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OPERATING INSTRUCTIONS
4300 SERIES DIGITAL VOLTMETERS

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NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

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I.

INTRODUCTION

Series 4300 Digital Voltmeters are low-cost all-electronic instruments whose characteristics are outlined in the specifications which follow. The Model 4318 serves as a basis for describing the other instruments in the series because it is the most complex instrument. For other models, see the list in this section to find which circuits, functions, and controls mentioned are to be disregarded.

Two schematic drawings are supplied with the manual. Schematic No. 43-2, Change A, is applicable to instruments carrying Serial Number .174 or higher; Schematic Number 43-2 (with no change letter), is applicable to the earlier instruments.

If this instrument is given the same care and handling as given to any sensitive electronic instrument, it can be expected to give years of trouble-free service. If a malfunction should occur, the schematic drawing should be consulted to locate test points, establish power supply voltages, and read oscilloscope waveforms.

If additional information is required, or if assistance is needed to fit the instrument to an application, please contact the nearest NLS Sales/Service Center.

TABLE 1.
4300 SERIES LIST OF MODELS

MODEL	NUMBER OF		FUNCTION CONTROLS			
	DIGITS	RANGES	POLARITY	RANGE*	PRINTER CONTACTS	REMOTE RANGING
4301	4	1	M	F		
4302	4	1	M	F	YES	
4303	4	1	A	F		
4304	4	1	A	F	YES	
4305	4	3	M	M		
4306	4	3	M	M	YES	
4307	4	3	A	M		
4308	4	3	A	M	YES	
4309	4	3	A	AM	YES	
4310	4	3	A	AM		
4311	4	3	A	AM	YES	YES
4312	4	4	M	M		
4313	4	4	M	M	YES	
4314	4	4	A	M		
4315	4	4	A	M	YES	
4316	4	4	A	AM	YES	
4317	4	4	A	AM		
4318	4	4	A	AM	YES	YES
4319	3	1	M	F		
4320	3	1	M	F	YES	
4321	3	1	A	F		
4322	3	1	A	F	YES	
4323	3	3	M	M		
4324	3	3	M	M	YES	
4325	3	3	A	M		
4326	3	3	A	M	YES	
4327	3	3	A	AM	YES	
4328	3	3	A	AM		
4329	3	3	A	AM	YES	YES
4330	3	4	M	M		
4331	3	4	M	M	YES	
4332	3	4	A	M		
4333	3	4	A	M	YES	
4334	3	4	A	AM	YES	
4335	3	4	A	AM		
4336	3	4	A	AM	YES	YES

*AM = Automatic and Manual Ranging
F = Fixed Range (single-range instrument)
M = Manual Ranging

II

SPECIFICATIONS

RANGES:	$\pm .9999/9.999/99.99/999.9$ VDC. Instruments equipped with an input filter must not have over 500 volts applied to the input.
ACCURACY:	$\pm .05\%$ of full scale, $\pm .02\%$ of reading, 60° to 104°F .
SPEED:	0.5 second reading time per range, or on manual range.
INPUT RESISTANCE:	On 1-volt range: 1 megohm; on all other ranges 10 megohms. These resistances are minimum whether the instrument is at balance, computing, or being subjected to above-range voltage.
POLARITY CHANGE:	Automatic or manual.
RANGE CHANGE:	Automatic, fixed, or manual -- depending upon model.
GROUND ISOLATION:	Signal leads can be floated 1000 volts about outer case.
COMMON MODE REJECTION:	Exceeds 60 db at 60 cps with 1000 ohm input line imbalance.
PRINT OUTPUT:	Decimal contact closures in parallel. 2-4-2-1 code is available upon request.
AC MEASUREMENTS:	Use NLS Model 1101, 1102, 1109, 1201, or 1204 AC-to-DC Converter. Accuracy is that of converter plus digital voltmeter.
PRIMARY POWER:	115/220, 50-60 cps, 50 watts, maximum.

WEIGHT: 25 pounds net; approximately 45 pounds shipping.

INPUT CONNECTOR: Front connector is normally supplied; rear connector is available upon request.

The relation of the preceding specifications to individual models is shown in the Table of Models in the Introduction. Specifications are subject to change without notice.

III

INSTALLATION AND OPERATION

1. UNPACKING

Instruments are shipped in two-piece polystyrene-bead containers. Cut the tape between the container halves and open. The instrument itself does not contain any packing material and is ready for operation as received. It is suggested that the container be saved if the instrument is to be shipped at a later date or if it is to be stored. If damage is seen, promptly notify the carrier.

2. POWER SOURCE

The instrument is ready for operation from conventional 115-volt, 60-cycle power sources. A 230-volt source may be used if the two primaries or the power transformer are wired in series instead of in parallel. The primary leads are connected to standoffs on the inside of the rear panel adjacent to the transformer. It is suggested that any wiring change to the primary be made at these points.

