Ballantine

MODEL 340

RF MILLIVOLTMETER

BALLANTINE LABORATORIES, INC.

P.O. BOX 97
BOONTON, NEW JERSEY 07005 USA
201-335-0900/TWX: 710-987-8380

90100141A

JUNE 1972

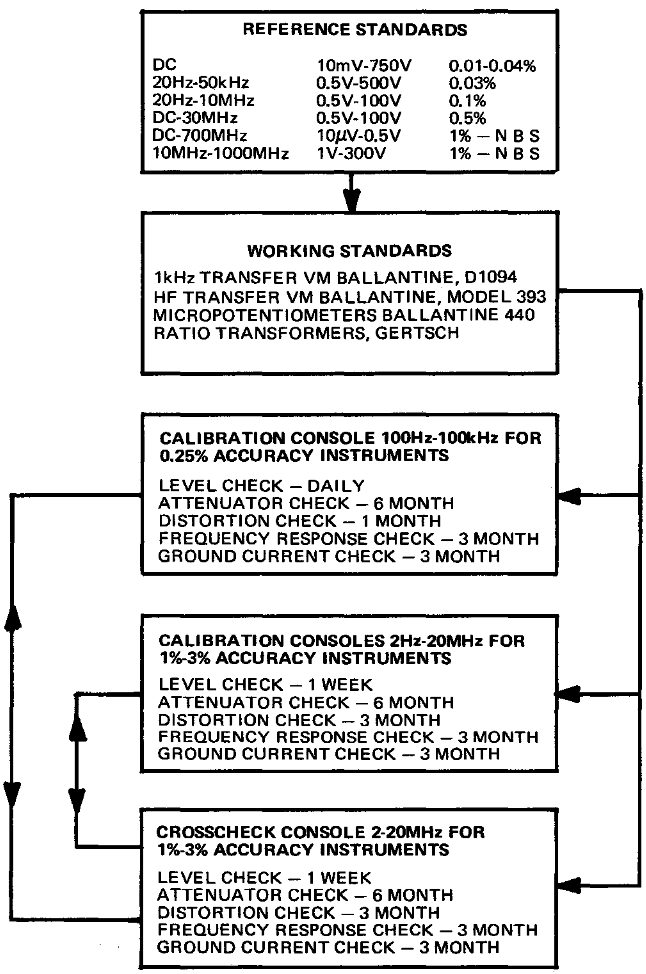
Printed in U.S.A.

WARRANTY

All Ballantine Laboratories, Inc. products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, except for vacuum tubes and batteries, or, in the case of certain major components listed in the instruction manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

CERTIFICATION

The equipment supplied on your order meets all applicable published Ballantine specifications as determined by thorough testing and inspection. Ballantine's calibration measurements are traceable to the National Bureau of Standards. All instruments used in calibrating Ballantine products are standardized by systematic reference to NBS-traceable standards as described in the validation procedures shown below.



Ballantine's Quality Assurance program satisfied the requirements of MIL-Q-9858.

INSTRUCTION BOOK CONTENTS

FOR

MODEL 340 RF MILLIVOLTMETER

ILLUSTRATIONS AND DIAGRAMS

TABLES

Figure 1. Ballantine Model 340 RF Millivoltmeter with Adapters

Figure 2. Rack Panel Mounted Ballantine Model 340-S/2 RF Millivoltmeter

1. GENERAL INFORMATION

1.1 Features

The Ballantine Model 340 RF Millivoltmeter is a sensitive, wideband, rms-responding voltmeter with a voltage range from 300 μV to 3 V, frequency range of 100 kc to 700 Mc, logarithmic indicator and a basic accuracy of better than 4%. It brings to high frequency voltage measurements the same convenience of logarithmic scales, sensitivity and accuracy that has always been associated with Ballantine voltmeters. A feature of the Ballantine Model 340 RF Millivoltmeter is its rms response to distorted sinewave voltages. This is particularly important at high frequencies because all existing calibration standards are based on rms-responding devices. High frequency waveforms are often highly distorted and the means for measuring this distortion are limited.

Signal voltages are measured in the Model 340 by a probe which is connected to the voltmeter by 3 feet of cable. This allows positioning the probe exactly at the point at which the voltage measurement is desired, thus minimizing errors due to transmission effects.

The basic input to the probe is coaxial — a flexible ⅛ inch diameter bellows is the center conductor and the outer conductor is a ⅝-24 external thread. For input voltages above 30 mV, a probe attenuator (Model 1340) is first connected to the probe. This probe attenuator has the same flexible center conductor and threaded outer conductor as the probe itself. Customer-designed adapters can be used to make connections to either the probe or the probe attenuator and probe when the very shortest transmission paths are required. For less demanding applications the Model 340 is supplied with a complete set of input adapters. A coaxial adapter (Model 2340) allows the probe to be connected to female Type N and BNC connectors. A spring-loaded probe tip (Model 4340) is supplied for in-circuit measurements, and a Tee-adapter (Model 5340) is available to match the probe to a 50 ohm transmission line.

1.2 Some Applications of the Model 340

RMS voltage measurement in grounded circuits
High frequency transistor measurements
Voltage measurements on coaxial systems
High frequency bridge measurements

1.3 Technical Characteristics

Voltage Range	300 μV to 3 V in 8 ranges of 10 db each
Frequency Range	0.1 Mc to > 1000 Mc calibrated to 700 Mc
Response	True rms, all voltages
Accuracy	Specified in % of reading at any point on the scale 0.1 - 100 Mc ±4% 100 - 700 Mc ±10%
Allowable Max Crest Factor	300 μV - 1 mV 200 - 60 1 mV - 3 mV 60 - 20 3 mV - 10 mV 20 - 6 10 mV - 30 mV 6 - 2 30 mV - 100 mV 200 - 60 0.1 V - 0.3 V 60 - 20 0.3 V - 1.0 V 20 - 6 1.0 V - 3.0 V 6 - 2
Scales	Two logarithmic voltage scales, 0.95 to 3.3 and 3.0 to 10.6 One linear decibel scale, 0-10
Probe Input Impedance	300 μV - 30 mV > 25 kΩ and 4 pF 30 mV - 3 V > 1 MΩ and 4 pF
Mean Square DC Output	0.1 to 1.0 V repeated for each 10 db ac range. 20 kΩ source impedance
Input Power	115/230 V, 50 - 420 cps, 40 W
Accessories, Supplied	Probe Attenuator, Model 1340 Coaxial Adapter, Model 2340 Probe Tip, Model 4340 Tee Adapter, Model 5340
Accessories, Optional	High Voltage Attenuator, Model 6340
Vacuum Tubes and Semiconductors	2 — 12AX7, 2 — 6AU6A, 1 — 6X4, 1 — OA2, 1 — OB2WA, 2 — 2NS25, 2 — S282G, 4 — 1N816, 5 — 1N1692, 2 Probe diodes (BL Special)
Dimensions (inches)	Portable: 13 H, 7½ W, 9½ D Rack: 8½ H, 19 W, 8½ D
Weight (pounds)	Portable or Rack, 16 Shipping weight: Portable 22, rack 34

2. OPERATION

2.1 Power Connection

The voltmeter is supplied ready to operate on 105 - 125 V, 50 cps - 420 cps or 210 - 250 V, 50 cps - 420 cps power line, as indicated on the decal mounted adjacent to the power cord.

2.1.1 Line Voltage Conversion from 115 V to 230 V or vice versa is possible. For conversion from 115 V operation to 230 V operation, connect the power transformer leads as follows:

Disconnect black-red lead from terminal 1 and black-yellow lead from terminal 3, and connect both together to terminal 2. Replace fuse F1 0.4 ampere by 0.2 ampere Slo-Blo fuse. Detailed information for 115 V / 230 V conversion is given on the schematic at the end of this instruction book.

2.2 Starting Procedure

Insert the three-prong plug into a proper ac power outlet. Use conversion unit where only two-prong outlets are available. Turn the function switch from OFF position. The pilot light should glow. The instrument is ready for use after a short warmup period.

