INSTRUCTIONS

FOR THE

MODEL 300-E
SENSITIVE
ELECTRONIC VOLTMETER

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY

INSTRUCTIONS

FOR THE

MODEL 300-E
SENSITIVE
ELECTRONIC VOLTMETER

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY

Printed in U.S.A.

11-65-Y-02

WARRANTY

Each Ballantine Laboratories, Inc. instrument, or part thereof, is warranted to be free from defects in material and workmanship. Ballantine Laboratories, Inc. obligation under this warranty is limited to repairing or replacing any instrument or part thereof, except vacuum tubes and batteries, which shall within one year after shipment to the original purchaser prove upon Ballantine Laboratories, Inc. examination to have become defective.

INSTRUCTION BOOK CONTENTS

For

MODEL 300E SENSITIVE ELECTRONIC VOLTMETER

ILLUSTRATIONS AND DIAGRAMS

TABLES

Fig. 1. Ballantine Model 300E Sensitive Electronic Voltmeter

1. SPECIFICATIONS

Voltage Range

300 μV to 300 V in 6 ranges, in steps of 20 db

Frequency Range

30 cps to 200 kc

Accuracy

2% .... 30 cps — 100 kc
3% .... 100 kc — 200 kc

Input Impedance

Range	R	C
0.003 V	2 MΩ	40 pF
0.03 V	2 MΩ	30 pF
0.3 V	2 MΩ	20 pF
3.0 V	2 MΩ	20 pF
30.0 V	2 MΩ	20 pF
300.0 V	2 MΩ	20 pF

Amplifier

Maximum gain is approximately equal to 45 db, response is ±1 db from 30 cps to 200 kc, maximum output voltage is approximately 0.6 V.

Null Detector

Meter is biased on scale when switch leg available at rear terminal board is closed.

Auxiliary Outputs

6.3 V (line frequency) at 0.3 A, and 250 V dc at 1 mA (available at rear terminal strip).

Input Connections

Binding posts on front panel, BNC connector in rear.

Front Panel Isolation

The front panel is isolated from signal-ground for ultimate connection to systems ground.

Adjustments

Sensitivity and scale-decading available through access holes in instrument case.

Power Supply

105 V to 125 V, 60-400 cps, 37 W

Tubes

4 Type 6AU6, 1 Type OA2, 1 Type 6X4

Dimensions

Panel Size: 5¼ x 9½ inches
Behind Panel: Depth — 9½ inches
Width — 8¼ inches

Weight

Approximately 10 pounds

2. GENERAL DESCRIPTION

The Ballantine Model 300E Voltmeter is an amplifier-detector type instrument designed primarily for the measurement of voltages in the audio spectrum.

Essentially the voltmeter comprises a high impedance attenuator followed by a degeneratively stabilized amplifier which feeds an average responding rectifier-meter circuit. Current from the rectifier circuit passes through a special logarithmically graded moving coil meter which has the logarithmic voltage and linear db scales associated with other well-known Ballantine voltmeters. The voltage is read with an accuracy unaffected by the position on scale of the value observed.

Input connections to the instrument are available at both front and rear. Binding posts are provided on the front panel while a BNC (UG-290-U) jack is provided in the rear. The two inputs are connected in parallel.

The instrument panel is isolated from the signal ground so that it may be ultimately connected to a systems ground. The maximum signal which may be introduced between the panel and signal ground is specified in Section 3.5.

The shaft of the range switch is extended at the rear of the instrument to permit adaptation to automatic programming. For mounting details, see fig. 2.

By means of a switch leg, available at a pair of terminals on a rear terminal board, the zero-signal meter indication may be biased on scale, making the instrument more useful as a null detector.

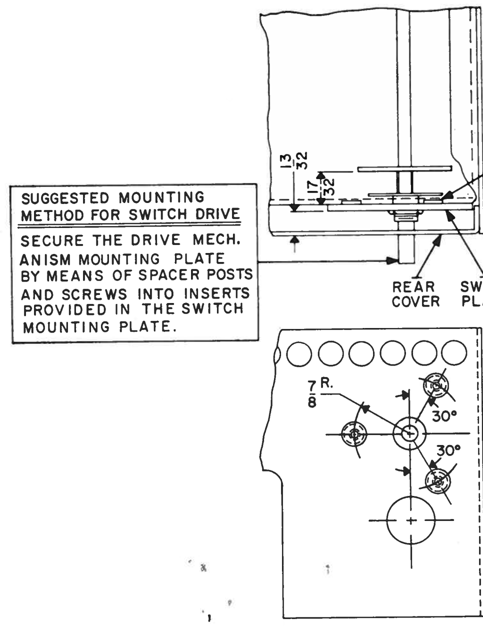


Fig. 2. Mounting Detail for Range Switch Drive

Also available at a pair of rear terminals is an amplifier output, providing a gain of approximately 45 db. (See Section 4.1)

Voltages of 6.3 V ($\pm 5\%$) at 0.3 A (line frequency), and 250 V ($\pm 10\%$) dc at 1 mA are available at rear mounted terminals.

3. OPERATION

3.1 Power Connection and Warmup

The Model 300E is supplied complete with tubes and fuse and is ready to operate as received. Connect the power cord to a source of power conforming with the specifications stated on the chassis adjacent to the power cord. See Schematic Diagram for line voltage conversion. Turn the ON-OFF switch located at the rear of the instrument to ON. Allow a warmup period of 5 minutes before use, unless the instrument has not been in service for many months, in which case allow a warmup period of at least 30 minutes.

3.2 Voltage Measurement

Connect the voltage to be measured to the input terminals, observing the *ground* polarization. Rotate the range control until an on-scale indication is observed. The position of the range knob, together with the meter indication, gives the value of the voltage at the input terminals.

If a dc component is also present when making ac measurements, care must be taken to insure that this dc component does not exceed 600 V (dc working voltage of input coupling capacitor). In the event that the dc component exceeds this value, an additional blocking capacitor, with the necessary dc working voltage may be placed in series with the input terminal. At low frequencies the value of this capacitance must be large enough (0.2 μF at 30 cps) to prevent degradation of the low frequency accuracy of the voltmeter.

