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INSTRUCTION AND OPERATING MANUAL
FOR

MODELS 505A, 505B
ELECTRONIC TACHOMETER
INDICATOR

Serial 2589 and above

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HEWLETT-PACKARD COMPANY
395 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U. S. A.

General Description

The Models 505A and 505B Electronic Tachometer Indicators are designed to measure the speed of rotating machinery. The measurement range of the Model 505A is 600 to 3,000,000 revolutions/min., while the Model 505B will measure from 10 to 50,000 revolutions/sec.

The tachometer indicator includes a frequency meter calibrated in rpm (or rps). The impulses which operate the instrument may be produced either by (1) a phototube assembly such as the Model 506A Optical Tachometer Pickup or (2) a transducer such as the Model 508A or Model 508B Tachometer Generator. This accessory equipment, is supplied separately. When a Model 506A is employed, the range specified above is obtained by the use of a half white (light reflecting) and half black (light absorbing) target. Impulses are produced when light reflected from the target attached to the rotating machinery actuates the phototube. The output from the phototube is connected by cable to the input of the tachometer indicator.

Facilities are provided by the Models 505A and 505B for accommodating and driving a recorder, so that a permanent record may be made of the rotation measured.

The Model 505A or Model 505B Electronic Tachometer Indicator also may be used as a frequency meter to measure the frequency of an alternating current voltage in the 10 to 50,000 cps range.

CAUTION

The maximum voltage (sum of the DC voltage and the AC peak voltage) applied to the input terminals of this instrument must not exceed 600 volts. Higher voltages will break down the capacitor in the input circuit of this instrument.

Parts Substitutions

Difficulty in procuring some of the parts used in this instrument may cause the electrical or physical values to deviate from those shown in this instruction manual. These substitutions have been made so as not to impair the performance of this instrument. Whenever replacement of any of these parts is necessary, either the substitute value or the original value may be used.

TABLE OF CONTENTS

MODELS 505A, 505B

ELECTRONIC TACHOMETER INDICATOR

	<u>Page No.</u>
Specifications	1
Operating Instructions	
Controls and Terminals.	2
Operating Procedure, as a Tachometer	4
With Model 506A Optical Tachometer Pickup.	5
With Model 508A or 508B Tachometer Generator.	6
Operating Procedure, as a Frequency Meter	7
Connecting a Recorder to the Model 505A (or 505B).	8
Circuit Description	8
Accessories	9
Model 506A Optical Tachometer Pickup	10
Specifications	10
Description.	10
Preparation of Target	11
Model 508A and 508B Tachometer Generators.	13
Maintenance	
Cover and Bottom Plate Removal	14
Hum Balance Adjustment	15
Adjustment of Current Regulator	15
Calibration Adjustment	16
Trouble Shooting	17
Table of Replaceable Parts	18

505A, 505B 6/10/54 Serial 2589 and Above

INSTRUCTIONS
MODELS 505A, 505B
ELECTRONIC TACHOMETER INDICATOR

Specifications

Frequency Rating --

Model 505A -

Range: 600 to 3,000,000 revolutions/min.

Full Scale Indication: 3,000; 6,000; 12,000; 30,000; 60,000;
120,000; 300,000; 600,000; 1,200,000
and 3,000,000 rpm.

Model 505B -

Range: 10 to 50,000 revolutions/sec.

Full Scale Indication: 50, 100, 200; 500; 1,000; 2,000; 5,000;
10,000; 20,000; and 50,000 rps.

Accuracy --

±2% of full scale.

Voltage Stability --

Power line voltage variations from 105 to 125 volts or from 210 to 250
volts will affect the meter indication less than ±1%.

Input Voltage --

Minimum Input Voltage - .5 volts. Variation of the input voltage from
.5 to 200 volts will affect the meter indication not more than ±1%.

Input Impedance --

Approximately 300,000 ohms shunted by 37 μ f.

RECORDER Output Characteristics --

Current - 1 ma.

Resistance - 1400 ohms ±100 ohms.

Power Supply Rating --

Voltage - 102 to 125 volts/210 to 250 volts

Frequency - 50/1,000 cycles/sec.

Wattage - 65 watts

Overall Dimensions --

Cabinet Model - 19" wide x 8-1/2" high x 11-1/2" deep

Rack Model - 19" wide x 8-3/4" high x 11-1/2" deep

Panel Size - 19" x 8-3/4"

Depth Behind Panel - 10-1/2"

Weight --

Cabinet Model - 20 lbs.

Rack Model - 20 lbs.

Operating Instructions

Inspection --

This instrument has been thoroughly tested and inspected before being shipped and is ready for use when received.

After the instrument is unpacked, the instrument should be carefully inspected for damage received in transit. If any shipping damage is found, follow the procedure outlined in the "Claim for Damage in Shipment" page at the back of this instruction book.

