34050

INSTRUCTION AND OPERATING MANUAL

MODEL 330B

DISTORTION ANALYZER

Serial 2023 and Above T-20

As repaired March 22, 1956

HEWLETT-PACKARD COMPANY

395 Page Mill Road • Palo Alto, California, U.S.A.

MODEL 330B

INSTRUCTION BOOK CORRECTIONS

Electrical Specifications - Delete RF Detector Circuit Specifications

Pages 1, 2	Delete the paragraph beginning: "The rf circuit includes V1 ----"
Page 3	Delete: "RF*" - "Tunes rf detector ----" Add: The binding posts on the back of the chassis may be used for connecting an external rf detector or other instruments to the Model 330B. These binding posts are connected to the input of the Model 330B when the "AF" - "RF" switch on the control panel is in the "RF" position.
Page 5, 6	Delete the section entitled: Procedure for Measuring Distortion in Modulated Carriers.
Page 7a	Delete the section: Procedure for Measuring Noise on AM Carriers.
Page 8	Delete: "Detector Section" - "Detector tube V1 ----"

330B 7/25/52 Serial 1459 to

C A U T I O N

The maximum voltage applied to the input terminals of the Model 330B,C,D Laboratory Amplifier must not exceed 425 dc volts or ac peak volts. Higher voltages will break-down the capacitors in the input system of the instrument.

MODEL 330B
DISTORTION ANALYZER

ELECTRICAL SPECIFICATIONS

Measurement Range:	Measures distortion at any frequency from 20 to 20,000 cps.
Elimination Characteristics:	Eliminates fundamental by more than 99.9%, while attenuating second harmonic by less than 10%.
Sensitivity:	Distortion levels of 0.3% are measured with full scale reading; levels of 0.1% can be read with good accuracy.
RF Detector Circuit:	Tunable from 550 kc to 60 mc; detector introduces negligible distortion.
AF Input Impedance:	Approximately 200,000 ohms shunted by 37 mmf.
Voltmeter Range:	Nine ranges are provided with full scale sensitivities of .03, .1, .3, 1, 3, 10, 30, 100, and 300 volts rms; a calibration from -12 to +2 decibels is also provided.
Voltmeter Frequency Range:	10 cps to 100 kc.
Voltmeter Accuracy:	Within ±3% of full scale over entire frequency range.
Voltmeter Input Impedance:	Approximately one megohm shunted by 35 mmf.
Noise Measurement:	Full scale readings can be made of 300 microvolts; noise measuring range is 10 cps to 20 kc.
Oscilloscope Terminals:	Gain from AF input to oscilloscope terminals is 75 db.
Required Power Source:	105- to 125-volt, 50/60 cycle single phase ac. Power required is approximately 90 watts.

O P E R A T I N G   I N S T R U C T I O N S

UNPACKING - INITIAL ADJUSTMENTS

This instrument has been thoroughly tested and inspected before being shipped and is ready for use when received. After unpacking, however, it is desirable to make a complete inspection of the instrument for possible damage in transit. If any such damage is found, follow the procedure set out at the back of this manual.

Before turning the instrument on for the first time, make certain that the tubes are all secure in their sockets.

GENERAL

The Model 330B Distortion Analyzer is primarily designed to measure harmonic distortion and noise in audio frequency voltages by the "total" measurement method. In its essentials, this method consists of first measuring the applied voltage, then eliminating the fundamental voltage from the wave under test and measuring the remaining voltages with a voltmeter. Comparison of the two voltages can then be made in decibels or in percentage.

In addition to making straight forward distortion measurements in audio frequency voltages, the Model 330B is designed also to measure the distortion in an amplitude-modulated radio carrier. For this type of measurement a linear rf detector has been incorporated into the instrument.

CIRCUIT DESCRIPTION

The circuit of the Model 330B, shown on page 19, consists of four parts which are called the detector, selective amplifier, voltmeter, and power supply sections.

The rf circuit includes VI and is known as a "shunt" diode dectector. Effectively, the circuit operates so as to

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"short" the positive portions of the rf currents to ground through the diode, while the negative portion of the rf current is filtered by the rf filter. This action results in a dc voltage which fluctuates in accordance with the modulation envelope of the rf wave.

The output of the detector is applied to the selective amplifier, consisting of tubes V2 to V6. A single-frequency attenuation characteristic for this amplifier is obtained by the use of a Wein Bridge. The bridge is in balance for one frequency which is essentially eliminated from the output of the amplifier, the remaining frequencies being further amplified and applied to the voltmeter section.

By use of a switching arrangement, the gain of the selective amplifier is increased from 20 to 40 db when it is desired to measure noise, and in addition the selectivity circuits are switched out of the system.

Tubes V11 to V14 constitute the voltmeter section, which is essentially a wide-band amplifier feeding into a linear full-wave rectifier circuit. A 0-1 ma meter in the rectifier circuit is calibrated in rms volts, and indicates in proportion to the average current passed by the circuit.

The power supply includes a conventional-full-wave rectifier and filter with a voltage-regulating circuit which supplies plate voltage for the selective amplifier and part of the voltmeter circuit.

Large resistance-capacity filters are used throughout to isolate the various circuits and to prevent feedback through the common power supply impedance.

O P E R A T I O N

"Total" distortion measurements with the Model 330B make it necessary that the output frequency of the system under test be quite stable in order that it can be "balanced out". The usual procedure for measuring distortion in systems such as amplifiers is to drive the amplifier under test with a stable audio oscillator of known performance, such as the -hp- Model 200B or 201B, and to make measurements at representative frequencies throughout the frequency range of the amplifier.

The Model 330B is designed to measure distortion in an audio voltage or in an amplitude-modulated carrier. In addition the instrument can be used as a high-impedance voltmeter and, with the added gain of the NOISE amplifier, as a noise-and-hum-measuring device or sensitive ac voltmeter. The operating procedure for each of these uses is detailed following the explanation of controls.

