INSTRUCTION BOOK

for

MODEL 305A PEAK RESPONDING ELECTRONIC VOLTMETER

BALLANTINE LABORATORIES, INC.
BOONTON, NEW JERSEY

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 305A PEAK RESPONDING ELECTRONIC VOLTMETER

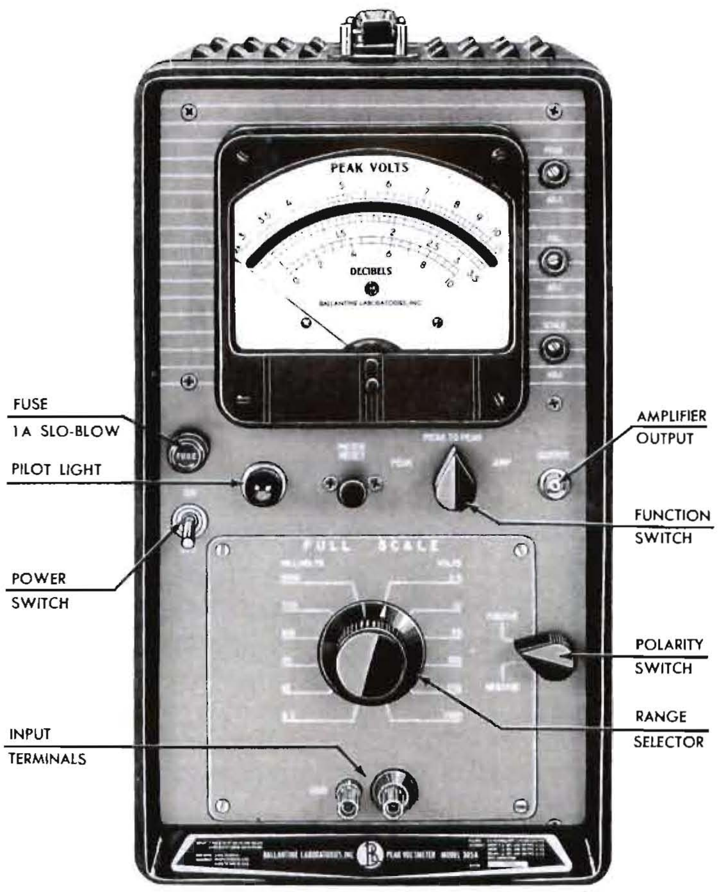
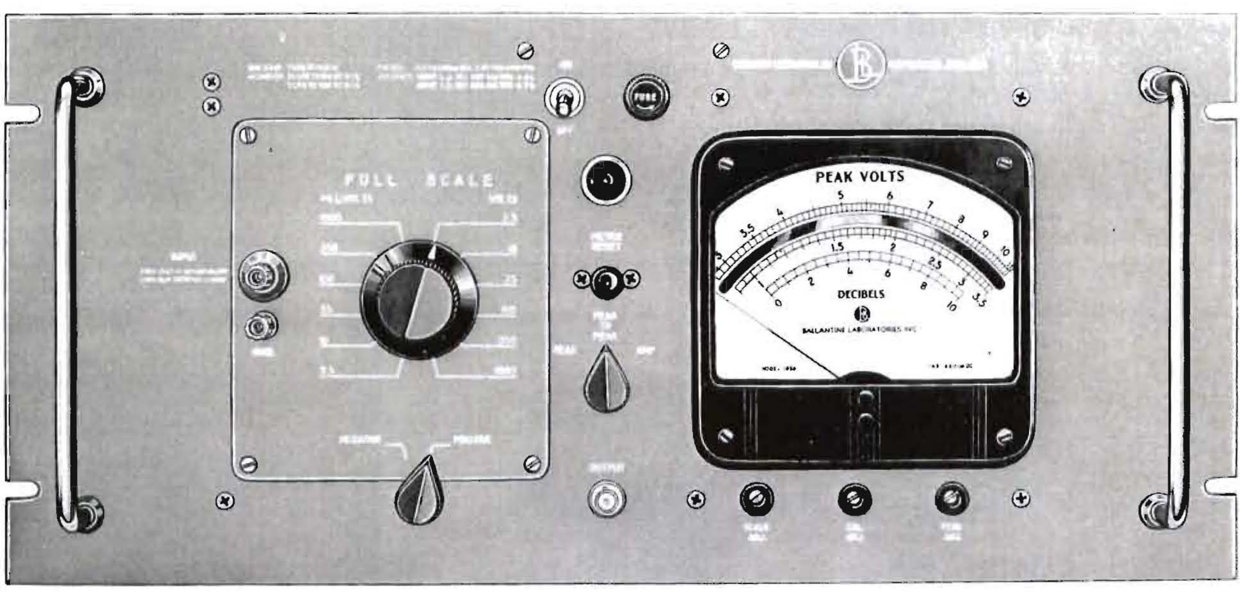


Fig. 1

Ballantine Model 305A
Peak Responding Electronic Voltmeter



Model 305A-S/2, Rack Panel Mounted Version

1. INTRODUCTION AND DESCRIPTION

1.1 Purpose and Use

The Ballantine Model 305A Peak Responding Electronic Voltmeter is an amplifier-detector type instrument provided with a peak detector circuit for peak-to-peak or peak value measurements. The instrument indicates peak-to-peak or peak amplitudes of repetitive waveforms including sine, square, triangular and complex waves, and pulse trains.

The measurement is indicated on either of two logarithmic voltage scales which allow the same high accuracy at all points. A third linear decibel scale with a range of 10 decibels is also provided.

The sensitive and stable wide-band amplifiers associated with a special peak detector circuit extend the sensitivity of the instrument into the microvolt region. This allows the measurement of low energy pulse trains with pulse widths down to 0.5 microsecond and repetition rates as low as 5 pps.

In addition to its function as a voltmeter, the 305A may be used as a wide-band, fast rise-time amplifier.

The instrument design provides all controls and adjustments on the front panel. The Model 305A may be obtained in portable and rack-mounted versions.

1.2 Technical Characteristics

Voltage Range

1 millivolt to 1000 volts peak-to-peak or peak in 12 ranges.

Frequency Range

5 to 500,000 cps. sine wave — 200 to 300,000 cps. square wave.

Pulse Range

Duration — 0.5 to 2,500 microseconds. Repetition rate — minimum 5 pps.

Accuracy

Sine Wave — ±2% 20 cps. to 200 kc.
±4% 5 cps. to 500 kc.

Square Wave — ±3% 200 cps. to 300 kc.

Pulses — ±3% above 3 microseconds and 100 pps.
±5% above 1 microsecond and 100 pps.
±5% below 1 microsecond and 100 pps. when correction is used.
±5% below 3 millivolts for all waveforms.

Input Impedance

2 megohms shunted by 10 pF on 350 millivolt range and above. 2 megohms and 25 pF below 350 millivolt range.

Meter Scales

Logarithmic voltage scales from 0.9 to 3.5 and 2.8 to 11
Linear decibel scale from 0 to 10.

Amplifier Characteristics

Output — Amplifier output available at BNC connector marked OUTPUT.

Gain — Maximum of 86 DB ±1 DB adjusted in 10 DB steps with range selector.

Frequency Response — 5 to 500,000 cps. ±3% if loading above 1 megohm with parallel capacity below 10 pF.

Source Impedance — At 1 kc approximately 3 ohms in series with 0.22 μF.

Maximum Output Voltage — 70 volts positive, 40 volts negative.

Maximum Loading — 30,000 ohms and 10 pF.

Warmup Drift

Less than 0.3% after 15 minute warmup.

Noise

10 to 14 microvolts RMS referred to first grid.

Line Voltage Effects

Specified accuracy over 100 volts to 130 volts or 200 volts to 260 volts line voltage.

Power Supply

100 to 130 volts or 200 to 260 volts 60 cycles 82 watts. Also available in 50 cycle version, designated Model 305A-S3.

Dimensions

Portable: 8 inches wide, 15 inches high, 10 inches deep.
Rack: 19 inches wide, 8¾ inches high, 8¼ inches deep.

Weight

Portable or rack: 21 pounds
Shipping weight: Portable 27 pounds, rack 40 pounds.

2. OPERATION

2.1 Power Connection

The voltmeter is supplied ready to operate on 100 to 130 volts 60 cycles power, or 50 cycles, if so ordered. A decal mounted adjacent to the power cord indicates this voltage and frequency. For highest stability a magnetically regulated power transformer is used in the instrument. To realize the full advantage of the transformer the instrument must be operated at the specified line frequency.

2.1.1 — Line Voltage Conversion — The 305A may be converted for 200 volts to 230 volts with instructions given on the schematic diagram at the end of this book.

2.2 Starting Procedure

Insert the three prong power plug into the AC outlet or use the conversion unit. Move the power switch to ON position. Red pilot light should glow.

For initial turn-on, or if instrument has been out of use for many months, permit a warmup period of at least 30 minutes. In other cases 10 minutes will suffice.

PERMIT AIR TO CIRCULATE FREELY AROUND THE INSTRUMENT. The voltmeter is calibrated in the vertical position and is intended for use in this manner. For convenient reading a tilting device is provided beneath the case.

