxd, elect 4.7μf 50vdc	4	150D475X9050B2	Sprague	56289	0180-1731	1
C10,24	fxd, elect 1200μf 20vdc	2	D33269	HLAB	09182	0180-1859	1
C12	fxd, film .068μf 200vdc	1	192P68392	Sprague	56289	0160-0166	1
C13,16,17	fxd, elect 100μf 50vdc	3	D32218	HLAB	09182	0180-1852	1
C14	fxd, elect 20μf 15vdc	1	30D206G015BB4	Sprague	56289	0180-0300	1
C15,28	NOT ASSIGNED	-	-	-	-	-	-
C19	fxd, film 510μμf 500vdc	1	CM15E511J	Arco	84171	0140-0047	1
C20	fxd, elect 20μf 50vdc	1	30D206G050DC4	Sprague	56289	0180-0049	1
C21	fxd, elect 100μf 25vdc	1	30D107G025DH4	Sprague	56289	0180-0094	1
C22,30	fxd, elect 5μf 150vdc	2	40D505F150DD4	Sprague	56289	0180-1841	1
C23	fxd, elect 2250μf 10vdc	1	D36218	HLAB	09182	0180-1917	1
C27	fxd, elect 100μf 6vdc	1	30D107G006DB4	Sprague	56289	0180-1734	1
C29	fxd, cer. .02μf 2000vdc Disc.	1	41C321	Sprague	56289	0160-2569	1
C31	fxd, cer. 200μf 15vdc	1	30D207G015DH4	Sprague	56289	0180-0104	1
C32	fxd, cer. 4400μf 2vdc	1	D33267	HLAB	09182	0180-1994	1
CR1,2,52,53	Rect. si. 3A 200prv	4	MR1032B	Motorola	04713	1901-0416	4
CR3	SCR 25prv	1	2N2322	G. E.	03508	1884-0026	1
CR4,11,14, 18,19,24-27, 37-41,48-51	Rect. si. 500ma 200prv	18	1N3253	R. C. A.	02735	1901-0389	8
CR5-7,12,13, 20,21,28,29, 32,34	Rect. si. 200ma 10prv	11	111S1	Sylvania	93332	1901-0461	7
CR8-10	Rect. si. 1A 200prv	3	G100D	G. I.	72699	1901-0327	3
CR15,16,22,23, 36,42,43	NOT ASSIGNED	-	-	-	-	-	-
CR17,30,31, 33,35	Diode si.	5	1N485B	Sylvania	93332	1901-0033	5
CR44-47	Rect. si. 500ma 1600prv	4	1N2359	Electr. Dev.	81751	1901-0037	4
DS1	Indicator light, neon	1	599-124	Drake	72765	1450-0048	1
DS2	Indicator light, incadescent	1	MCL-B-3-1738	T. E. C.	07137	1450-0306	1
F1	Fuse cartridge 1A@125V 3AG SB	1	313001	Littlefuse	75915	2110-0007	5
L1	Coil 100μh	1		HLAB	09182	9100-1900	1
Q1	Diff. amp.	1	BD1148	HLAB	09182	1854-0221	1
Q2-6,13,17, 19,20,22,23 30,31	SS NPN si.	13	4JX16B533	HLAB	09182	1854-0027	7
Q7,18,25,32	NOT ASSIGNED	-	-	-	-	-	-
Q8,9,33,34	Power PNP Ger.	4		HLAB	09182	1850-0168	4
Q10	SS NPN Ger.	1		HLAB	09182	1851-0037	1
Q11,12,26,27	SS PNP si.	4	2N2907A	Sprague	56289	1853-0099	4
Q14,15	Power PNP Ger.	2		HLAB	09182	1850-0168	2
Q16	SS PNP si.	1	40362	R. C. A.	02735	1853-0041	1
Q21,24	SS NPN si.	2		HLAB	09182	1854-0244	2
Q28,29	SS PNP Ger.	2	2N1378	T. I.	01295	1850-0182	2

