CHAPTER

4

CHAPTER 4

MAINTENANCE

4.1 GENERAL CONSIDERATIONS

The Model 26.268 DVM is designed for long-term accuracy and trouble free operation. The use of solid-state and conservatively rated components, in conjunction with high-quality etched-circuit boards, ensures long-term reliability.

In addition to the material contained in this paragraph, schematic and wiring diagrams of the DVM are provided in Appendix 2 (including component location diagrams) and a complete list of replaceable parts, including descriptions and part numbers, is contained in Appendix 1. (Information on ordering spare or replacement parts from EAI is found immediately after the title page in the front of this handbook.)

It should be noted that these maintenance instructions and data cannot cover all possible troubles and malfunctions; it is, therefore, essential that maintenance personnel become thoroughly familiar with the DVM circuitry. General purpose maintenance data cannot be substituted for technical knowledge of the instrument.

NOTE

Whenever the 26.116-1 Summing Resistor Network, the 26.242 Comparator and Diode Gate Unit, or the 12.937-1 Network of the DVM are serviced, the DVM must be recalibrated to insure specified accuracy. If the 6.736 Reference Amplifier or 43.141 Regulator of the DVM power supply are serviced or replaced, the power supply output levels must be carefully and accurately checked.

4.2 TROUBLE ANALYSIS

To assist in analyzing malfunctions, the DVM circuits should be considered as subdivided into four groups: the input circuits (including both dc amplifiers and associated circuits), the resistor matrix and comparator circuit, the digitizing circuits (including the programmer, and the four BCD counters), and the reference and power circuits. All measurements of signal circuits should be made with a high impedance device, such as an oscilloscope, to prevent circuit loading and possible misleading results.

4.2.1 Test Connector Functions

The test connector (J3) provided at the rear of the DVM is a very useful troubleshooting aid. Many signals within the DVM are terminated at this connector, permitting easy access with a sharp test prod. If desired, a test cable may be constructed to mate with J3 and terminate the signals at a remote chassis or panel equipped with tip jacks or their equivalent. The mating connector for this purpose is a 25 pin male Cannon connector (EAI Part Number 542 098-0).

The following table (Table 4.1) lists the signals present at each pin of J3.

Table 4.1. Test Connector J3 Functions

J3 Pin	Signal Description
1	Reference Amplifier Balance Output
2	-100 Volt Reference Level ±.005% with Respect to +10 Volt Reference
3	+40 Volt Level ±1%
4	No Connection
5	-20 Volt Level ±1%
6	-110 Volt Level ±.5%
7	Conversion Complete Signal (Waveform e, Figure 3.4)
8	Amplifier B Output
9	Amplifier A Output
10	+2 Volt Level ±15%
11	+15 Volt Level ±5%
12	+20 Volt Level ±1%
13	-7.5 Volt Level ±7%
14	-15 Volt Level ±5%
15	Zero Set Signal (Waveform d, Figure 3.4)
16	Ground
17	Stabilizer Output, Amplifier A
18	Stabilizer Output, Amplifier B
19-25	No Connection

4.2.2 Reference Circuit and Power Supplies

All power and reference supplies for the DVM are contained in the DVM chassis. The levels and tolerances are listed in Paragraph 1.3 of Chapter 1. (See Figure 5.2, Chapter 5 for Control Location.) A rough check of the -100 volt reference supply can be made with a VTVM or scope; however, for an accurate check a test circuit of at least ±0.005% accuracy should be used.

Check the reference amplifier balance as follows:

1. Allow 1/2 hour warm-up if the power supply has been off.

2. Connect a multimeter (Triplett, Model 630A, or equal) between pins 1 and 16 of J3. The meter should fluctuate about zero (±0.05 volt) on the 3-volt range*.

3. If the meter does not read within these limits, adjust R9 on the 6.736 Card. (See Figure 5.2, Chapter 5.)

CAUTION

Relatively high levels of voltage may be generated as the balance control is rotated. Use high voltage ranges of meter first, reducing to the 3-volt range as the voltage null is approached.