Although the instrument is designed to withstand rather severe overloads without damage, there are limits to the amount of overloading which may be safely imposed. In general, on the lower ranges, this is dictated by the maximum grid voltage which the amplifier input tube can withstand without damage. On the higher ranges the maximum voltage rating of components in the input attenuator restricts the maximum voltage which may be safely applied. Table I below lists the maximum overload ratios for the various ranges.

TABLE I

MAXIMUM OVERLOAD RATIOS		
Range	**Overload Ratio**	**Maximum Input**
0.003 V	30,000 to 1	100 V
0.03 V	3,000 to 1	100 V
0.3 V	3,000 to 1	1,000 V
3.0 V	300 to 1	1,000 V
30.0 V	30 to 1	1,000 V
300.0 V	3 to 1	1,000 V

3.3 Current Measurement

By using the Ballantine Series 600 Shunt Resistors in conjunction with this voltmeter it is possible to measure ac currents from 0.3 μA to 10 A. For a complete description of the accuracy, current, and frequency range of these shunt resistors, refer to the Ballantine catalog.

3.4 Input Impedance

At low frequencies the input terminals present a constant resistive component (2 MΩ ±1%) to the input signal, while the capacitive component is a function of the range switch setting and is given in Table II. Although the capacitive component is essentially independent of frequency, the resistive component decreases as the higher frequencies are approached. Figure 3 shows the approximate variation of input resistance vs. frequency.

TABLE II

Input Capacitance vs. Range Switch Setting	
Range	**Capacitance**
0.003 V	40 pF
0.03 V	30 pF
0.3 V	20 pF
3.0 V	20 pF
30.0 V	20 pF
300.0 V	20 pF

3.5 Panel Isolation

The Model 300E has been constructed so that the panel is electrically isolated from the chassis or instrument signal ground. This permits connection of the panel to a rack or system ground independent of the chassis. There is a limit, however, to the maximum voltage which may be introduced between panel and chassis without serious degradation of instrument accuracy. This maximum voltage is a function of signal source impedance, frequency, and voltmeter range.

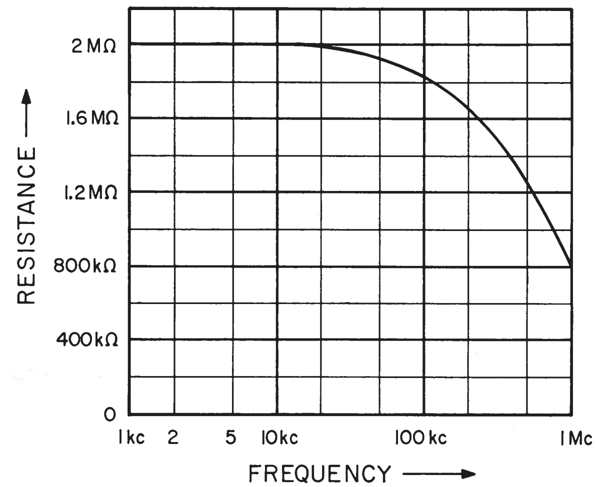


Fig. 3. Input Resistance vs. Frequency

Listed in Table III are voltages which will introduce an additional 1% error when connected between panel and chassis, when the panel-chassis and signal voltages are of the same frequency.

If the Model 300E is used as a *portable* instrument, it is recommended that the panel be electrically connected to the chassis. Use of the Model 300E for *above ground* measurements is not recommended.

TABLE III

MAXIMUM PANEL-CHASSIS VOLTAGE FOR ADDITIONAL 1% ERROR WHEN PANEL-CHASSIS AND SIGNAL VOLTAGES ARE OF THE SAME FREQUENCY

Signal Source Impedance — 200 kΩ

Voltmeter Range	Frequency 30 cps	50 cps	1000 cps
0.003 V	100 mV	50 mV	2 mV
0.03 V	1 V	500 mV	20 mV
0.3 V	10 V	5 V	200 mV
3 V			2 V

Signal Source Impedance — 20 kΩ

Voltmeter Range	Frequency 30 cps	50 cps	1000 cps
0.003 V	1 V	0.5 V	20 mV
0.03 V	10 V	5 V	200 mV
0.3 V			2 V

4. AUXILIARY FUNCTIONS

4.1 Amplifier

A pair of rear mounted terminals, one of which is at signal ground potential, make it possible to use the instrument as an amplifier. The gain of the amplifier is approximately 45 db, reducible in steps of 20 db by means of the range switch on the front panel. The response of the amplifier is flat within ±1 db over the range of 30 cps to 200 kc. The maximum output voltage is approximately 0.6 V, while the output impedance is approximately 300 Ω in series with 0.1 μF. The load impedance should always be sufficiently high so as not to impair performance as a voltmeter; 30 kΩ or higher appears to cause no degradation of meter performance in the specified range. Although the output of the amplifier is neither linear nor distortion-free, the amplifier output has been included for those who may find it of some use in monitoring waveforms, etc.

4.2 Null Detector

Although the Model 300E possesses adequate sensitivity for most bridge measurement work, a condition may arise where the unbalanced voltage will be less than 300 μV, in which case the pointer of the voltmeter will fall below the left-hand extremity of the scale when working on the 0.003 V range. By shorting a pair of rear mounted terminals marked NULL, a small bias current is supplied to the meter bringing the pointer to an on-scale reading even in the absence of an input signal. In this condition the instrument serves only to indicate the relative magnitudes of very low potentials.

4.3 250 V DC

A source of 250 (±10%) V dc at a current of 1 mA is available at a pair of rear mounted terminals. The negative terminal is at signal ground potential. The ripple voltage, when operating from a 115 V, 60 cps source is approximately 0.2 V and is predominantly 120 cps.

4.4 6.3 V

A source of 6.3 (±5%) V at 0.3 A and line frequency is available at a pair of rear mounted terminals. This potential is balanced with respect to signal ground.

5. CIRCUIT DESCRIPTION

The basic voltmeter circuits are shown on Simplified Schematic, Fig. 4. A complete schematic and replacement parts list are located at the end of this instruction book.