CONTROL	FUNCTION
RF*	Tunes rf detector circuit to transmitter frequency.
INPUT - MIN - MAX	Attenuates external voltage applied to AF INPUT terminals.
RANGE - x1 - x10 - x100	In conjunction with FREQUENCY control, selects frequency to be eliminated.
FREQUENCY	In conjunction with RANGE control, selects frequency to be eliminated. A vernier frequency control is provided directly below the FREQUENCY control.
METER - DISTORTION - SET LEVEL - NOISE	Sets up circuit for various types of measurements.
R.M.S. volts - DB	Determines full-scale voltmeter value.
BALANCE	Used with FREQUENCY controls to balance fundamental from voltage under measurement.
OFF - ON	Turns power off and on.

*Binding posts and a switch are also provided as part of the detector controls. Their use is explained under the use of the detector.

In addition to the above controls, three pairs of binding posts are provided on the front panel. The AF INPUT binding posts connect directly into the selective amplifier, while the METER binding posts connect directly into the voltmeter. The OSCILLOSCOPE binding posts are provided so that an oscilloscope can be used to view the voltage applied to the meter. An oscilloscope used in this manner is helpful in determining the characteristics of distortion, noise, etc.

<u>Procedure For Measuring AF Distortion in Percentage</u>.

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1. Turn on the Model 330B; allow a heating period of five minutes or more.

2. Set R.M.S. VOLTS - DB switch to 100% position.

3. Set Amplifier switch (labeled METER - DISTORTION - SET LEVEL - NOISE) to SET LEVEL position.

4. Set AF - RF switch to AF position.

5. Connect audio frequency voltage to be measured to AF INPUT terminals. The lower of these terminals is grounded and therefore should never be connected to any point which is at a dc or ac potential.

6. Slowly turn INPUT control clockwise until meter reads exactly full scale (1.0).

7. Set RANGE control to a range which includes the fundamental frequency of the wave to be measured. The frequency coverage of the three ranges is:

   x1 Range - 20 cps to 200 cps
   x10 Range - 200 cps to 2000 cps
   x100 Range - 2000 cps to 20,000 cps

8. Set amplifier switch to DISTORTION.

9. Adjust FREQUENCY control until reading of frequency dial when multiplied by RANGE factor equals frequency of fundamental applied voltage. For example, if frequency of fundamental is 400 cps, set tuning dial to "40" and RANGE switch to "x10"*. The meter reading will fall off when the proper frequency setting is obtained.

* If fundamental frequency is not known, "search" for meter dip. Change ranges on RANGE control as necessary.

10. Tune BALANCE control and FREQUENCY vernier until minimum meter reading is obtained. When balancing in this manner, tuning becomes sharper as the meter reading decreases; therefore, it is usually necessary to repeat the tuning of these controls five or six times until no further meter reduction can be obtained. Keep decreasing setting of voltmeter switch as necessary to have large meter deflections.

11. Distortion can now be read directly in percentage. For example, if the meter reads 1.5 with the voltmeter switch in the 3% position, the distortion is 1.5%.

Procedure for Measuring AF Distortion in Decibels.

Distortion measurements in db are very similar to those in percentage. The only differences are:

1. In step 6 of the above percentage procedure, the INPUT-MIN - MAX control should be adjusted to "0" on the DB scale instead of to full scale.

2. In step 11 of the above percentage procedure, distortion will be indicated directly in db instead of percentage. Each position that the voltmeter switch is reduced corresponds to 10 db below the original voltage level. As an example of how db readings are determined, assume that, after balancing, the meter reads -6db with the voltmeter switch in the -20 position. In this instance distortion would be 46 db below the original level, because the switch has been reduced 4 positions from the original +20 level and the meter indicates an additional -6db.

Procedure for Measuring Distortion in Modulated Carriers.

1. Set switch on upper rear of the instrument to a range covering the transmitter carrier frequency. The ranges of each of the five positions of this switch are:

   Range 1 - 530 kc to 1.4 mc
   Range 2 - 1.4 mc to 3.8 mc
   Range 3 - 3.5 mc to 10 mc
   Range 4 - 8.5 mc to 24 mc
   Range 5 - 20 mc to 60 mc

2. Loosely couple the binding posts on the rear of the Model 330B to the transmitter. In almost every case this coupling is made to the transmitter final amplifier plate tank coil, and provision is usually made by the transmitter manufacturer for this coupling.

3. Adjust the degree of coupling between the transmitter and Distortion Analyzer as follows:

   a. Adjust transmitter so that it is 30%-modulated by a fixed audio frequency.

   b. Set AF - RF control to RF position.

   c. Set Voltmeter switch to 300-volt position.

   d. Set amplifier switch to SET LEVEL position, and turn INPUT control completely clockwise.

   e. Tune RF control for maximum meter reading. Reduce voltmeter switch as necessary to obtain readable meter deflection.

   f. Adjust the coupling so that approximately a full-scale meter reading will be obtained when the voltmeter switch is in the 100% position. Usually this will require that the coupling be lessened by fewer turns or more space on the coupling coil or by inserting a resistor in the transmission line connecting the transmitter and Distortion Analyzer.

   g. Next, the transmitter should be modulated to the desired degree with the desired frequencies. The Distortion Analyzer should be operated in accordance with either the "Procedure For AF Distortion Measurements in Percentage" (except that step 4 should be disregarded) or the "Procedure For AF Distortion Measurements in Decibels", as preferred.

<u>Procedure for Measuring Voltage Directly</u>.

1. Set amplifier switch to METER position.

2. Set voltmeter switch to highest (300) position.

3. Connect voltage to be measured to METER terminals. The lower of these terminals is grounded and should never be connected to any point at a dc or ac potential.