3. FUSING

The power fuse is wired into the primary circuits of the power transformer where it protects against damage being caused by short circuits occurring in the instrument. For this reason, the fuse should always be of the value specified to avoid damaging components. The correct fuse is a 3AG, slo-blo type, rated at 1 ampere. The fuse is located in an extractor post located on the rear panel.

4. POWER GROUNDING

The third pin on the power plug grounds the outer shield of the instrument. If using an adapter, ground the green adapter wire to the outlet box or plate. The third pin of the instrument power plug should not be cut.

5. INPUT FILTER

Instruments in the 4300 Series may be ordered either with or without an input filter. When equipped with a filter, the instrument cannot accept inputs above 500 volts. If in doubt about whether or not the instrument is equipped with a filter, check the inside of the instrument. If a filter is used, it will be found between the chopper and relays K-1 and K-2. Figure 1 graphs the ideal characteristics of such a filter.

6. CONTROLS

The number and type of controls is determined by the measuring capability of the individual model. Since Model 4318 has more capabilities than other instruments in the series, a description of its controls suffices for other instruments.

The POWER switch has six positions:

- . OFF -- In this position the instrument is completely deenergized; however the outer chassis is still tied to the power-line ground.
- . AUTO -- This position provides continuous readings at the rate regulated by the DISPLAY control.
- . MANUAL -- In this position a particular reading may be preserved and displayed indefinitely.
- . MANUAL PRINT -- In this position the instrument records a single reading on an associated data recorder.
- . AUTO PRINT -- This position allows the instrument to record continuously. When a voltage measurement is completed, a print command is issued to the data recorder through N.O. contacts. The print complete signal initiates a new reading through Form C contacts located in the data recorder. See figures 3 and 4.