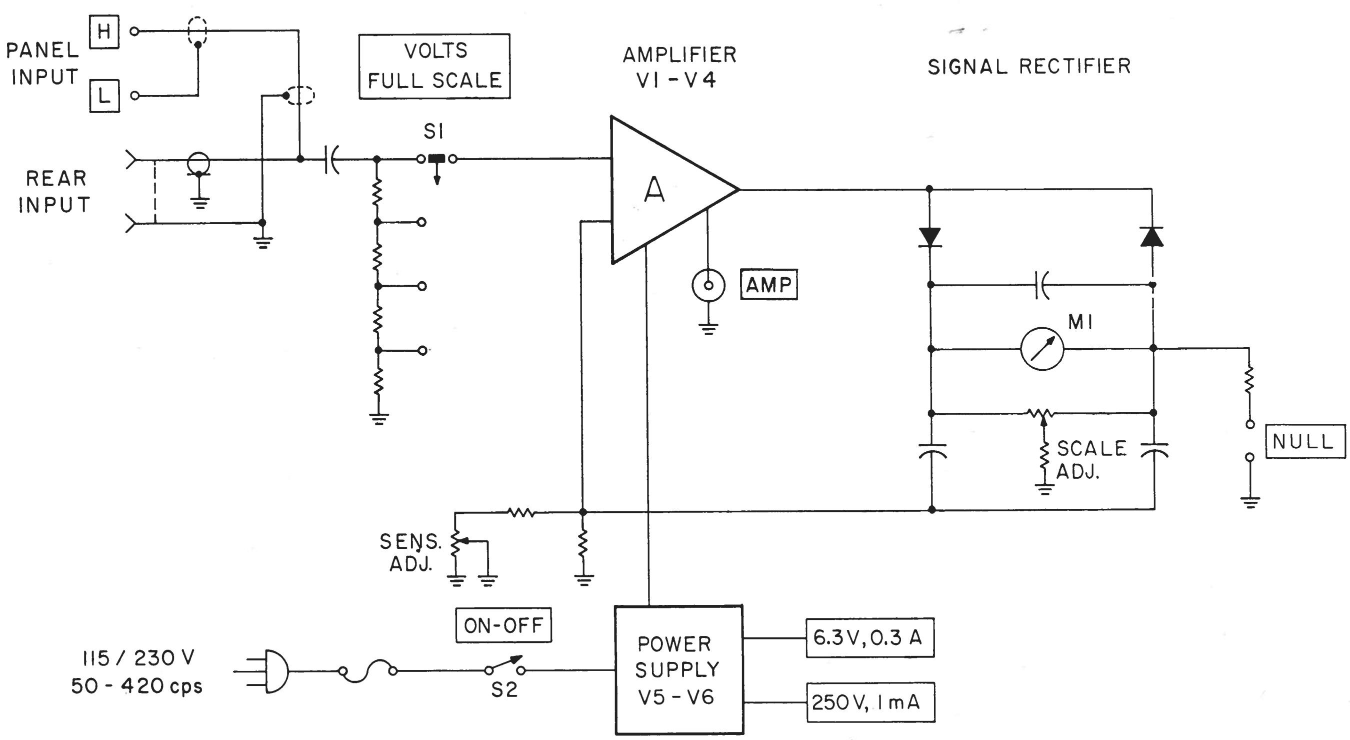


Fig. 4. Simplified Schematic of Model 300E

5.1 Input Attenuator

Since the amplifier of the Model 300E always operates with the same basic sensitivity (0.0003 V to 0.003 V), an attenuator must be provided at the input for reducing higher voltages to this range.

Actually the input attenuator of this Model 300E consists of three separate attenuators. See schematic diagram at rear of instruction book. Table IV is a listing of range switch settings and attenuation ratios.

TABLE IV

ATTENUATOR RATIOS

Range	Attenuation Ratio
0.003 V	1
0.03 V	10
0.3 V	100
3.0 V	1,000
30.0 V	10,000
300.0 V	100,000

Except for one range (0.03 V) the attenuation ratio is determined at all frequencies in the specified range by the attenuator resistors alone. On the 0.03 V range capacitive compensation is used at the higher frequencies. On this range the crossover from a resistive to a capacitive attenuator occurs at about 25 kc. Capacitor C3 (see schematic diagram at rear of instruction book) provides a means of adjusting the high frequency response on this range. **Note:** The user is cautioned against making any adjustment of C3 without first reading Section 6.3.4.

5.2 Amplifier

The amplifier consists of four capacitively coupled pentode stages, the first three of which are operated to provide voltage gain while the final stage is used as a transducer to convert voltage to current for the rectifier-meter circuit. For an amplifier output, the signal voltage developed across the unbypassed cathode resistor of the final stage is employed.

Local feedback as well as overall feedback (32 db or greater) is employed to minimize distortion and gain changes from whatever cause. The amplifier response without feedback is shaped to fall off from the midband value at a rate of approximately 6 db per octave. As a result of this, and the amount of feedback available, the stability of the amplifier at the band extremes (30 cps and 200 kc) is essentially that of midband.

The high and low frequency response of the amplifier is inherently flat; hence there are no adjustments relating thereto.

The gain or sensitivity of the amplifier is adjustable over a small range by means of R18 in the feedback network. See Section 6.3.3.

The heater of the input amplifier stage is operated on dc to minimize the line frequency signal components injected in this low level stage. Thus the error introduced when measuring voltages of line frequency and its harmonics is substantially reduced.

5.3 Rectifier-Meter Circuit

AC current available from the last amplifier stage is passed through the rectifier-meter circuit and the feedback network to ground.

The rectifier is of the full wave bridge type employing semiconductor diodes. Direct current from it passes through meter M1. The capacitor across M1 serves to reduce the indicator flutter at the lower frequencies. The response of the circuit is average, although the meter is calibrated RMS in terms of a sinewave.

Resistors R41 and R42 provide for an adjustment of the meter indication at 3 on scale. See Section 6.3.2. A small current, determined primarily by the value of R42 and the potential with respect to ground at the top of the rectifier-meter circuit, is passed down through the rectifier circuit. The division and direction of this current through the meter is determined by the position of the slider on R41.

The signal rectifiers are hermetically sealed, small area silicon junction diodes which are virtually immune to aging and environmental conditions. The inherently non-linear characteristic of the diode rectifier is reduced to negligible proportions by incorporating the rectifier circuit within the feedback loop.

5.4 Power Supply

Amplifier plate and screen voltages are obtained from a full wave vacuum tube rectifier employing an rc filter, and a gaseous regulator tube. Low voltage dc power for the first amplifier stage heater is obtained from a full wave rectifier employing hermetically sealed silicon junction diodes, and a capacitive filter. All other amplifier heaters are operated on ac, balanced with respect to ground.