2.3 Function of Switches

TITLE	POSITION	FUNCTION
Power	ON	Applies AC Power to Instrument
	OFF	Removes Power
METER RESET	Depressed	Decreases discharging time constant of detector from 3.3 to 0.7 seconds for fast decay of pointer. When depressed, the reading is highly in error and no measurement should be taken in this position
Function Switch	PEAK	Disables Negative Peak Detector Instrument indicates Peak Amplitude
	PEAK-TO-PEAK	Instrument measures Peak-to-Peak Amplitude of Input Waveform
	AMP	Connects Output Amplifier to Output Jack Detector Circuit is disconnected
Polarity	POSITIVE	The output of the amplifier is in phase with the voltmeter input. With function switch in PEAK position, instrument indicates positive peak
	NEGATIVE	The output is out of phase with the voltmeter input. With function switch in PEAK position, instrument measures negative peak
Range Selector	MILLIVOLTS 3.5 to 1000 VOLTS 3.5 to 1000	Attenuates input signal and indicates full scale voltage.

2.4 Measurement of Peak-to-Peak Amplitudes

2.4.1 — Measurement of Peak-to-Peak Value of Symmetrical Waveforms (AC) — Measurement of nearly symmetrical waveforms whose positive and negative amplitudes differ by less than a 1 to 2 ratio is accomplished by the following procedure:

SET	TO
Function Switch	PEAK-TO-PEAK
Polarity Switch	POSITIVE
Range Selector	1000 volts and turn counter-clockwise until the meter gives a steady deflection
METER RESET	Depress to speed decay of pointer. Release and take reading or wait for indicator decay

2.4.2 — Measurement of Peak-to-Peak Value of Unsymmetrical Waveforms and Pulse Trains — Use the following procedure:

SET	TO
Function Switch	PEAK-TO-PEAK
Polarity Switch	POSITIVE, if Positive Peak is Higher in Amplitude, or NEGATIVE, if Negative Peak is Higher. If waveform is not exactly known, use peak measurement to determine higher peak. If polarity switch is not in agreement with higher peak, the accuracy of measurement may be affected.
Other Controls	As in 2.4.1

2.5 Measurement of Peak Amplitudes

Before making a peak value measurement the PEAK ADJ control should be checked for calibration. The checking and readjustment procedures are outlined under 2.11.3.

Changing the position of the polarity switch may cause a switching transient when making a peak measurement. This effect may be eliminated by switching the polarity switch to positive and then negative shortly before measuring.

The procedure for measuring the peak value of a waveform depends on its degree of symmetry.

2.5.1 — Nearly Symmetrical Waveforms with Positive and Negative Amplitudes in Less than a 1 to 2 Ratio — Proceed as follows:

SET	TO
Function Switch	PEAK
Polarity Switch	POSITIVE to measure Positive Peak, NEGATIVE to measure Negative Peak
Other Controls	As in 2.4.1

2.5.2 — Unsymmetrical Waveforms with Peak Amplitudes in More than 1 to 2 Ratio. Only the higher peak amplitude can be measured accurately. The lower peak may be calculated by subtracting the higher peak amplitude from the peak-to-peak value as measured in 2.5.

SET	TO
Function Switch	PEAK
Polarity Switch	Position giving Higher Indication
Other Controls	As in 2.4.1

2.6 AC Overload Considerations

The instrument is designed to withstand severe overloads without damage to components.

The maximum AC voltage which may be applied to the instrument on the four lowest ranges is limited by the maximum allowed voltage to the grid of the first tube. For an extended time this should not exceed 100 volts peak-to-peak. The input tube may not necessarily be damaged by higher voltages applied for a short time.

RANGE	MAXIMUM INPUT
3.5 to 100 millivolts	100 V peak-to-peak or 35 V RMS
350 millivolts to 1000 V	1000 V peak-to-peak or 350 V RMS

2.7 DC Component of Input Signal

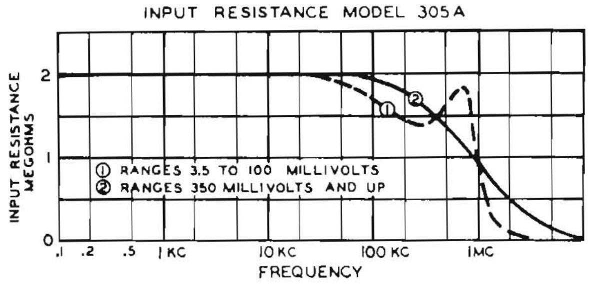
The voltage measurement by the instrument does not include the dc component of the signal. If the dc component is measured independently the complete peak values may be calculated by adding algebraically.

The maximum dc input to the instrument is 1000 volts. If the dc input is greater, an external capacitor must be connected in series with the insulated input terminal. For measurements down to 5 cycles this capacitor should be 0.22 μF or higher.

2.8 Input Impedance

The input impedance of the instrument depends on the setting of the range switch. For ranges of 350 millivolts and above, the input impedance is represented by 10 pF in

INPUT RESISTANCE MODEL 305A



parallel with 2 megohms. For ranges from 3.5 millivolts to 100 millivolts the input impedance is 25 pF in parallel with 2 megohms.

The capacitive component of input impedance is practically constant over the entire frequency range of the instrument. The resistive component changes with frequency as shown in the following graph.

In normal use with low impedance sources, the input impedance does not present any appreciable loading. However, when the source impedance approaches 10,000 ohms the effects of loading should be considered.

2.9 Use as an Amplifier

The instrument may be employed as a wide-band fast rise-time amplifier to deliver up to 70 volts into a low capacitance load. For use as an amplifier:

SET	TO
Function Switch	AMP
Polarity Switch	POSITIVE for In-Phase Output NEGATIVE for Reversed Output
Range Switch	Range to give Scale Reading or to a Higher Range

Connect input signal to input terminals and take output from BNC connector marked OUTPUT. Adjust range switch for desired amplification without distortion.

Amplifier characteristics are described in 1.2, 2.6, 2.7 and 2.8.

To utilize the full frequency range and shortest rise-time of the amplifier the capacitive loading at the output must not exceed 10 pF and the load resistance should not be below 30,000 ohms.

Capacitive loading of the output may be increased above 10 pF if fast rise-time and wide band-width are not required. The resistive loading may also be increased if maximum output voltage is not necessary.

2.10 Panel Controls with Screw Adjustment

Three adjustable controls are provided to the right of the indicating meter.

CONTROL	FUNCTION
SCALE ADJ	Controls the Scale Linearity
CAL ADJ	Controls the Sensitivity and Calibration of the Instrument. *Adjustment of this control affects the instrument's accuracy and should only be undertaken after reading Section 4.6.3, and when required accurate calibration equipment is available.*
PEAK ADJ	Controls the Scale Linearity of Peak measurement and may be changed to allow Peak measurement below 1 millivolt.

The controls are set at Ballantine Laboratories for best overall accuracy on a wide variety of waveforms.

The SCALE ADJ and PEAK ADJ controls may be readjusted to compensate for tube aging or for special measurements as in 2.11.1 and 2.11.3. These adjustments should be checked every 200 hours of operation.

2.11 Use of Adjustable Controls

2.11.1 The SCALE ADJ control should be adjusted when an indication of precisely 1.0 on the upper voltage scale does not produce a reading of 1 ±0.25% on the lower voltage scale on the next higher range. The input voltage, of course, must be quite constant during this check.

For general use this check should be made with a sine wave. If the instrument is to be used only for measurement of a particular waveform or type of waveform, then the adjustment may be made using this waveform and higher accuracy on this particular signal will be obtained. Proceed as follows:

A. Allow 30 minutes or more warmup.

B. Connect an amplitude stable voltage source of approximately 1 volt and 100 to 2000 cycles to the input terminals.

C. Set polarity to POSITIVE, function to PEAK-TO-PEAK and range to 1000 millivolts. Adjust input voltage until meter reads exactly 10 on the upper scale.

D. Switch to 3.5 volt range. Meter should read 1 on lower scale. If not, turn SCALE ADJ to give exactly 1. Tap meter face lightly during measurement to reduce friction effects.

E. Repeat C and D until indicated range agrees with attenuator range to within ±0.1%.

2.11.2 CAL ADJ — DO NOT READJUST — See Note in 2.10.

2.11.3 PEAK ADJ — is to be adjusted if, when measuring perfectly symmetrical waveforms, the PEAK indication is not exactly 50% of the PEAK-TO-PEAK indication.

Procedure:

A. Allow at least 1 hour warmup. Set Function Switch to PEAK-TO-PEAK, Polarity Switch to POSITIVE and Range Switch to 1000 MILLIVOLTS.

B. Connect a stable distortionless (less than 0.5%) sine wave source of approximately 1 volt and 100 to 2000 cycles to the input terminals. Adjust the input voltage for an indication of 10 on the upper scale.

C. Set Function Switch to PEAK. The indication should be exactly 5. If not, adjust PEAK ADJ until an indication of 5 ±0.20% is obtained. Tap meter slightly as in 2.11.1.-D.

2.12 Peak Measurements Below 1 Millivolt

The PEAK ADJ control may be used to extend the voltmeter range for peak measurement down to 10 microvolts. This also allows use of the voltmeter as a sensitive peak responding null detector.

The frequency range for extended measurement is the same as for all PEAK indications. The specified accuracy applies, to which an additional error of ±10 microvolts is added.

Procedure:

A. Short the input terminals.

B. Set Function Switch to PEAK, Polarity Switch to polarity of signal and Range Switch to 10 millivolts or above.

C. Set PEAK ADJ to give an indication of 1 on lower volts scale.

D. Remove short, apply signal and set range to 3.5 MILLIVOLTS. Pointer will indicate a slightly fluctuating reading which may be interpreted using the lower voltage scale between 1 and 2. 1 now corresponds to 0 and 2 corresponds to 1 millivolt. Every subdivision is 50 microvolts.