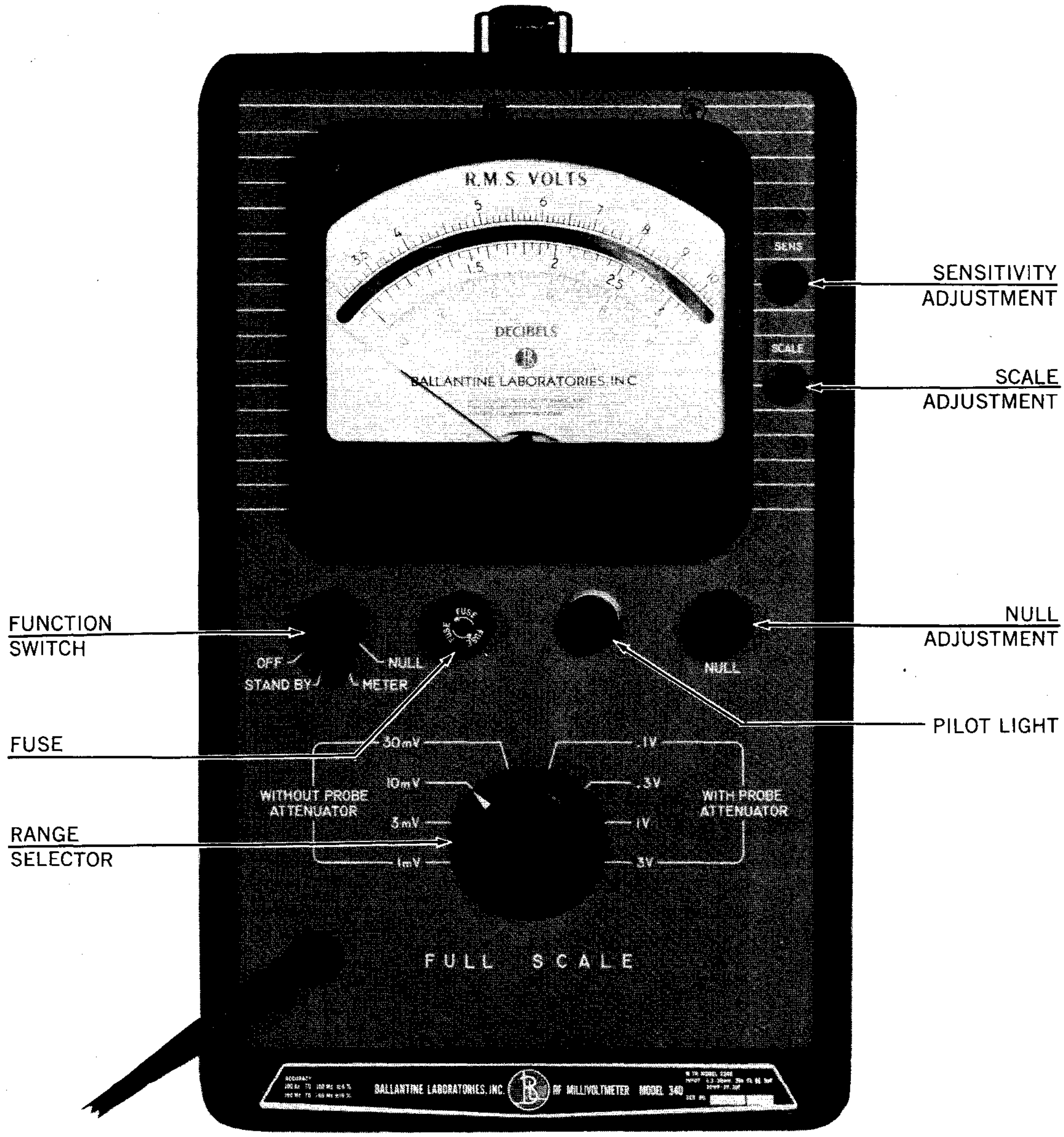


Figure 3. Model 340 — Location of Controls

2.2.1 Warmup Period

The instrument is usable after approximately 20 seconds. After 15 minutes the indication will be within 1.0% of the final value.

When the instrument has not been in use for many months or has been stored in high humidity allow a warmup period of at least one hour.

NO SOURCE OF HEAT SHOULD BE CLOSE TO THE BACK OF THE INSTRUMENT. PERMIT AIR TO CIRCULATE FREELY AROUND THE VOLTMETER TO AVOID EXCESSIVE TEMPERATURE RISE IN THE INSTRUMENT.

The voltmeter is calibrated in the vertical position. For convenience in reading, a tilting device is provided beneath the case.

2.3 Function of Controls (see fig 3. for control locations)

Function Switch

OFF	Turns instrument off.
STANDBY	Turns instrument on with the exception of the chopper. Use this switch position between series of measurements to prolong life of chopper.
METER	Turns chopper on and allows instrument to be used as a calibrated voltmeter.
NULL	Biases meter on-scale with no signal input. Use to set NULL adjustment and for sensing voltages below the normal minimum reading of 300 microvolts.

Range Selector

FULL SCALE	Selects voltage range of instrument in 10 db steps. Voltages from 300 μV to 30 mV are measured without probe attenuator. Voltages from 30 mV to 3 V must be measured with probe attenuator in place as well as with correct position of FULL SCALE range selector.

Panel Adjustments

NULL	With shielded, open-circuit input on 1 mV range, and function switch at NULL, rotate NULL adjustment control for minimum indication. This adjustment should be made after a 15 minute warmup each time the instrument is turned on and before the start of any critical measurements.
SENS	Allows a small adjustment in voltmeter sensitivity to correct for changes due to component aging.
SCALE	Adjusts a biasing current to the indicator so that full scale on one range will correspond exactly to bottom scale on the next higher range.

2.4 Voltage Measurements

2.4.1 For True RMS Voltage Measurements Below 30 mV

Set	To
Function Switch	METER
Range Selector	30 mV

Connect the unknown voltage to the probe input using the proper adapter as required and rotate the range selector counterclockwise until an indication appears on the meter scale. Take the reading from the scale indicated by the range selector. Because of the logarithmic meter scale and Ballantine special design, the accuracy of the measurement is the same at any point on the scale.

After a 15 minute warmup, and whenever a series of critical measurements are to be made on either the 1 mV or 3 mV range, check the NULL adjustment.

2.4.1.1 NULL Adjustment serves to "zero" or cancel out small residual voltages in the input system of the voltmeter. Since these residuals tend to be a function of time and temperature, the adjustment should be made and checked frequently for greatest accuracy.

To make the NULL adjustment:

Set	To
Function Switch	NULL
Range Selector	1 mV

Shield the probe input — for example, by connecting the Coaxial Adapter, Model 2340, to the probe but not screwing it all the way on to connect the center conductors. Allow a few minutes for any heat generated in handling the probe to dissipate. Rotate the NULL adjustment for a minimum indication.

The minimum indication should fall between 1 - 3 db on the meter scale. A higher null is an indication of excessive noise or thermal potentials and should be investigated. (See paragraph 4.5.3)

2.4.2 For True RMS Voltage Measurements Above 30 mV

Set	To
Function Switch	METER
Range Selector	3 V
Attach	**To**
Probe Attenuator, Model 1340	Probe

Connect the unknown voltage to the probe attenuator input using the proper adapter as required and rotate the range selector counterclockwise until an indication appears on the meter scale. Take the reading from the scale indicated by the range selector.

After a 15 minute warmup and whenever a series of critical measurements are to be made on either the 0.1 V or 0.3 V range, check the NULL adjustment (see paragraph 2.4.1.1)

2.5 Possible Error Sources

The causes of some measuring difficulties are listed below:

2.5.1 Indicator Remains in Extreme Left Position

This condition may be caused by:

a) Power cord disconnected
b) Fuse open
c) Function switch in OFF or STANDBY position
d) Input voltage lower than range selected
e) Failure to remove Probe Attenuator for measurements below 30 mV

2.5.2 Indicator Remains in Extreme Right Position

This condition may be caused by:

a) Input voltage higher than range selected
b) Failure to attach Probe Attenuator for measurements above 30 mV
c) Excessive external fields
d) Excessive ground currents

2.5.3 Indicator Reads High and Pointer Stays on Scale for Next Higher Range

This condition may be caused by:

a) Function switch in NULL position
b) Excessive external fields
c) Excessive ground currents

2.5.4 Indicator Beats or Flutters

This condition may be caused by:

a) Large spurious input voltage at or near 94 cps
b) Strong magnetic fields such as exist adjacent to certain power transformers and line voltage regulators
c) Noisy or unstable input signal

Because of the wide frequency range and high sensitivity of the Model 340, other measuring errors may be introduced when proper measuring techniques are not used. The most common error sources are listed below. A comprehensive analysis of errors is given in NBS Conference on Standards and Electronic Measurements paper "Techniques and Errors in High Frequency Voltage Calibration," by Dr. E. Uiga and W. F. White. A copy of this paper is available without charge from Ballantine Laboratories.

2.5.5 Loading Errors can occur whenever a source of emf with other than zero source impedance is measured by a voltmeter with other than infinite input impedance. Current drawn by the voltmeter produces a voltage drop in the source impedance and the resulting measured terminal voltage differs from the emf by the amount of this voltage drop.

The Model 340 is a high input impedance device. For input voltages below 30 mV, the low frequency input impedance can be represented as more than 25,000 ohms in parallel with 4 pF. Above 30 mV the shunt resistance can be considered infinite while the capacitance remains approximately at 4 pF. However, at high frequencies this situation changes. Both the resistive and capacitive components of input impedance are frequency sensitive — shunt resistance decreases with frequency, shunt capacitance increases. This is shown in figure 4.