6. MAINTENANCE AND SERVICING

Servicing of the instrument by the user is feasible, providing the procedures outlined in this section are followed. However, it cannot be emphasized too strongly that the work should be entrusted only to technicians having the highest skill and experience in measurement techniques. A refined and comprehensive method of recalibration is beyond the scope of this manual and cannot be effected without specialized equipment having an order of accuracy much greater than that of the instrument being checked. Such equipment and personnel trained in its use are available in the Calibration Department of Ballantine Laboratories, Inc., so that if trouble develops which cannot be corrected except by the replacement of special components, it is recommended that the instrument be returned to Ballantine Laboratories, Inc. for servicing. The instrument in all cases should be preceded by a letter indicating the fault or desired service.

6.1 General Instructions

6.1.1 Fuse Replacement — The fuse is of the Slo-Blo type and is rated at 0.4 A for 115 V operation and 0.2 A for 230 V operation. The fuse holder is of the extractor post type located at the rear of the chassis.

6.1.2 Line Voltage Conversion — It is possible to operate the instrument from either a 115 V or 230 V line supply. To convert from 115 to 230 V operation, or vice versa, see the schematic diagram located at the back of this manual.

6.2 Periodic Checks

6.2.1 Equipment Required —

a. A stable, distortion-free, and accurately calibrated source of voltage with a signal frequency in the range of 400 - 1,000 cps. Output of the source should be continuously variable over a range of at least 1.0 mV to 10.0 V. The Ballantine Model 420 Precision Calibrator is such a source of voltage.

b. A stable, distortion-free, variable frequency signal generator covering a range of at least 30 cps to 200 kc. The output should be variable over a range of at least 1.0 mV to 3.0 V.

c. A stable, sensitive, flat responding voltmeter covering a frequency range of at least 30 cps to 200 kc, and a voltage range of 1.0 mV to 1000.0 V. The Ballantine Model 300G is such a voltmeter.

6.2.2 2000 Hours Operation Check — At the end of each 2000 hours or 1 year of operation it is recommended that the checks outlined in the following sections be made:

6.3.1 Attenuator Decading
6.3.2 Scale Adjustment
6.3.3 Accuracy Adjustment
6.3.4 High Frequency Response
6.3.5 Low Frequency Response

6.2.3 4000 Hours Operation Check — At the end of each 4000 hours or 2 years of operation it is recommended that all vacuum tubes be checked and the checks outlined in the following sections be made:

6.3.1 Attenuator Decading
6.3.2 Scale Adjustment
6.3.3 Accuracy Adjustment
6.3.4 High Frequency Response
6.3.5 Low Frequency Response

6.3 Performance Checks

6.3.1 Attenuator Decading — When the signal input to the instrument is increased or decreased by precise factors of 10, and the range switch changed accordingly, the indication of the instrument should not vary by more than ±0.1%. Thus, if the instrument is indicating 5.0 on a given range, increasing the input by a factor of 10 (±0%) and switching to the next higher range, should produce an indication of 5 (±0.1%). Decading checks should be made with an undistorted sinewave signal of midband frequency (400 to 1,000 cps).

There are no controls or adjustments relating to the attenuator decading, this factor being solely determined by the attenuator resistors. If it is discovered that the decading is in error, in all probability one or more of the attenuator resistors has changed in value. However, some of the other possible sources of difficulty are:

a. Grid current in the amplifier input tube, VI.

b. Misadjustment of Capacitor C3. **Note:** No adjustment of C3 should be made without reference to Section 6.3.4.

The resistors employed in the attenuator are hermetically sealed film type of advanced design, exhibiting a stability approaching that of wire wound units, but free from the reactive effects inherent in the latter. Initially the resistors are matched to a tolerance of ±0.1%, in addition to which the temperature coefficients of the various values are closely matched. In view of the above it is recommended that the user make no resistor replacements, except perhaps as an emergency measure on a temporary basis. It is recommended that the instrument be returned to Ballantine Laboratories, Inc. for servicing.

6.3.2 Scale Adjustment — When an undistorted sinewave signal produces a deflection of precisely 30 on a given range, switching to the next higher range should produce a deflection of precisely 3.0 on scale. During its calibration at Ballantine Laboratories, Inc.,

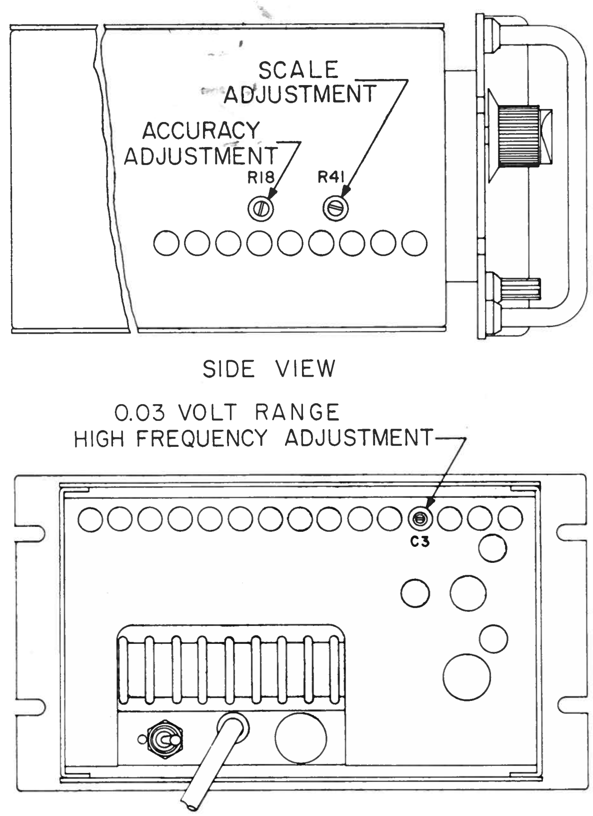


Fig. 5. Instrument Adjustments

the instrument is very carefully adjusted for this condition, and it should seldom, if ever, be found necessary to readjust. In the event that readjustment does become necessary, the control relating to this is R41, and is available through an access hole in the left-hand side of the instrument case. See Fig. 5.