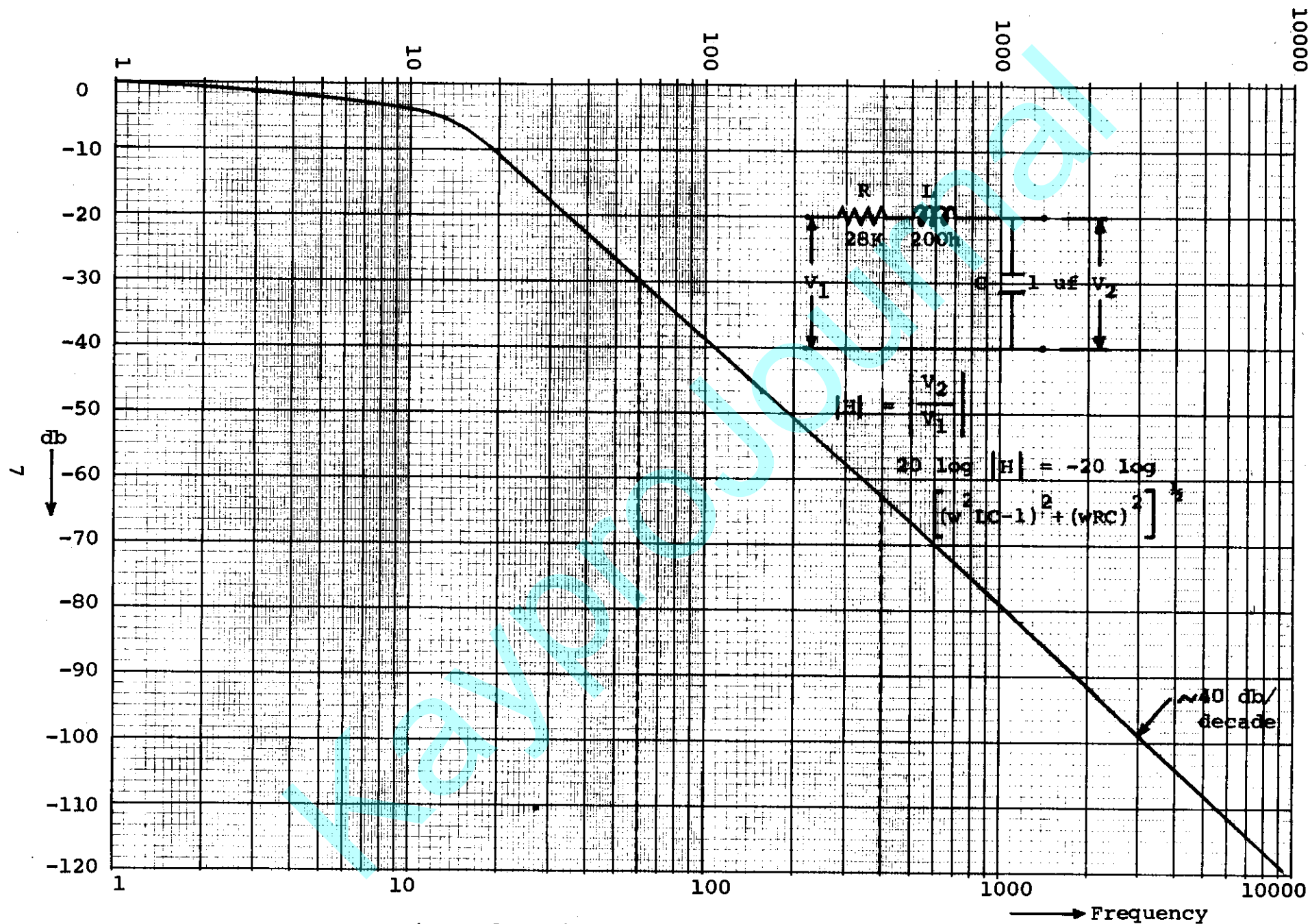


Figure 1. Ideal Input Filter Characteristics

- . RESET -- This is a spring-return position. If the POWER SWITCH is turned to this position and released, a new read-and-print command is initiated. If a data recorder is being used, it will finish, but the data will be erroneous if the RESET has been actuated while the recorder is recording a prior signal.

The RANGE switch has six positions:

- . REMOTE -- External circuits range the instrument. See Section 8, Remote Operation.
- . AUTO -- Up to 1000 VDC is measured. The decimal point shifts as needed to provide correct readings.
- . 1000V, 100V, 10V and 1V -- Manual range settings.

- A Note About Polarity Indication -

The Model 4318 provides automatic polarity indication. Other 4300 Series polarity-control options are manual, for which a + POLARITY switch is provided, and fixed, which requires that the measured voltage be applied with + to the red lead and - to the black. If the wrong polarity is applied to either a manual or fixed polarity instrument, the readout will display all zeroes.

The DISPLAY control adjusts the persistence of display from the minimum time listed in Specifications, Section II, to a maximum of no change. In the infinite, full clockwise position, a reading may be indefinitely stored in the presence of a fluctuating input. For this reason, the DISPLAY control effectively stabilizes readings when it is properly set short of infinity. This effect can be used to adjust the speed of the instrument to a data recorder if diode CR-6 is removed.

7. INPUT CONNECTION

Red is usually used for signal high; black is usually used for signal low. Readout polarity sign is + when signal on red is most positive. Blue is common with instrument chassis and should be connected to earth or system ground.

If no earth or system ground exists (as with a floating battery), leave blue open.

8. REMOTE OPERATION

The ranging function may be controlled remotely by a single-pole, four-position switch, or equivalent circuit as part of an automatic program. For this function a 34-pin connector is provided on the rear panel. This connector is internally wired to reed relays which are physically outside of the high CMR guard area. Connections are made (with Pin L common) to the pins as follows:

VDC RANGE	PIN
1000	J
100	K
10	H
1	M

The internal relays operate on 12-15 VDC; polarity position is unimportant. Switching circuit is shown in figure 2.

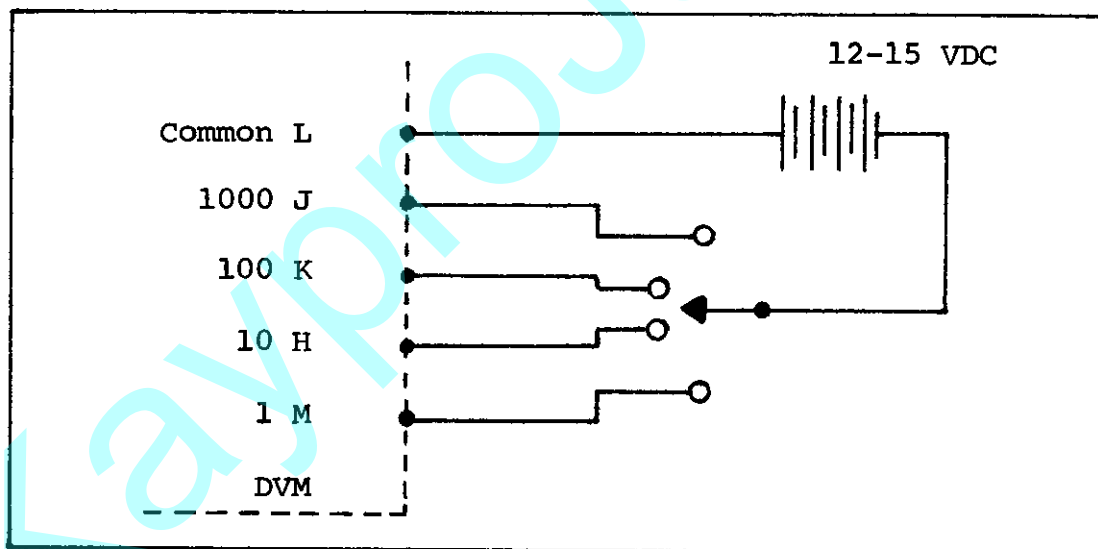


Figure 2.

REMOTE SWITCHING CIRCUIT

It is also possible to record data remotely if the recorder contains the correct print-complete circuit. This circuit is described under 9., Printer Operation. The digital voltmeter POWER switch must be set at AUTO PRINT.