Controls and Terminals --

PHOTOTUBE - This jack is provided for connecting a Model 506A Optical Tachometer Pickup, or similar phototube type transducer, to the Model 505A (or 505B). When the Model 506A plug is inserted in the PHOTOTUBE jack, the phototube is connected to the Model 505A (or 505B) DC power supply and amplifier input.

NOTE: With power connected to the instrument, the ON-OFF switch at ON, and a plug in the PHOTOTUBE jack, there will be approximately 90 volts DC on the upper INPUT binding post.

TEST - This switch is provided for testing the input voltage level to determine if it is adequate to operate the instrument.



Model 505B Electronic Tachometer Indicator, RPS



Model 505A Electronic Tachometer Indicator, RPM, Rack Mounted

USE-LINE FREQ-CALIBRATE - This rotary switch changes (1) connections to the meter and (2) arrangement of the input circuit. By means of the connections set up by the switch, the meter may be used to perform several indicating functions.

Switch Position

Function

USE

The meter is connected to indicate RPM (Model 505A) or RPS (Model 505B) and the INPUT terminals are connected to the input of the amplifier.

LINE FREQ.

The meter is connected to indicate frequency in terms of RPM (or RPS), and a 6.3V secondary of the power transformer is connected to the input of the amplifier. With the circuit so arranged, the meter indicates the power line frequency as a check on the instrument calibration.

CALIBRATE

The meter is connected as a DC milliammeter to measure the current drawn by the switching tubes (V4, V5). The current is adjusted by means of the CALIBRATE control so that the meter pointer coincides with the calibration mark (C) on the meter scale. The amplifier input is short circuited when the switch is in this position.

RANGE - This switch is used to insert the correct coupling capacitors and meter shunt resistor in the circuit for any desired range of measurement.

CALIBRATE - This control (variable resistor R29) is used to adjust the current drawn by the switching tubes (V4, V5).

RECORDER - The RECORDER jack is provided for connecting a recorder to the instrument. The Model 505A (or 505B) is designed to drive an Easterline-Angus Automatic Recorder. However, other recorders may be substituted if their resistance is 1400 ohms \pm 100 ohms and a full scale indication can be obtained with a current of one milliamper.

ON-OFF - This toggle switch controls all the power supplied to the instrument from the power line. The red indicating lamp above the ON-OFF switch lights to indicate that power is connected to the instrument.

FUSE - The fuseholder, located on the back of the instrument, contains a 1 ampere cartridge fuse (for 115 volt operation). To replace the fuse, unscrew the fuseholder cap and remove the blown fuse, insert a new fuse of the same type and replace the fuseholder cap. For 230 volt operation this fuse should have a 1/2 ampere rating. Replacement fuses must be of the "Slo-Blo" type as specified in the Table of Replaceable Parts in this instruction manual. (The instrument is shipped from the factory wired for 115V operation unless specially ordered for 230V operation.

Power Cable - This is a special three conductor power cable with a standard two prong male plug molded on one end. The third conductor (green) protrudes from the power cable near the plug and may be used to connect the instrument chassis to an external ground.

INPUT - These binding posts are connected to the input circuit of the instrument. The binding post marked G is connected to the chassis.

When used with a Model 508A (or 508B) Tachometer Generator or when used as a frequency meter, connection to the instrument is made at the INPUT binding posts.

CAUTION: With power connected to the instrument, the ON-OFF switch at ON, and a plug in the PHOTOTUBE jack, there will be approximately 90 volts DC on the upper input binding post.

Operating Procedure, as a Tachometer --

1. Plug the instrument into a 115/230 volt, 50/1,000 cycle power source. Turn the ON-OFF switch to ON. To obtain maximum accuracy, allow the instrument to warm up for approximately 30 minutes.
2. Set the USE-LINE FREQ. -CALIBRATE switch to the CALIBRATE position. Adjust the CALIBRATE control so that the meter pointer coincides with the meter scale division labeled "C". On the Model 505A meter, "C" is located at approximately 5100 on the 0-6000 scale; on the Model 505B meter, "C" is located at approximately 85 on the 0-100 scale. This step in the procedure calibrates the instrument. The calibration should be rechecked occasionally while making measurements.
3. If the frequency of the power source is 60 cycles, set the RANGE switch to 6000 on the Model 505A, to 100 on the Model 505B. (If the power source is of a frequency other than 60 cycles, set the RANGE switch to cover the frequency.) Change the USE-LINE FREQ. -CALIBRATE switch to the LINE FREQ. position. For a Model 505A, the meter indication should be 60 times that of the frequency of the power source; for a Model 505B, the meter indication, in rps, should be the same numerically as the frequency of the power source. This measurement serves as a check on the calibration of the instrument. So long as the current is set at the 5100 rpm (85 rps) mark, overall calibration will be within rated accuracy ($\pm 2\%$ of full scale, or better).