To make the scale adjustment connect an undistorted sinewave of midband frequency (400 - 1,000 cps) to the input terminals and adjust the amplitude for an indication of precisely 30 on any range (except the 300 V range). Switch the instrument range knob to the next higher range. The indication should be precisely 3.0. Because of the relatively high damping at the low end of the meter scale, sufficient time should be allowed to permit the indicating needle to come to its final position. It is also recommended that the meter be tapped lightly to remove any effects of pivot friction. If the indication is not precisely 3.0, correct by means of control R41. Recheck and readjust if necessary.

6.3.3 Accuracy Adjustment — The design of the instrument is such that it should maintain its accuracy over extended periods of time and use. At Ballantine Laboratories, Inc. this accuracy is very carefully adjusted and checked. Moreover, an attempt is made to distribute the various inherent errors, so that the best possible overall accuracy results. The user, therefore, is cautioned against making any readjustments without fully determining that the instrument is in error.

All checks of accuracy should be made with an undistorted sinewave at a midband frequency (400 - 1,000 cps). The external standard meter, if used, should be accurate to 0.25% or better, and preferably of the RMS responding type.

If it has been established that the instrument is in error, the first attempt at correction should be tube replacement. Access to the tubes may be had by removing the top cover plate of the instrument.

If tube replacement does not restore accuracy, a small adjustment is possible with control R18, available through an access hole in the left-hand side of the case. See Fig. 5. A larger adjustment is available by changing the value of R17, although the necessity to change this value is good indication that something else it at fault in the instrument.

To adjust the accuracy, first check the scale adjustment as outlined in Section 6.3.2 and readjust if necessary. Next connect an undistorted sinewave signal of midband frequency (400 - 1,000 cps) to the input terminals and check the accuracy at at least 10 points throughout the scale, noting the error and its sign at each point. Readjust R18 so that the maximum positive and maximum negative errors are equal in magnitude.

6.3.4 High Frequency Response — A discussion of all the factors entering into high frequency response of this instrument is beyond the scope of this manual. The basic voltmeter has no adjustments relating thereto, the instrument being inherently flat up to its specified top frequency. One attenuator range (0.03 V) has an adjustment (C3) and a procedure for making this adjustment will be outlined below. All checks of response must be made with a distortion-free sinewave signal, and the instrument used as a reference must have an extremely low response error over the range of 400 cps to 200 kc.

On the most sensitive range of the instrument the response is determined solely by the amplifier and meter rectifier circuit. On all other ranges the attenuator response enters in also.

To check the high frequency response of the instrument connect together the instruments shown in Fig. 6. Set the signal generator to a frequency of 1 kc, the output of the signal generator to a level consistent with the range of the Model 300E which it is desired to check, and the level monitor for a suitable indication. Note the indications of both the Model E and the level monitor. Next set the signal generator to frequencies of 10 kc, 50 kc, 100 kc and 200 kc, in each case keeping the indication on the level monitor the same as it was at 1 kc, and noting the indication of the instrument under test.

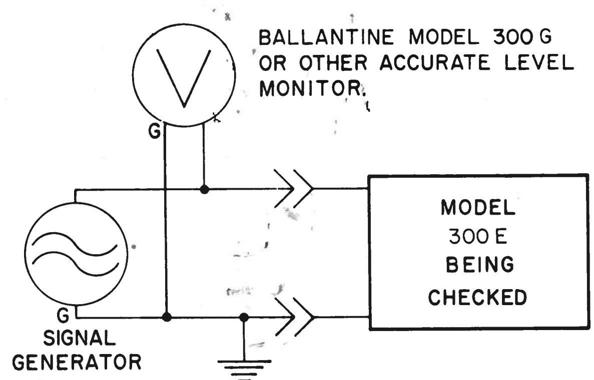


Fig. 6. Frequency Response Check

If it has been determined that the instrument response is in error at the high frequencies, the response of the most sensitive or amplifier range should be checked. If the response of this range is found normal, the trouble must be in one or more of the attenuators.

If the response of the most sensitive range is not normal, the first attempt at correction should be tube replacement. If tube replacement does not restore normal response, one or more of the following items may be defective:

a. Capacitors — C7, C10

b. Resistors — R15, R16, R24, R25, R32, R39

c. Signal diodes — CR1, CR2. These units are of a hermetically sealed silicon junction type, which are virtually immune to shock, vibration, temperature, aging effects, etc., and it is not very likely that they will ever be the source of trouble.

If the response is normal on the most sensitive range, but error exists on the 0.03 V range, capacitor C3 should be adjusted for flattest response or best agreement with the most sensitive range. Access may be had to C3 through a hole in the rear chassis cover. See Fig. 5. If adjustment of C3 fails to establish normal response, Capacitor C4 may be defective. Access to C4 may be had by removing the top chassis cover and then the attenuator shield.

The four remaining attenuator ranges (0.3, 3.0, 30 and 300 V) have an inherently flat response over the range of the instrument. There are, therefore, no adjustments relating to these ranges.

If the above procedure fails to establish normal high frequency response it is recommended that the instrument be returned to Ballantine Laboratories, Inc. for servicing.

6.3.5 Low Frequency Response — The low frequency response is determined solely by the amplifier, rectifier-meter portion of the instrument and hence is independent of range switch setting. This response is inherently flat and there are no controls or adjustments relating thereto.

To check the low frequency response connect together the instruments shown in Fig. 6. Set the signal generator to a frequency of 1 kc and set the range switches on the instrument being checked and the level monitor to give on-scale deflections, noting the indication of each. Next set the signal generator to frequencies of 100, 70, 50 and 30 cps, in each case keeping the indication on the level monitor the same as it was at 1 kc, and noting the indication of the instrument under test. This indication should be constant within $\pm 1\%$.

If this response is abnormal, the first attempt at correction should be tube replacement. In particular V1, V2, V3 and V4 should be checked for grid current. Other components, which if defective, might lead to abnormal low frequency response are:

a. Coupling capacitors C1, C9, C12, C13, C15, C16, C19 and C21.

b. Bypass capacitor C6.

c. Decoupling capacitors C8 A, B, C, C11 A, B, C, C18A.

d. Regulator tube V5.