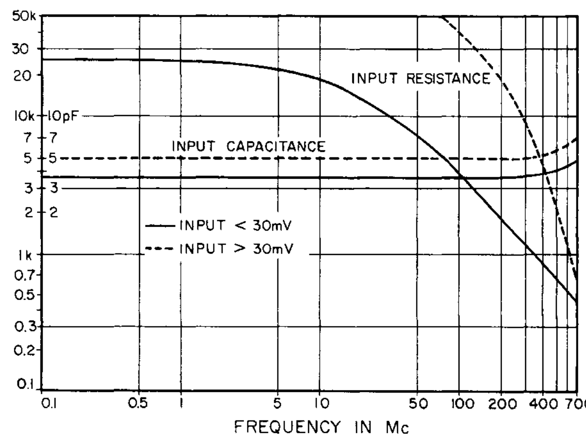


Fig. 4. Model 340 Input Impedance

For any critical voltage measurement it is necessary to check for loading errors by determining the actual source impedance of the emf at the frequency of interest and, with the aid of figure 4, the input impedance of the Model 340. The relationship between source emf, E_S, terminal voltage, V_T, source impedance, Z_S, and voltmeter impedance, Z_T, is given by:

$$E_S = V_T \left(1 + \frac{Z_S}{Z_T}\right)$$

2.5.6 Voltage Drop in Connecting Leads can cause appreciable errors at high frequencies when the inductive reactance of these leads becomes large and the input impedance of the voltmeter has decreased from its low frequency value. The situation is similar to the loading error effects discussed in 2.5.5. In this case the impedance of the connecting leads is analogous to the source impedance.

Coaxial connections to the Model 340 should be made whenever possible to reduce the error due to voltage drop in connecting leads. The Model 2340 Coaxial Adapter, supplied with the Model 340, converts the probe input to accept female type N or BNC connectors. It can be used, as can all the adapters, both with and without the probe attenuator for measurements over the entire voltage range.

The Model 4340 Probe Tip with its associated ground lead should not be used at higher frequencies if errors due to the voltage drop in connecting leads is suspected. The inductance of the ground lead is approximately 0.1 μH which at 100 Mc represents a reactance of 63 ohms.

2.5.7 Stray Field Pickup is particularly troublesome at high frequencies. Any loop in the signal input circuit can have a voltage induced in it that is proportional to the area of the loop, the stray field density, and the frequency.

Again, coaxial connections are the best when stray field pickup is suspected. Location and removal of the offending sources should be tried, and every attempt made to reduce the loop area at the signal input.

2.5.8 Transmission Line Effects have to be considered whenever the distance between the voltage to be measured and the Model 340 probe input is not negligibly short compared to a wavelength. The Model 340 is a high impedance device and will therefore introduce reflections on any transmission line. These reflections produce a voltage standing wave pattern. The magnitude of the voltage standing wave radio determines the maximum difference that can exist between the source of voltage to be measured and that indicated by the Model 340. The actual difference will depend on the distance between the source and the Model 340.

Figure 5 shows the error that will exist when the Model 340 is connected to the voltage source by a short section of 50 ohm coaxial transmission line. This set of curves is derived from transmission line equations and the input capacitance of the Model 340 (see figure 4).

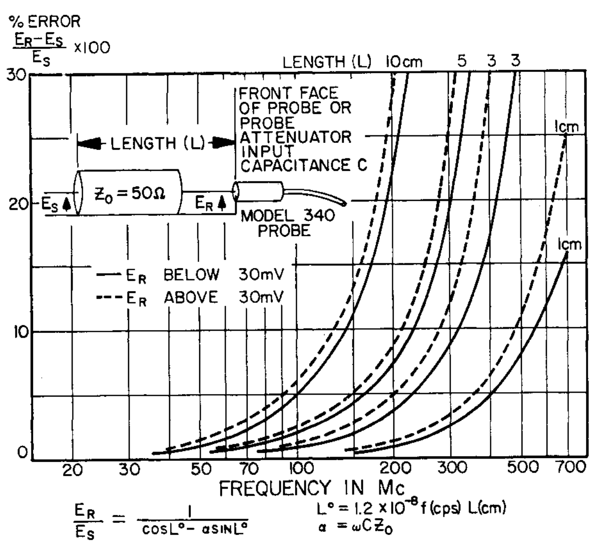


Fig. 5. Model 340 Transmission Line Errors

Transmission line effects can be minimized by shortening the length of connection between source and Model 340. This may require the construction of specially threaded adapters that will connect to the ground of the Model 340 probe.

Transmission line effects may also be minimized by measuring in a matched 50 ohm transmission system. For this application the Model 340 probe is first connected to the Model 5340 Tee Adapter which is then connected to the 50 ohm transmission line where the measurement is desired. The maximum vswr of this system as a function of frequency is shown in figure 6. This tabulation shows the maximum errors that can exist due to reflections caused by the Model 340, assuming the transmission line itself is perfectly matched.

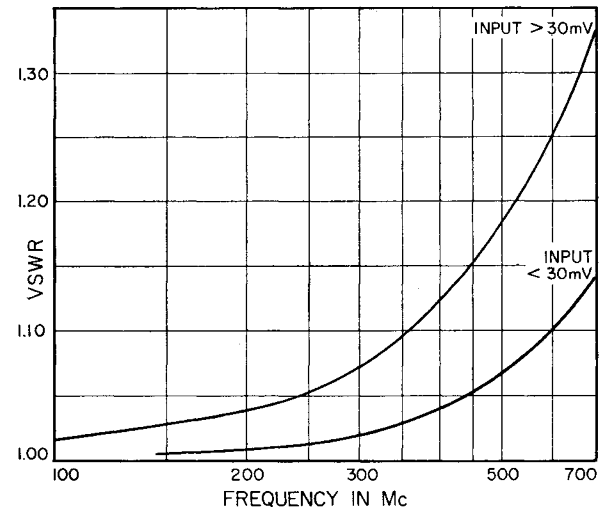


Fig. 6. Model 5340 VSWR

2.5.9 Ground Current Errors can be particularly troublesome whenever low-level, high frequency voltages are measured. Special circuit precautions have been made in the Model 340 to reduce the effects of ground currents — either currents of power line frequnecy or high frequencies. However, particularly with high frequency ground currents, it is impossible to completely eliminate these effects. Therefore every effort should be made to reduce the leakage from signal sources into the power line ground. Avoid positioning power line cords close to the Model 340 or to any low-level sources that are being measured. Work at the highest possible measurement levels.

2.5.10. Response and Waveform Errors are minimized in the Model 340 because the instrument responds to the rms value of the input signal. This feature is particularly important in the calibration of the Model 340. All high frequency calibration devices (Micropotentiometers, A-T Voltmeters, HF Transfer Voltmeters) are rms-responding. When they are used to calibrate a Model 340, errors due to distortion in the signal sources will be minimized.

The rms feature of the Model 340 is likewise important when measuring unknown voltages. Distortion in the voltage will not lead to the uncertain reading of a peak-responding or average-responding instrument. However, particularly at high frequencies, response and waveform errors must still be considered when using the Model 340. If the signal being measured is connected to the Model 340 over a finite length of transmission line — which in practice is always the case — and if the signal contains higher frequency harmonics, these harmonics will be transmitted over a longer electrical length than the fundamental. This longer length will alter the amplitude of the harmonics at the input of the Model 340, in relationship to the amplitude of the fundamental, and therefore alter the rms voltage as measured by the Model 340. In addition, above 700 Mc the Model 340 itself no longer exhibits a flat response but instead goes into a series resonant peak. Harmonics above 700 Mc will therefore be further emphasized and the reading of the Model 340 will further depart from a true rms indication of the signal voltage.

2.8 Overload Characteristics

The maximum ac voltage that should be applied directly to the probe is 10 volts. The maximum ac voltage that should be applied to the probe attenuator is 300 volts. Higher voltages may damage one or both of the probe diodes.

TABLE I

DB LEVEL CONVERSION								
Reference Level	Subtract from DB Readings on FS Ranges							
	1 mV	3 mV	10 mV	30 mV	0.1 V	0.3 V	1.0 V	3.0 V
1 V, 1 mW in 1000 Ω (dbv)	70 db	60 db	50 db	40 db	30 db	20 db	10 db	0 db
0.775 V, 1 mW in 600 Ω (dbm)	67.8	57.8	47.8	37.8	27.8	17.8	7.8	−2.2
0.224 V, 1 mW in 50 Ω	57.0	47.0	37.0	27.0	17.0	7.0	−3.0	−13.0

2.6 Use of the DB Scale

The db scale of the Model 340 is linear and reads from 0 to 10, corresponding to bottom scale and full scale voltage readings. To convert db readings to various reference levels, use Table I.

To simplify the conversion and to compute db levels of other references, a handy db slide rule is available from Ballantine Laboratories on request, free of charge.

2.7 Effect of DC Component

The input signal to the probe is coupled to the two detector diodes by 1000 pF capacitors. Any dc component of the input signal will be blocked by these capacitors and therefore will not be measured. The probe and probe attenuator have been tested to withstand 300 V dc. Applying higher dc voltages may damage one or both of the probe diodes.

2.9 Effect of Power Line Voltage Variations

Operation is possible with line voltages of 105 to 125 volts. Variation of the line voltage within this range will not affect the sensitivity of the instrument by more than 1%. Some readjustment of the NULL may be necessary if measurements are being made on either the 1 mV or 0.1 V ranges. Transient variations in the line voltage may introduce additional noise on these two ranges as well.