4. Reduce voltmeter switch as necessary to obtain readable meter deflection.

5. Full scale value of switch settings is indicated by voltmeter switch calibration.

Procedure for Increasing Sensitivity of Voltmeter.

1. The sensitivity of the voltmeter section of the Model 330B can be increased 10 times by setting the amplifier switch to the SET LEVEL position or 100 times by setting the amplifier switch to the NOISE position. This feature makes the instrument very convenient to use for measuring hum, noise, and other small voltages in the audio and supersonic range.

2. Set amplifier switch to either the SET LEVEL or NOISE position, as desired. With the switch in the SET LEVEL position the sensitivity of the voltmeter is increased by 20 db $\pm\frac{1}{2}$db to 100 kc. With the switch in the NOISE position the sensitivity of the voltmeter is increased by 40 db $\pm$ 1 db to 15 kc.

3. Set voltmeter switch to 10-volt position.

4. Set AF - RF switch to AF position.

5. Connect voltage to be measured to AF INPUT terminals. The lower of these terminals is grounded and should never be connected to any point at a dc or ac potential.

6. Turn INPUT - MIN - MAX control completely clockwise.

7. Set voltmeter switch as necessary to obtain readable meter deflection.

   CAUTION: If a voltmeter reading greater than 10 volts is obtained in this measurement, the amplifier should not be used to increase the sensitivity of the voltmeter. The readings should be made directly with the voltmeter.

8. The voltage calibration of the R.M.S.VOLTS - DB control is now divided by a factor of either ten or one hundred as indicated above. For example, if a reading of one volt is obtained on meter, the true value of the voltage being measured is either one-tenth or one-hundredth of a volt, depending upon whether the amplifier switch is in the SET LEVEL or NOISE position, respectively.

Procedure for Measuring Noise on AM Carriers

1. If necessary, adjust the coupling between the transmitter and Distortion Analyzer as described in steps 1 to 3 of the above "Procedure for Measuring Distortion in Modulated Carriers".

2. Modulate the transmitter 100% with a desired single frequency such as 1000 cps.

3. Set the amplifier switch to the SET LEVEL position.

4. Set the voltmeter switch to the +20 db position.

5. Adjust the INPUT control so that the meter pointer is at the 0 db mark.

6. Remove the modulation from the transmitter. The meter reading should drop when the modulation is removed.

7. Set the amplifier switch to the NOISE position.

8. Turn the voltmeter switch back until a reading is obtained on the meter.

9. Noise can now be read in db as so many db below a 100% modulated carrier. However, it is necessary to add 20 db to the difference in the two meter readings because of the change in the setting of the amplifier switch. For example, if the final meter reading is -6 db with the voltmeter switch in the -20 db position, the noise level is 20 db plus the difference in the two meter readings (46 db) or 66 db below 100% modulation.

Procedure for Measuring Incidental AM on FM Carriers

1. Noise on FM carriers can be measured with the use of the -hp- Model 335B FM Monitor and Modulation Meter. The instruction manual for the Model 335B contains directions for adjusting that instrument for incidental am measurements. The Model 330B Distortion Analyzer can be used as the voltmeter which is required for FM noise measurements, as described in the Model 335B manual.

Procedure for Measuring FM Noise on FM Carriers

1. FM Noise on FM carriers can be measured with the Model 330B and a FM Monitor such as the -hp- Model 335B.

2. Connect terminals 3 and 5 of the FM Monitor to the AF input terminals of the Model 330B.

3. Modulate the transmitter 100% with a single frequency such as 1000 cps that is below the knee on the standard de-emphasis curve.

4. Set the amplifier switch of the Model 330B to the SET LEVEL position and the voltmeter switch of the Model 330B to the +20 db position.

5. Adjust the INPUT control so that the meter pointer reads 0 db.

6. Remove the modulation from the transmitter. the Model 330B meter reading should drop. Then set the amplifier switch to the NOISE position.

7. Reduce the setting of the voltmeter multiplier so that a reading is obtained on the meter.

8. The FM noise can now be read as so many db below 100% modulation. However, it is necessary to add 20 db to the difference in the two meter readings because of the change in the setting of the amplifier switch. For example, if the final meter reading is -6 db with the voltmeter multiplier in the -20 db position, the noise level is 20 db plus the difference in the two meter readings (46 db) or 66 db below 100% modulation.

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M A I N T E N A N C E

GENERAL-TUBES

The Model 330B Distortion Analyzer requires no periodic maintenance other than occasional replacement of tubes and removal of any accumulated dust and dirt. The design of the circuit is such that changing tubes will have only slight effect on the calibration of the instrument. Tubes which differ widely from the average type characteristics can, however, affect the calibration noticeably and yet seemingly function properly; for this reason it is desirable to check calibration when certain tubes are changed.

AMPLIFIER SECTION

If tubes are changed in the amplifier section (V2 to V6), it is possible that the gain of the circuit may change up to about one db. This amplifier is highly stabilized by the use of negative feedback so that large gain variations will not be obtained.

To check the gain when one or more tubes have been replaced in the amplifier, apply a small voltage of, say one-half volt, to the voltmeter section and note the exact reading of the voltmeter. Then, apply the same voltage to the AF INPUT terminals. Turn the INPUT control to MAX and note the reading of the voltmeter. The reading should be almost exactly 10 times the first reading, corresponding to a gain of 20 db. If necessary, select new tubes to obtain proper gain.

DETECTOR SECTION

Detector tube V1 may be replaced without special precautions.

VOLTMETER SECTION

Tubes V11 to V13 in the voltmeter section can usually be replaced without precautions. However, in the case of replacement of V14, it is desirable to check the calibration of the instrument if peak accuracy is desired. Procedure for checking calibration of the system is given below.