4.2.3 Input Circuit

The general operating condition of the two unloading amplifiers can be checked by performing the following balance procedure: (Inability to balance usually indicates an amplifier circuit malfunction.)

1. Allow 1/2 hour warm-up time if unit has been off.

2. Connect a multimeter (Triplett, Model 630A, or equal) between J3-17 and and J3-16. (Check amplifier A.)

**The meter needle vibrates since the stabilizer output at this point is pulsating dc.*

3. If the meter does not read between ±0.05 volt, adjust R10 on the 12.937-1 Network Card until the needle vibrates about zero. (See Figure 5.2, Chapter 5.)

CAUTION

Relatively high levels of voltage may be generated as the balance control is rotated. Use high voltage ranges of meter first, reducing to the 3-volt range as the voltage null is approached.

4. Repeat this procedure for amplifier B; connect the meter between J3-18 and J3-16. Adjust R11 on the 12.937-1 if necessary.

If the DVM functions normally with negative inputs but malfunctions with positive inputs, amplifier B is probably at fault (the polarity relay, K1, could also cause this effect). With a known input, the output of amplifier A can be checked at J3-9. The amplifier A gain should be 1.25; the output of amplifier B (equal but opposite to amplifier A) can be checked at J3-8.

4.2.4 Resistor Matrix and Comparator Circuit

The resistor matrix is best checked by performing the accuracy check outlined in Paragraph 4.3 of this chapter.

Malfunction of the comparator is indicated (but not confirmed) if the DVM, with no input connected, displays a maximum readout of ±1.1999. Also if the DVM registers all zeros with a signal input, the comparator could be at fault. A suspected comparator malfunction can be verified by monitoring pin 47 of connector A8 with a scope; compare to waveform (i) of Figure 3.4.

4.2.5 Digitizing Circuit

The visual readout indicator serves as one of the best trouble indicators for checks of the digitizing circuitry. Accordingly, the troubleshooting procedures of this sub-paragraph are grouped with respect to possible indicator displays. If the DVM is removed from the computer, test cables should be used to reconnect J1 and J2 to the computer mating receptacles.

4.2.5.1 *Indicators Displaying Fixed Reading.* A fixed readout display (assuming the input amplifiers and comparator have been eliminated as possible trouble sources) usually indicates that the digitizing cycle has stopped. The loss of the master clock pulses (12-18 kc clock) will stop the digitizing cycle. Check for the clock pulses at pin F of connector A5.

If one or more of the lower order display readouts are at zero, the counting cycle probably has stopped in the lowest order decade that is displaying a digit higher than zero. The suspected decade counter can be checked by interchanging it with the next lower order counter. If the count again stops at the suspected card, the fault is isolated to that card. All of the counters are interchangeable including the Model 38.032-1 1000's counter. However, as previously noted, if the 1000's counter is repositioned during trouble analysis it should be returned to the 1000's position. The DVM will function with this card in any position, but, since it normally drives two lamps, it should be returned to the 1000's position to insure longer lamp life.

4.2.5.2 *Indicator Displaying Continually-Changing Random Digits*. This display indicates the digitizing circuits are functioning but trouble may exist in the input circuits.

4.2.5.3 *Two Digits Displayed Simultaneously on a Single Indicator*. This display usually indicates a faulty diode in the BCD to decimal conversion matrix. The faulty diode can be isolated by noting the particular combination of digits.

NOTE

Noise on the input signal may cause one or more of the lowest order displays to flicker between digits.

4.3 ACCURACY CHECK

Due to the high accuracy of the DVM, a complete calibration procedure is necessarily an exacting process. It is the purpose of this paragraph to provide an accuracy check to determine which, if any, of the calibration adjustments are necessary to bring the DVM within the required specification. It is suggested that all results be double checked before attempting the indicated calibration adjustments.