9. PRINTER OPERATION

Connections to a data recorder, such as the NLS Model 155 Printer, are made through a 75-pin connector at the rear of the digital voltmeter. When a voltage is being displayed, appropriate reed relays in the instrument are energized, making available contacts to which a printer, remote readout, punch, or other device may be wired. These reed relays must not be connected to circuits which subject them to excessive switching current. The contact ratings for switching current are:

Maximum current - .5 ampere at 250 VDC

Maximum voltage - 400 VDC at .2 ampere

In addition to making connections for information to be printed, there is need for the printer to "know" when to start printing and for the digital voltmeter to "know" when the printer has finished its print cycle. Intelligence lines carrying this information are also connected to the 75-pin connector. Here is a typical operating cycle:

1. The DVM computes an input voltage.
2. The value of this voltage is displayed and appropriate reed contacts are closed.
3. A "print command" is issued by the DVM. This command is represented by the closing of two contacts to which the printer is connected.
4. The printer goes through its print cycle during the DVM display time.
5. At the end of the print cycle, the printer closes contacts which signal a "print complete" to the DVM.
6. The "print complete" signal is received by a relay in the DVM, closing a circuit which allows the instrument to again compute an input voltage - and the cycle is complete.

Table 2 shows the connections to be made to the 75-pin connector for operating data recorders. This table shows where to connect each digit in each decade, the decimal points, and the polarity signs.

TABLE 2. PRINTER CONNECTIONS FOR DECADES, PRINT COMMAND, AND PRINT COMPLETE

DIGIT	UNIT*	TENS	HUNDREDS	THOUSANDS
0	11	14	10	13
1	17	21	16	20
2	24	27	23	26
3	30	33	29	32
4	36	39	35	38
5	42	45	41	44
6	48	51	47	50
7	54	57	53	56
8	60	64	59	63
9	67	72	66	71
Common	75	78	74	77
*The units decade is not used with 3-digit instruments				
DECIMAL FOR 1 VOLT max. Pin 5 DECIMAL FOR 10 VOLT max. Pin 2 DECIMAL FOR 100 VOLT max. Pin 7 DECIMAL FOR 1000 VOLT max. Pin 3				
POLARITY SIGNS				
+ Symbol Pin 18 - Symbol Pin 25 +, - Common Pin 12				

In addition, connections must be made between the data recorder and the digital voltmeter to provide the Print Command and Print Complete signals. The digital voltmeter is equipped with a Print Complete relay (K-51, referred to as Print Feedback in the schematic). The voltage necessary to operate this relay may be derived either internally or externally; however, it is preferable to operate this relay externally and take the necessary voltage from the associated data printer. (The NLS Models 155 and RS-2 are equipped to supply this voltage.) Figure 3 shows the connections to be made when taking voltage from the data recorder. Note

that a 470 ohm resistor is located across the relay coil; this resistor is retained when the voltage source is at about -30 volts DC, when the voltage source is at about -15 volts DC, the 470 ohm resistor should be removed from the circuit. Although figure 3 shows operation in one polarity, the opposite polarity may be used as a source if the 50uf capacitor connected to pins 76 and 4 is reversed so that the capacitor positive connection goes to pin 76 and the negative connection goes to pin 4. To make this change it is only necessary to unsolder the capacitor and reinstall it reversed.

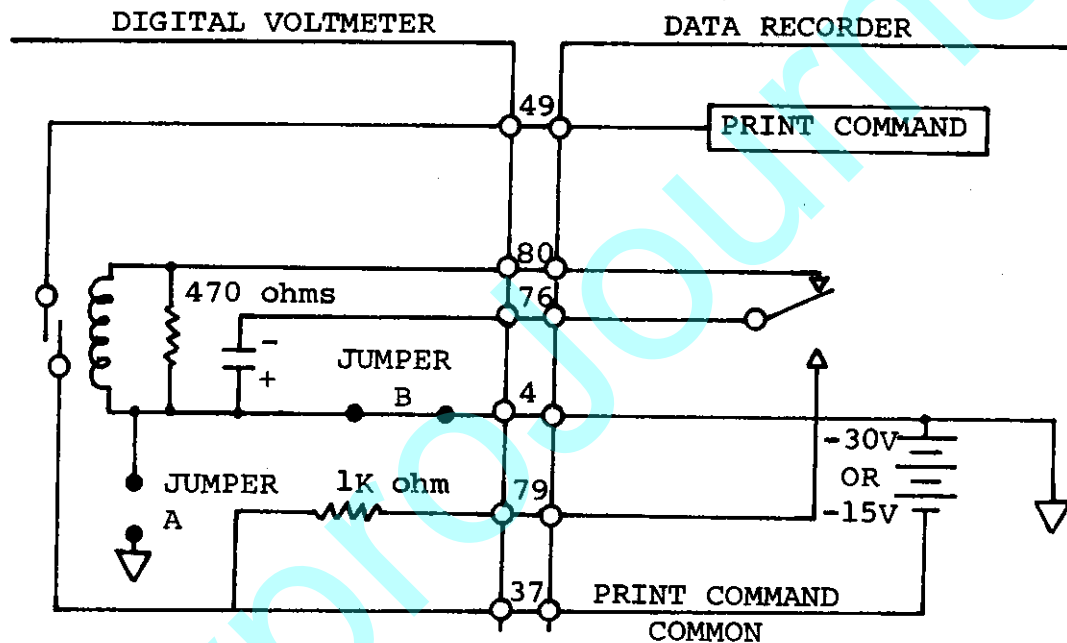


Figure 3. Print Complete and Print Command Connections with an External Voltage Source used to Operate the Relay