When measurement is finished, the PEAK ADJ should be reset according to 2.11.3 to avoid errors in normal measurement.

2.13 Measuring Short Pulses with Low Duty Cycles

When pulses with duration less than 1 microsecond or repetition rates below 100 pps are measured, and when the duty cycle is below 0.002, a correction should be added to the readings if the readings fall between 0 and 4 db on the decibel scale.

The correction depends upon the duty cycle, thus:

Duty Cycle (Pulse Width In) (Sec. X Rep. Rate in Sec.$^{-1}$)	Add To Reading	Multiply Reading By
0.0002 to 0.002	+2%	1.02
0.00002 to 0.0002	+4%	1.04
below 0.00002	+6%	1.06

The measuring error decreases with increasing indication so that the readings above 4 db on the decibel scale are within specified accuracy. When corrections are applied to readings below 4 db, the total error does not exceed ±5%.

2.14 Techniques for Higher Accuracy Measurements

The instrument accuracy is specified for the SCALE ADJ control set with a sine wave input. This provides the best compromise between accuracy and variety of measureable waveforms in normal use.

Generally, if accuracy is foremost, Peak-to-Peak measurement should be preferred to peak measurement, or if peak measurements are made the PEAK ADJ should be checked according to 2.11.3.

For some special waveforms higher accuracy measurements are possible when techniques described below are used.

2.14.1 Measuring flat top waveforms, pulse trains and square waves may be made up to 1% more accurate by setting the SCALE ADJ with the particular waveform as described in 2.11.1.

2.14.2 In measuring below 10 cycles set POLARITY Switch to NEGATIVE.

2.14.3 When measuring below 3 millivolts, the noise of the input stage affects the accuracy. This noise is approximately 10 to 12 microvolts rms as referred to the first grid. The actual error depends upon the signal amplitude and waveform. For sine wave the corrections are thus:

AT	CORRECTION
1 Millivolt	—4%
3 Millivolts	—1.5%

Above 4 Millivolts the noise error is negligible.

2.15 Use as an Ammeter

When the Model 305A is coupled with the Ballantine Series 600 Shunt Resistors, peak currents from 1 microampere to

10 amperes may accurately be measured. These and other accessories may be found in the general catalog of Ballantine instruments.

2.16 Measuring Above 1000 Volts Peak

With the Ballantine Model 1305B Voltage Multiplier, the range of the 305A may be extended to 28 kilovolts Peak-to-Peak.

2.17 Power Line Effects

The instrument is operative from 80 volts to 140 volts and 58 cycles to 65 cycles.

Line variations from the specified operating voltage affects the accuracy of the instrument by approximately ±0.15% per 10% of line voltage change.

Line frequency variations change the accuracy by approximately 0.5% per cycle deviation from 60 cycles.

2.18 Effect of R. F. Line Transients

Line transients may enter the instrument through the input circuitry and affect the indication. Careful shielding of the input leads is a necessity when the power line contains large transients of this type and accurate measurements are desired. The voltmeter does not respond to these transients through its own power cord.

3. CIRCUIT DESCRIPTION

The block diagram, schematic and replacement parts list are included at the end of the instruction book.

3.1 Input Attenuator

The voltage to be measured is applied through the input sending parts and dc blocking capacitor C1 to the input attenuator. This attenuator is at lower frequencies a resistive divider and presents a 2 megohms load to the input signal. At higher frequencies above 25 kc the attenuator becomes a capacitive divider. The dividing ratio of latter is adjusted to the correct value by trimmers C2 and C3. The attenuation ratios are as follows:

Range Switch Setting FULL SCALE	Input Att.	Attenuation Ratio Midsection Att.	Total
3.5 mV	1	1	1
10 mV	1	3.162	3.162
35 mV	1	10	10
100 mV	1	31.62	31.62
350 mV	31.62	3.162	100
1000 mV	31.62	10	316.2
3.5 V	31.62	31.62	1000
10 V	1000	3.162	3162
35 V	1000	10	10000
100 V	1000	31.62	31620
350 V	31620	3.162	100000
1000 V	31620	10	316200

3.2 Input Amplifier

The input amplifier consists of two capacitively coupled penthode stages V1 and V2 followed by a direct coupled split-phase inverter stage V3. The amplifier has over 40 db negative feedback at midfrequencies with the roll-off rate of 6 db per octave at the high and low frequency ends. The response at the high frequency end is adjustable to a limited amount by variable capacitor C6

The first stage tube V1 is shock-mounted and shielded to reduce microphonics and hum pickup. First and second stage heaters are operated with dc. The plate voltage of direct coupled stage V2 can be adjusted with the screen series resistor R18. Neon bulb NE2 protects V3 in case of V2 failure or removal.

The Polarity switch S2 connects the following buffer stage to the plate or cathode of the phase inverter stage V3 which inverts the phase of the signal so that pulses will always drive output amplifier positively to assure fast rise-time and prevent cut-off of the output stage.

3.3 Buffer Stage and Midsection Attenuator

Buffer stage V4 is a cathode follower which couples the high source impedance of the plate of input amplifier to the relatively low resistance midsection attenuator. To equalize the high frequency response of the plate take-off (NEGATIVE) with the high frequency response to the cathode take-off (POSITIVE) a variable capacitor C15 is connected to the cathode when signal is taken from the plate.

The midsection attenuator is a four-step string attenuator. Over most of the frequency range it acts as a resistive divider. Fixed capacitors C18 and C19 provide correction at the highest frequency range of the instrument.

3.4 Output Amplifier

The output amplifier consists of two capacitively coupled penthode stages V5 and V6 and a direct coupled cathode follower V7. The loop feedback is approximately 38 db at midfrequencies with a roll-off rate of 6 db per octave at both ends of the frequency response. The high frequency response is slightly adjustable by the variable capacitor C20. The heater of V5 is operated with dc. The plate voltage of V6 may be adjusted with screen resistor R41. Neon bulb V8 limits the cathode voltage of V7 during the warmup period and protects the tube.

3.5 Peak-to-Peak Detector

The output amplifier is connected over capacitor C26 and function switch S3 to the peak-to-peak detector which consists of two vacuum diodes, V12 for positive and negative detection and a charging capacitor C32. Divider R57, R58 provides a dc bias to the detector.

The diodes charge capacitor C32 with a short time constant of approximately 0.01 microseconds. C32 discharges over a 22 megohm resistor R59 with a time constant of 2.2 milliseconds. A high discharging-charging time constant ratio insures true peak detection of the input signal.

The detector stages are connected to the differential cathode follower V13. C33 between the grid and cathode of V13 increases the detector efficiency for low repetition rate pulses.

3.6 Pulse Stretcher

The differential cathode follower V13 which acts as an impedance transformer feeds the signal to another pair of peak rectifiers V14 which together with condensers C34 and C35 are charged to the peak value of signal. The discharge over resistors R63 and R64 has very long time constant of 3.3 seconds so that the peak charge on C34 and C35 stays almost constant, even between a pulse train for repetition rate of 5 pps.

For fast discharge R62 and R65 can be connected parallel to R63 and R64 by operating the METER RESET Switch S4.

For peak-to-peak measurement both capacitors C34 and C35 are connected to the second differential cathode follower V15. For peak measurement the negative channel of the pulse stretcher is disconnected by Function Switch S3 and an adjustable bias over the divider R66, R68 and PEAK ADJ R67 is fed to the cathode follower. With PEAK ADJ the scale linearity for peak measurement is controlled.

3.7 Measuring Stage

The cathode follower V15 feeds a shaped pole piece moving coil indicator. The current range of the indicator from 0 to 10 db is 190 to 600 microamperes.

The CAL ADJ control R76 in series with the indicator changes the voltage sensitivity of the indicator and is used to set the sensitivity of the instrument during calibration. The SCALE ADJ control R70 affects the balance of the differential cathode follower. It influences the on-scale indication more than the full scale indication, and so is used to control the scale linearity of indication.

The heaters of all tubes in the peak detector-pulse stretcher circuit are regulated to assure high stability of balance against line voltage variations.

3.8 Power Supply

A constant voltage transformer together with electronic regulation is used in power supply to stabilize the heater and +B voltages and achieve excellent stability against line voltage changes and transients. A silicon rectifier voltage doubler circuit is used in the +B rectifier circuit. Three separate filament circuits are used. One XX for tubes in power supply, one YY for amplifiers, and a rectified dc filament for tubes V1, V2 and V5.

4. MAINTENANCE

4.1 General

The instrument is designed for an extended period of trouble-free service. The loading of components and tubes is kept well below ratings, the tube heaters are regulated and the operating temperature of all components is low. It is expected that under normal laboratory use the tube life will extend to 4000 hours without need for recalibration of the instrument. When the tubes are replaced with tubes of normal characteristics the voltmeter performance will be restored without the need of extensive calibration.

A periodic maintenance as described below is recommended to guarantee the maximum accuracy of the instrument and help prevent possible breakdowns in service.

4.2 Recommended Maintenance Procedure

The following periodic checks are recommended.

4.2.1 Every 200 hours a scale and peak adjustment check.

4.2.2 Every 1000 hours a 1000 hour check.

4.2.3 Every 2000 hours a 2000 hour check.

4.3 Necessary Maintenance Equipment

To perform the tests listed under 4.2 the following equipment is needed:

4.3.1 A variable output (approx. 1 volt) stable voltage source 400 cycles to 2 kc with below 0.5% waveform distortion. (For checks 4.2.1, 4.2.2 and 4.2.3.)