Allow a 1/2 hour warm-up period of all equipment to assure DVM circuit and test equipment stabilization before starting the check procedure. Apply the inputs listed in Table 4.2 and check for the indicated readout (+% of additional full scale error due to the error of the power source).

Table 4.2. Accuracy Check Inputs, First Test

Input Level	DVM Readout	Summing Resistor Gates Checked
-9.999 VDC	-0.9997 to -1.0001	8 and 1
-7.777 VDC	-0.7775 to -0.7779	4, 2 and 1
-6.666 VDC	-0.6664 to -0.6668	4 and 2
-5.555 VDC	-0.5553 to -0.5557	4 and 1
-3.333 VDC	-0.3331 to -0.3335	2 and 1

If certain combinations are in error, one particular summing resistor gate adjustment may seem to be indicated as faulty. However, this should not be considered as conclusive since two gates may be in error and their errors may cancel when used in combination with each other. If erroneous readouts are obtained, apply the inputs listed in Table 4.3 and check for the indicated readout.

Table 4.3. Accuracy Check Inputs, Second Test

Input Level*	DVM Readout	Summing Resistor Gates Checked
-8.003 VDC	-0.8001 to -0.8005	8000
-4.003 VDC	-0.4001 to -0.4005	4000
-2.003 VDC	-0.2001 to -0.2005	2000
-1.003 VDC	-0.1001 to -0.1005	1000
-0.803 VDC	-0.0801 to -0.0805	800

If all the gates are in error, with the 8000's gate error largest and the error progressively decreasing (the 800's gate error the smallest), the full scale setting may need adjustment, or, the -100 volt reference may be out of tolerance. Check these adjustments as outlined in Chapter 5 (it is best to check reference first since adjustment of the full scale control interacts with the gate adjustments).

If one or more of the gates are in error adjust these gates as outlined in Chapter 5.

**The last digit of the input (millivolt digit) should be 3 millivolts + the % error of the dc source; this assures that the 1000's 8, 4, 2, and 1 and the 100's 8 gates conduct.*

NOTE

After making any adjustment to the DVM repeat the check-out procedure starting with Table 4.2.

If both checks are within specifications proceed as follows:

1. Apply an input of -10.000 volts and note the readout (should be between -0.9998 and -1.0002).

2. Apply an input of +10.000 volts. The readout should be between +0.9998 and +1.0002 units plus any error between the two voltage sources (if separate positive and negative supplies are used) in addition to the basic full scale error of the power sources. (If the positive readout is in error the dc gain control may require adjustment.)

   If all of the voltages are read out within the tolerances specified, the DVM is within the required accuracy specifications and no further check is required nor is calibration needed.

4.4 DISPLAY INDICATORS

Only two troubles can occur directly involving the display unit. The numerals and symbols are displayed by a multiple lens rear projection arrangement. The light source for each numeral or symbol is an individual incandescent lamp. Since the lamps are operated at less than rated voltage, filament life is exceptionally long under normal conditions.

4.4.1 Display Unit Checks

The display unit is best checked by applying a voltage to the DVM through a potentiometer, and increasing the voltage slowly while observing the display. If any digit fails to light, either the lamp is faulty or the associated lamp driver transistor is faulty. The easiest way to check is to substitute a lamp bulb known to be good in the suspected position. If the trouble remains, the associated lamp driver transistor should be checked.

4.4.1.1 *Lamp Replacement.* To replace an indicator lamp, proceed as follows:

1. Remove the left-hand side panel of the computer so that the rear of the display unit is exposed.

2. Apply an input to the DVM which causes an adjacent decade indicator to display the same numeral as that which has failed.

3. Observe the rear of the display unit, and note the position of the illuminated lamp on the adjacent indicator. Remove the bulb in the corresponding position of the faulty decade indicator. Visual observation or an ohmmeter continuity check of the suspected bulb may be used to determine whether bulb replacement is required or if the driver transistor should be suspected.