6.4 Troubleshooting

6.4.1 Equipment Required —

a. A stable, distortion-free, and accurately calibrated source of voltage with a signal frequency in the range of 400 cps to 1 kc. The output of the source should be continuously variable over a range of at least 1 mV to 10 V. The Ballantine Model 420 is such a source.

b. A stable, distortion-free, variable frequency signal generator covering a range of at least 30 cps to 200 kc, the output of which should be variable over a range of at least 1 mV to 3 V.

c. A stable, sensitive, flat responding voltmeter covering a frequency range of at least 30 cps to 200 kc, and a voltage range of 1 mV to 1,000 V. The Ballantine Model 300G is such a voltmeter.

d. A volt-ohm-milliameter exhibiting an input impedance of at least 10 MΩ or higher when measuring dc voltages.

6.4.2 General Malfunction — In case of malfunction, as evidenced by insufficient or even absence of response, instability, high hum or noise level, intermittent operation or other disturbance, the first step is to check all tubes, replacing any which exhibit low gm, grid current, shorts, etc.

NOTE — VOLTAGES DANGEROUS TO HUMAN LIFE EXIST IN THIS EQUIPMENT. EXERCISE EXTREME CARE WHENEVER THE COVER PLATES ARE REMOVED FROM THE INSTRUMENT.

With all tubes operating normally the voltage at the tube elements may be measured and checked against those on the schematic at the rear of this manual. All measurements should be made with the instrument input terminals short circuited and the range switch on the most sensitive range.

NOTE — IT IS POSSIBLE TO DAMAGE THE SIGNAL DIODES, IF THE PLATE OF V4 IS ACCIDENTALLY CONNECTED TO THE CHASSIS OR GROUND. IT IS ALSO POSSIBLE TO DAMAGE THE DIODES, METER, OR BOTH IF VIRTUALLY ANY PORTION OF THE METER-RECTIFIER CIRCUIT IS GROUNDED. THE USER IS THEREFORE CAUTIONED TO TAKE EXTREME CARE WHEN MEASURING IN THIS SECTION OF THE INSTRUMENT.

The instrument used to measure dc potentials should have an input resistance of not less than 10 megohms. Any radical departure (in excess of 15%) from the voltages shown may indicate the nature of the trouble. In the event of a defective component it should be replaced in accordance with the Replacement Parts List located at the end of this manual. If the component or components are not available locally, they may be obtained from Ballantine Laboratories, Inc.

6.4.3 Signal Tracing — In the event that the procedure thus far fails to reveal the nature of the trouble, recourse may be made to signal tracing. The procedure is as follows:

a. With the instrument on the 0.3 V range, connect a signal of 3 mV, 1,000 cps, to the input terminals.

b. Short out the feedback resistor R13.

c. Measure the signal voltages at V1, V2, V3, and V4 using a sensitive, high input impedance voltmeter such as the Ballantine Model 300G. When making these measurements precautions should be taken against introducing spurious signals into high impedance circuits. Operating the instrument on a grounded plate with the operator making contact with this ground should be sufficient.

NOTE — BECAUSE OF THE PRESENCE OF HIGH VOLTAGES, DO NOT MAKE CONTACT WITH GROUND UNTIL THE DESIRED CONNECTION HAS BEEN MADE AND THE HAND REMOVED THEREFROM. OBSERVE SAME PRECAUTION WHEN REMOVING CONNECTIONS.

Compare the voltages measured with those listed on the schematic diagram located at the rear of this manual. Any radical departure (greater than ±10%) from the voltages indicated may indicate the nature of the trouble.

6.4.4 Power Supply Malfunction — The power supply of this instrument is of extremely simple design and, except for vacuum tube (V5, V6) replacement, should seldom if ever cause any trouble. The diodes (CR3, CR4) employed in the dc heater supply are of the hermetically sealed silicon junction type and have a virtually limitless life.

On the schematic diagram located at the rear of this manual are the pertinent dc, ac and ripple (for 60 cps) voltages. Measurements of these voltages should be made with zero signal input, and the instrument range knob set to 300 V. Any radical departure from these voltages may indicate the nature of the trouble.

6.4.5 Troubleshooting Chart — To assist in troubleshooting, a chart has been prepared which lists symptoms, possible cause and/or remedy, and where possible, a reference to a pertinent section of the manual.

TROUBLESHOOTING CHART

Symptom	Possible Cause and/or Remedy	Pertinent Sections
Instrument inoperative	Fuse blown. ON-OFF switch. Line cord. Power supply defective. Vacuum tubes V1, V2, V3, V4. Amplifier component. Signal diode CR1, CR2. Meter. Capacitor C20.	6.1.1 5.4, 6.4.4. 5.2, 6.4.3 5.3 5.3 5.3
Erratic meter indication	Vacuum tubes V1, V2, V3, V4, V5, V6. Attenuator switch or component. Amplifier component. Power supply component.	 5.1, 6.4.5 5.2, 6.4.3 5.4, 6.4.4
Meter indicating with zero input signal	Excessive heater-cathode leakage V1, V2, V3, V4. Capacitor C21. Resistor R41 or R42. Amplifier oscillating.	 5.3 5.2, 6.4.3
Microphonics	V1 excessively microphonic. Imperfectly soldered connection. Poor electrical contact in range switch.	
Excessive hum (meter beats when signals near line frequency or harmonics are measured)	Excessive heater-cathode leakage V1, V2. Instrument being operated in strong magnetic field of another instrument or equipment. *Ground* current flowing in signal carrying lead.	
Scale adjustment off — impossible to correct by means of R38	Vacuum tubes V1, V2, V3, V4. Diode CR1, CR2. Resistor R41, R42. Capacitor C20, C19, C21.	5.3, 6.3.2

TROUBLESHOOTING CHART *(Continued)*		
Symptom	**Possible Cause and/or Remedy**	**Pertinent Sections**
Range switch does not decade	Resistor R1, R2, R3, R4, R5, R6, R7, R8. Capacitor C3, C4. Amplifier tube V1 (excessive grid current).	5.1, 6.3.1 5.1, 6.3.1
Accuracy off — adjustment of R16 does not correct	Attenuator resistor R1, R2, R3, R4, R5, R6, R7, R8. Scale adjustment not properly made. Amplifier tube V1, V2, V3, V4. Defective diode CR1, CR2. Meter M1.	5.1, 6.3.1 5.3, 6.3.2
Abnormal high frequency response	Amplifier tube V1, V2, V3, V4. Diode CR1, CR2. Capacitor C7, C10, C3, C4.	5.2
Abnormal low frequency response	Amplifier tube V1, V2, V3, V4. Capacitors C1, C9, C10, C13, C15, C16, C17, C21, C8A, B, C, C11A, B, C. Regulator tube V5. Diode CR1, CR2.	5.2