When it is desired to operate this relay from an internal voltage source, figure 4 should be followed. Note that if voltage is drawn from the digital voltmeter to operate a relay in the printer, it will be necessary to provide a guard shield to minimize CMR losses. The source of voltage, when derived internally, is available at pin 79 which connects to a -20 volt line, reduced by the 200 ohm resistor (R-17) so as to provide correct operating voltage.

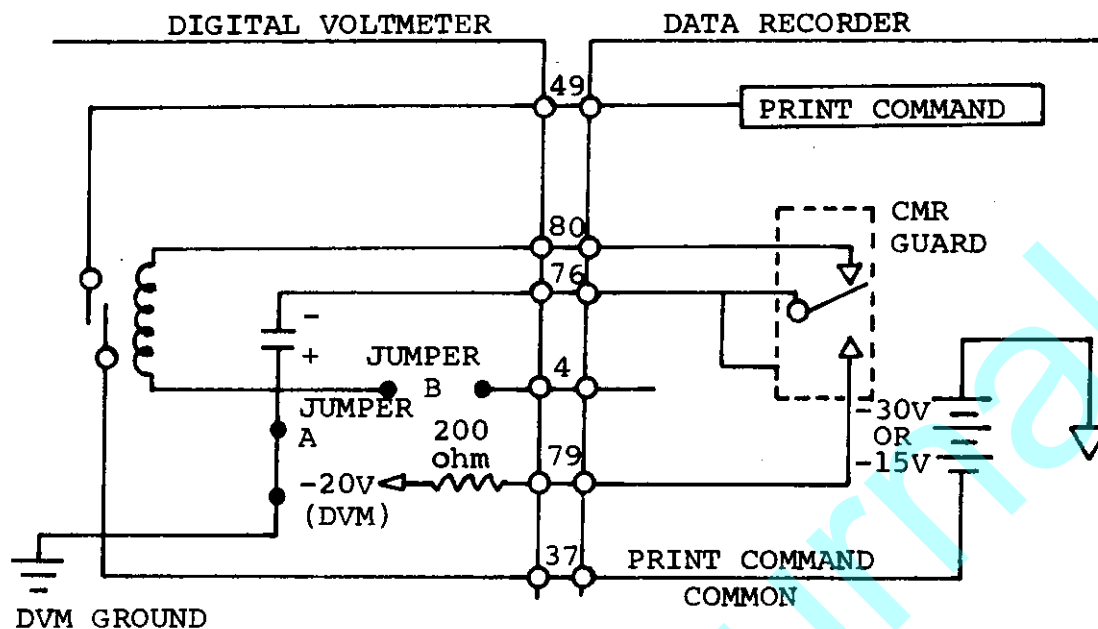


Figure 4. Print Complete and Print Command Connections with an Internal DVM Voltage Source used to Operate the Relay

The jumper connections shown in figures 3 and 4 are located at the top of the right end of the printed circuit board which is vertically mounted across the width of the instrument.

IV

CALIBRATION

When a 4300 Series instrument is not making readings within specifications, calibration is required. In the calibration information given in this section, the instrument is assumed to be in good working order and only in need of calibration. If there are any defective components, it may be difficult, if not impossible, to properly calibrate the instrument.

The calibration procedure is divided into three distinct areas: amplifier adjustment, reference voltage-supply adjustment, and ranging adjustment. It is important that these areas be taken as listed and that the steps in each area be followed in listed sequence.

EQUIPMENT NEEDED

The following are required:

1. Stable, but not necessarily precise, sources of 10, 100, and 1000 volts DC.
2. A decade voltage divider, such as the Dekavider, Model DV-411.
3. A bank of nine standard cells, such as the NLS P/N 3006.
4. A ratio box with precise divisions of 10:1 and 100:1, such as the NLS P/N 3020.

AMPLIFIER ADJUSTMENT

1. Turn on the voltmeter and allow it to warm up for at least 45 minutes with the top and bottom covers on.
2. Apply a known voltage which, in a properly calibrated voltmeter, would display a numeral 5 in the right-hand window. A value of $.5 \pm 10\%$ may be used with the range set at 1000V, smaller values such as .05 or .005 are also satisfactory if the range is shifted to 100V or 10V, respectively. However, it is preferable to make this adjustment with the instrument on the 10-volt range with .005 volt.