4.4.1.2 *Lamp Adjustment.* Since a multiple lens optical system is used to focus a symbol on the front screen of the display unit, proper positioning of the bulb filament is important to assure clarity of the associated symbol. If a digit or symbol appears blurred or fuzzy (and the DVM appears to be operating correctly), proceed as follows:

1. Apply an input to the DVM which causes the blurred symbol to be illuminated.

2. Remove the illuminated lamp in the position with the blurred symbol, rotate the bulb 180° (the bulbs have a bayonet base), and replace it. If this procedure fails to correct the trouble, install a new bulb.

CHAPTER 5

CHAPTER 5

CALIBRATION

5.1 INTRODUCTION

This chapter contains instructions for a complete calibration of the DVM. It should be noted that calibration of an instrument with the accuracy of the DVM is an exacting procedure requiring precision equipment and extremely stable voltage sources not normally available in field installations (to obtain ±0.01% of full scale +1 digit accuracy). Unless such equipment is available, EAI recommends that the DVM be returned to the factory if re-calibration becomes necessary.

Prior to attempting the calibration check, the accuracy check outlined in Chapter 4 should be performed. The check performs a twofold function; it ascertains that calibration is necessary and it localizes the exact calibration adjustment required. This last feature of the check permits calibration of certain circuits without having to perform the entire calibration procedure.

5.2 REQUIRED EQUIPMENT

The equipment listed in Table 5.1 is the type recommended to calibrate the DVM to 0.01% of full scale +1 digit.

5.3 CALIBRATION PROCEDURES

Allow a one-hour warm up period for the DVM and all test equipment to assure circuit stabilization before proceeding. Ascertain that the +10 and -10 volt computer reference supplies are carefully balanced before attempting any adjustments.

5.3.1 Reference Level Adjustment

1. Balance the reference amplifier as outlined in Chapter 4.
2. Set up the test circuit illustrated in Figure 5.1. (The setting of the voltage divider is 10 to 1.)

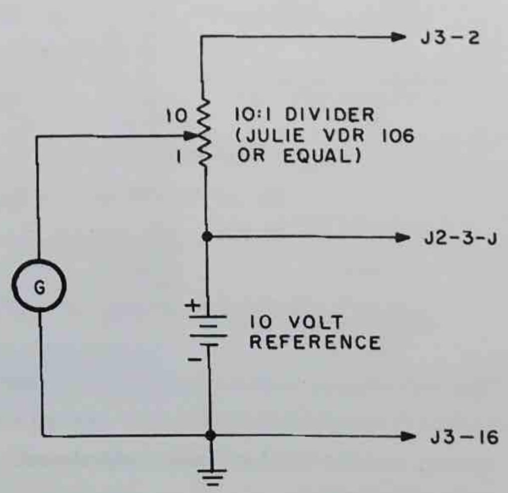


Figure 5.1. Reference Level Adjustment Test Setup

Table 5.1. Recommended Test Equipment

Component	Recommended Type	Used For
Precision Voltage Divider (6-Place)	Julie VDR 106 (Or Equal)	1. Reference Adjustment 2. DC Gain Adjustment 3. Summing Network Trimming Adjustment
Galvanometer (Capable of Detecting 1/10 Micro-volt or Better	Hewlett-Packard, Model 425A (Or Equal)	1. Reference Adjustment 2. DC Gain Adjustment 3. Summing Network Trimming Adjustment
Secondary Standard Volt Cell (Calibrated at 0.002%)	Epley MIN II Calibrated Against a Primary Standard (Or Equal)	Reference Adjustment
Two 30,000 Ohm, Ten-Turn Potentiometers	Helipot, Model 30,000-A1 (Or Equal)	Summing Network Trimming Adjustment
Stable 10 Volt DC Source	See Procedure in test for calibrating a stable 10 volt source to 0.005%.	1. DC Gain Adjustment 2. Summing Network Trimming Adjustment