CALIBRATION CHECK

Probably the most accurate method which can be used in the field to check the calibration of the voltmeter section of the Model 330B is a test using a cathode-ray oscilloscope and a freshly-calibrated dynamometer type voltmeter.

After any new replacement tubes have heated in the Model 330B, apply a low-frequency (50-60) cps voltage simultaneously to both the voltmeter section of the Model 330B and the dynamometer type voltmeter. Readings of the two instruments should agree closely. Try another new tube if necessary.

Next, calibrate the cathode-ray tube of the oscilloscope by applying a low-frequency sinusoidal voltage simultaneously to the dynamometer voltmeter and to the vertical-deflecting electrodes of the c-r tube. No horizontal sweep voltage should be used. Directions for connecting to the deflecting electrodes of the tube are usually given by the manufacturer of the oscilloscope. By measuring the peak-to-peak deflection of the c-r tube trace with a graph screen and by noting the reading of the voltmeter, the deflection voltage of the c-r tube can be quickly determined. It is important that the voltage used to calibrate the c-r tube be essentially sinusoidal and free from harmonics.

Now connect the voltmeter section of the Model 330B in parallel with the vertical-deflecting plates of the c-r tube and apply sinusoidal voltages of frequencies up to one hundred kilocycles to the combination of the two instruments. The voltage reading shown by the Model 330B should agree closely with that indicated by the magnitude of deflection of the c-r tube trace. If such is not the case, try another new tube in the voltmeter section of the Model 330B and repeat the calibration check.

The above procedure will give a reasonable check at all frequencies within the range of the Model 330B, although a check cannot be made of small voltages. Low voltage ranges can be checked by starting with a voltage within one of the ranges checked on the oscilloscope and working downward. For example, if the accuracy and frequency response of the 100-volt range of the Model 330B have been checked on the oscilloscope, apply a 25-volt wave to the Model 330B and note the reading on the 100-volt range. Then switch to the 30-volt range and note that the reading is correct. By extending this procedure, all ranges of the instrument can be checked.

Although the above methods will not give precision results, they will often prove helpful in determining whether or not old tubes have exceeded their service life or new tubes are satisfactory to use.

MECHANICAL DRIVE

A special wire cable driving arrangement is used in the Model 330B for rotating the selective amplifier tuning condenser. This driving system has a life far beyond the life of the equipment. However, should any drive failure ever occur, the instrument should be returned to the factory for repair. Under no circumstances should adjustment of the drive be attempted because the calibration of the instrument will be destroyed.

RESIDUAL METER READING

It may be noticed when the amplifier switch is on DISTORTION and the RANGE switch is in the x1 position that there is a noticeable deflection of the meter pointer on the lowest voltmeter range with no signal input. This condition can usually be remedied by "turning over" the power plug on the Model 330B.

Strong rf fields can also cause a meter reading under certain conditions. If this condition occurs, ground the cabinet of the instrument.

SCHEMATIC WIRING DIAGRAM VOLTAGES

Conditions of DC Voltage Measurements

1. 115V, 60 cycles Power Supply

2. Measured between the indicated points and chassis with an electronic voltmeter of 100 megohms input resistance.

3. Input terminals short circuited, "RF-AF" switch in "AF" position, switch S4 in the "NOISE" position.

SCHEMATIC DIAGRAM OF MODEL 330B, AMPLIFIER & FILTER SECTION.

SERIAL 1458 & ABOVE

— NOTES —

CONDITIONS OF DC VOLTAGE MEASUREMENT

1. LINE VOLTAGE AT 115/230 VOLTS, 50/60~
2. [INPUT] AT [MIN]
3. [RANGE] AT [XI]
4. INPUT SELECTOR AT [AF]
5. [FREQUENCY] AT 100
6. FUNCTION SELECTOR AT [NOISE]
7. VOLTMETER RANGE AT [300 R.M.S. VOLTS]
8. [BALANCE] AT MAXIMUM CLOCKWISE POSITION.
9. VOLTAGES MEASURED BETWEEN INDICATED POINTS AND CHASSIS WITH VOLTMETER HAVING AN INPUT RESISTANCE OF 122 MEGOHMS (-hp- MODEL 410B)

CONDITIONS OF AC VOLTAGE MEASUREMENT

1. THRU 8 SAME AS DC CONDITIONS
9. VOLTAGES MEASURED BETWEEN INDICATED POINTS WITH A 1000 OHMS/VOLT OR BETTER AC METER

ALL VOLTAGES R.M.S.

ALL CAPACITANCE VALUES IN μμF UNLESS OTHERWISE NOTED.

ALL RESISTANCE VALUES IN OHMS UNLESS OTHERWISE NOTED.

1K = 1000 OHMS.