2.10 DC Output

A dc output is available at the rear of the instrument case through a BNC connector. The dc output varies from 0.1 to 1.0 volts for each 10 db ac voltage range and is proportional to the mean square of the ac input. The source impedance is 20 kilohms.

3. CIRCUIT DESCRIPTION

The basic circuitry of this instrument is shown in figure 7, Simplified Schematic, while a complete schematic and replacement parts list are located at the end of this manual.

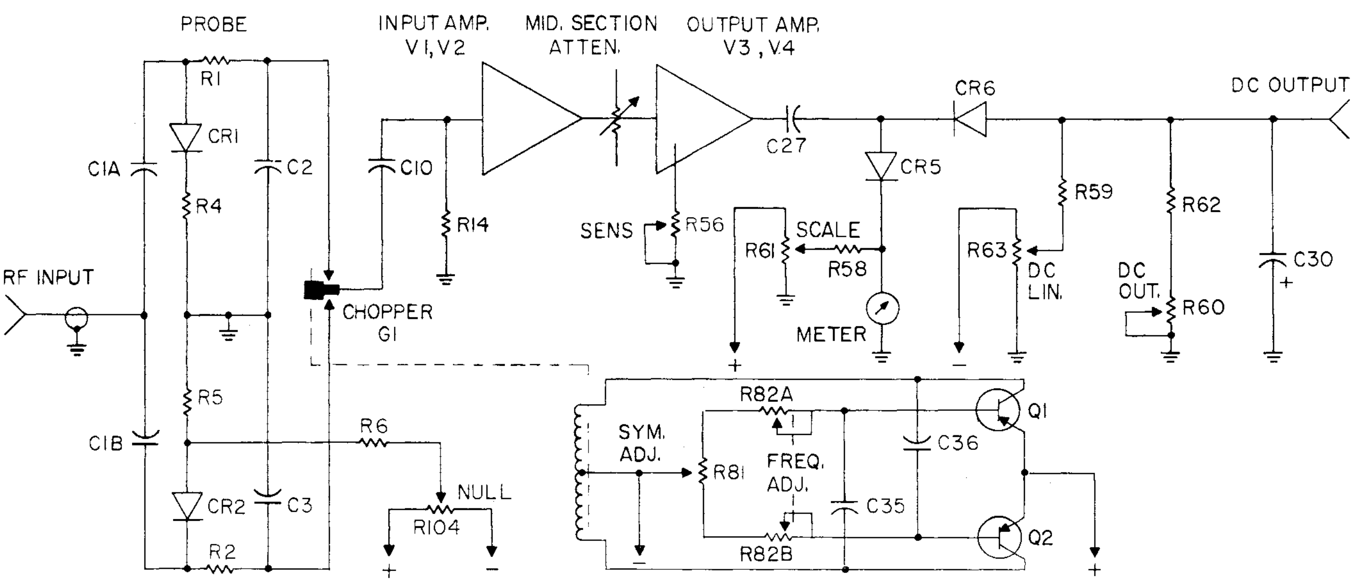


Fig. 7. Model 340 Simplified Schematic

3.1 Probe

The probe of the Model 340 is designed to convert ac voltages, 300 μV to 3 V, to equivalent dc voltages on an rms basis over a frequency range from 100 kc to 700 Mc.

The probe consists, electrically, of a single input-dual output ceramic input capacitor, C1, of 1000 - 1000 pF. The input ac signal voltage is coupled through this capacitor to the two germanium diode detectors, CR1 and CR2, which are connected, in opposite polarity, to ground through R4 and R5. These resistors serve to improve the high frequency response by introducing a correction to the series resonance of the diodes.

Both diodes are always operated with less than 30 mV applied ac voltage. They are therefore always operated in that region where their characteristics can be described as square-law. The diodes are specially selected for resistance, thermal characteristics, and frequency response. The dc outputs from the diodes, one negative and one positive, are connected over decoupling filters R1-C2 and R2-C3 to a special low-noise cable and then to the Model 340 chassis input. After being converted to a 94 cps signal by means of a chopper, amplified, and detected, an equivalent dc signal is averaged and has its square-root taken in the indicating meter to produce a reading proportional to the rms of the ac input voltage to the probe.

R6 is used to inject a current into R5 controlled by the NULL adjustment. The resulting voltage drop, adjusted in magnitude and polarity, serves to balance out any residual dc output from the probe with no ac signal input. R3 is connected to R5 to maintain electrical symmetry at high frequencies.

The probe is housed in a double-walled tube to provide thermal insulation to the diode circuits. The inner wall carries the signal ground. It is connected at one end to the diode grounds and the ground braids of the probe cable, and at the other end is terminated in a ⅝-24 thread to match the probe adapters.

3.1.1 Model 1340 Probe Attenuator is designed to provide a stable 40 db attenuation over a frequency range of 100 kc to 700 Mc when connected ahead of a Model 340 probe. This attenuation is used to reduce ac input signals from 30 mV to 3 V to the range 300 μV to 30 mV where they can be measured by the probe with an rms response. Failure to use such an attenuator ahead of the probe would drive the probe diodes out of their square-law region and the resulting response would no longer be rms.

The attenuation is provided by a specially constructed, factory-adjusted capacitor C1 and a fixed, mica disc capacitor, C2. Physically the Model 1340 Probe Attenuator screws directly on to the ⅝-24 thread of the probe. Its input is constructed exactly as the probe input — flexible bellows center conductor and ⅝-24 ground shell. All adapters for the probe connect as well to the probe attenuator.

3.1.2 Model 2340 Coaxial Adapter is used to convert the probe or probe attenuator input to a coaxial connector mating with Type N or Type BNC female connectors. It adds approximately 0.3 inch of transmission line between the probe input and the front face of a mating Type N connector and about 1 pF of added input capacitance.

3.1.3 Model 4340 Probe Tip is designed for in-circuit measurement below approximately 100 Mc. It consists of a stainless-steel tip, covered with a spring-loaded nylon insulator, that can be made either to press against the point of measurement or be hooked on to a circuit wire. An attached ground cable with alligator clip provides the signal ground connection. The inductance of this ground lead, together with the added length of transmission path of the probe tip, limits the use of this adapter to relatively low frequencies.

3.1.4 Model 5340 Tee Adapter is designed to allow the use of the Model 340 for voltage measurements on matched 50 ohm transmission lines. It consists of a milled aluminum block with a Type N male input connector and Type N female output connector that can be inserted in the transmission line under measurement. The Model 340 probe, with or without probe attenuator, depending on the voltage being measured, screws into the threaded portion of the aluminum block and makes connection with the center conductor of the block. On the opposite side of the block is an insulated knob that is adjusted to one of two positions — for input signals above or below 30 mV. This knob controls a pair of vanes that compensate for the change in loading of the Tee Adapter when either the Model 340 with or without its probe attenuator is used.

Figure 6 shows the maximum uncertainty in measured voltage that is introduced by the vswr of the Model 5340 Tee Adapter.

3.1.5 Model 6340 High Voltage Attenuator adapts the Model 340 to voltage measurements from 3 to 300 V over the frequency range of 0.1 to 100 Mc. It is connected to the Model 1340 Probe Attenuator, which in turn is connected to the probe itself, and provides an additional 40 db of voltage attenuation. The added error is 1% from 0.1 to 10 Mc and 2% from 10 to 100 Mc.

3.2 Chopper Input

To convert the dc output of the probe to ac, this instrument uses a mechanical modulator or chopper, which is regarded as the best choice for this purpose, particularly because of the low level involved. Of the various conversion means available the mechanical modulator displays:

a. The highest conversion efficiency
b. The lowest residual noise level
c. The lowest residual dc
d. The lowest dc drift

To avoid dependence on power supply frequency and to reduce the effects of power supply hum, the chopper operates at a frequency of 94 cps. The signal frequency after conversion is therefore 94 cps. The chopper is driven by a 94 cps, bistable multivibrator using two rugged transistors which convert 12 volts dc to square wave ac. Since the transistors operate only as switches, they dissipate very little power, leading to low internal temperatures and long life. R82 permits a small adjustment of operation frequency, while R81 provides for an adjustment of symmetry. It should be noted that if the drive supply (7 pin connector on top of unit) is removed with the power on, and then reconnected, the transistors will be saturated and the unit will not restart until the power is interrupted and reapplied. There will be no damage done.

The input chopper is of the single pole, double throw type using gold alloy, twin contacts, designed especially for low level operation. The dc signals are coupled to the chopper by low-pass filters formed by C5, R10-C8 and C6, R11-C9. C10, C11, R12, and R14 couple the resulting ac output from the chopper, at the correct impedance level, to the input amplifier.

3.3 Input Amplifier

The ac signal (94 cps) from the chopper is sent to an input amplifier having a gain of approximately 1,000. The amplifier uses a dual triode, V1, and a pentode, V2, with overall feedback stabilization of 26 db or greater. To reduce noise the bandwidth is severely restricted by making the plate load of the last stage a parallel resonant circuit tuned to the signal frequency. To further reduce noise the input triodes are operated semi-starved, and metal film and deposited carbon type resistors are used at all critical points. The heaters of the input triode are operated on dc (rectified and filtered ac) while the plate and screen supply for all these tubes are stabilized by a gaseous regulator tube.