NOTE

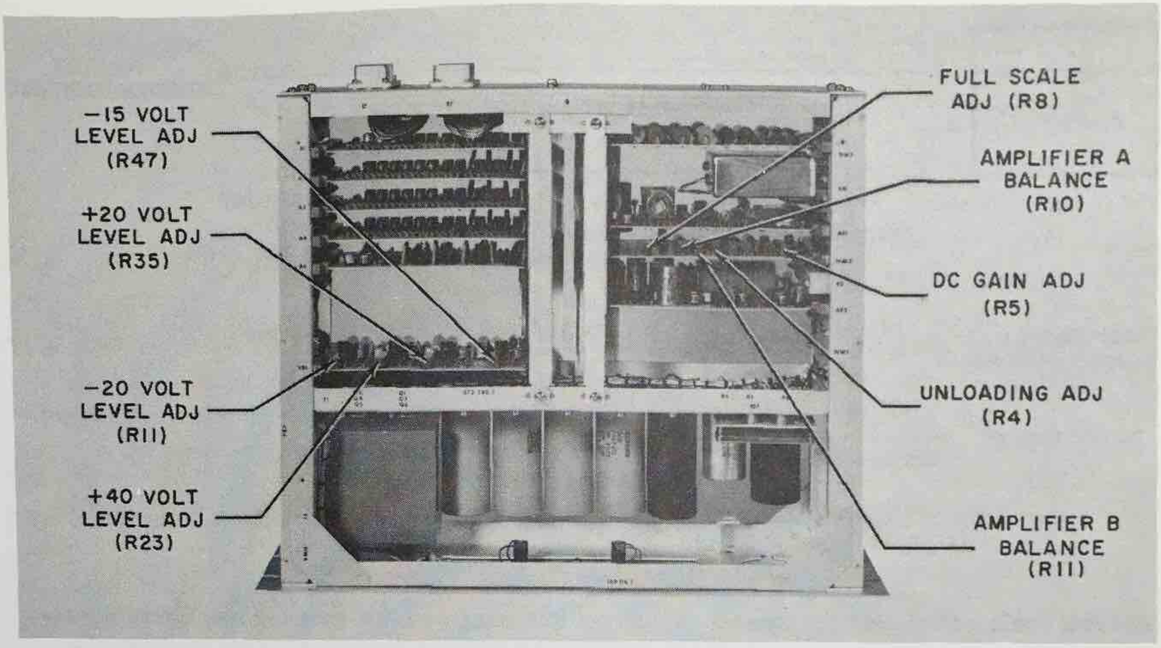
It is assumed that all other power supply levels have been checked and meet the specifications listed in Chapter 1.

3. Adjust R29 and R30 on the 6.736 Unit (Figure 5.2) until a null is obtained on the galvanometer. (This procedure sets the reference level at -100 vdc ±0.005% with respect to the +10.000 volt reference.)

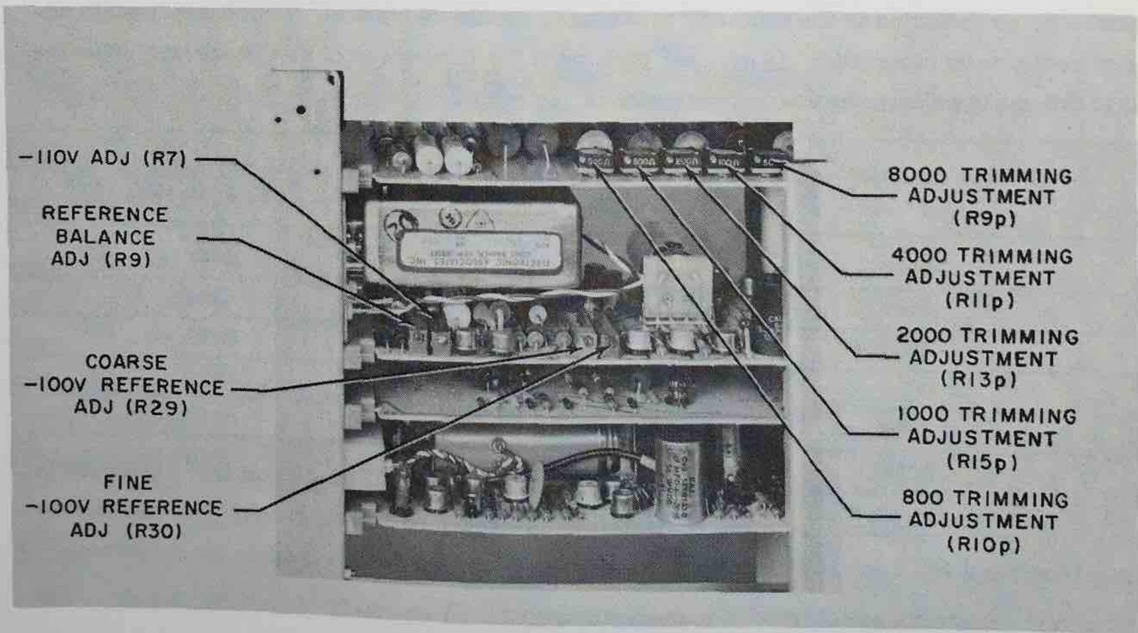
5.3.2 Test Reference Calibration (-10 VDC)