4.3.2 A dc voltmeter 1 volt to 500 volts with 10 megohms input resistance ± 3% accuracy. (For checks 4.2.2 and 4.2.3.)

4.3.3 A voltage calibrated (± 0.5% or better) distortion-free source, 400 cycles to 2 kc (such as Ballantine Model 420 Precision Calibrator or an accurate ± 0.5% or better) voltmeter with stable distortion-free voltage source. (For tests 4.2.2 and 4.2.3.)

4.3.4 A tube checker which measures tube transconductance. (For test 4.2.3.)

4.4 Removal of the Case

The tests 4.2.2 and 4.2.3 require the removal of the case, which can be done as follows:

a. Place the instrument with the front panel down on a table.

b. Remove the power cord, unscrew the three #10 binder head screws from the back.

c. Lift up the case.

To put the case back proceed in reverse order.

WARNING: WHEN INSTRUMENT IS OPERATED WITHOUT THE CASE THE DANGER OF ELECTRIC SHOCK EXISTS. EXERCISE EXTREME CARE.

The highest voltages are:

On Power Supply Chassis	850 Volts AC
On Amplifier Chasis	300 Volts DC

4.5 The 200 Hour Check

This serves to check the adjustment of PEAK ADJ and SCALE ADJ controls and is performed according to the 2.11.1 and 2.11.3.

4.6 The 1000 Hour Check

This entails a check of the general performance of the instrument and consists of the following tests:

Correct the SCALE ADJ and PEAK ADJ as described under 2.11.1 and 2.11.3.

4.6.1 Check the dc coupled stages V3 and V7 as follows:

a. Remove the case (See 4.4).

b. Short the voltmeter input terminal, set the range switch to 1000 volts, connect the power cord, turn the instrument ON.

c. After 10 minutes warmup measure the dc voltage on Pin 7 of V3 and V7. The voltage should be—

50 to 68 volts for V3 and
100 to 115 volts for V7.

When the voltage is out of limits the tubes V2 or V6 should be replaced. Any tube within the manufacturer's specifications is suitable for replacement. However, for highest stability, tubes with approximately 50 hours of aging under similar conditions as in the voltmeter are recommended.

After tube replacement the Pin 7 voltage should be adjusted to following limits:

Pin 7 Tube V3	60 volts to 68 volts
Pin 7 Tube V7	106 volts to 116 volts

The adjustment is made by connecting an Allen-Bradley Type EB ½ watt resistor in series or in parallel with R18 or R41. An increase in R18 or R41 will increase the voltage. A decrease of R18 or R41 will decrease the Pin 7 voltage.

4.6.2 Checking the Phase Inverter for Symmetry — Proceed as follows:

a. Connect a distortion-free sine wave source (4.3.1 or 4.3.3) to the input of the voltmeter.

b. Set Function Switch to PEAK-TO-PEAK
Range Switch to any range 350 mV to 3.5 Volts
Polarity Switch to POSITIVE

Adjust the input voltage to produce an accurately readable indication at any point in the upper 1/3 of the meter scale. Note the indication.

c. Switch the Polarity Switch to NEGATIVE. Note the new indication.
The two indications should not differ more than 0.5%. If the difference is more than 0.5% correct as follows:

d. Remove the instrument case (See 4.4).

e. Shunt, or add in series an Allen-Bradley Type EB ½ watt resistor to R21. Add the series resistor when the POSITIVE response is higher than the NEGATIVE response. 100 ohms gives approximately 1% correction.

Shunt R21 when the NEGATIVE response is higher. 1 megohm gives approximately 1% correction. (Fig. 2)

R21 is located between the Pin 5 of Tube V3 and the lowest terminal board on the amplifier chassis.

4.6.3 A check of the CAL ADJ control should be made only when an accurately calibrated voltage source (4.3.3) of good waveform is available.

A 0.5% or more accurate RMS or average responding laboratory standard instrument could be used with a 400 cycle to 2 kc distortion-free voltage source. Line frequency is not suitable for calibration purposes because of high distortion and too low frequency. When an RMS calibrated instrument is used as a standard the conversion from RMS to peak-to-peak can be made as follows:

1 volt Peak-to-Peak = 0.354 volts RMS of sinewave

For CAL ADJ check, proceed as follows:

a. Allow a minimum of 0.5 hours warmup.

b. Check SCALE ADJ as described under 2.11.1.

c. Apply accurate 1 volt Peak-to-Peak ±0.25% to the voltmeter.

Set — Range Switch to 1000 mV
Function Switch to PEAK-TO-PEAK
Polarity Switch to POSITIVE

Adjust CAL ADJ to give an exact reading of 10 on the upper voltage scale. Tap the meter slightly before taking the reading.

4.7 The 2000 Hour Check

Includes all checks described under 4.6 PLUS the tube check and the power supply check.

4.7.1 Tubes should be tested for proper transconductance and low grid current. Any common tube tester may be used for the transconductance test. Tubes with transconductance below the manufacturer's limits should be replaced.

The grid current of Tubes V1, V2 and V6 should be measured by measuring the grid voltage at Pin 1 of those tubes with range switch set to 3.5 millivolts and the input to the voltmeter shorted. The maximum grid voltage is:

Tube 1	+0.05 V
Tube 2	+0.2 V
Tube 6	+0.2 V

Tubes which measure a higher grid voltage should be replaced.

Tubes which measure normal do not have to be replaced until transconductance drops, or grid current or some other fault is observed. Tests at Ballantine Laboratories indicate that this may take over 10,000 hours of operation.

4.7.2 +B voltage should be measured at Pin 1 of Tube 9. This voltage should be 300 V to 310 V. If the voltage is out of these limits it should be brought within them by adding to, or shunting R56 with Allen-Bradley Type EB resistor. (Fig. 4).

If Tube V10 in the power supply is replaced, the power supply ripple at Pin 1 of Tube 9 should be checked as described under 5.9.2, page 13. If the ripple is more than 12 mV pp adjustment of R49 should be made to bring the ripple into 12 mV pp limits.

5. SERVICE AND TROUBLE SHOOTING

5.1 General

In case of voltmeter malfunction, limited servicing by the user is feasible provided skilled personnel and recommended equipment are available and the procedures outlined below are followed.

However, it should be pointed out that the described procedures are only simplified outlines of recommended service and calibration. Refined service and comprehensive calibration requires accurate and special equipment normally not available to the user. Therefore if trouble develops which cannot be corrected by the simplified methods outlined here or when accurate recalibration of the instrument is needed, it is recommended that the voltmeter be returned to Ballantine Laboratories for service and/or recalibration. If it should become necessary to return the instrument or any part thereof to Ballantine Laboratories, Inc. for examination or servicing, at least 4 inches of packing material should be placed around all sides of the instrument to prevent damage during shipment. Ship via Railway Express or motor truck. A letter describing the trouble or desired service will help our Service Department greatly and insure a fast return.

5.2 Necessary Equipment

For successful servicing and trouble shooting, the following equipment is needed:

5.2.1 A DC Voltmeter, 1 Volt to 500 Volts Full Scale ±3%, 10 megohm input resistance (For Test 5.4).

5.2.2 A sensitive AC voltmeter, 10 cycles to 100 kc, 1 millivolt to 100 volts, ±3% (For Test 5.5). Ballantine Model 300, 300D, 310A, or 302C would be suitable for this purpose.

5.2.3 Signal Generator 10 cycles to 1 Mc, 1 volt output (For Tests 5.5, 5.6, 5.7).

5.2.4 Approximately calibrated sensitive oscilloscope DC to 1 Mc (For Tests 5.6, 5.10).

5.2.5 Accurate voltage calibrator, 1 volt ± 0.25%, 1 kc, such as Ballantine Model 420 (For Test 5.5).

5.2.6 Accurate HF voltage source, such as Ballantine Micropotentiomerers or Model 393 Voltmeter (For Tests 5.6, 5.7).

5.3 Simple Service Problems

5.3.1 Pilot Light Replacement is accomplished from the front. After unscrewing the red plastic cap the bayonet base pilot light can be removed and replaced.

5.3.2 Fuse Replacement — The fuse is Slow-blow type (Bussman MDL or equivalent) rated 1 amp for 115 and 0.5 amp for 230 V operation and may be replaced by unscrewing the fuseholder cap on the front panel.

Before replacement, the reason for fuse failure should be investigated and corrected. Normally it will be on the primary side of the power transformer. Because of the special nature of the regulator transformer a short in the filament or +B circuit does not necessarily burn out the fuse nor harm the power transformer.

5.3.3 Tube Replacement — This may be done after removing the case (see 4.4). Any tube within tube manufacturer's specifications can be used for replacement. When replacing tubes V2 and V5 preaging of the tubes for approximately 50 hours is recommended. After replacing those tubes the DC voltages should be checked and adjusted according to the instructions in 4.6.1.

5.3.4 Conversion to 230 V Operation — After removing the instrument from the case (see 4.4), consult the wiring diagram at the end of the instruction book for detailed information.

5.4 DC Voltage Checks

A check of the DC voltages on tube pins should be undertaken when the voltmeter shows malfunctioning which cannot be corrected by tube replacement.