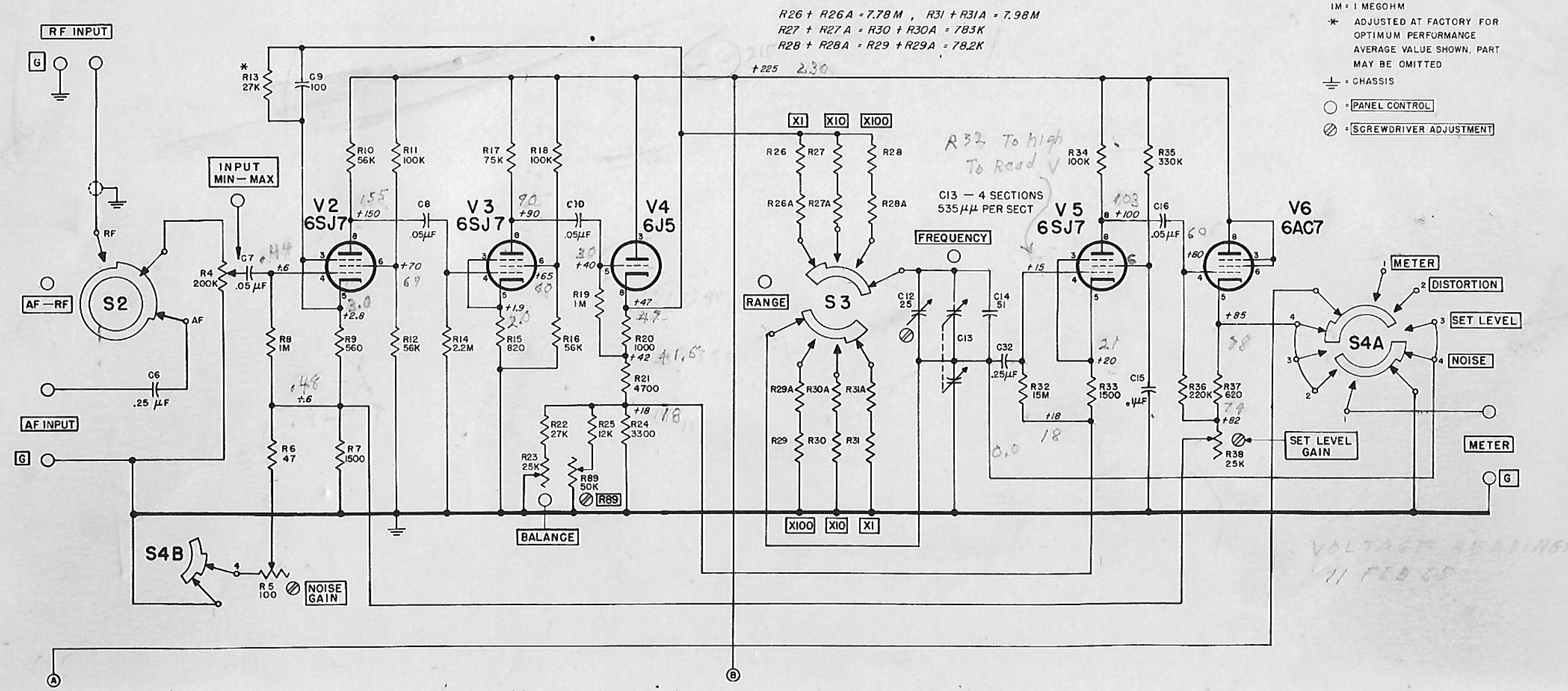
1M = 1 MEGOHM

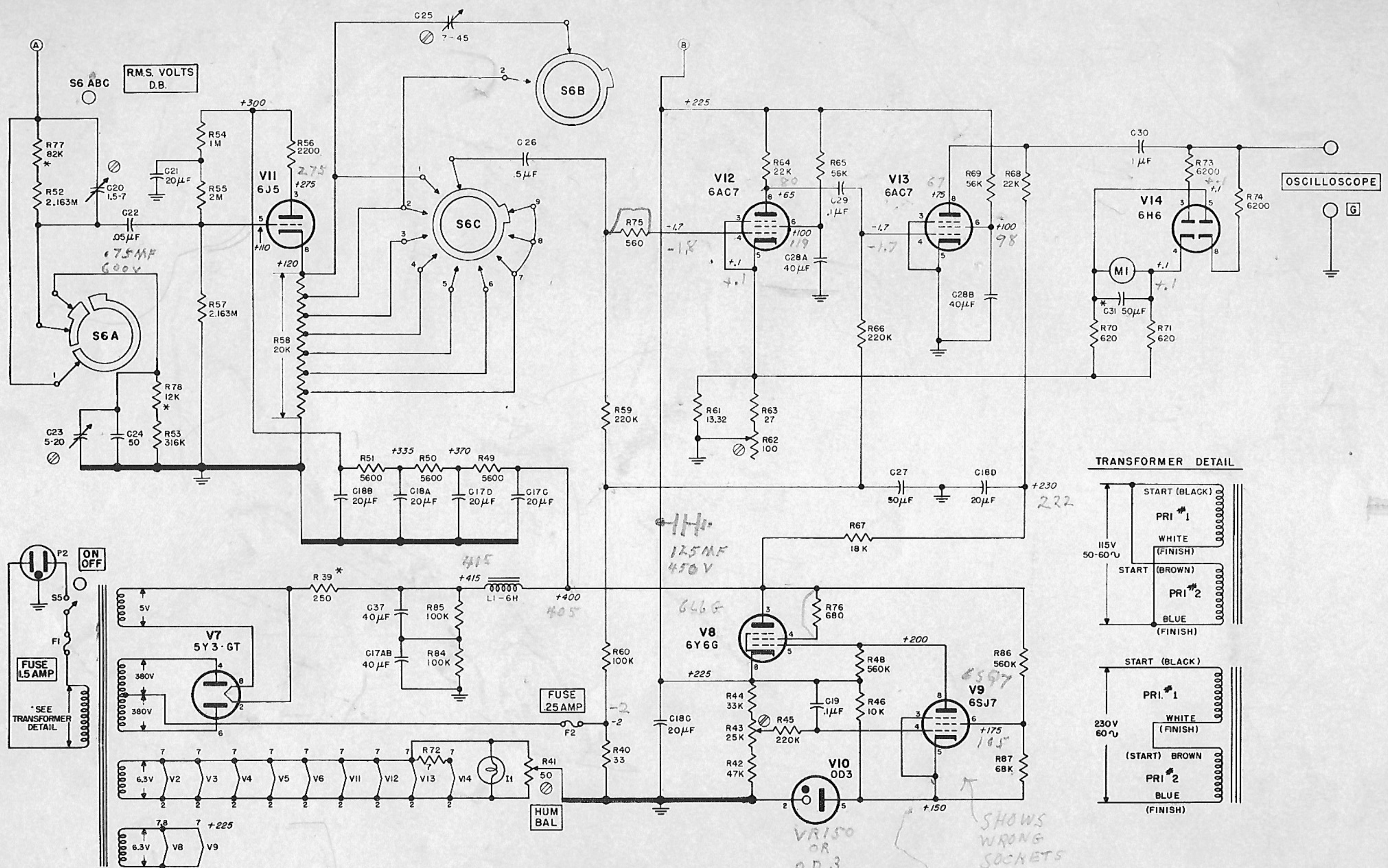
* ADJUSTED AT FACTORY FOR OPTIMUM PERFORMANCE AVERAGE VALUE SHOWN, PART MAY BE OMITTED