The following procedure provides a -10 vdc ±0.005% test reference source which may be used in lieu of computer reference for the full scale adjustment, summing resistor trim pot adjustments, and the DVM unloading adjustment. (This source may also be used for dc gain adjustment if desired.)

1. Set up the test circuit illustrated in Figure 5.3. (The setting of the voltage divider is determined by the actual potential of the standard cell.)



(a) Controls Accessible from Top



(b) Controls Accessible from Bottom

Figure 5.2. Calibration Controls Location

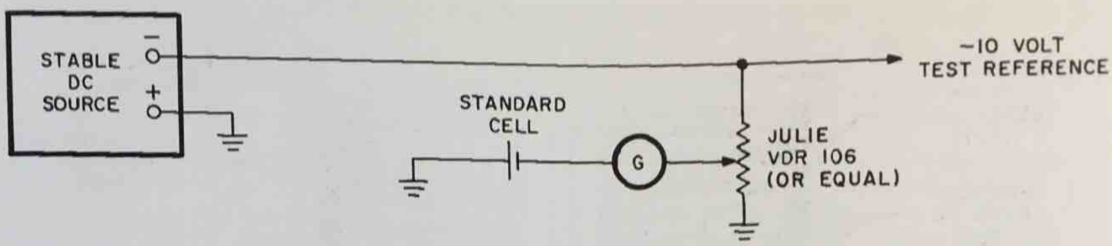


Figure 5.3. -10 Volt Test Reference Calibration Setup

2. Adjust the stable dc source output for a null on the galvanometer. This sets the test reference level at -10 vdc ±0.005%.

5.3.3 Full Scale Adjustment

The full scale adjustment can *appear* to correct summing resistor gate errors; likewise, adjustment of the summing resistor gates may *appear* to correct a misadjustment of full scale. An indication of full scale misadjustment, therefore, should be verified by the accuracy check procedure outlined in Chapter 4, Paragraph 4.3. Also for this reason, the initial control position, as indicated in the following procedure, should be marked. Thus the full scale adjustment can be returned to its original position if the final check of this procedure indicates that full scale adjustment was not the cause of the error.

NOTE

Before attempting to adjust the full scale adjustment check the -100 volt reference level as outlined in Paragraph 5.3.1 above.

1. Check the amplifier balance as outlined in Chapter 4.

2. Set up the test circuit shown in Figure 5.4. (The -10 volt test reference is obtained from the computer or as described in Paragraph 5.3.2 above.)

3. Zero the DVM indicators as outlined in Chapter 2, Paragraph 2.1.1.

4. Set the voltage divider for 9.998 volts; adjust the unloading potentiometers for a galvanometer null. *Note and carefully mark the present position of the full scale control* (Figure 5.2, R8 on the 12.937-5 Network.)