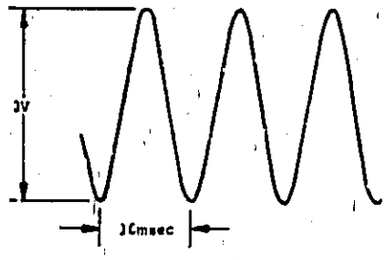
Reference Designator	Description	Quantity	Mfr. Part # or Type	Mfr.	Mfr. Code	HP Stock No.	RS
R1	var. ww 100Ω ±5% 1w	1	Model 100	I.R.C.	07716	2100-1450	1
R2	Factory selected, approx. value 2550Ω ±1% 1/4w	1		HLAB	09182	0811-1939	1
R3,85,88,107	fxd, comp 510Ω ±5% 1/2w	4	EB-5115	A.B.	01121	0686-5115	1
R4	var. ww ±3% 10-turn, ±0.05%	1	2201B Spl.	Borg	96791	2100-2159	1
R5,6,19,20, 50,51	fxd, comp 5.1KΩ ±5% 1/2w	6	EB-5125	A.B.	01121	0686-5125	1
R7	var. ww 250Ω	1	Type 110-F4	C.T.S.	11236	2100-0439	1
R8	fxd, comp 75KΩ ±5% 1/2w	1	EB-7535	A.B.	01121	0686-7535	1
R9	fxd, comp 20KΩ ±5% 1/2w	1	EB-2035	A.B.	01121	0686-2035	1
R10,61	fxd, comp 7.5KΩ ±5% 1/2w	2	EB-7525	A.B.	01121	0686-7525	1
R11	fxd, comp 6.2KΩ ±5% 1/2w	1	EB-6225	A.B.	01121	0686-6225	1
R12	fxd, comp 3.3KΩ ±5% 1/2w	1	EB-3325	A.B.	01121	0686-3325	1
R13,14	fxd, comp 430KΩ ±5% 1/2w	2	EB-4345	A.B.	01121	0686-4345	1
R15,16	fxd, comp 47KΩ ±5% 1/2w	2	EB-4735	A.B.	01121	0686-4735	1
R17,48	fxd, comp 3.6KΩ ±5% 1/2w	2	EB-3625	A.B.	01121	0686-3625	1
R18	fxd, comp 22 megΩ ±5% 1/2w	1	EB-2265	A.B.	01121	0686-2265	1
R21	fxd, comp 10 megΩ ±5% 1/2w	1	EB-1065	A.B.	01121	0686-1065	1
R22	var. comp 100KΩ Series 70	1		C.T.S.	71450	2100-0095	1
R23,33,34,38, 55,72,79,80, 100,101	fxd, comp 1KΩ ±5% 1/2w	10	EB-1025	A.B.	01121	0686-1025	2
R24,39,49,57, 58,92,93, 103	NOT ASSIGNED	-	-	-	-	-	-
R25	fxd, comp 100Ω ±5% 1/2w	1	EB-1015	A.B.	01121	0686-1015	1
R26	fxd, ww 200Ω ±5% 20w	1	Type 2BRS-37	H.H.	73978	0811-1907	1
R27	fxd, ww 500Ω ±5% 7w	1	Type 7X	W.L.	63743	0811-1859	1
R28,73	fxd, ww 1KΩ ±5% 7w	2	Type 7X	W.L.	63743	0811-1862	1
R29	fxd, ww 12Ω ±5% 20w	1	Type 2BRS-37	H.H.	73978	0811-1896	1
R30	fxd, comp 3KΩ ±5% 1/2w	1	EB-3025	A.B.	01121	0686-3025	1
R31	fxd, comp 10Ω ±5% 1/2w	1	EB-1005	A.B.	01121	0686-1005	1
R32,37	fxd, comp 620Ω ±5% 1/2w	2	EB-6215	A.B.	01121	0686-6215	1
R35	fxd, comp 1.8KΩ ±5% 1/2w	1	EB-1825	A.B.	01121	0686-1825	1
R36,108	fxd, comp 22Ω ±5% 1/2w	2	EB-2205	A.B.	01121	0686-2205	1
R40	fxd, comp Selected ±5% 1/2w	1	Type EB	A.B.	01121	-	-
R41	fxd, comp 15KΩ ±5% 1/2w	1	EB-1535	A.B.	01121	0686-1535	1
R42	fxd, comp 200Ω ±5% 1/2w	1	EB-2015	A.B.	01121	0686-2015	1
R43,98	fxd, comp 5.6KΩ ±5% 1/2w	2	EB-5625	A.B.	01121	0686-5625	1
R44,45	fxd, comp 3.9KΩ ±5% 1/2w	2	EB-3925	A.B.	01121	0686-3925	1
R46,47	fxd, ww 0.5Ω ±5% 3w 20ppm	2	Type 3X	W.L.	63743	0811-1830	1
R52	fxd, film 430Ω ±5% 2w	1	Type C42S	Corning	16299	0764-0024	1
R53,70	fxd, comp 10KΩ ±5% 1/2w	2	EB-1035	A.B.	01121	0686-1035	1
R54	fxd, ww 714Ω ±1% 1/4w	1		HLAB	09182	0811-1935	1
R56,66	fxd, ww 634Ω ±1% 1/4w	2		HLAB	09182	0811-1934	1
R59,60,77	fxd, comp 100KΩ ±5% 1/2w	3	EB-1045	A.B.	01121	0686-1045	1
R62,76	fxd, comp 1.3KΩ ±5% 1/2w	2	EB-1325	A.B.	01121	0686-1325	1
R63,96,97	fxd, comp 200KΩ ±5% 1/2w	3	EB-2045	A.B.	01121	0686-2045	1
R64	fxd, comp 68Ω ±5% 1/2w	1	EB-6805	A.B.	01121	0686-6805	1
R65	fxd, ww 210Ω ±1% 1/4w	1		HLAB	09182	0811-1926	1
R67	fxd, ww 2KΩ ±1% 1/4w	1		HLAB	09182	0811-1936	1
R68	Factory selected, approx. value 10.0KΩ ±1% 1/4w	1		HLAB	09182	0811-1946	1
R69	var. ww 500Ω ±5% 1w	1	Model 100	I.R.C.	07716	2100-0898	1
R71	fxd, comp 36KΩ ±5% 1/2w	1	EB-3635	A.B.	01121	0686-3635	1
R74	fxd, comp 300Ω ±5% 1/2w	1	EB-3015	A.B.	01121	0686-3015	1
R75	fxd, comp 1.5KΩ ±5% 1/2w	1	EB-1525	A.B.	01121	0686-1525	1
R78,86	var, ww 25KΩ Series 70	2		C.T.S.	71450	2100-1534	1
R81,84	fxd, comp 6.8KΩ ±5% 1/2w	2	EB-6825	A.B.	01121	0686-6825	1