3.4 Midsection Attenuator

Signals from an input amplifier are sent to the output amplifier via the midsection attenuator. This attenuator, in addition to providing range switching, permits the input signal-to-noise ratio to increase whenever it introduces attenuation. The attenuator is a simple resistive-divider type and employs deposited carbon resistors.

3.5 Output Amplifier and Signal Rectifier

Signals from the midsection attenuator are further amplified in the output amplifier, which in configuration is very similar to the input amplifier. A dual triode, V3, and a pentode, V4, are operated with overall feedback stabilization of 26 db. Again in the interest of low noise the triodes are operated semi-starved, while the plate and screen potentials are derived from a gaseous regulator tube.

In contrast to the input amplifier, where all three tubes are operated to provide voltage gain, the output tube of this amplifier serves to convert voltage to current. This output current drives two rectifiers, CR5 and CR6. CR5 delivers a half-wave rectified current to the indicating meter M1. CR6 delivers a similar current, of opposite polarity, to load resistors R62 and R60 and the resulting voltage drop, filtered, is available as a dc output proportional to the mean square of the ac input to the probe. The currents through both rectifiers are combined and go either to signal ground directly or through compensating resistors R75, R76, R77 and R78 to ground. Compensation is necessary on the 1 mV and 0.1 V ranges for the residual noise of the probe and amplifier, and on the 30 mV and 3 V ranges for a slight non-linearity in probe diode square-law characteristic.

3.6 Power Supply

All necessary operating potentials are derived from a line operated power supply. High potentials for plates and screens are obtained from rectified ac, rc filtered, and gaseous-tube stabilized. All tube heaters except V1 are operated on ac balanced with respect to ground. The heater of V1 is operated on rectified ac with rc filtering. R92, a potentiometer across this dc supply, is adjusted to provide minimum hum in the input stages.

4. MAINTENANCE

4.1 General

The Model 340 is designed for extended trouble-free service. High grade components operated below rating and low operating temperature result in more than 3,000 hours of expected operating periods without the need for amplifier tube changes or circuit adjustments.

The purpose of periodic maintenance procedures is to assure the specified accuracy, check the condition of the voltmeter and detect and replace deteriorated tubes or components before they have an appreciable effect on instrument performance. The procedure is designed not only to measure and correct voltmeter performance at the time of test, but to foresee the possible troubles and guarantee the instrument accuracy through the next maintenance period.

4.2 Recommended Maintenance consists of two types of periodic checks.

4.2.1 2,000 hour checks.

4.2.2 4,000 hour checks.

4.3 Necessary Maintenance Equipment

4.3.1 Stable Signal Source, adjustable from 10 mV to 1 V, capable of being set to $\pm 1/4\%$, frequency in range 100 kc - 1 Mc.

4.3.2 Sensitive AC Vacuum Tube Voltmeter, such as Ballantine Model 300H.

4.3.3 Sensitive DC Vacuum Tube Voltmeter, such as Ballantine Model 365.

4.3.4 Tube Checker

4.4 Removal of the Case

Place the voltmeter face down on a table. Remove the power cord and the two #10 binder head screws at the rear of the case. Lift up the case. To replace the case, proceed in reverse order.

WARNING: When the instrument is operated without the case the danger of electric shock exists. Take extreme care not to come in contact with high voltage points. The highest voltage on the chassis is 400 V dc.

4.5 2,000 Hour Check consists of the following:

4.5.1 Scale Adjustment checks the scale linearity of the logarithmic indicator. It is equivalent to the zero adjustment of a linear meter. For such adjustment

Set	To
Function Switch	METER
Range Selector	10 mV

Apply a stable source of 100 kc - 1 Mc to the probe input. Adjust the amplitude to produce a meter reading of exactly 10 on the upper voltage scale. Reduce the source by exactly 10 db. The meter should now indicate exactly 1 on the lower voltage scale. If it does not, rotate the SCALE ADJ control, R61, located at the right side of the front panel. Repeat this procedure until readings of exactly 10 and 1 are obtained.

4.5.2 Sensitivity Adjustment corrects for any change in overall gain due to aging of amplifier components, tubes, probe diodes, or probe attenuator. For sensitivity adjustment:

Set	To
Function Switch	NULL
Range Selector	1 mV

Adjust NULL adjustment according to paragraph 2.4.1.1. Then:

Set	To
Function Switch	METER
Range Selector	10 mV

Apply 10 mV, ±¼%, from a stable source of 100 kc - 1 Mc to the probe input. The meter should read exactly 10 mV. If not, adjust SENS control located at the right side of the front panel. Then:

Set	To
Function Switch	METER
Range Selector	1 V

Attach the Probe Attenuator, Model 1340, to the probe. Apply 1 V, ±¼%, from a stable source of 100 kc - 1 Mc to the probe attenuator. The meter should read exactly 1 V. Ordinarily no adjustment to the probe attenuator should be necessary. If the error on the 1 V range is less than 1½%, the SENS control should be readjusted to split this error with and without probe attenuator. If the error on the 1 V range is greater than 1½%, C1 should be adjusted for a 1 V reading by rotating the input insulator of the probe attenuator — whose threads have been sealed with Loctite — with a wrench designed to fit the two .062 inch holes spaced .280 apart. After adjustment, the insulator should be resealed with Loctite.

4.5.3 Noise Check is necessary to insure that the original low noise level of the instrument is not increased by aging of components or environmental conditions. At Ballantine Laboratories the noise is measured as follows: With probe open-circuited and shielded,

Set	To
Function Switch	NULL
Range Selector	1 mV

Adjust NULL control for minimum indication. Record the db scale meter reading. Then:

Set	To
Function Switch	NULL
Range Selector	30 mV

Record db scale meter reading. The difference in the two meter readings should not exceed 1 db. If the difference in meter readings does exceed this figure, all components in the probe and input circuitry up to and including V1 may be suspected.

The noise level is of greatest importance when making measurements on either the 1 mV or 0.1 V range. On other ranges the noise level can be appreciably higher and not affect the accuracy of measurement.

4.5.4 Range Switching Check determines the accuracy of the midsection attenuator that is connected between V2 and V3. To check this attenuator, make the NULL adjustment per paragraph 2.4.1.1 and then:

Set	To
Function Switch	METER
Range Selector	30 mV

Apply a stable source to the probe input of approximately 15 mV. Adjust the amplitude of the source until the meter reads exactly 1.5 on the lower voltage scale. Then reduce the source by precise steps of 10 db, turning the range selector progressively to 10, 3 and 1 mV. The meter should continue to indicate 1.5 ±0.02 on the lower voltage scale.

4.5.5 DC Output Check determines the accuracy of the dc output.

Set	To
Function Switch	METER
Range Selector	10 mV

Apply a stable source from 100 kc - 1 Mc to the probe input and adjust until the meter reads exactly 10 mV. Now connect an accurate dc indicator to the dc output BNC connector at the rear of the instrument. This dc indicator should have high enough resistance not to load the 20 kΩ dc source resistance. The dc indication should be 1.0 V ±1%. If it is not, adjust R60, the DC Output Adjustment (see figure 8).

Now reduce the amplitude of the ac source by exactly 10 db to 3.17 mV. The dc indication should be 0.1 V ±1%. If it is not, adjust R63, the DC Linearity Adjustment (see figure 8).

4.5.6 Stability with Line Voltage checks the overall condition of the instrument.

Set	To
Function Switch	METER
Range Selector	10 mV

Apply a stable source of 100 kc - 1 Mc to the probe input. Adjust the amplitude of the source to obtain a meter reading of exactly 10 mV. Check the line voltage to make sure it is 115 - 117 volts. Now adjust the line voltage to 105 volts, and then to 125 volts. The meter indication should not change by more than 1%. If it does, the chopper supply voltage or frequency may be in error, or the amplifier tubes may have aged beyond acceptable limits (see 4.6.1 and 5.3).

4.6 4,000 Hour Check consists of all the tests listed under the 2,000 hour check. In addition, all tubes should be checked and the chopper supply adjusted.

4.6.1 Chopper Supply Adjustment checks the frequency and symmetry of the chopper supply.

Set	To
Function Switch	METER
Range Selector	10 mV

Apply a stable 10 mV signal, 100 kc - 1 Mc, to the probe input. Adjust R82, Frequency Adjustment, for a maximum meter indication (see figure 8).

Connect a wideband ac voltmeter across terminals 36 and 38 on the chopper driver board. Adjust R81, Symmetry Adjustment, for a maximum voltmeter reading. Readjust R82, if necessary, for a maximum Model 340 meter indication (see figure 9).