7. SHIPPING INSTRUCTIONS

If it should become necessary to return the voltmeter to Ballantine Laboratories, Inc. for examination or servicing, it should be very carefully packed with at least 4 inches of cushioning material placed around all sides of the instrument to prevent damage during shipment. Ship via REA Express, motor truck, or air freight, to

BALLANTINE LABORATORIES, INC.
90 Fanny Road
Boonton, New Jersey

8. REPLACEMENT PARTS LIST

REFER TO MODEL 300E CIRCUIT DIAGRAM, DWG. MD-959G

B. L. Part No.	*Circuit Symbol*	*Capacitors*	*Manufacturer*
2363	C1	0.1 μF, 5%, Type 355F104J, 600 V	Gudeman
2514	C2	7.5 pF, 5%, Type QC, 500 V	Quality Components
2437	C3	0.7-9 pF, Type VC1G, 1500 V	JFD
2235	C4	33 pF, 5%, Type CM15-E-330J, 500 V	Arco
2036	C6	500 μF, Type DFP, 25 V	Sprague
2228	C7	50 pF, 5%, Type CM15-E-500J, 500 V	Arco
2042	C8A	50 μF, Type DFP, 150 V	Sprague
	C8B	50 μF, Type DFP, 150 V	Sprague
	C8C	50 μF, Type DFP, 150 V	Sprague
2364	C9	0.033 μF, 5%, Type 355C333J, 200 V	Gudeman
2240	C10	20 pF, 5%, Type CM15-C-200J, 500 V	Arco
2042	C11A	50 μF, Type DFP, 150 V	Sprague
	C11B	50 μF, Type DFP, 150 V	Sprague
	C11C	50 μF, Type DFP, 150 V	Sprague
2362	C12	0.22 μF, 5%, Type 355C224J, 200 V	Gudeman
2365	C13	0.01 μF, 5%, Type 355C103J, 200 V	Gudeman
2512	C14	1 pF, 5%, Type QC, 500 V	Quality Products
2362	C15	0.22 μF, 5%, Type 355C224J, 200 V	Gudeman
2366	C16	0.0022 μF, 5%, Type 355C222J, 200 V	Gudeman
2367	C17	0.1 μF, 10%, Type 355C104K, 200 V	Gudeman
2043	C18A	10 μF, Type DFP, 500 V	Sprague
	C18B	10 μF, Type DFP, 500 V	Sprague
	C18C	10 μF, Type DFP, 500 V	Sprague
2368	C19	1 μF, 5%, Type 355C105J, 200 V	Gudeman
2055	C20	25 μF, Type DPE-14395, 25 V	Sprague
2368	C21	1 μF, 5%, Type 355C105J, 200 V	Gudeman
2019	C26	1000 μF, Type DFP, 15 V	Sprague

Resistors

1476	R1(1)	1,800,000 ohms, 1%, Type PT-1000	Ballantine
1477	R2(2)	2,000,000 ohms, 1%, Type PT-1000	Ballantine
1478	R3(3)	1,998,000 ohms, 1%, Type PT-1000	Ballantine
1441	R4(1)	200,000 ohms, 1%, Type PT-500	Ballantine
1442	R5(2)	20,200 ohms, 1%, Type PT-500	Ballantine
1443	R6(3)	1,800 ohms, 1%, Type PT-500	Ballantine
1444	R7(3)	180 ohms, 1%, Type PT-500	Ballantine
1445	R8(3)	20 ohms, 1%, Type PT-500	Ballantine

NOTE: Matched set Resistors MUST be replaced as a complete set in order to provide the specification accuracy.

(1) Resistors R1 and R4 are a matched set and should be ordered as Resistor Set #1597.
(2) Resistors R2 and R5 are a matched set and should be ordered as Resistor Set #1598
(3) Resistors R3, R6, R7 and R8 are a matched set and should be ordered as Resistor Set #1596

REPLACEMENT PARTS LIST *Continued*

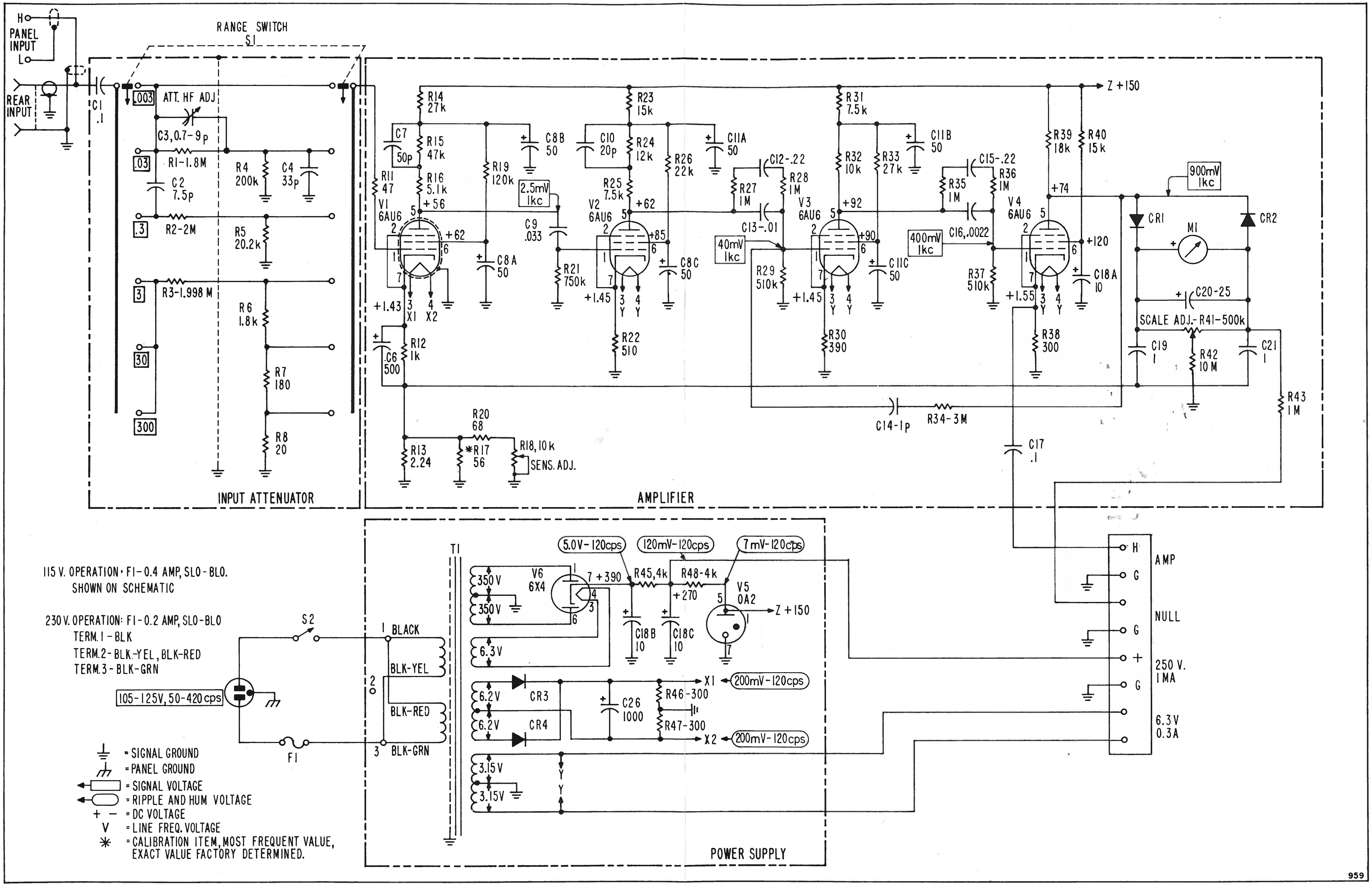
REFER TO MODEL 300E CIRCUIT DIAGRAM, DWG. MD-959G