Reference Designator	Description	Quantity	Mfr. Part # or Type	Mfr.	Mfr. Code	Stock No.	RS
R82,83	fxd, comp 39KΩ ±5% 1/2w	2	EB-3035	A.B.	01121	0686-3035	1
R87,89	fxd, comp 2.2KΩ ±5% 1/2w	2	EB-2225	A.B.	01121	0686-2225	1
R90,91	fxd, film 56Ω ±5% 2w	2	Type C42S	Corning	16299	0764-0013	1
R94,95	fxd, comp 12KΩ ±5% 1/2w	2	EB-1235	A.B.	01121	0686-1235	1
R99	var, ww 100Ω	1	Type 110-F4	C.T.S.	71450	2100-0281	1
R102	fxd, comp 51KΩ ±5% 1/2w	1	EB-5135	A.B.	01121	0686-5135	1
R104,105	fxd, comp 680KΩ ±5% 1w	2	GB-6845	A.B.	01121	0689-6845	1
R106	fxd, comp 20KΩ ±5% 1w	1	GB-2035	A.B.	01121	0689-2035	1
R109	fxd, ww 500Ω ±0.1% 2.5w	1	Type T2C	R.C.L.	01686	0811-1991	1
R110	fxd, ww 4.5KΩ ±0.1% 2.5w	1	Type T2C	R.C.L.	01686	0811-1993	1
R111	fxd, ww 45KΩ ±0.1% 10w	1	Type T10	R.C.L.	01586	0811-1995	1
R112,113	fxd, ww 225KΩ ±0.1% 1.5w	2	Type 7060	R.C.L.	01686	0811-1998	1
R114,115	fxd, ww 5005Ω ±0.1% 1/4w	2	Type R303B	R.C.L.	01686	0811-1943	1
R116	fxd, ww 1KΩ ±0.1% 2.5w	1	Type T2C	R.C.L.	01686	0811-1992	1
R117	fxd, ww 100Ω ±0.1% 3.5w	1	Type T3	R.C.L.	01686	0811-1990	1
R118	fxd, ww 10Ω ±0.1% 2.5w	1	Type T2C	R.C.L.	01686	0811-1988	1
R119	fxd, ww 1Ω ±0.1% 2.5w	1	Type R834	R.C.L.	01686	0811-2062	1
R120	fxd, ww 0.1Ω ±0.1% 2.5w	1	Type R835	R.C.L.	01686	0811-2061	1
R121	fxd, comp 5.1 megΩ ±5% 1w	1	GB-5155	A.B.	01121	0689-5155	1
R122	fxd, comp 510KΩ ±5% 2w	1	Type C42S	Corning	16299	0698-0030	1
R123	fxd, ww 50KΩ ±5% 10w	1		HLAB	09182	0811-0955	1
R124	fxd, ww 500Ω ±5% 10w	1		HLAB	09182	0811-0952	1
R125	fxd, ww 5Ω ±5% 10w	1		HLAB	09182	0811-0950	1
S1	FUNCTION switch 3 position, ON/OFF	1		HLAB	09182	3100-1903	1
S2	RANGE switch 10 position	1		HLAB	09182	3100-1905	1
S3	OUTPUT switch Type LL blk.	1	T1GM6A	Carling	73559	3101-0983	1
S4	AC REF. switch, slide	1	4663-F	Muter	42190	3101-0039	1
T1	Bias transformer	1		HLAB	09182	9100-1896	1
T2	Coupling transformer	1		HLAB	09182	9100-1897	1
T3	Power transformer	1		HLAB	09182	9100-1898	1
T4	High voltage transformer	1		HLAB	09182	9100-1899	1
VR1	Diode, zener 6.19v	1		HLAB	09182	1902-0049	1
VR2	Diode, zener 4.27v	1		HLAB	09182	1902-3070	1
VR3	NOT ASSIGNED	-	-	-	-	-	-
VR4,6	Diode, zener 6.2v	2	1N821	N. A. Elect.	06486	1902-0761	2
VR5	Diode, zener 6.2v	1	1N825	Transitron	83877	1902-0777	1
VR7	Diode, zener 14.7v 10% 1.5w	1		Motorola	04713	1902-0212	1
	Panel-front	1		HLAB	09182	06920-00001	
	Chassis-transformer	1		HLAB	09182	06920-00002	
	Chassis-rear	1		HLAB	09182	06920-00003	
	Bracket-P.C. Board	2		HLAB	09182	06920-00004	
	Bracket-P.C. Board	2		HLAB	09182	06920-00005	
	Cover-side	2		HLAB	09182	5000-6145	
	Cover-top	1		HLAB	09182	5000-6146	
	Cover-bottom	1		HLAB	09182	5000-6147	
	Heat sink	1		HLAB	09182	06920-20001	
	Insulator double	1		HLAB	09182	0340-0086	1
	Insulator double	1		HLAB	09182	0340-0090	1
	Stand tilt half module	1		HLAB	09182	1490-0032	1
	Hinge	2		HLAB	09182	5040-0700	1
	Foot assembly half module	2		HLAB	09182	5060-0728	1
	Connector	1		Tower	60427	1251-0148	1