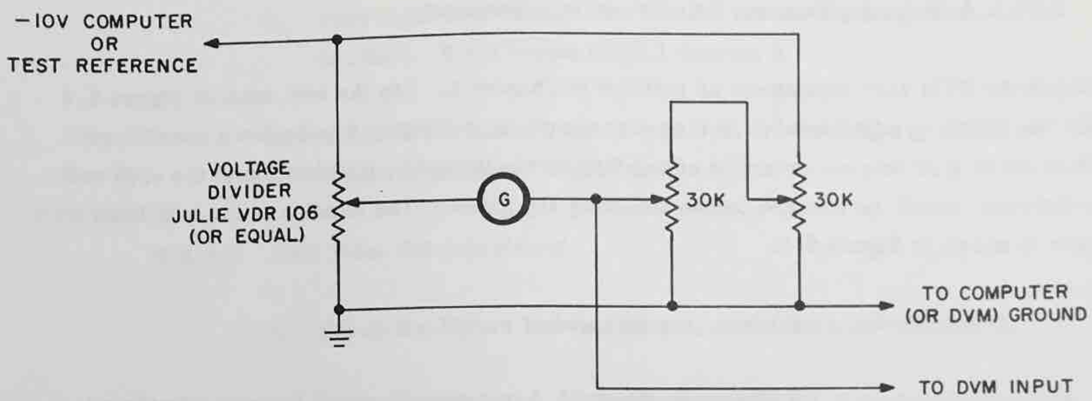


Figure 5.4. Test Setup for Full Scale and Summing Resistor Trim Pot Adjustment

5. Adjust the full scale control for a DVM readout of -0.9998.

6. Once the full scale adjustment has been completed check that the DVM makes a smooth counting transition through each of the trim gates as indicated in Table 5.2.

Table 5.2. DVM Counting Transition Check

Apply Input For DVM Readout Of	Increase Input For Readout Of	Further Increase Input For Readout Of
-.7998	-.7999	-.8000
-.3998	-.3999	-.4000
-.1998	-.1999	-.2000
-.0998	-.0999	-.1000
-.0798	-.0799	-.0800
-.0398	-.0399	-.0400

If the unit does not make a smooth counting transition, (for example if the DVM switches from -.7998 unit to -.8000 unit thus skipping -.7999) it indicates a summing resistor trim pot is improperly set. Recheck all of the gates as outlined in the accuracy check in Chapter 4. If it is found that all of the gates are out, reset the full scale control to the recorded initial position and repeat the accuracy check to isolate the faulty summing resistor trimming adjustment(s).

5.3.4 Summing Resistor Gate Trim Pot Adjustment

Check the DVM zero adjustment as outlined in Chapter 4. Use the test setup of Figure 5.4 for the following adjustments. If the accuracy check in Chapter 4 indicates a specific gate is in error it is only necessary to adjust that particular gate. (Calibration of the -100 volt reference should be checked before adjusting any gates.) The location of the individual trim pots is shown in Figure 5.2.