5. SERVICING AND TROUBLESHOOTING

In case of voltmeter malfunction, servicing by the user is feasible provided skilled personnel and recommended equipment are available, and the procedure outlined in this and Section 4 are followed. It should be mentioned that the procedures in this manual are of a simplified nature. Refined and comprehensive service and calibration require specialized equipment not normally available to the average user. Therefore if trouble develops which cannot be corrected by the procedures outlined here, or when a most accurate calibration is desired, it is recommended that the instrument be returned to Ballantine Laboratories, Inc. The instrument should in all cases be preceded by a letter stating the nature of the trouble or the desired service. (See Section 6 for shipping instructions.)

5.1 Necessary Equipment

5.1.1 Stable Signal Source, adjustable from 10 mV to 1 V, capable of being set to ±¼%, frequency in range 100 kc - 1 Mc.

5.1.2 Sensitive AC Vacuum Tube Voltmeter, such as Ballantine Model 300H.

5.1.3 Sensitive DC Vacuum Tube Voltmeter, such as Ballantine Model 365.

5.1.4 Tube Checker

5.2 Simple Service Problems

5.2.1 Removal of the Instrument Case is required for all servicing.

Place the voltmeter face down on a table. Remove the power cord and the two #10 binder head screws at the rear of the case. Lift up the case. To replace, proceed in the reverse order.

WARNING: When instrument is operated without the case, the danger of electric shock exists. Take extreme care not to come in contact with the high voltage points.

The highest voltage on the chassis is 400 V dc.

5.2.2 Pilot Light Replacement

The pilot lamp, Type 1815, is accessible by unscrewing the red plastic cap located on the front panel.

5.2.3 Fuse Replacement

The use 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 and is located on the front panel.

5.2.4 Line Voltage Conversion

It is possible to operate the Model 340 for either a 115 V or 230 V line supply. The line voltage for which the instrument is connected on leaving the factory is indicated on a decal located adjacent to the line cord.

At the rear of the instrument on the power cord receptacle bracket are three terminals marked 1, 2, and 3. The power transformer connections are as follows:

Terminal	Power Transformer Leads	
	115 V	**230 V**
1	Black, Black-Red	Black
2	No Connection	Black-Yellow, Black-Red
3	Black-Yellow, Black-Green	Black-Green

5.3 General Instructions

When there is malfunction that is not simply corrected by any of the normal calibration adjustments (see Section 4) the following procedure is recommended:

5.3.1 Check all tubes on a reliable tube tester; replace any tubes which exhibit low gm, shorts, grid current, etc.

5.3.2 If tube replacement does not restore normal operation, check all dc and ac operating potentials and compare with those listed on schematic (Fig. 10) located at the rear of the manual. An abnormal voltage may give a clue to the nature of the defect.

5.3.3 If neither 5.3.1 nor 5.3.2 indicates the nature of the difficulty, make a thorough physical examination for broken or discolored components, broken leads, defective connections, etc.

5.4 Signal Tracing

If the simple checks outlined in section 5.3 fail to reveal the cause of malfunction, signal tracing should be tried

Set	To
Function Switch	METER
Range Selector	10 mV

Apply a stable source of 10 mV, 100 kc - 1 Mc, to the input of the probe. With a sensitive, accurate, high impedance ac voltmeter, check the ac signal voltages and compare with those shown on the schematic (Figure 10) located at the end of this manual. Any radical difference from those indicated may provide a clue to the difficulty.

5.5 Chopper Replacement

If it has been determined that the chopper needs replacement, the procedure is as follows (see figures 8 and 9):

5.5.1 Remove the instrument case.

5.5.2 Remove the three screws that hold the shield covering the input circuitry.

5.5.3 Disconnect the three bare copper leads running from the base of the chopper. Note the connection for each lead before removing.

5.5.4 Remove the 7 pin top connector from the top of the chopper.

5.5.5 Remove the 2 screws which secure the chopper base to the chassis.

5.5.6 The chopper may now be removed from the instrument.

5.5.7 Install the new chopper, observing the reverse of the procedure above. Use the special low thermal emf solder provided.

5.6 Probe Replacement

The two signal diodes in the probe may be damaged by applying excessive ac or dc voltages to the probe. Should the diodes be damaged the sensitivity of the instrument will be greatly in error and cannot be corrected by the panel SENS control.

It is recommended that if the probe diodes, or any other probe components, are damaged, the entire instrument be returned to Ballantine Laboratories for repair and recalibration. Special equipment and experienced personnel are available for this work.

Probe repairs by the user are most easily accomplished by replacing the entire probe. The following procedure should be followed:

5.6.1 Obtain a replacement probe assembly from Ballantine Laboratories. Specify the serial number of the instrument.

5.6.2 Remove the instrument case (see 5.2.1).

5.6.3 There are four probe connections just behind the front panel, three connected to the feed-thru capacitors and one to a ground lug. Carefully unsolder these four connections, then unclamp the two coaxial cables. The probe cable can now be pulled through the opening in the front panel.

5.6.4 Insert the new probe cable through the panel, reclamp the coaxial cables, and solder the four connections as before. Use the special low emf solder provided. Use as little solder as possible.

5.6.5 Check the sensitivity of the instrument, and adjust if necessary, following the procedure of paragraph 4.5.2.

5.7 Troubleshooting Chart

To assist in troubleshooting, this chart lists symptoms, possible causes, and where possible, pertinent sections of this manual.

Symptoms	Possible Cause and/or Remedy	Pertinent Sections
Instrument inoperative	No power, fuse blown	5.2.3
Pilot light does not light	Defective power supply	3.6
Instrument indication with no input	Function switch in NULL position	2.5.3
	NULL control improperly adjusted	2.3
	Noisy input tube V1	4.5.3
	Defective chopper	5.5
Instrument apparently operating but no indication	Function switch in STANDBY	2.5.1
	Defective chopper	5.5

Symptoms	Possible Cause and/or Remedy	Pertinent Sections
Instrument is out of calibration:	Function switch in NULL	2.5.3
a. on all ranges at low frequencies	R61 SCALE adj off R56 SENS adj off Defective tube or component Defective probe	4.5.1 4.5.2 2.7, 2.8, 5.6
b. on all ranges above 30 mV at low frequencies	Model 1340 attenuator off	4.5.2
c. on 1 mV and 0.1 V ranges	R104 NULL adj off R57, R71, R72, R75, R76	2.4.1.1 3.5
d. on 30 mV and 3 V ranges	R73, R74, R77, R78 R31 - R34	3.5 3.4
e. on 3 mV and 0.3 V ranges	R31 - R34	3.4
f. on 10 mV and 1 V ranges	R31 - R34	3.4
g. on all ranges at high frequencies	Defective probe	3.1, 5.6
h. on all ranges above 30 mV at high frequencies	Defective Model 1340 Probe Attenuator	3.1.1
Excessive drift on most sensitive range	Instrument in warm or drafty location Defective input component	
Excessive change in indication with line voltage change	Weak or defective tubes Chopper supply improperly adjusted Chopper drive voltage low	4.6.2
Indication normal, dc output low or absent	C30, C31 defective or shorted Defective resistor R59, R60, R62, R63 Defective diode CR6	3.5 3.5
Chopper supply frequency incorrect, not possible to correct with R82	Defective resistor R81 - R85 Defective capacitor, C35, C36 Defective chopper C1 Defective transistor Q1, Q2	3.2 3.2 5.5 3.2

6. SHIPPING INSTRUCTIONS

If it should be necessary to return the instrument to Ballantine Laboratories, Inc. make certain that at least four inches of padding material surrounds the instrument to prevent damage during shipment. Ship via Railway Express or motor truck to