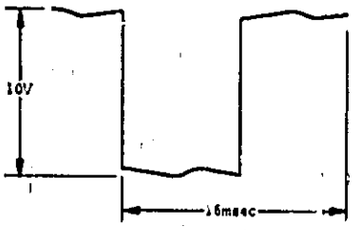
Reference Designator	Description	Quantity	Mfr. Part # or Type	Mfr.	Mfr. Code	Stock No.	R
	Cord, 18-3 SVT 7.5 ft.	1		HLAB	09182	8120-0078	1
	Fuseholder	1	342014	Littlefuse	75915	1400-0048	1
	Binding post assembly	1		HLAB	09182	1510-0009	1
	Binding post assembly	1		HLAB	09182	1510-0008	1
	Knob 1/4 I.D. insert pointer	2		HLAB	09182	0370-0077	1
	Capacitor clip	5		HLAB	09182	1400-0321	1
	Mica washer	4	#734	Reliance Mica	08530	0340-0174	4
	Nut, captive	4	C8020-632-4	Tinnerman	89032	0590-0052	1
	Barrier strip	1	600-YSY-2	Kulka	75382	0360-1209	1
	Jumper	1	422-13-11-013	Cinch	71785	0360-1143	1
	Insulator	8		HLAB	09182	0340-0168	6
	Insulator, transistor pin	8		HLAB	09182	0340-0166	6
	Micro-dial	1	1309 SPECIAL	HLAB	09182	1140-0035	1

SCHEMATIC DIAGRAMS

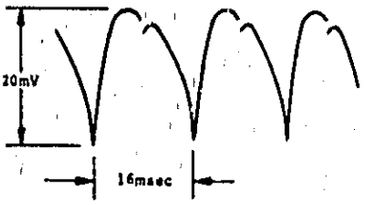
AC OUTPUT
BETWEEN HI(+) AND LO(-)
RANGE SWITCH SET TO 1 VOLT.



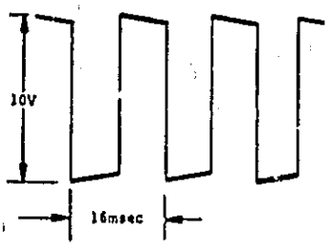
INVERTER DRIVE OUTPUT
BETWEEN Q28 AND Q29 COLLECTORS



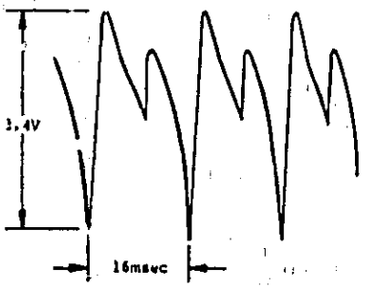
DC OUTPUT RIPPLE
BETWEEN HI(+) AND LO(-)
RANGE SWITCH SET TO 1 VOLT.



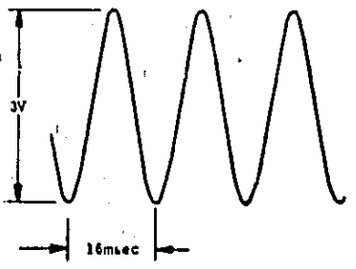
INVERTER OUTPUT (DC)
BETWEEN Q14 AND Q15 COLLECTORS
FUNCTION SELECTOR SET TO DC
RANGE SWITCH SET TO 1 VOLT