3. Adjust R-127 clockwise until the readout displays a 5 in the right-hand window.

NOTE

Steps 3A, B, C, D, E, and F are to be followed only if the instrument is equipped with potentiometer R-109. This adjustment is not present on instruments having S/N .174 and over.

- A. Open the top outer cover and, through the hole in the inner cover, adjust R-109 to the full clockwise position. The physical location of R-109 is shown in figure 6.
- B. Through the other hole in the inner top cover, adjust R-127 clockwise until the polarity display begins to change from + to - with every scan; when this occurs, slowly rotate R-127 counterclockwise until a single polarity is displayed.
- C. Change the value of the input voltage to .8, .08 or .008 and apply it in the manner described in Step 2 above.
- D. Adjust R-109 to indicate 8 in the right-hand window.
- E. Repeat Step 2. If the polarity indication remains stable, the amplifier adjustment procedure is complete; if the polarity sign is not stable, continue with Step F.
- F. Adjust R-127 to stabilize the polarity sign, and repeat Steps C, D, and E.

REFERENCE VOLTAGE ADJUSTMENT (STANDARDIZATION)

CAUTION

On four-range instruments, manually select the 10v range before connecting input leads to standard cells.

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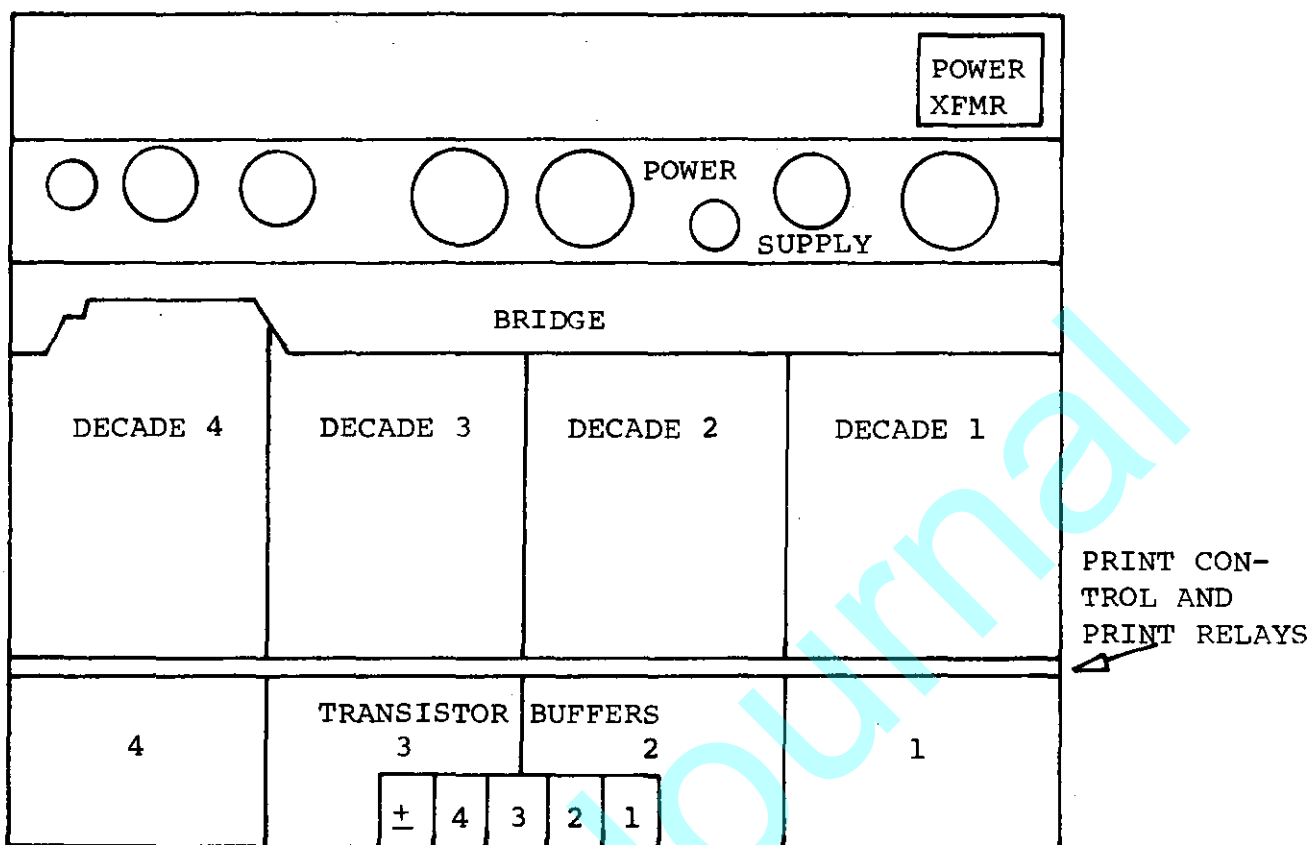