For DC voltage measurement proceed as follows:

Remove the case (4.4)

Short the input terminals

Set — Range Switch to 1000 V
Function Switch to PEAK-TO-PEAK
Polarity Switch to POSITIVE

Measure tube pin voltages with a 10 megohm input resistance voltmeter and compare the results with the following table:

TUBE PIN VOLTAGES MEASURED TO THE CHASSIS

TUBE \ PIN	1	2	3	4	5	6	7	8	9
V1	0-0.05	2.1	0	6.1	90	110	2.1		
V2	0-0.2	1.5	12.2	18.3	55-65	100-130	1.5		
V3	55-65	235-255	100	100	235-255	235-255	56-68		
V4		250	100	100	250	250	110		
V5	0-0.05	1.5	6.1	12.2	90-140	100-130	1.5		
V6	0-0.2	1.6	100	100	100-113	130-160	1.6		
V7	100-113	300-310	100	100	300-310	300-310	102-115		
V9	300-310	295	150	150	150		295		385
V10	105	107	150	150	295	150	107		
V11	107	0	—	0	107	—	0		
V12	70	70	100	100	70	—	—		
V13	300-310	70	93	100	100	300-310		93	100
V14	93	93	100	100	93		90*		
V15	300	90	100	100	100	300	90*	100	100

*Measured with METER RESET depressed.

All voltages, unless otherwise specified, should be within ±10% of the TABLE VALUES.

Tube	*Pin No.*	*Tube Element*	*Voltage V RMS*
V1	1	Control Grid	0.011
V1	2	Cathode	0.0107
V2	1	Control Grid	0.0075
V3	1	Control Grid	1.45
V3	7	Cathode	1.36
V3	2, 5, 6	Plate	1.36
V4	1	Control Grid	1.36
V4	7	Cathode	1.30
V5	1	Control Grid	0.13
V5	2.7	Cathode	0.126
V6	1	Control Grid	0.13 to 0.16
V6	5	Plate	23.5
V7	1	Control Grid	23.5
V7	7	Cathode	22.5
V12	1	Cathode	22.5
V12	2	Plate	22.5

If any voltage is outside the specified limit the associated tube should be checked, connections inspected and components measured until the reason for voltage deviation is found and corrected.

5.5 Signal Tracing

If the reason for the voltmeter malfunction cannot be found by a dc voltage check, signal tracing should be used to locate the trouble.

For signal tracing apply a 1 volt Peak-to-Peak (0.35 volt RMS) 1 kc signal to the input of the voltmeter and set:

Range Switch to 1 VOLT
Function Switch to PEAK-TO-PEAK
Polarity Switch to POSITIVE

Use a sensitive high input impedance voltmeter (5.2.2) to measure the AC voltage at tube pins listed in the table below. The measured voltages should be within ±10% of the listed values.

If disagreement with the tabulated voltages is found, the whole amplifier in which the discrepancy is found should be checked since in feedback amplifiers trouble in any of the stages will likely affect voltages elsewhere in the circuit.

If all signal voltages measure normal and the incorrect indication is still observed, the peak detector circuit should be checked as follows:

With 1 volt Peak-to-Peak and the voltmeter controls set as above the dc cathode voltages of tubes V13 and V15 should be measured. This measurement should be

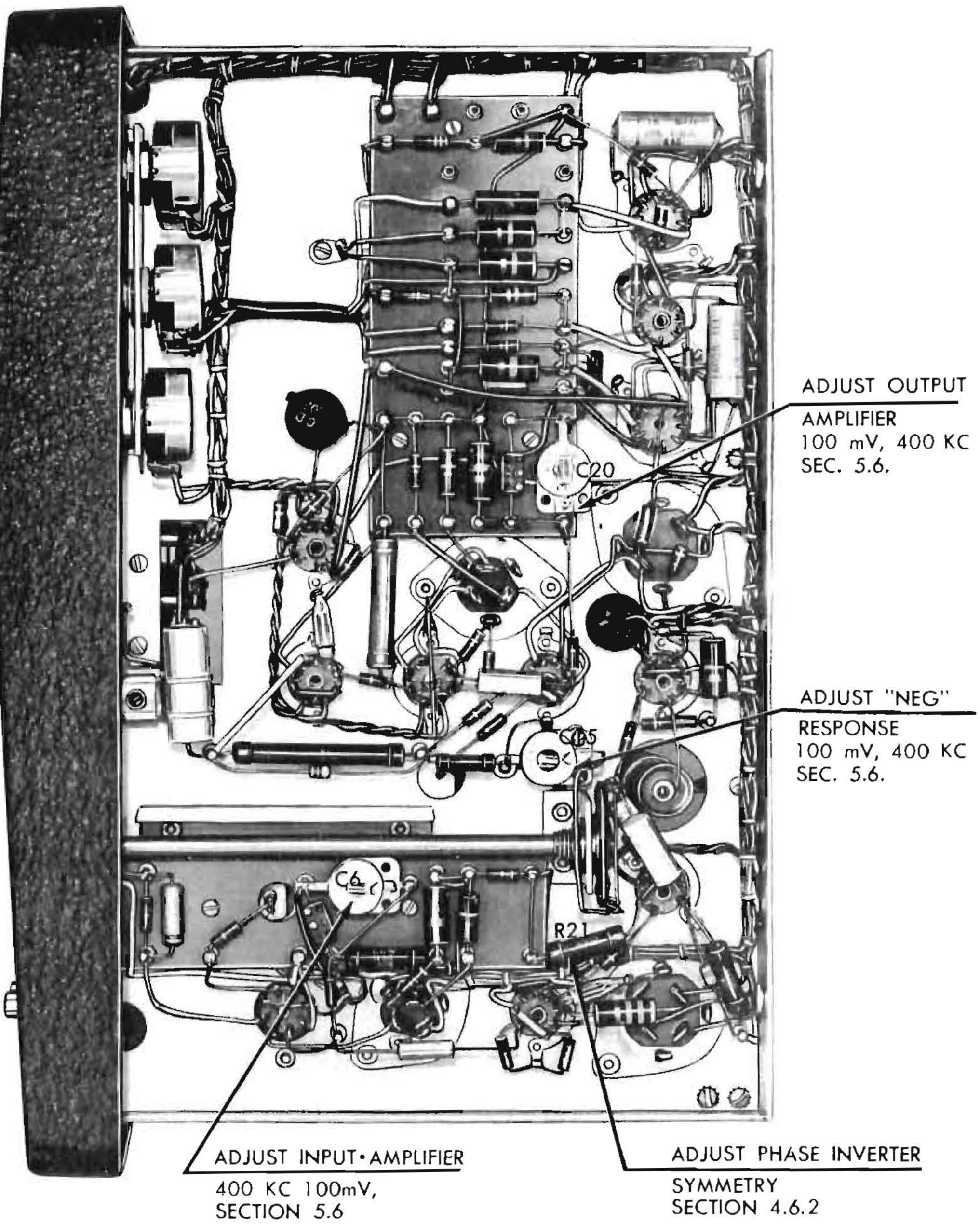

ADJUST OUTPUT
AMPLIFIER
100 mV, 400 KC
SEC. 5.6.
C20
ADJUST "NEG"
RESPONSE
100 mV, 400 KC
SEC. 5.6.
R21
ADJUST INPUT•AMPLIFIER
400 KC 100mV,
SECTION 5.6
ADJUST PHASE INVERTER
SYMMETRY
SECTION 4.6.2

Fig. 2

repeated with the same input signal but with the range switch on 3.5 volts FULL SCALE.

The voltages should be:

TUBE	PIN	1 V FS	3.5 V FS
V13	3	120	104
V13	8	94	97
V15	3	130	112
V15	8	80	97

5.6 Amplifier Frequency Response Adjustment

This should be corrected when the voltmeter gives a correct indication on the 3.5 millivolt Full Scale Range at mid-frequencies (400 cycles to 2 kc) but an excessive error at higher frequencies.

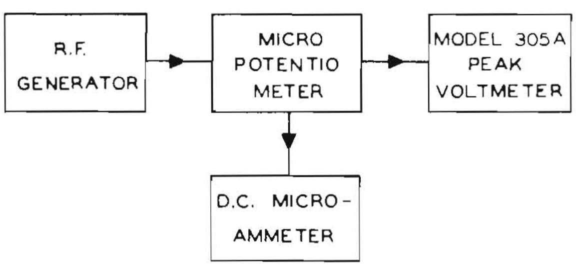
The adjustment of the amplifier response should be made after replacement of defective tubes and components and after the midband accuracy according to 4.6.3 has been checked or corrected. Also, Capacitors C18 and C19 should be checked.

To correct the amplifier frequency response proceed as follows:

a. Remove the instrument from the case (4.4).

b. Set Range Switch to 100 mV
Function Switch to PEAK-TO-PEAK
Polarity Switch to POSITIVE

c. Connect a 15 to 30 millivolt rms micropotentiometer to the voltmeter input and a generator with less than 0.5% distortion to the micropotentiometer, as shown in following diagram.



d. Adjust the signal level to some convenient point on the scale and take the reading.

e. Keeping the micropotentiometer output constant, increase the frequency to 400 kc. The voltmeter should indicate 0.5 to 1% below the previous reading. If not, adjust C6 and C20 to specified limits. Adjustment of C6 and C20 should be made so that both trimmers will have approximately the same capacitance value. The location of C6 and C20 is shown on photograph (Fig. 2).

f. Turn the Polarity Switch to NEGATIVE. Adjust C15 until meter gives the same indication as in POSITIVE position.

5.7 Attenuator Frequency Response

Adjustment should be made when the voltmeter exhibits excessive error at higher frequencies on ranges 350 mV to 3.5 volts or 10 volts to 1000 volts. The adjustment of attenuator frequency response should be undertaken only after the amplifier frequency response has been checked or corrected. The adjustment of the 10 volts to 1000 volts range should be done before the adjustment of 350 millivolts to 3.5 volts range because the first adjustment affects the second.