⏚ = CHASSIS

○ = [PANEL CONTROL]

⊘ = [SCREWDRIVER ADJUSTMENT]





SCHEMATIC DIAGRAM OF MODEL 330 B

POWER SUPPLY & VOLTMETER SECTION
SERIAL 2023 & ABOVE

PRODUCTION CHANGE

Serial 1459 and above

Replaceable Parts List--

Change R59 to:
Resistor: fixed, composition, 120,000 ohms, ±10%, 1 W, HP Stock #24-120K, Mfr. B, GB 1241

Change C30 to:
Capacitor: fixed, paper, oil filled, approximately 1 μf, 600 vdcw HP Stock #17-12, Mfr. N, 23F467G103

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
C1-C5	These circuit references not assigned		
C6	Capacitor: fixed, paper, .25 µf, 600 vdcw	16-48	
C7	Capacitor: fixed, paper, .05 µf, ±10%, 600 vdcw	16-15	CC 73P47396
C8	Capacitor: fixed, paper, .05 µf, 600 vdcw	16-15	CC 73P47396
C9	Capacitor: fixed, mica, 100 µµf, ±10%, 500 vdcw	14-100	V Type OXM
C10	Capacitor: fixed, paper, .05 µf, ±10%, 600 vdcw	16-15	CC 73P47396
C11	This circuit reference not assigned		
C12	Capacitor: variable, air, 3.6 - 26 µµf	12-9	AA #A-25L
C13	Part of Tuning Capacitor and Drive Assembly		
C14	Capacitor: fixed, ceramic, 51 µµf, ±5%, NPO Temp. Coeff. 500 vdcw	15-6	A, Hi-Q CI-3
C15	Capacitor: fixed, paper, .1 µf, ±10%, 600 vdcw	16-1	CC 73P10496
C16	Capacitor: fixed, paper, .05 µf, ±10%, 600 vdcw	16-15	CC 73P47396
C17 ABCD	Capacitor: fixed, electrolytic, 20, 20, 20, 20 µf, 450 vdcw	18-42	X #FPQ-444
C18 ABCD	Capacitor: fixed, electrolytic, 20, 20, 20, 20 µf, 450 vdcw	18-42	X #FPQ-444
C19	Capacitor: fixed, oil filled paper, .1 µf, ±10%, 600 vdcw	16-1	CC 73P10496
C20	Capacitor: variable, ceramic, 1.5 - 7 µµf, 500 vdcw	13-7	L TS2A NPO

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
C21	Capacitor: fixed, electrolytic, 20 µf, 450 vdcw	18-20	X #FPS-144
C22	Capacitor: fixed, paper, .05 µf, ±10%, 600 vdcw	16-15	CC 73P47396
C23	Capacitor: variable, ceramic, 5 - 20 µµf, 500 vdcw	13-20	L TS2A N300
C24	Capacitor: fixed, mica, 40 µµf, ±10%, 500 vdcw	14-40	V Type OXM
C25	Capacitor: variable, ceramic, 7 - 45 µµf, 500 vdcw	13-1	L TS2A
C26	Capacitor: fixed, paper, .5 µf, ±10%, 400 vdcw	16-58	Brill 4TM-P5
C27	Capacitor: fixed, electrolytic, 50 µf, +200%, -10%, 50 vdcw	18-50	X TC-39
C28 AB	Capacitor: fixed, electrolytic, 20, 20, 20, 20 µf, 450 vdcw	18-42	X #FPQ-444
C29	Capacitor: fixed, oil filled paper, .1 µf, ±10%, 600 vdcw	16-1	CC 73P10496
C30	Capacitor: fixed, paper, 1 µf, ±20%, 400 vdcw	16-44	CC 88P10504S4
C31	Capacitor: fixed, electrolytic, 50 µf, +200%, -10%, 50 vdcw	18-50	X TC-39
C32	Capacitor: fixed, paper, .25 µf, 600 vdcw	16-48	
C33 - C36	These circuit references not assigned		
C37	Capacitor: fixed, electrolytic, 40 µf, 450 vdcw	18-40	X FPS-146
R1 - R3	These circuit references not assigned		
R4	Resistor: variable, composition, 200,000 ohms, linear taper	210-22	B