Figure 5. Front View from the Top, with Hinged Board Removed

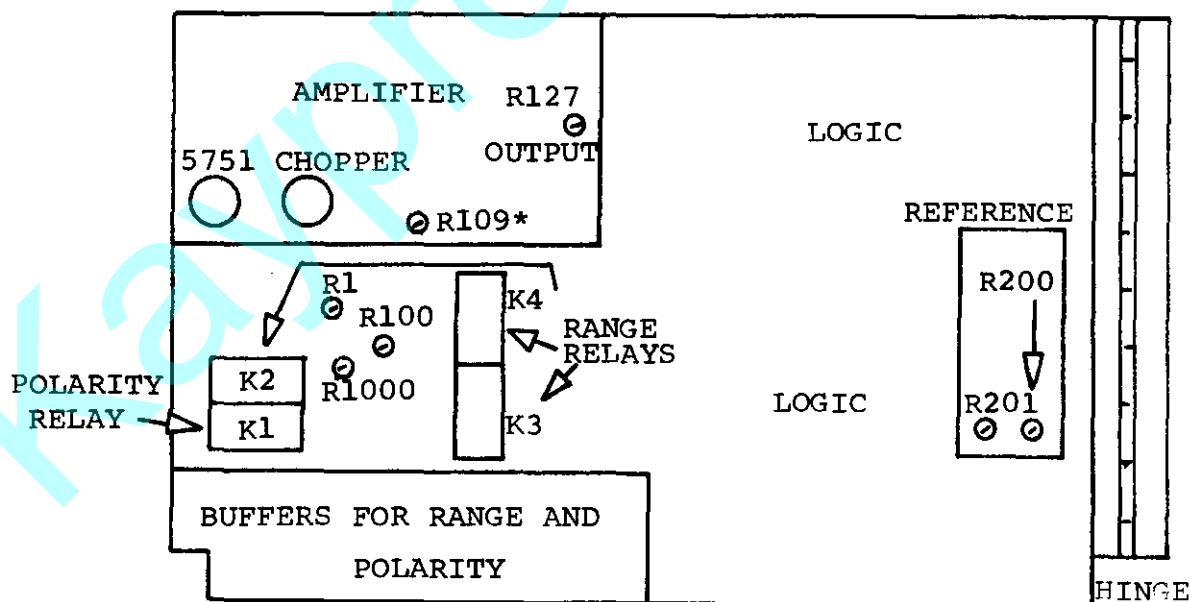


Figure 6. Front View of Top of the Hinged Board as seen in Operating Position. The printed circuit side is up. Instruments with S/N .109 and on have adjustments located where shown on inner cover of instrument.
 *R109 is not used with instruments over S/N .174.

1. Connect the standard-cell bank to the input of the instrument. The black lead is connected to the negative terminal; the red lead is connected to the positive nine-volt end of the cell bank.
2. Adjust R-10* (fine adjustment) and, if necessary, R-11 (coarse adjustment) until the display reads correctly the value of the standard-cell bank. Potentiometers R-10 and R-11 are accessible from the bottom of the instrument. It is necessary to remove the bottom outside cover and reach through holes in the inner cover; do not remove inner covers. The most convenient way to reach these adjustments is simply to place the digital voltmeter on its side when making the adjustments. See also figure 6 for physical location.

RANGING ADJUSTMENTS

WARNING

THIS PROCEDURE REQUIRES THE USE OF DANGEROUSLY HIGH VOLTAGE. BE CAREFUL! ALSO OBSERVE WARNING ON TOP INNER COVER.

All ranging adjustments are made with the inner covers in place and with a positive potential applied to the red lead, negative to the black.

100-VOLT RANGE

1. Connect the input terminals of the ratio box to a stable, but not necessarily accurate source of 95 to 99 volts.
2. Set the ratio box at 10:1.
3. Also connect the input cable of the voltmeter to the input of the ratio box.
4. Set the digital voltmeter at the 100-volt range; record the value of the display.

*With instruments having S/N 4300.109, R-10 is replaced by R-201 and R-11 by R-200. With these models, all adjustments are made through the top inner cover.