To adjust the attenuator response proceed as follows:

a. Remove the Range and Polarity Switch Knobs and Escutcheon Plate by removing four #4 binder head screws from the front panel.

b. Replace the range switch knob and turn the switch four positions back from the most clockwise position (10 volt range).

Set Function Switch to PEAK-TO-PEAK
Polarity Switch to POSITIVE or NEGATIVE

c. Apply 1 kc 3 to 10 volts Peak-to-Peak distortion-free sinewave to the input. Set the input level to a conveniently readable point on the scale.

d. By means of a Ballantine Model 393 Type C Voltmeter or equivalent accurate device keep the input voltage constant within 0.25%; change the frequency to 200 kc.

e. Adjust trimmer C2 with an insulated screwdriver until the indication is exactly the same as for 1 kc. For location of C2 see photograph (Fig. 3).

To adjust the 350 millivolts to 3.5 volts ranges proceed as follows:

a. Set the range switch to the sixth position clockwise (1 volt).

b. Apply a 1 kc approximately 1 volt Peak-to-Peak distortion-free sinewave to the input and set the level to a convenient point on the scale.

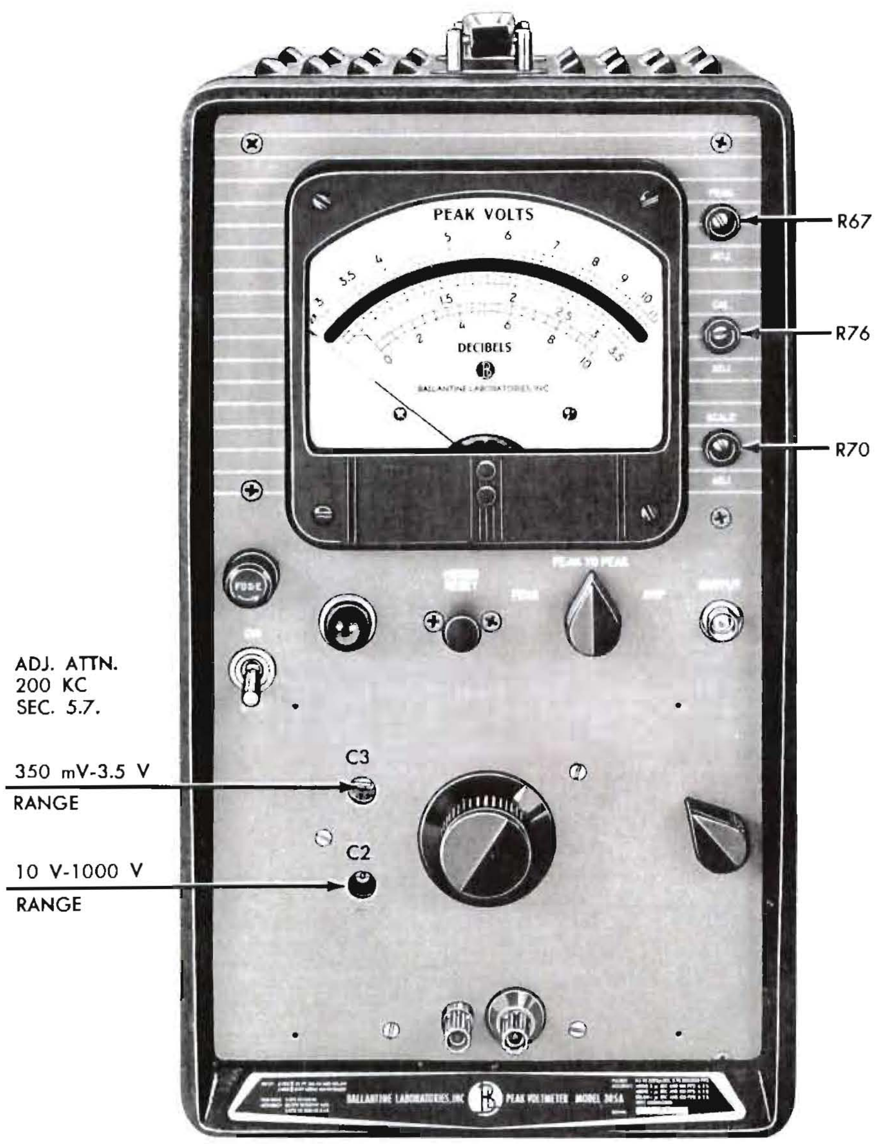
c. Keep the input voltage constant to 0.25% and change the frequency to 200 kc.

d. Adjust Trimmer C3 with screwdriver until the indication is exactly the same as for 1 kc. For location of C3, see photograph (Fig. 3).

e. Replace the escutcheon plate and knobs.

5.8 Replacement of Attenuator Resistors

The attenuator resistors are stable and carefully matched in value, temperature coefficient and HF characteristics. They do not dissipate any power and it is very unlikely that trouble with attenuator resistors will occur. Therefore, before changing any resistors, a careful check should be made for any other source of trouble such as loading the attenuator by a tube which draws grid current, etc. After all possible causes are investigated and the instrument still is in error on some ranges at low frequencies (approximately 1 kc), the attenuators should be investigated. Every portion of in-



R67
R76
R70
ADJ. ATTN.
200 KC
SEC. 5.7.
C3
350 mV-3.5 V
RANGE
C2
10 V-1000 V
RANGE
PEAK VOLTS
DECIBELS

Fig. 3

put and midsection attenuator is used in several ranges as marked on the wiring diagram. The group of ranges which show the error will be the group with the faulty attenuator and the specific resistor can easily be detected.

To correct an attenuator resistor, the value of the suspected resistor, together with other resistors in the same attenuator, should be measured accurately to 0.1%. The measured value should be within 1% of the value stated in the parts list at the end of the instruction book. However, the attenuation ratios figures from the measured resistance values should be within 0.25% of the values stated on Table, par. 3.1.

If the attenuation value differs by more than 0.25%, the faulty resistor should be replaced with a selected resistor of correct value and of the same type and make, since the selection of one with 0.25% accuracy is highly impractical for most users. It is strongly recommended that the voltmeter be sent to Ballantine Laboratories for service when such trouble occurs.

5.9 Servicing the Power Supply

The power supply should be checked if the filament or +B voltages are not normal, or excessive error is observed when measuring 60 (50) cycles or 120 (100) cycles signal or when indication is unstable with stable signal input.

5.9.1 Shorts in filament or +B circuit do not normally cause the fuse to blow because of the characteristics of the power transformer. This also does not damage the transformer.

Small deviations in +B voltage from +300 to +310 volts measured on Pin 1 of Tube 9 should be corrected as described under 4.7.2.

If the +B measures approximately 250 volts and heater voltages 4.5 volts rms, a short circuit in Tubes 9 and 10 filament may be suspected.

If the +B measures approximately 150 volts and all tubes look unlit, a short circuit in the amplifier filament circuits may be suspected.

A short circuit in +B circuit or defective by-pass or filter capacitor causes the burnout of R44 and results in no +B voltage.

5.9.2 Excessive Hum in +B Voltage or Tubes V1, V2 or V5 filament circuit causes a high error when making 60 (50) cycle or 120 (100) cycle measurements, and increases 60 (50) cycle to 120 (100) cycle component at the amplifier output with shorted input. In a normal instrument the amplitude of random noise equals that of 60 cycle or 120 cycle component.

The peak-to-peak hum amplitude on Pin 1 of Tube 9 could be measured by using another peak responding voltmeter or calibrated oscilloscope. If the hum is higher than specified, Tube V10 should be changed or R49 or R50 shunted by an Allen-Bradley Type EB resistor. The value of the shunt resistor can be found experimentally and would be greater than 1 megohm. (Fig. 4).

5.9.3 Instability of Indication in form of random pointer fluctuation above 100 millivolt ranges may be caused by a faulty reference Tube V11 which should be replaced. If the instability occurs on sensitive ranges of the instrument, shielding of the input wiring should be checked for RF pickup.