B. L. Part No.	*Circuit Symbol*	*Resistors*	*Manufacturer*
1097	R11	47 ohms, 5%, Type EB	Allen-Bradley
1057	R12	1,000 ohms, 5%, Type EB	Allen-Bradley
1768	R13	2.24 ohms, Special	Ballantine
1081	R14	27,000 ohms, 5%, Type EB	Allen-Bradley
1660	R15	47,000 ohms, 1%, Type N20	Corning
1047	R16	5,100 ohms, 5%, Type EB	Allen-Bradley
	R17	Value determined in Calibration	
1921	R18	10,000 ohms, 20%, Type J Pot	Allen-Bradley
1085	R19	120,000 ohms, 5%, Type EB	Allen-Bradley
1357	R20	68 ohms, 1%, Type CPX-½	Hi-Q Aerovox
1012	R21	750,000 ohms, 5%, Type EB	Allen-Bradley
1061	R22	510 ohms, 5%, Type EB	Allen-Bradley
1042	R23	15,000 ohms, 5%, Type EB	Allen-Bradley
1043	R24	12,000 ohms, 5%, Type EB	Allen-Bradley
1046	R25	7,500 ohms, 5%, Type EB	Allen-Bradley
1039	R26	22,000 ohms, 5%, Type EB	Allen-Bradley
1010	R27	1,000,000 ohms, 5%, Type EB	Allen-Bradley
1010	R28	1,000,000 ohms, 5%, Type EB	Allen-Bradley
1014	R29	510,000 ohms, 5%, Type EB	Allen-Bradley
1062	R30	390 ohms, 5%, Type EB	Allen-Bradley
1046	R31	7,500 ohms, 5%, Type EB	Allen-Bradley
1044	R32	10,000 ohms, 5%, Type EB	Allen-Bradley
1081	R33	27,000 ohms, 5%, Type EB	Allen-Bradley
1005	R34	3,000,000 ohms, 5%, Type EB	Allen-Bradley
1010	R35	1,000,000 ohms, 5%, Type EB	Allen-Bradley
1010	R36	1,000,000 ohms, 5%, Type EB	Allen-Bradley
1014	R37	510,000 ohms, 5%, Type EB	Allen-Bradley
1063	R38	300 ohms, 5%, Type EB	Allen-Bradley
1041	R39	18,000 ohms, 5%, Type EB	Allen-Bradley
1042	R40	15,000 ohms, 5%, Type EB	Allen-Bradley
1920	R41	500,000 ohms, 20%, Type J, Pot	Allen-Bradley
1463	R42	10,000,000 ohms, 1%, Type CPX-1	Hi-Q Aerovox
1010	R43	1,000,000 ohms, 5%, Type EB	Allen-Bradley
1740	R45	4,000 ohms, 5%, Type 452E	Sprague
1063	R46	300 ohms, 5%, Type EB	Allen-Bradley
1063	R47	300 ohms, 5%, Type EB	Allen-Bradley
1740	R48	4,000 ohms, 5%, Type 452E	Sprague

REPLACEMENT PARTS LIST *Continued*

REFER TO MODEL 300E CIRCUIT DIAGRAM, DWG. MD-959G

B. L. Part No.	*Circuit Symbol*	*Other Components*	*Manufacturer*
7920	CR1, 2	Diodes, Type 11X4148, Special	General Electric
5559	CR3, 4	Diodes, Type TM1, Special	Transitron
3410	F1	Fuse, 0.4 A, Slo-Blo	Bussmann
3159	M1	Meter, Indicating, Special	Ballantine
3258	S1	Switch, Range Selector	Ballantine
3268	S2	Switch, ON-OFF, Type 80994H	Arrow, Hart, Hegeman
3047	T1	Transformer, Power	Ballantine
7907	V1, 2, 3, 4	Tubes, Type 6AU6A, Code 16	RCA
3106	V5	Tube, Type OA2	RCA
3105	V6	Tube, Type 6X4	RCA
4139	—	AC Power Cord	Ballantine



CAPACITORS: NOT MARKED — MICROFARADS (10^{-6} F)
P — PICOFARADS (10^{-12} F)
RESISTORS: NOT MARKED — OHMS (Ω)
k — KILOHMS ($10^{3}\,\Omega$)
M — MEGOHMS ($10^{6}\,\Omega$)
VOLTAGES: NOT MARKED — VOLTS (V)
mV — MILLIVOLTS (10^{-3} V)

Fig. 7. Schematic of Model 300E Sensitive Electronic Voltmeter
Dwg. No. MD-959G

BALLANTINE LABORATORIES, INC.
BOONTON, N. J.