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
R5	Resistor: variable, wirewound, 100 ohms, linear taper	210-4	G Type 43
R6	Resistor: fixed, composition, 47 ohms, ±10%, 1 W	24-47	B GB 4701
R7	Resistor: fixed, composition, 1500 ohms, ±10%, 1 W	24-820	B GB 1521
R8	Resistor: fixed, composition, 1 megohm, ±10%, 1 W	24-1M	B GB 1051
R9	Resistor: fixed, composition, 560 ohms, ±10%, 1 W	24-560	B GB 5611
R10	Resistor: fixed, composition, 56,000 ohms, ±10%, 1 W	24-56K	B GB 5631
R11	Resistor: fixed, composition, 100,000 ohms, ±10%, 1 W	24-100K	B GB 1041
R12	Resistor: fixed, composition, 56,000 ohms, ±10%, 1 W	24-56K	B GB 5631
R13	Resistor: fixed, composition, 27,000 ohms, ±10%, 1 W Electrical value adjusted at factory	24-27K	B GB 2731
R14	Resistor: fixed, composition, 2.2 megohm, ±10%, 1 W	24-2.2M	B GB 2251
R15	Resistor: fixed, composition, 820 ohms, ±10%, 1 W	24-820	B GB 8211
R16	Resistor: fixed, composition, 56,000 ohms, ±10%, 1 W	24-56K	B GB 5631
R17	Resistor: fixed, composition, 75,000 ohms, ±5%, 1 W	24-83	B GB 7535
R18	Resistor: fixed, composition, 100,000 ohms, ±10%, 1 W	24-100K	B GB 1041
R19	Resistor: fixed, composition, 1 megohm, ±10%, 1 W	24-1M	B GB 1051

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
R20	Resistor: fixed, composition, 1000 ohms, ±10%, 1 W	24-1000	B GB 1021
R21	Resistor: fixed, composition, 4700 ohms, ±10%, 2 W	25-4700	B HB 4721
R22	Resistor: fixed, composition, 27,000 ohms, ±10%, 1 W	24-27K	B GB 2731
R23	Resistor: variable, composition, 25,000 ohms, linear taper	210-54	B
R24	Resistor: fixed, composition, 3300 ohms, ±10%, 1 W	24-3300	B GB 3321
R25	Resistor: fixed, composition, 12,000 ohms, ±10%, 1 W	24-12K	B GB 1231
R26 - R31	Part of Range Switch Assembly		
R32	Resistor: fixed, composition, 15 megohms, ±10%, 1/2 W	23-15M	B EB 1561
R33	Resistor: fixed, composition, 1500 ohms, ±10%, 1 W	24-1500	B GB 1521
R34	Resistor: fixed, composition, 100,000 ohms, ±10%, 1 W	24-100K	B GB 1041
R35	Resistor: fixed, composition, 330,000 ohms, ±10%, 2 W	25-330K	B HB 3341
R36	Resistor: fixed, composition, 220,000 ohms, ±10%, 1 W	24-220K	B GB 2241
R37	Resistor: fixed, composition, 620 ohms, ±5%, 1 W	24-84	B GB 6215
R38	Resistor: variable, composition, 25,000 ohms, linear taper	210-11	G BA1-010-1990
R39	Resistor: fixed, wirewound, 250 ohms, ±10%, 10 W Electrical value adjusted at factory	26-1	S Type 1-3/4E

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
R40	Resistor: fixed, composition, 33 ohms, ±10%, 1 W	24-33	B GB 3301
R41	Resistor: variable, wirewound, 50 ohms, linear taper	210-2	C #21-010-067
R42	Resistor: fixed, composition, 47,000 ohms, ±10%, 1 W	24-47K	B GB 4731
R43	Resistor: variable, composition, 25,000 ohms, linear taper	210-11	G BA1-010-1990
R44	Resistor: fixed, composition, 33,000 ohms, ±10%, 1 W	24-33K	B GB 3331
R45	Resistor: fixed, composition, 220,000 ohms, ±10%, 1/2 W	23-220K	B EB 2241
R46	Resistor: fixed, composition, 10,000 ohms, ±10%, 2 W	25-10K	B HB 1031
R47	This circuit reference not assigned		
R48	Resistor: fixed, composition, 560,000 ohms, ±10%, 1 W	24-560K	B GB 5641
R49	Resistor: fixed, composition, 5600 ohms, ±10%, 1 W	24-5600	B GB 5621
R50	Resistor: fixed, composition, 5600 ohms, ±10%, 1 W	24-5600	B GB 5621
R51	Resistor: fixed, composition, 5600 ohms, ±10%, 1 W	24-5600	B GB 5621
R52	Resistor: fixed, composition, 2.163 megohms, ±1%, 1 W	31-2.163M	GG Type CP-1
R53	Resistor: fixed, composition, 316,000 ohms, ±1%, 1 W	31-316K	GG Type CP-1
R54	Resistor: fixed, composition, 1 megohm, ±10%, 1 W	24-1M	B GB 1051
R55	Resistor: fixed, composition, 2 megohms, ±1%, 1 W	31-2M	GG Type CP-1

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
R56	Resistor: fixed, composition, 2200 ohms, ±10%, 1 W	24-2200	B GB 2221
R57	Resistor: fixed, composition, 2 megohms, ±1%, 1 W	31-2M	GG Type CP-1
R58	Resistor: fixed, wirewound, 20,000 ohms, (Replacement Resistor for Voltmeter Range Switch Assembly)	4A-71	HP
R59	Resistor: fixed, composition, 220,000 ohms, ±10%, 1/2 W	23-220K	B EB 2241
R60	Resistor: fixed, composition, 100,000 ohms, ±10%, 1 W	24-100K	B GB 1041
R61	Resistor: fixed, wirewound, 13.32 ohms	4A-90	HP
R62	Resistor: variable, wirewound, 100 ohms, linear taper	210-28	Muter, #10516
R63	Resistor: fixed, composition, 27 ohms, ±10%, 1 W	24-27	B GB 2701
R64	Resistor: fixed, composition, 22,000 ohms, ±10%, 2 W	25-22K	B HB 2231
R65	Resistor: fixed, composition, 56,000 ohms, ±10%, 1 W	24-56K	B GB 5631
R66	Resistor: fixed, composition, 220,000 ohms, ±10%, 1/2 W	23-220K	B EB 2241
R67	Resistor: fixed, composition, 18,000 ohms, ±10%, 1 W	24-18K	B GB 1831
R68	Resistor: fixed, composition, 22,000 ohms, ±10%, 2 W	25-22K	B HB 2231
R69	Resistor: fixed, composition, 56,000 ohms, ±10%, 1 W	24-56K	B GB 5631
R70	Resistor: fixed, composition, 620 ohms, ±5%, 1 W	24-86	B GB 6225