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

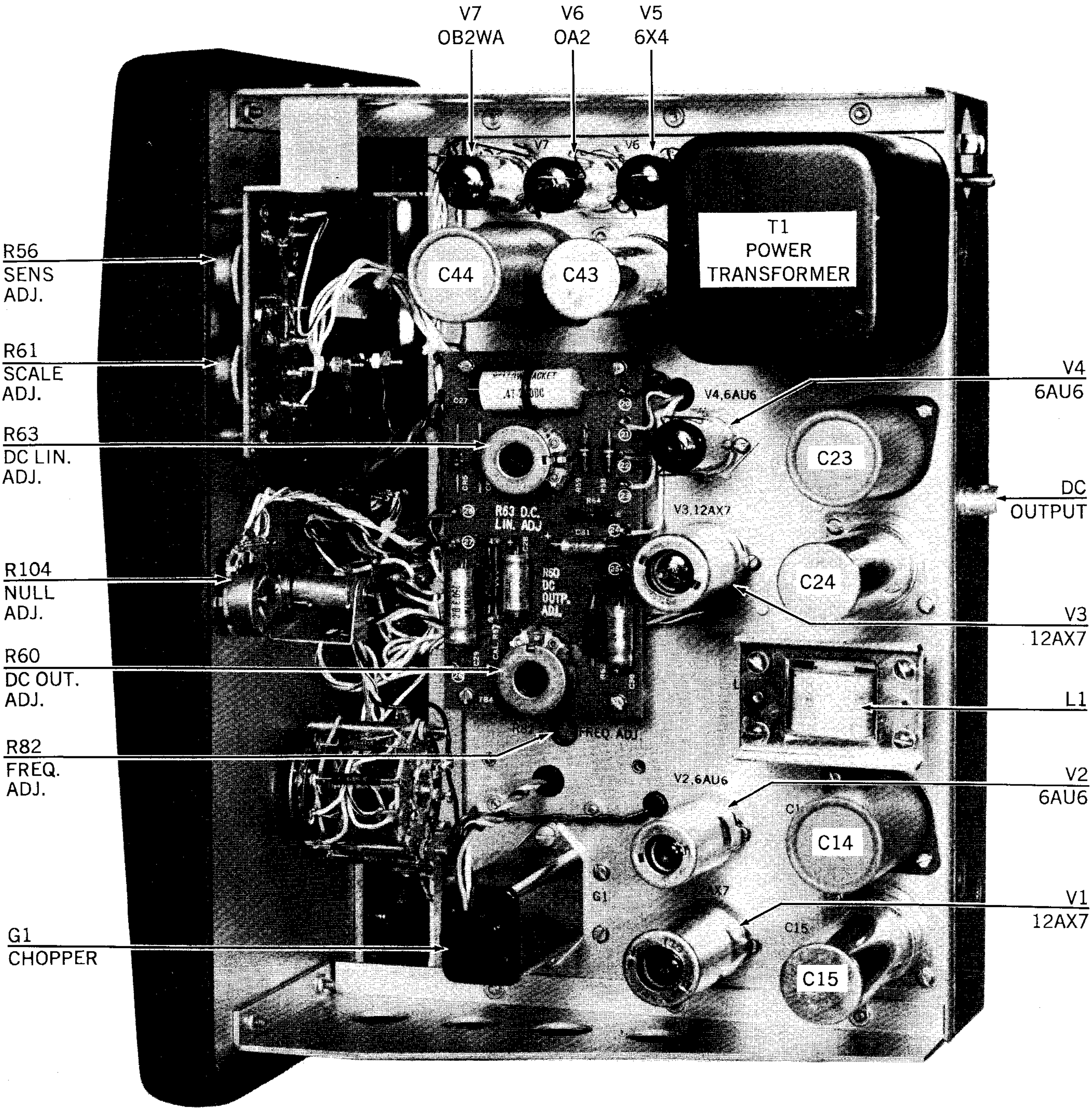


Fig. 8. Model 340 — Right Hand Side View

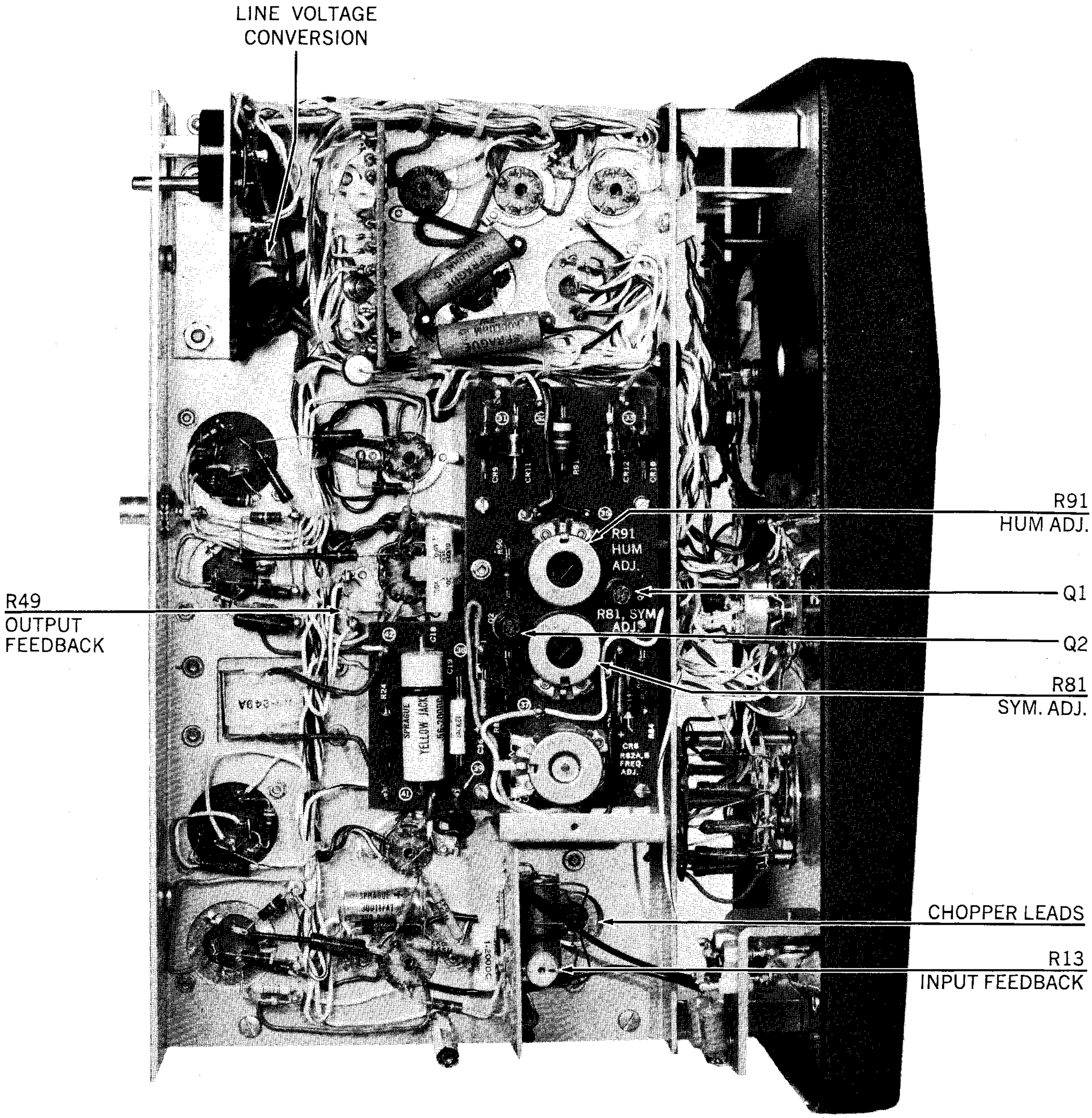


Figure 9. Model 340 — Left Hand Side View
Input Shield Removed

7. REPLACEMENT PARTS LIST

REFER TO MODEL 340 CIRCUIT DIAGRAM, DWG. ME-2350G

B. L. Part No.	*Circuit Symbol*	*Capacitors*	*Manufacturer*
2582	C5	1,000 pF, GMV, Type FB2B	Allen-Bradley
2582	C6	1,000 pF, GMV, Type FB2B	Allen-Bradley
2582	C7	1,000 pF, GMV, Type FB2B	Allen-Bradley
2394	C8	.1 μF, 5%, Type 192P10452, 200 V	Sprague
2394	C9	.1 μF, 5%, Type 192P10452, 200 V	Sprague
2393	C10	.1 μF, 5%, Type 114P1045R5S4, 50 V	Sprague
2366	C11	.0022 μF, 5%, Type 355C222J, 200 V	Gudeman
2386	C12	1,500 pF, 5%, Type 192P15252, 200 V	Sprague
2367	C13	.1 μF, 5%, Type 148P10452, 200 V	Sprague
2780	C14A	500 μF, −10%, +150%, Type DFP, 20 V	Sprague
	C14B	200 μF, −10%, +150%, Type DFP, 20 V	Sprague
2042	C15A	50 μF, −10%, +100%, Type DFP, 150 V	Sprague
	C15B	50 μF, −10%, +100%, Type DFP, 150 V	Sprague
	C15C	50 μF, −10%, +100%, Type DFP, 150 V	Sprague
2387	C16	820 pF, 5%, Type 192P82152, 200 V	Sprague
2781	C17	250 μF, −10%, +75%, Type 30D117A1, 3 V	Sprague
2389	C18	.56 μF, 5%, Type 148P56452, 200 V	Sprague
2364	C19	.033 μF, 5%, Type 148P33352, 200 V	Sprague
2386	C21	1,500 pF, 5%, Type 192P15252, 200 V	Sprague
2367	C22	.1 μF, 5%, Type 148P10452, 200 V	Sprague
2782	C23A	20 μF, −10%, +250%, Type DFP, 10 V	Sprague
	C23B	50 μF, −10%, +100%, Type DFP, 150 V	Sprague
	C23C	100 μF, −10%, +250%, Type DFP, 10 V	Sprague
2042	C24A	50 μF, −10%, +100%, Type DFP, 150 V	Sprague
	C24B	50 μF, −10%, +100%, Type DFP, 150 V	Sprague
	C24C	50 μF, −10%, +100%, Type DFP, 150 V	Sprague
2386	C25	1,500 pF, 5%, Type 192P15252, 200 V	Sprague
2784	C26	25 μF, −10%, +75%, Type 30D110A1, 3 V	Sprague
2392	C27	.47 μF, 5%, Type 148P47452, 200 V	Sprague
2783	C28	50 μF, −10%, +75%, Type 30D133A1, 6 V	Sprague
2781	C29	250 μF, −10%, +75%, Type 30D117A1, 3 V	Sprague
2783	C30	50 μF, −10%, +75%, Type 30D133A1, 6 V	Sprague
2786	C31	10 μF, −10%, +75%, Type 30D107A1, 3 V	Sprague
2785	C35	6.8 μF, 10%, Type 150D685X9035B2, 35 V	Sprague
2785	C36	6.8 μF, 10%, Type 150D685X9035B2, 35 V	Sprague
2543	C41	1,500 pF, +80%, −20%, Type Y5V, 3 kV	Erie
2543	C42	1,500 pF, +80%, −20%, Type Y5V, 3 kV	Erie
2789	C43A	10 μF, −10%, +50%, Type DFP, 500 V	Sprague
	C43B	10 μF, −10%, +50%, Type DFP, 500 V	Sprague
	C43C	50 μF, −10%, +50%, Type DFP, 150 V	Sprague
2756	C44A	1,000 μF, −10%, +150%, Type DFP, 15 V	Sprague
	C44B	1,000 μF, −10%, +150%, Type DFP, 15 V	Sprague
2367	C45	.1 μF, 5%, Type 148P10452, 200 V	Sprague
7803	C46	1 μF, −10%, +75%, Type 30D100A1, 3 V	Sprague
2781	C47	250 μF, −10%, +75%, Type 30D117A1, 3 V	Sprague
		Resistors	
1117	R10	10 ohms, 5%, Type EB	Allen-Bradley
1117	R11	10 ohms, 5%, Type EB	Allen-Bradley
1228	R12	27 ohms, 5%, Type CB	Allen-Bradley
1793	R13	7.4 ohms, 1%, Special	Ballantine
1388	R14	5,000,000 ohms, 2%, Special	Ballantine
1075	R15	27 ohms, 5%, Type EB	Allen-Bradley
7228	R16	25,000 ohms, 5%, Type N-20	Corning
1039	R17	22,000 ohms, 5%, Type EB	Allen-Bradley
2744	R18	500,000 ohms, 1%, Type MF6C-¼-TO	Electra