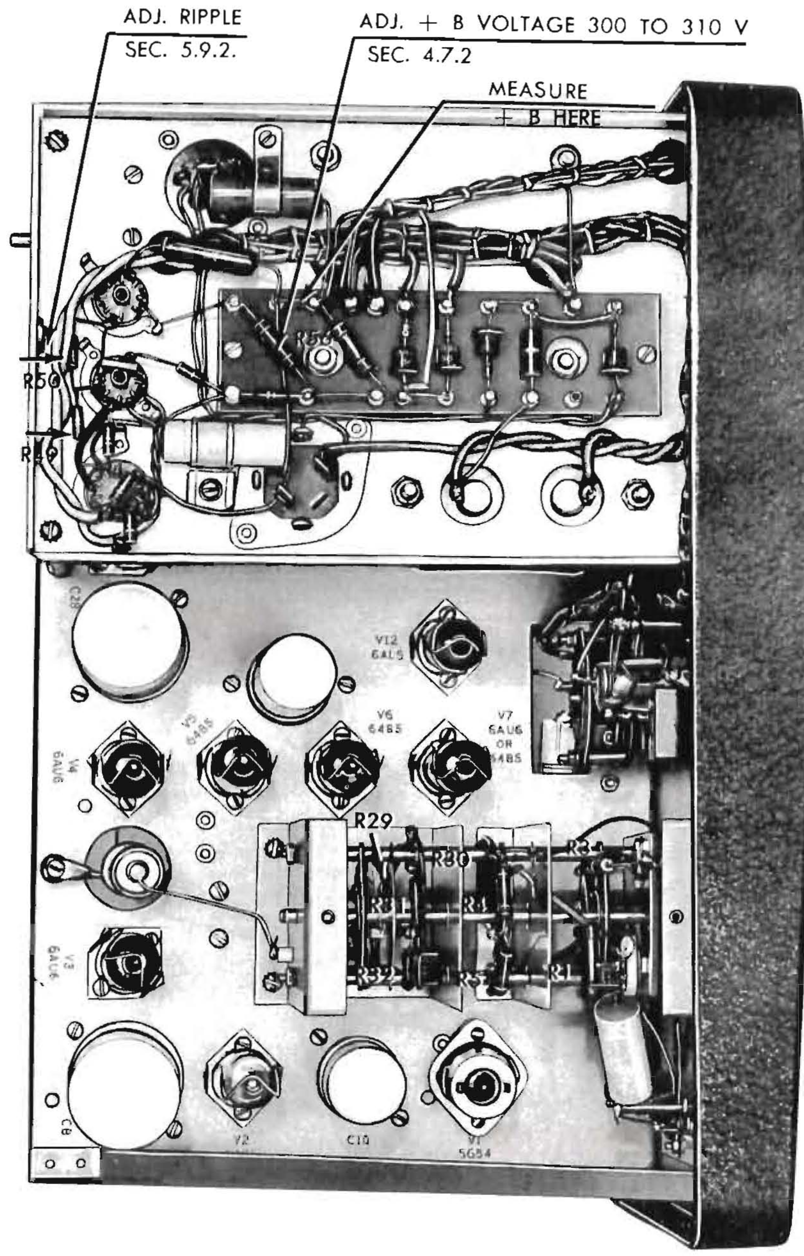

ADJ. RIPPLE
SEC. 5.9.2.
ADJ. + B VOLTAGE 300 TO 310 V
SEC. 4.7.2
MEASURE
+ B HERE
R50
R29
R30

Fig. 4

5.10 Trouble Shooting

Symptoms	Possible Cause	Pertinent Section
Instrument inoperative Pilot light does not light	No power Blown fuse Defect in power supply	5.3.2
Meter indicating with no input	Input not shielded, picks up hum PEAK ADJ off Defective tube (heater cathode leak)	2.11.3
Microphonics	Microphonic tube V1 or V5 Loose connection	
High error at 60 (50) and 120 (100) cycle measurement	Hum pickup in the connections Ground current in measuring circuit Strong magnetic field Heater damage in V1, V2, V5 High hum of power supply	5.9.2
Unstable indication	Insufficient shielding in input wiring Defective V11 Defective power supply	5.9
Inaccurate peak measurement	Misadjusted PEAK ADJ Defective V6	2.11.3
Impossible to set SCALE ADJ	Tubes V12, V13, V14, V15 Resistors R70, R73, R74	
High error in lower part of the scale	SCALE ADJ needs adjustment	2.11.1
Error in NEGATIVE position only	Defective Resistor R21	4.6.2
High frequency response or short pulse measurement in error in POS and NEG position	Frequency response of the amplifiers or attenuators incorrect	5.6 5.7
Same in NEGATIVE position only	C15 misadjusted	5.6
DC Voltages abnormal	Defective power supply V9, V11 Short in tubes or circuit	5.9

REPLACEMENT PARTS LIST

REFER TO MODEL 305A SCHEMATIC DIAGRAM, DWG. No. ME-2936B

B. L. Part No.	*Circuit Symbol*	*Capacitors*	*Manufacturer*
2363	C1	.1 μF, 600 V, 5%, Type 663-UW	Goodall
2438	C2	1-5 pF, Type 5M11-160-102	E. F. Johnson
2429	C3	7-45 pF, Type 503-27	Erie
2251	C4	62 pF, 500 V, 5%, Type CM-15	Arco
2255	C5	3,300 pF, 500 V, 5%, Type CM-20	Arco
2429	C6	7-45 pF, Type 503-27	Erie
2236	C7	200 pF, 500 V, 5%, Type CM-15	Arco
2752	C8A	10 μF, 350 V, Type DFP	Sprague
2752	C8B	50 μF, 350 V, Type DFP	Sprague
2752	C8C	60 μF, 350 V, Type DFP	Sprague
2372	C9	.022 μF, 200 V, 10%, Type 192P	Sprague
2753	C10A	20 μF, 300 V, Type DFP	Sprague
2753	C10B	20 μF, 300 V, Type DFP	Sprague
2753	C10C	30 μF, 50 V, Type DFP	Sprague
2080	C11	35 μF, 6 V, Type 30D132	Sprague
2510	C12	.47 pF, 10%, Type QC	Quality
2367	C13	.1 μF, 200 V, 10%, Type 192P	Sprague
2364	C14	.033 μF, 200 V, 5%, Type 192P	Sprague
2431	C15	3-12 pF, Type 503-27	Erie
2535	C16	.01 μF, (—0+100) 6 mc tol., Type BYA6S1	Cornell-Dubilier
2067	C17	12 μF, 250 V, Type BR-1225	Cornell-Dubilier
2508	C18	6.2 pF, 5%, Type QC	Quality
2248	C19	18 pF, 500 V, 5%, Type CM-15	Arco
2429	C20	7-45 pF, Type 503-27	Erie
2236	C21	200 pF, 500 V, 5%, Type CM-15	Arco
2371	C22	.047 μF, 200 V, 10%, Type 192P	Sprague
2753	C23A	20 μF, 300 V, Type DFP	Sprague
2753	C23B	20 μF, 3000 V, Type DFP	Sprague
2753	C23C	30 μF, 50 V, Type DFP	Sprague
2509	C24	1 pF, 10%, Type QC	Quality
2370	C26	.22 μF, 400 V, 10%, Type 355E224K	Gudeman
	C27	.85 μF, 850 V (Supplied as part of #3052, T1)	Sola
	C27	1.0 μF, 850 V (Supplied as part of #3055, T1)	Sola
2754	C28A	1,000 μF, 25 V, Type DFP	Sprague
2754	C28B	1,000 μF, 25 V, Type DFP	Sprague
2751	C29	80 μF, 300 V, Type DFP	Sprague
2750	C30A	80 μF, 350 V, Type DFP	Sprague
2750	C30B	20 μF, 350 V, Type DFP	Sprague
2370	C31	.22 μF, 400 V, 10%, Type 355E224K	Gudeman
2228	C32	50 pF, 500 V, 5%, Type CM-15	Arco
2256	C33	500 pF, 500 V, 10%, Type DM-15	Arco
2354	C34	.15 μF, 200 V, Type 192P	Sprague
2354	C35	.15 μF, 200 V, Type 192P	Sprague

REPLACEMENT PARTS LIST *Continued*

REFER TO MODEL 305A SCHEMATIC DIAGRAM, DWG. No. ME-2936B

B. L. Part No.	*Circuit Symbol*	*Resistors*	*Manufacturer*
1460	R1	2,000,000 ohms, Type CPX-1, 1%	Aerovox
1063	R2	300 ohms, Type EB, 5%	Allen-Bradley
2663	R3	67,500 ohms, Type CPX-½, 1%	Aerovox
2665	R4	63.3 ohms, Type CPX-½, 1%	Aerovox
2664	R5	1,940 ohms, Type CPX-½, 1%	Aerovox
1099	R6	10 ohms, Type EB, 10%	Allen-Bradley
1460	R7	2,000,000 ohms, Type CPX-1, 1%	Aerovox
1057	R8	1,000 ohms, Type EB, 5%	Allen-Bradley
1662	R9	30,000 ohms, Type N25, 2%	Corning
1086	R10	1,500 ohms, Type EB, 5%	Allen-Bradley
1065	R11	200 ohms, Type EB, 5%	Allen-Bradley
1440	R12	69.8 ohms, Type CPX-½, 1%	Aerovox
1091	R13	91,000 ohms, Type EB, 5%	Allen-Bradley
1015	R14	470,000 ohms, Type EB, 5%	Allen-Bradley
1064	R15	220 ohms, Type EB, 5%	Allen-Bradley
1213	R16	33,000 ohms, Type HB, 5%	Allen-Bradley
1206	R17	5,100 ohms, Type HB, 5%	Allen-Bradley
1251	R18	100,000 ohms, Type GB, 5%	Allen-Bradley
1071	R19	47 ohms, Type EB, 10%	Allen-Bradley
1082	R20	240 ohms, Type EB, 5%	Allen-Bradley
1479	R21	9,000 ohms, Type CPX-1, 1%	Aerovox
1479	R22	9,000 ohms, Type CPX-1, 1%	Aerovox
1071	R23	47 ohms, Type EB, 10%	Allen-Bradley
1012	R24	750,000 ohms, Type EB, 5%	Allen-Bradley
1258	R25	10,000 ohms, Type GB, 5%	Allen-Bradley
1063	R26	300 ohms, Type EB, 5%	Allen-Bradley
1201	R27	20,000 ohms, Type HB, 5%	Allen-Bradley
1057	R28	1,000 ohms, Type EB, 5%	Allen-Bradley
1654	R29	15,000 ohms, Type N20, 1%	Corning
1658	R30	4,740 ohms, Type N20, 1%	Corning
1657	R31	1,500 ohms, Type N20, 1%	Corning
1655	R32	694 ohms, Type N20, 1%	Corning
1214	R33	27,000 ohms, Type HP, 5%	Allen-Bradley
1057	R34	1,000 ohms, Type EB, 5%	Allen-Bradley
1071	R35	47 ohms, Type EB, 10%	Allen-Bradley
1440	R36	69.8 ohms, Type CPX-½, 1%	Aerovox
1085	R37	120,000 ohms, Type EB, 5%	Allen-Bradley
1015	R38	470,000 ohms, Type EB, 5%	Allen-Bradley
1663	R39	18,000 ohms, Type LP1-4	Corning
1098	R40	120 ohms, Type EB, 5%	Allen-Bradley
1252	R41	62,000 ohms, Type GB, 5%	Allen-Bradley
1071	R42	47 ohms, Type EB, 10%	Allen-Bradley
1506	R43	12,500 ohms, Type CPX-2, 1%	Aerovox
1271	R44	10 ohms, Type GB, 10%	Allen-Bradley
1015	R45	470,000 ohms, Type EB, 5%	Allen-Bradley
1015	R46	470,000 ohms, Type EB, 5%	Allen-Bradley
1739	R47	22 ohms, Type 151E, 5%	Sprague