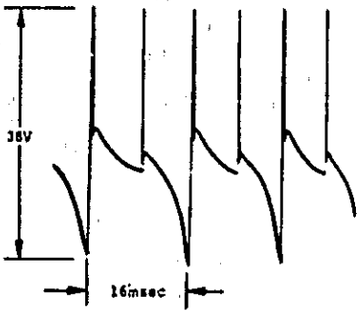
DC OUTPUT RIPPLE
RANGE SWITCH SET TO 100 VOLTS

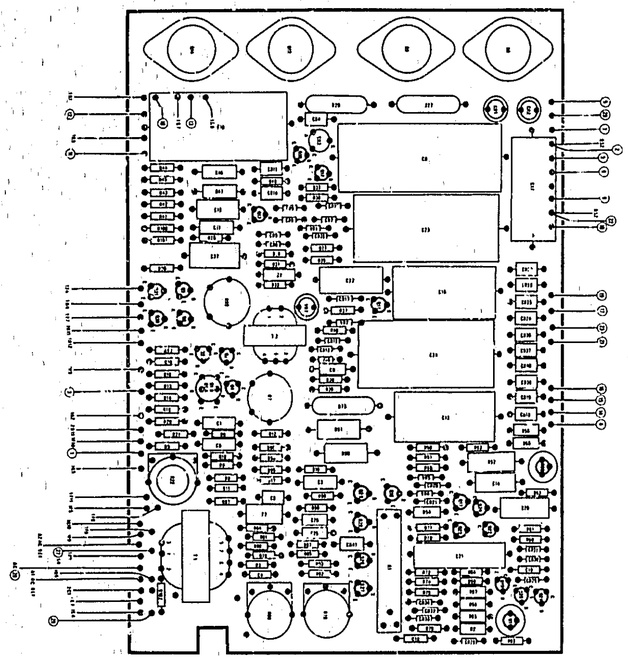


INVERTER OUTPUT (AC)
BETWEEN Q14 AND Q15 COLLECTORS
FUNCTION SELECTOR SET TO AC
RANGE SET TO 1 VOLT

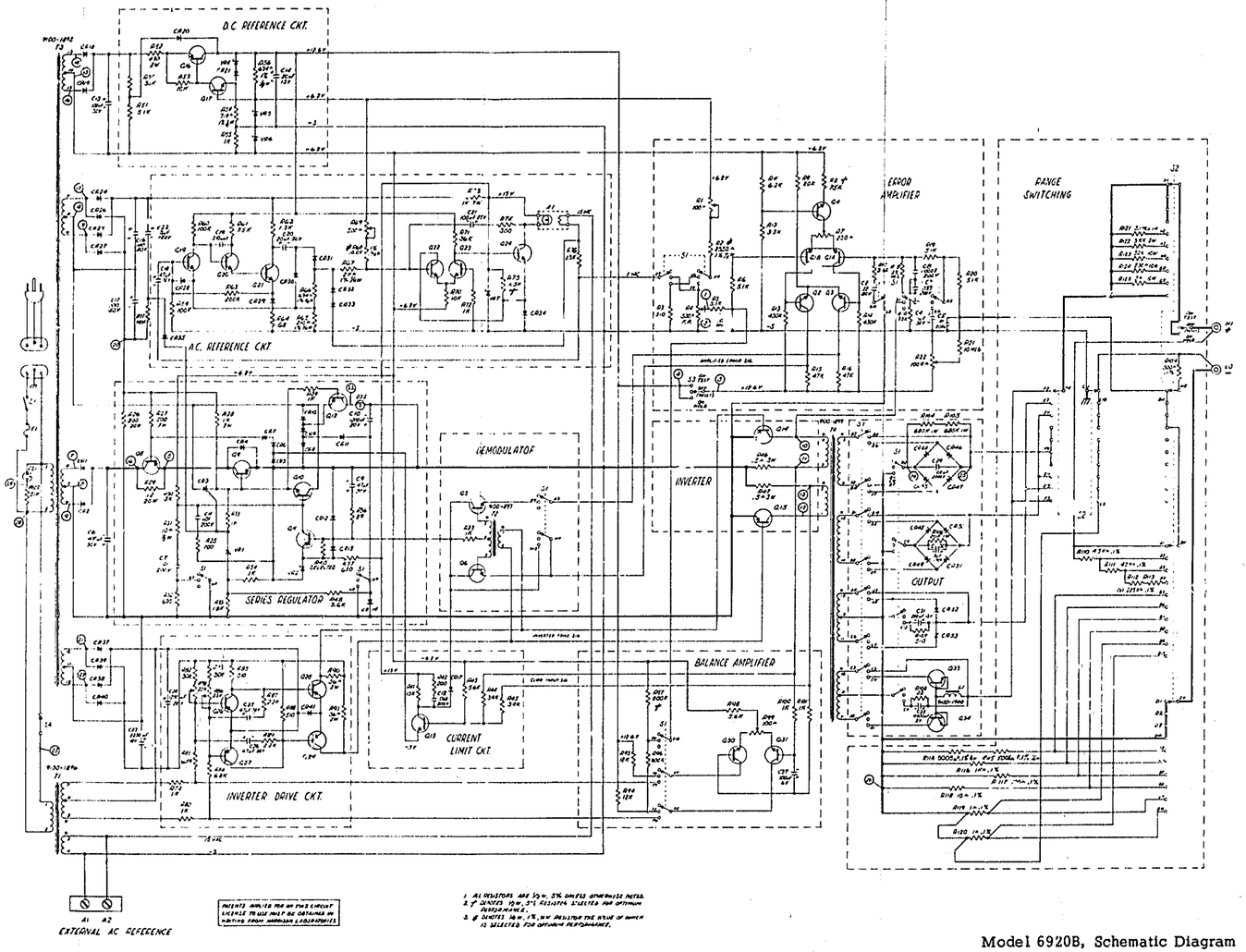


DC OUTPUT RIPPLE
RANGE SWITCH SET TO 500 VOLTS





NOTES
1. CATHODES OF DIODES ALL FACING TOWARDS BOTTOM OF BOARD
2. POSITIVE SIDES OF ALL CAPACITORS FACING TOWARDS BOTTOM OF BOARD EXCEPT WHERE SHOWN
3. UPPER P.C. BOARD ALL PARTS MOUNTED AS S1 EXCEPT 2811 & 2C1



Model 6920B, Schematic Diagram

MANUAL CHANGES

MANUAL CHANGES
Model 6920B Meter Calibrator
Manual Serial Number Prefix 6D

Make all corrections in the manual according to errata below, then check the following table for your calibrator serial number and enter any listed change(s) in the manual.

SERIAL		MAKE
Prefix	Number	CHANGES
All		
6D	0451-0625	Errata
7D		1
7D	0776-0925	1,2
7D	0926-1000	1,2,3
7D	1001-1150	1,2,3,4
7D	1151-1350	1,2,3,4,5
7D	1351-1900	1 thru 6
1105A	1901-1950	1 thru 7
1105A	1951-2000	1 thru 8
1116A	2001-2230	1 thru 9
1201A	2231-2269	1 thru 10
1201A	2270-3360	1 thru 11
1515A	3361-3520*	1 thru 12
1533A	3521-3920	1 thru 13
1533A	3921-4120	1 thru 14
1724A	4121-4320	1 thru 15
1744A	4321-4750	1 thru 16
1836A	4751-5150	1 thru 17
1930A	5151-5700	1 thru 18
2032A	5701-6110	1 thru 19
2139A	6111-up	1 thru 20

ERRATA:

In the specifications table 1-1, page 1-2 change the OVERLOAD PROTECTION specification to read as follows:

DC OPERATION: May be shorted in voltage ranges and open circuited in current ranges without damage.

AC OPERATION: In the AC mode, overvoltage protection is not guarenteed under all conditions. The output may be shorted in the voltage ranges but avoid opening the output when in the current range.*