REPLACEMENT PARTS LIST *(Continued)*

REFER TO MODEL 340 CIRCUIT DIAGRAM, DWG. ME-2350G

B. L. Part No.	*Circuit Symbol*	*Resistors*	*Manufacturer*
7253	R19	155,000,000 ohms, 1%, Type MF7C	Electra
7228	R20	25,000 ohms, 5%, Type N-20	Corning
1039	R21	22,000 ohms, 5%, Type EB	Allen-Bradley
2618	R22	500,000 ohms, 1%, Type CPX-½	Aerovox
7253	R23	155,000,000 ohms, 1%, Type MF7C	Electra
7226	R24	301 ohms, 1%, Type N-20	Corning
1062	R25	390 ohms, 5%, Type EB	Allen-Bradley
1048	R26	4,700 ohms, 5%, Type EB	Allen-Bradley
1300	R31(1)	1,000,000 ohms, 1%, Type CPX-½	Aerovox
1309	R32(1)	100,000 ohms, 1%, Type CPX-½	Aerovox
1324	R33(1)	10,000 ohms, 1%, Type CPX-½	Aerovox
2619	R34(1)	1,121 ohms, 1%, Type CPX-½	Aerovox
1116	R41	24,000 ohms, 5%, Type EB	Allen-Bradley
1026	R42	100,000 ohms, 5%, Type EB	Allen-Bradley
1300	R43	1,000,000 ohms, 1%, Type CPX-½	Aerovox
1007	R44	2,000,000 ohms, 5%, Type EB	Allen-Bradley
1116	R45	24,000 ohms, 5%, Type EB	Allen-Bradley
1026	R46	100,000 ohms, 5%, Type EB	Allen-Bradley
1010	R47	1,000,000 ohms, 5%, Type EB	Allen-Bradley
1007	R48	2,000,000 ohms, 5%, Type EB	Allen-Bradley
1793	*R49	7.4 ohms, 1%, Special	Ballantine
1062	R50	390 ohms, 5%, Type EB	Allen-Bradley
1674	*R51	130 ohms, 1%, Type N-20	Corning
1682	R52	1,000 ohms, 1%, Type N-20	Corning
1680	R53	20,000 ohms, 5%, Type N-20	Corning
7227	R54	38.3 ohms, 1%, Type N-20	Corning
1042	R55	15,000 ohms, 5%, Type EB	Allen-Bradley
1940	R56	300 ohms, 30%, Type UPM 45	CTS
1681	*R57	4,700 ohms, 1%, Type N-20	Corning
1026	R58	100,000 ohms, 5%, Type EB	Allen-Bradley
1026	R59	100,000 ohms, 5%, Type EB	Allen-Bradley
1940	R60	300 ohms, 30%, Type UPM 45	CTS
1939	R61	1,000 ohms, 30%, Type UPM 45	CTS
1657	R62	1,500 ohms, 1%, Type N-20	Corning
1939	R63	1,000 ohms, 30%, Type UPM 45	CTS
1680	R64	20,000 ohms, 5%, Type N-20	Corning
1657	R73	1,500 ohms, 1%, Type N-20	Corning
7209	*R78	870 ohms, 1%, Type N-20	Corning
1849	R81	300 ohms, 10%, Type PM-AW	CTS
6850	R82A	300 ohms, 10%, Type PE2AW	CTS
	R82B	300 ohms, 10%, Type PE2AW	CTS
7209	R84	870 ohms, 1%, Type N-20	Corning
7209	R85	870 ohms, 1%, Type N-20	Corning
1101	*R86	15 ohms, 5%, Type EB	Allen-Bradley
1874	R87	150 ohms, 5%, Type BWH	IRC
1939	R91	1,000 ohms, 30%, Type UPM 45	CTS

(1) Part of a matched set — must be purchased as Set No. 1569.

* Calibration Item — In some instruments the component listed may not be used at all or its value may differ from the value shown.

REPLACEMENT PARTS LIST *(Continued)*

REFER TO MODEL 340 CIRCUIT DIAGRAM, DWG. ME-2350G

B. L. Part No.	*Circuit Symbol*	*Resistors*	*Manufacturer*
1875	R92	.91 ohms, 5%, Type BWH	IRC
6164	R93	4,000 ohms, 5%, Type 244 E 4025	Sprague
6164	R94	4,000 ohms, 5%, Type 244 E 4025	Sprague
1054	R95	2,000 ohms, 5%, Type EB	Allen-Bradley
1054	R96	2,000 ohms, 5%, Type EB	Allen-Bradley
1007	R97	2,000,000 ohms, 5%, Type EB	Allen-Bradley
1026	R98	100,000 ohms, 5%, Type EB	Allen-Bradley
1082	R99	240 ohms, 5%, Type EB	Allen-Bradley
1046	R102	7,500 ohms, 5%, Type EB	Allen-Bradley
1023	R103	200,000 ohms, 5%, Type EB	Allen-Bradley
1938	R104	10,000 ohms, 30%, Type 45	CTS
5555	CR1, 2, 14, 15	Diode, Type T13G	Transitron
5573	CR3, 4	Diode, Type S282G	Transitron
7920	CR5, 6	Diode, Type 1N4148	General Electric
5588	CR7, 8	Rectifier, Type 1N816	Sperry
5579	CR9, 10, 11, 12, 13	Rectifier, Type 1N1692	Transitron
3410	F1	Fuse, 0.4 A, Type MDL Slo-Blo	Bussmann
3099	G1	Chopper, Special	Ballantine
3475	I1	Pilot Light, Type 1815	General Electric
3072	L1	Coil, Special	Ballantine
6006	M1	Meter, Indicator, Special	Ballantine
3292	S1	Switch, Range Selector, Special	Ballantine
3282	S2	Switch, Function, Special	Ballantine
3059	T1	Transformer, Power	Ballantine
3140	V1, 3	Tube, Type 12AX7	Amperex
7907	V2, 4	Tube, Type 6AU6	RCA
3105	V5	Tube, Type 6X4	RCA
3106	V6	Tube, Type OA2	RCA
5578	V7	Tube, Type OB2WA	Tung-Sol
5596	Q1, 2	Transistor, Type 2N525	General Electric

PROBE

		Capacitors	
2270	C1A	1,000 pF, 20%, Special	Ballantine
	C1B	1,000 pF, 20%, Special	Ballantine
2266	C2	50 pF, 10%, Type 652-020, 500 VDC	Erie
2266	C3	50 pF, 10%, Type 652-020, 500 VDC	Erie
		Resistors	
7230	R1	51,000 ohms, 5%, Type HFR	Corning
7230	R2	51,000 ohms, 5%, Type HFR	Corning
1150	R3	10,000,000 ohms, 5%, Type TR	Allen-Bradley
1249	*R4	150 ohms, 10%, Type CB	Allen-Bradley
1249	*R5	150 ohms, 10%, Type CB	Allen-Bradley
1152	R6	4,700,000 ohms, 5%, Type TR	Allen-Bradley
		Other Components	
3144	CR1, 2	Diode, Special	Ballantine

* Calibration Item — In some instruments the component listed may not be used at all or its value may differ from the value shown.