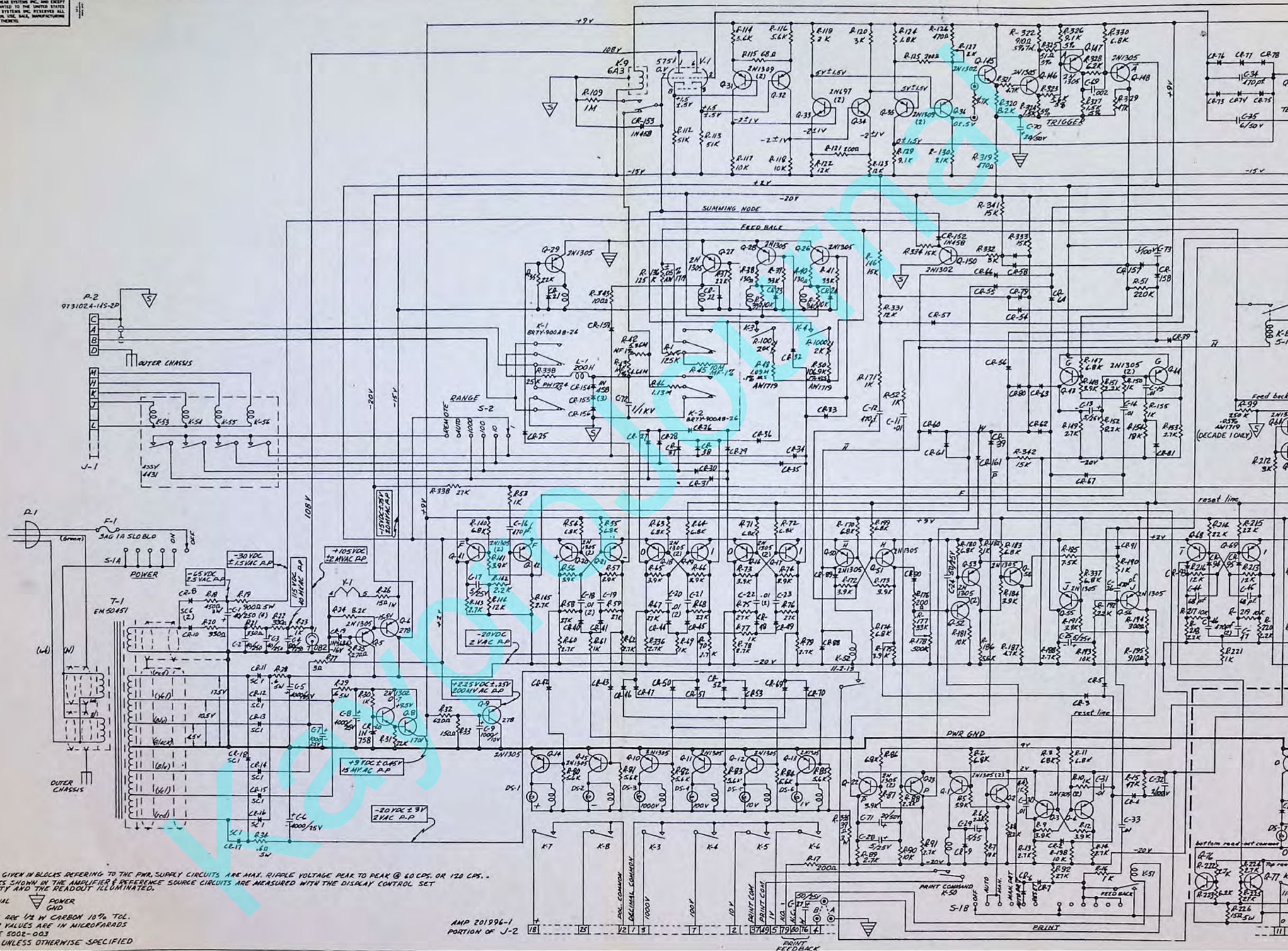
5. Disconnect the voltmeter input cable from the input of the ratio box and reconnect it to the output of the ratio box.
6. Set the digital voltmeter to the 10-volt scale; record the value of the display.
7. If the reading recorded in Step 4 is the same as recorded in Step 6, except for decimal-point position, the 100-volt range is calibrated. Example: If, in Step 4, a value of 97.43 was recorded, then the value recorded in Step 6 must be 9.743. If this digital correspondence is present, Steps 8, 9, and 10 are to be eliminated; otherwise proceed with Step 8.
8. Set the digital voltmeter to the 100-volt range and move the input cable back to the input of the ratio box.
9. Adjust R-100 (through a hole in the top of the inner cover, as shown in figure 6) until the reading digitally corresponds to the figure recorded in Step 6.
10. Set the digital voltmeter to the 10-volt range and move the input cable to the output of the ratio box. If digital correspondence is not present, repeat Steps 8, 9, and 10.

1000-VOLT RANGE

CAUTION

High voltage is required for this step.

1. Follow the same procedure as outlined in Steps 1 through 10 of the 100-volt ranging adjustment except: set the ratio box to 100:1 and apply from 950 to 999 volts to the ratio box input. If digital correspondence is not present, adjust R-1000 (located just to the right of R-100). When finished, promptly remove high voltage.



1. VAC. VALUES GIVEN IN BLOCKS REFERRING TO THE PWR. SUPPLY CIRCUITS ARE MAX. RIPPLE VOLTAGE PEAK TO PEAK @ 60 CPS. OR 120 CPS. -
 2. ALL VOLTAGES SHOWN IN THE AMPLIFIER & REFERENCE SOURCE CIRCUITS ARE MEASURED WITH THE DISPLAY CONTROL SET TO INFINITY AND THE READOUT ILLUMINATED.

- 3. RESISTORS ARE 1/4 W CARBON 10% TOL.
- 4. CAPACITOR VALUES ARE IN MICROFARADS
- 5. DIODES ARE 5002-003
- NOTES: UNLESS OTHERWISE SPECIFIED

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