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
R71	Resistor: fixed, composition, 620 ohms, ±5%, 1W	24-86	B GB 6225
R72	Resistor: fixed, wirewound, 7 megohms, ±10%, 2W	26-18	Z CM 8027
R73	Resistor: fixed, composition, 620 ohms, ±5%, 1W	24-84	B GB 6215
R74	Resistor: fixed, composition, 620 ohms, ±5%, 1W	24-84	B GB 6215
R75	Resistor: fixed, composition, 560 ohms, ±10%, 1W	24-560	B GB 5611
R76	Resistor: fixed, composition, 680 ohms, ±10%, 1W	24-680	B GB 6811
R77-R83	These circuit references not assigned		
R84	Resistor: fixed, composition, 100,000 ohms, ±10%, 1W	24-100K	B GB 1041
R85	Resistor: fixed, composition, 100,000 ohms, ±10%, 1W	24-100K	B GB 1041
R86	Resistor: fixed, composition, 560,000 ohms, ±10%, 1W	24-560K	B GB 5641
R87	Resistor: fixed, composition, 68,000 ohms, ±10%, 1W	26-68K	B GB 6831
R88	This circuit reference not assigned		
R89	Resistor: variable, composition, 50,000 ohms, 1W	210-18	G #33-010-176
	Binding Post:	312-3	HP
	Binding Post Insulator:	G-83A	HP
F1	Fuse: 1.6A, (115V operation) withstands 200% overload for 25 sec.	211-15	E, MDL-1.6
F1	Fuse: .8A, (230V operation) withstands 200% overload for 25 sec.	—	E, MDL-.8

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

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TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
F2	Fuse: .25A, 3AG type	211-6	T, 312.250
	Fuseholder:	312-8	T, #342001
	Indicator Lamp Assembly:	312-10	BB, #807BS
	Knob: 1-5/8" diam.	37-12	HP
	Knob: 1-1/2" diam.	37-11	HP
	Knob: 2" diam.	37-13	HP
I1	Lamp:	211-47	O, Mazda #47
M1	Meter:	112-6	HP
P1	Power Cable:	812-56	HP
L1	Reactor: 6 H @ 125 MA, 240 ohms	911-12	HP
S1	This circuit reference not assigned		
S2	Rotary Switch:	310-32	HP
S3	Range Switch Assembly:	33B-19W	HP
S4 AB	Rotary Switch:	310-49	HP
S5	Toggle Switch:	310-11	D, 20994-HW
S6 ABC	Voltmeter Range Switch Assembly: (Included Replacement Resistor Stock #4A-71)	33B-19C	HP
T1	Power Transformer:	910-56	HP
V1	This circuit reference not assigned		
V2	Tube: 6SJ7	212-6SJ7	ZZ
V3	Tube: 6SJ7	212-6SJ7	ZZ
V4	Tube: 6J5	212-6J5	ZZ
V5	Tube: 6SJ7	212-6SJ7	ZZ
V6	Tube: 6AC7	212-6AC7	ZZ
V7	Tube: 5Y3GT	212-5Y3GT	ZZ
V8	Tube: 6Y6G	212-6Y6G	ZZ
V9	Tube: 6SJ7	212-6SJ7	ZZ
V10	Tube: OD3	212-OD3	ZZ
V11	Tube: 6J5	212-6J5	ZZ
V12	Tube: 6AC7	212-6AC7	ZZ
V13	Tube: 6AC7	212-6AC7	ZZ
V14	Tube: 6H6	212-6H6	ZZ

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

LIST OF MANUFACTURERS CODE LETTERS FOR REPLACEABLE PARTS TABLE

Code Letter	Manufacturer
A	Aerovox Corp.
B	Allen-Bradley Co.
C	Amperite Co.
D	Arrow, Hart and Hegeman
E	Bussman Manufacturing Co.
F	Carborundum Co.
G	Centralab
H	Cinch Manufacturing Co.
I	Clarostat Manufacturing Co.
J	Cornell Dubilier Electric Co.
K	Electrical Reactance Co.
L	Erie Resistor Corp.
M	Federal Telephone and Radio Corp.
N	General Electric Co.
O	General Electric Supply Corp.
P	Girard-Hopkins
HP	Hewlett-Packard
Q	Industrial Products Co.
R	International Resistance Co.
S	Lectrohm, Inc.
T	Littelfuse, Inc.
U	Maguire Industries, Inc.
V	Micamold Radio Corp.
W	Oak Mfg. Co.
X	P.R. Mallory Co., Inc.
Y	Radio Corp. of America
Z	Sangamo Electric Co.
AA	Sarkes Tarzian
BB	Signal Indicator Co.
CC	Sprague Electric Co.
DD	Stackpole Carbon Co.
EE	Sylvania Electric Products, Inc.
FF	Western Electric Co.
GG	Wilkor Products, Inc.
HH	Amphenol
II	Dial Light Co. of America
JJ	Leecraft Manufacturing Co.
ZZ	Any tube having RMA standard characteristics

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number, type number and serial number when referring to this instrument for any reason.

WARRANTY

Hewlett-Packard Company warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof (except tubes, fuses and batteries). This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and which upon our examination is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number, type number and serial number. On receipt of this information, we will give you service instruction or shipping data.

2. On receipt of shipping instruction, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

All shipments of Hewlett-Packard instruments should be made via Railway Express. The instruments should be packed in a wooden box and surrounded by two to three inches of excelsior or similar shock-absorbing material.

DO NOT HESITATE TO CALL ON US

HEWLETT-PACKARD COMPANY

Laboratory Instruments for Speed and Accuracy

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