* When in the current ranges, refer to the following caution note.

The following caution applies to paragraphs 3-25 thru 3-28

CAUTION

In AC operation the OUTPUT SWITCH must always be reset to its OFF position before changing ranges or functions, or before removing a load. This will avoid possible damage to the load or to the meter calibrator.

ERRATA:

On the schematic diagram, change transistors Q33 and Q34 (lower right hand corner) to PNP transistors.

CHANGE 1:

In the replaceable parts table, make the following changes:

Q1: Change Type No. to SA2361 (Amelco) and HP Part No. to 1854-0312.

VR5: Change to Diode, Zener 6.2V ±5%, 1N825, Transitron, HP Part No. 1902-1221.

CHANGE 2:

On the title page, change the Serial Number Prefix from 6D to 7D.

In the replaceable parts table make the following changes:

C28: Add C28, fxd, ceramic 470pF 6kV, 09182, HP Part No. 0150-0036.

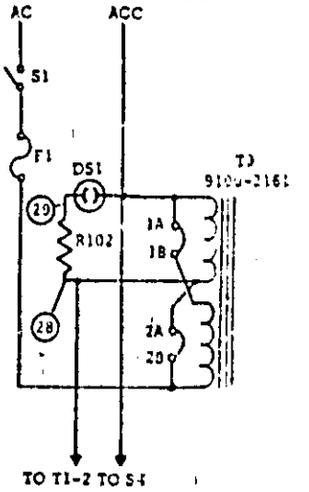
R49: Add R49, fxd, comp 30kΩ, ±5%, 1/2W, EB-3035, A. B.. HP Part No 0686-3035.

* See Note under Change 12

R64: Change to fxd, comp 120Ω, ±5%, 1/2W, EB-1215, A. B., HP Part No. 0686-1215.

T3: Change to Power Transformer, 09182, HP Part No. 9100-2161.

On the schematic, the primary of power transformer T3 should be connected as shown in the adjacent sketch for 115Vac operation. For 230Vac operation, the jumpers between lugs 1A and 1B and 2A and 2B must be removed and lugs 1B and 2A connected together. (For 230Vac, 50Hz operation the unit must also be realigned in accordance with Option 005). Also on the schematic connect new resistor (R49) and capacitor (C28) in series between terminal 5 and 6 of T4. R49 to terminal 6 and C28 to terminal 5.