5.3.4.1 *8000 Trim Pot Adjustment*

1. Set up the Figure 5.4 test circuit, check the zero adjustment.

2. Apply an input of -8.0015 volts to the DVM. (Check galvanometer for a null condition.)

3. Adjust R9p on the 26.116-1 Summing Resistor Network (NW2) until the readout flickers between -0.8001 and -0.8002*.

4. Re-check zero; if zero requires resetting repeat Steps 1 through 3.

5. Vary input to ascertain that the unit counts smoothly from -.7998 to -.8000. If not repeat Steps 1 through 4.

6. If this is the last trim pot adjustment to be made, repeat accuracy check of Chapter 4.

5.3.4.2 *4000 Trim Pot Adjustment*

1. Set up the Figure 5.4 test circuit; check the zero adjustment.

2. Apply an input of -4.0015 volts to the DVM. (Check galvanometer for a null condition.)

3. Adjust R11p on the 26.116-1 Summing Resistor Network (NW2) until the readout flickers between -0.4001 and -0.4002*.

4. Re-check zero; if zero required resetting repeat Steps 1 through 3.

**Approach all settings from the high side, e.g., 8.003 to 8.002 to flickering condition.*

5. Vary input to ascertain that the unit counts smoothly from -.3998 to .4000. If not repeat Steps 1 through 4.

6. If this is the last trim pot adjustment to be made, repeat the accuracy check of Chapter 4.

5.3.4.3 *2000 Trim Pot Adjustment*

1. Set up the Figure 5.4 test circuit; check the zero adjustment.

2. Apply an input of -2.0015 volts to the DVM. (Check galvanometer for a null condition.)

3. Adjust R13p on the 26.116-1 Summing Resistor Network (NW2) until the readout flickers between -0.2001 and -0.2002*.

4. Re-check zero; if zero requires resetting repeat Steps 1 through 3.

5. Vary input to ascertain that the unit counts smoothly from -.1998 to -.2000. If not repeat Steps 1 through 4.

6. If this is the last trim pot adjustment to be made, repeat the accuracy check of Chapter 4.

5.3.4.4 *1000 Trim Pot Adjustment*

1. Set up the Figure 5.4 test circuit; check the zero adjustment.

2. Apply an input of -1.0015 volts to the DVM. (Check galvanometer for a null condition.)

3. Adjust R15p on the 26.116-1 Summing Resistor Network (NW2) until the readout flickers between -0.1001 and -0.1002*.

4. Re-check zero; if zero requires resetting repeat Steps 1 through 3.

5. Vary input to ascertain that the unit counts smoothly from -.0998 to -.1000. If not repeat Steps 1 through 4.

**Approach all settings from the high side.*

6. If this is the last trim pot adjustment to be made, repeat the accuracy check of Chapter 4.

5.3.4.5 *800 Trim Pot Adjustment*

1. Set up the Figure 5.4 test circuit; check the zero adjustment.

2. Apply an input of -0.8015 volts to the DVM. (Check galvanometer for a null condition.)

3. Adjust R10p on the 26.116-1 Summing Resistor Network (NW2) until the readout flickers between -0.0801 and -0.0802*.

4. Re-check zero; if zero required resetting repeat Steps 1 through 3.

5. Vary input to ascertain that the unit counts smoothly from -.0798 to -.0800. If not repeat Steps 1 through 4.

6. Repeat the accuracy check of Chapter 4.

5.3.5 DC Gain Adjustment (Figure 5.2)

Prior to making this adjustment ascertain that the computer reference supplies are balanced.

1. Apply the -10 volt computer reference to the DVM input and note the readout display.

2. Apply the +10 volt computer reference to the DVM input. If the readout is not the same as Step 1, adjust R5 on the 12.937-5 Network (NW3).

3. Repeat Steps 1 and 2 if adjustment is necessary.

5.3.6 Amplifier Unloading Adjustment (Figure 5.2)

1. Set up the test circuit shown in Figure 5.5.

2. Place the switch in position A. The DVM should read -1.0000 unit.

**Approach all settings from the high side.*

3. Place the switch in position B. The DVM should read ≥ -0.9980. (Indicating a current flow of ≤ 0.02 microamperes.)

4. If readout is less than -0.9980 volts, adjust R4 on the 12.937-1 Network (NW3) for a readout greater than or equal to -0.9980 unit. This provides the DVM with an input impedance ≥ 500 megohms at full scale.

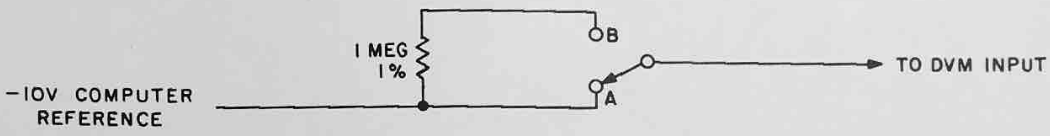


Figure 5.5. DVM Unloading Adjustment Test Setup