REPLACEMENT PARTS LIST *Continued*

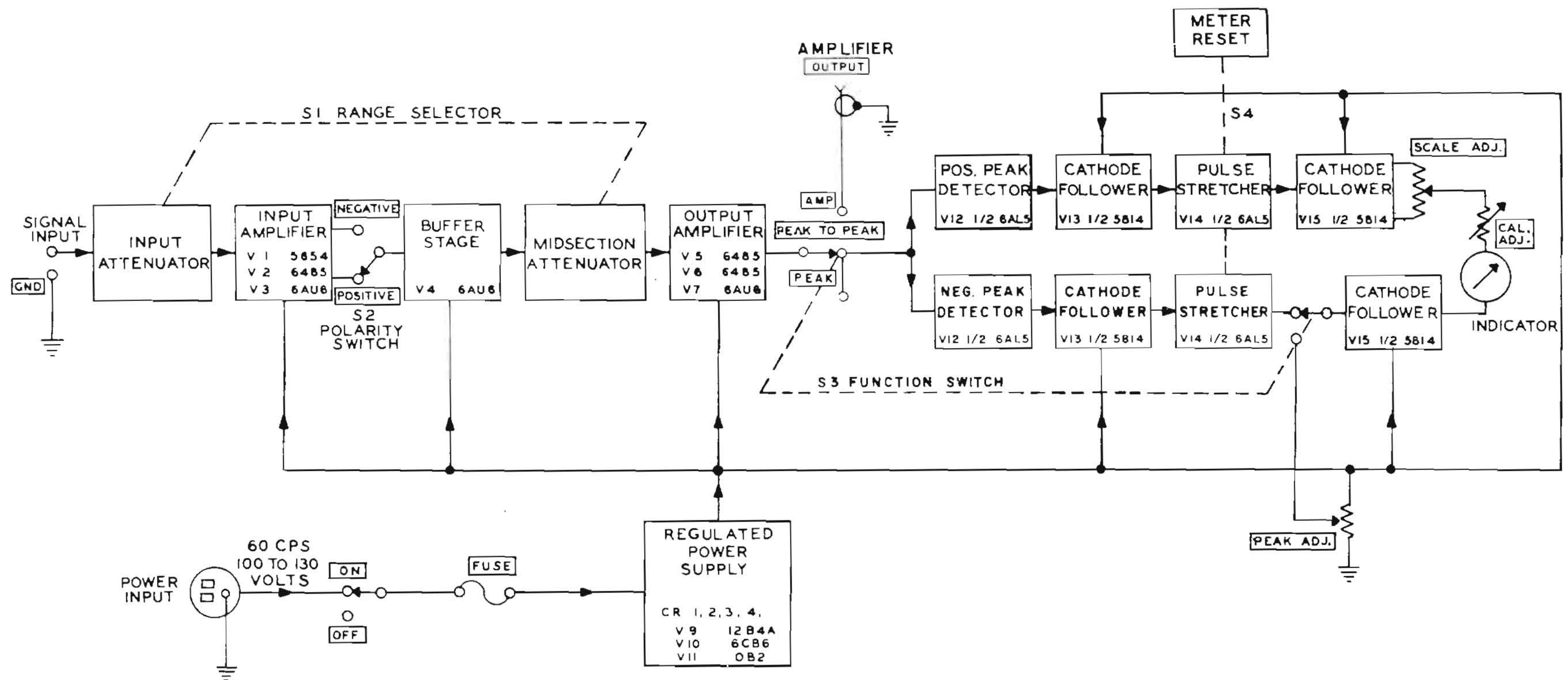
REFER TO MODEL 305A SCHEMATIC DIAGRAM, DWG. No. ME-2936B

B. L. Part No.	*Circuit Symbol*	*Resistors*	*Manufacturer*
1015	R48	470,000 ohms, Type EB, 5%	Allen-Bradley
1021	R49	270,000 ohms, Type EB, 10%	Allen-Bradley
1032	R50	47,000 ohms, Type EB, 5%	Allen-Bradley
1071	R51	47 ohms, Type EB, 10%	Allen-Bradley
1741	R52	25,000 ohms, Type 27E, 5%	Sprague
1732	R53	1,500 ohms, Type SKT, 5%	Sprague
1303	R54	250,000 ohms, Type CPX-½, 1%	Aerovox
1021	R55	270,000 ohms, Type EB, 5%	Allen-Bradley
2666	R56	135,000 ohms, Type CPX-½, 1%	Aerovox
1001	R57	10,000,000 ohms, Type EB, 10%	Allen-Bradley
1004	R58	3,900,000 ohms, Type EB, 5%	Allen-Bradley
1000	R59	22,000,000 ohms, Type EB, 10%	Allen-Bradley
1214	R60	27,000 ohms, Type HB, 5%	Allen-Bradley
1254	R61	27,000 ohms, Type GB, 10%	Allen-Bradley
1015	R62	470,000 ohms, Type EB, 5%	Allen-Bradley
1000	R63	22,000,000 ohms, Type EB, 10%	Allen-Bradley
1000	R64	22,000,000 ohms, Type EB, 10%	Allen-Bradley
1015	R65	470,000 ohms, Type EB, 5%	Allen-Bradley
1085	R66	120,000 ohms, Type EB, 5%	Allen-Bradley
1832	R67	50,000 ohms, Type 43-50, 000	Clarostat
1019	R68	330,000 ohms, Type EB, 5%	Allen-Bradley
1071	R69	47 ohms, Type EB, 10%	Allen-Bradley
1835	R70	2,000 ohms, Type 43-2000	Clarostat
1071	R72	47 ohms, Type EB, 10%	Allen-Bradley
1209	R73	30,000 ohms, Type HB, 5%	Allen-Bradley
1216	R74	15,000 ohms, Type HB, 5%	Allen-Bradley
1733	R75	70,000 ohms, Type WWA-26	Dale
1833	R76	25,000 ohms, Type 43-25, 000	Clarostat
1059	R77	750 ohms, Type EB, 5%	Allen-Bradley
1050	R78	3,900 ohms, Type EB, 5%	Allen-Bradley

REPLACEMENT PARTS LIST *Continued*

REFER TO MODEL 305A SCHEMATIC DIAGRAM, DWG. No. ME-2936B

B. L. Part No.	*Circuit Symbol*	*Other Components*	*Manufacturer*
5574	CR1, 2	500 MA, PIV, 400 V, Type 1N1763A	RCA
7421	CR3, 4	Rectifier, Silicon, Type 36591	RCA
3407	F1	Fuse, 1 amp, Type MDL (60 cps)	Bussmann
3411	F1	Fuse, ½ amp, Type MDL (50 cps)	Bussmann
3475	I1	Pilot Light, Type 1815	General Electric
3187	M1	Indicating Meter	Ballantine
3265	S1A, B, C	Attenuator Switch, Type H	Ballantine
3266	S2	Positive-Negative Switch, Type 23	Ballantine
3267	S3A, B	Peak-to-Peak Switch, Type H	Ballantine
3238	S4A, B	Push Button Switch, Type 64500-170	Ballantine
3268	S5	ON-OF Switch, Type 80994H	Arrow-Hart, Hegeman
3052	T1	Power Transformer (60 cps)	Ballantine
3055	T1	Power Transformer (50 cps)	Ballantine
3126	V1	Type 5654 Tube	General Electric
5570	V2	Type 6485 Tube	Raytheon
7907	V3	Type 6AU6A Tube	RCA
7907	V4	Type 6AU6A Tube	RCA
5570	V5	Type 6485 Tube	Raytheon
5570	V6	Type 6485 Tube	Raytheon
7907	V7	Type 6AU6A Tube	RCA
3138	V8	Type NE-2	General Electric
5569	V9	Type 12B4A Tube	RCA
3149	V10	Type 6CB6 Tube	RCA
5578	V11	Type OB2WA Tube	Tung-Sol
3108	V12	Type 6AL5 Tube	RCA
3133	V13	Type 5814A Tube	General Electric
3108	V14	Type 6AL5 Tube	RCA
3133	V15	Type 5814A Tube	General Electric
3138	V16	Type NE-2	General Electric



BLOCK DIAGRAM

MODEL 305A PEAK RESPONDING ELECTRONIC VOLTMETER

MODEL 305A PEAK RESPONDING ELECTRONIC VOLTMETER