In the replaceable parts table, make the following changes:

Q2, 3: Change to SS NPN Si., 2N3390, G. E., HP Part No. 1854-0202.

R122: fxd, met. ox. 510k ±5%, 2W, Type C42S, Corning, HP Part No. 0698-3672.

On the schematic, change all of the terminal numbers for FUNCTION SELECTOR switch, S1, as shown in the following chart. Electrical connections to the present switch remain the same; only the terminal numbers should be changed.

S1 Terminal Number Changes

OLD	NEW
A1	A3
A2	A4
A7	A10
A8 *	A9 *
B10 *	D9 *
B4	D3
B5	D4
B6	D5
B11 *	D10 *
C10 *	E10 *
D7 *	F7 *
B12	D11
C2	E2
C3	E3
C4	E4
C6	E6
C7	E7
C8	**
C9	E9
C11	E11
C12	E12
D1	F1
D2	F2
D3	F3
D4	F4
D5	F5
D8	F8

OLD	NEW
D9	F9
D10	F10
E4	G4
E6	G6
E7	G7
E8	G8
F4	H3
F5	H4
F6	H5
F7	H7
F8	H8
F9	H9
F10	H11
F11	H12
G1	J1
G2	J2
G5	J5
G6	J6
G7	J7
G8	J8
G9	J9
G10	J10
H3	K3
H4	K4
H11	K11
H12	K12

* Jumpered
** Not Used

FUNCTION SELECTOR switch S1 has been changed from a four deck switch to a five deck switch. The HP Part Number remains the same (3100-1903). The following drawing shows how to physically locate any terminal on switch S1. For example, Terminal A2 would be located on the front side of the outermost deck.

CHANGE 4:

In the replaceable parts table, change potentiometer R7 to 500Ω ±10%, HP Part No. 2100-0328.

CHANGE 5:

In the replaceable parts table, change R62 from 1/2W to 3W resistor, HP Part No. 0811-1803.

CHANGE 6:

In the replaceable parts table, change transformer T1 to HP Part No. 06920-80092, and T2 to HP Part No. 06920-80091.

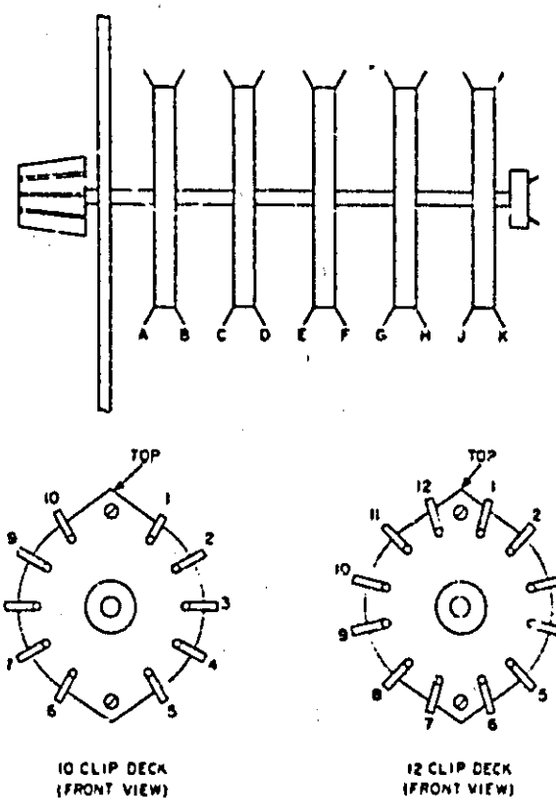
CHANGE 7:

In the replaceable parts table, change transistors Q33 and Q34 to a matched pair of transistors, HP Part No. 06920-80001, quantity 1. These transistors must be replaced as a pair.

ERRATA:

In the replaceable parts list, make the following change:

L1: Change to HP Part No. 06920-60093.



S1 CONTACT LOCATIONS

On page 1-1, delete all of Paragraphs 1-5 and 1-6. On Page 3-2, delete the NOTE concerning the output dial. Although the output dial can be mechanically positioned below 010, it is not calibrated below 010.

CHANGE 8:

In the replaceable parts table and on the schematic, make the following changes:

A1 (photocell): Change to HP Part No. 1990-0316.

Q1: Change to HP Part No. 1854-0375.

Add R58: Add new resistor R58, 12kΩ, ±1%, 1/8W, HP Part No. 0698-5088. R58 is connected across the photocell resistance.

R70: Change to 6.8k, ±5%, 1/2W, HP Part No. 0686-6825.

R71: Change to 20k, ±5%, 1/2W, HP Part No. 0686-2035.

R75: Change to 13k (nominal) ±5%, HP Part No. 0686-1335.

AC Power Connector: Change to HP Part No. 1251-2357.

CHANGE 9:

In the replaceable parts table and on the schematic, make the following changes:

C11: Change to .1μF, 200V, HP Part No. 0170-0019.

Add C33: Add new capacitor C33, fxd, 4.7μF, 6V, HP Part No. 0180-1954. C33 is connected across R34 in the series regulator circuit.

R25: Change to 1kΩ, ±5%, 1/2W, HP Part No. 0686-1025.

CHANGE 10:

The standard colors for this instrument are now mint gray (for front and rear panels) and olive gray (for all top, bottom, and side surfaces). Option X95 designates use of the former color scheme of light gray and blue gray. Option A85 designates use of a light gray front panel with olive gray used for all other external surfaces. New part numbers are shown below.

CHANGE 11:

In the replaceable parts table and on the schematic, change R43 from 5.6k, 1/2W, 0686-5625 to 13k, 1/2W, 0686-1335.

CHANGE 12:

NOTE: This change also applies to the following 1201A serial numbers:

1201A – 02287	1201A – 03327
1201A – 03104	1201A – 03331
1201A – 03156	1201A – 03334
1201A – 03209	1201A – 03335
1201A – 03277	1201A – 03336
1201A – 03286	1201A – 03337
1201A – 03292	1201A – 03338
1201A – 03297	1201A – 03339
1201A – 03307	1201A – 03340
1201A – 03308	1201A – 03341
1201A – 03309	1201A – 03344
1201A – 03317	1201A – 03346
1201A – 03321	1201A – 03352
1201A – 03322	1201A – 03353
1201A – 03324	1201A – 03354
1201A – 03326	1201A – 03355
1201A – 03357	
1201A – 03358	
1201A – 03359	

In the replaceable parts table and on the schematic, make the following changes:

R82, 83: Change to 43k, 1/2W, HP Part No. 0686-4335.

CR41: Delete

R103: Add 10Ω, 1W, HP Part No. 0689-1005. On schematic, connect R103 in place of CR41 in inverter driver circuit.

CHANGE 13:

The transistor formerly used for Q28 and Q29 has been discontinued by the manufacturer. Change the part number for these transistors to 1853-0012, which is directly interchangeable with the former device.

ERRATA:

In Paragraphs 3-38, 3-40, and in Figure 3-5, change the external oscillator output rating to 15Vac ±10% at (typically) 6 to 8mA.

Change the part number of pilot light DS1 to 1450-0566. This new light is more reliable than the former one.

CHANGE 14:

The values of three resistors are no longer specified. Instead, these resistors are selected for optimum performance in each unit. R82 and R83 are now nominally 56k, 1/2W, HP Part No. 0686-5635, and are selected to optimize the adjustment range of R78 and R86, which minimize zero crossover distortion in the inverter. The nominal value of R43 is now 10k, 1/2W, HP Part No. 0686-1035. R43 is selected to adjust the current limit to about 150% of rated current.

ERRATA:

In par. 2-7, change "6920A" to "6920B". In par. 2-9 and the note following it, change "Harrison Laboratories" to "Hewlett-Packard".

DESCRIPTION	HP PART NO.		
	STANDARD	OPTION A85	OPTION X95
Front Panel	06920-00006	06920-00001	
Rear Panel	06920-00007	06920-00003	Refer to
Cover, Top	5000-3061	5000-3061	Manual Parts
Cover, Bottom	5000-3062	5000-3062	List
Cover, Side	5000-9432	5000-9432	

ERRATA:

In the parts list, change the HP Stock No. of R1 to 2100-1770 and that of R69 to 2100-1772. The resistors have not been changed; just their part numbers have.

CHANGE 15:

Make the following changes to the parts list and the schematic: change R22 in the error amplifier circuit to 100k, 10%, 2100-3214; change R78 and R83 in the inverter drive circuit to 20k, 10%, 2100-0555.

CHANGE 16:

Change counting display from HP Part No. 1110-0035 to 1140-0046 on page 6-8. The new part is not directly interchangeable with the old one because of a modification to the front panel.

CHANGE 17:

Delete Fuseholder HP Part No. 1400-0084.

Add: Fuseholder body HP Part No. 2110-0564, carrier HP Part No. 2110-0565, and spacer HP Part No. 5020-2568. Change Fuseholder nut to HP Part No. 2110-0569.

CHANGE 18:

On page 6-8, delete Capacitor clip, quantity 5, HP Part No. 1400-0321. Add cable tie, quantity 5, HP Part No. 1400-0493.

CHANGE 19:

On the schematic diagram, add a new capacitor, C34, in parallel with R33, with its + side toward the VR1 end of R33. In the replaceable parts list, add C34, 1μF 20V HP Part No. 0180-0230; change R34 to 910 ohm, 5% HP Part No. 0686-9115; change Q10 to HP Part No. 1854-0215.

CHANGE 20:

In the parts list and on the schematic diagram add ferrite bead inductor, HP Part No. 9170-0894 to the emitter leg of Q10.

ERRATA:

In the parts list, change the part number of R1 to 2100-0568 and that of R69 to 2100-0554. The new resistors are completely interchangeable with the old ones.

▶ Also, change Q1 to HP Part No. 1854-0875. This supersedes any earlier changes to Q1.

7/19/82