CAUTION

No external voltage should be applied to the INPUT terminals when the power line frequency is being measured. Application of external voltage during this measurement may cause an inaccurate line frequency indication.

4. Change the USE-LINE FREQ. -CALIBRATE switch to the USE position.
5. Set the RANGE switch to cover the rpm (or rps) to be measured. If the approximate rpm or rps is unknown, turn the RANGE switch to the highest range.

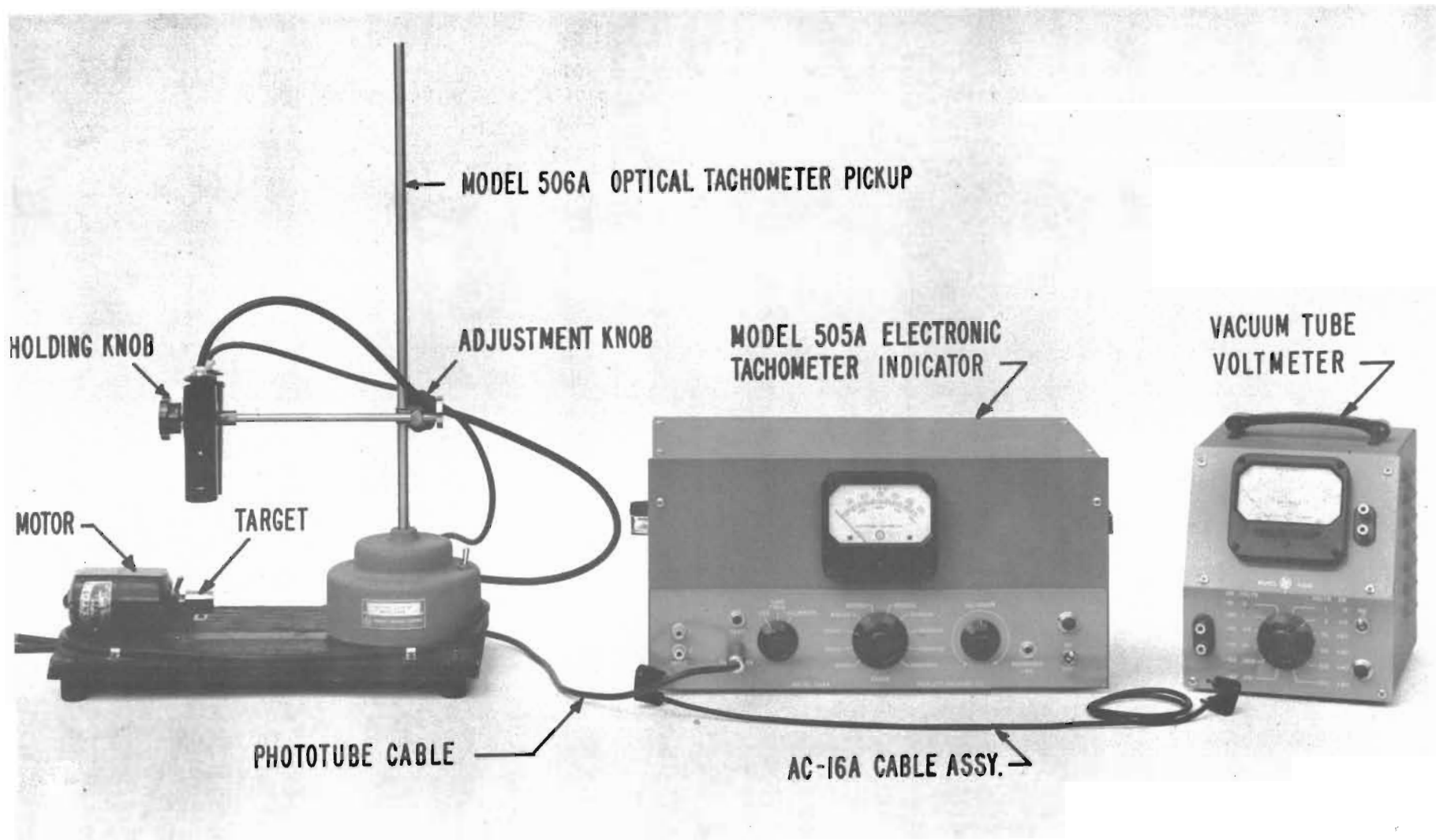


Fig. 1. Model 505A Electronic Tachometer Indicator Connected to Model 506A Optical Tachometer Pickup Facilities for Connection to Vacuum Tube Voltmeter Shown

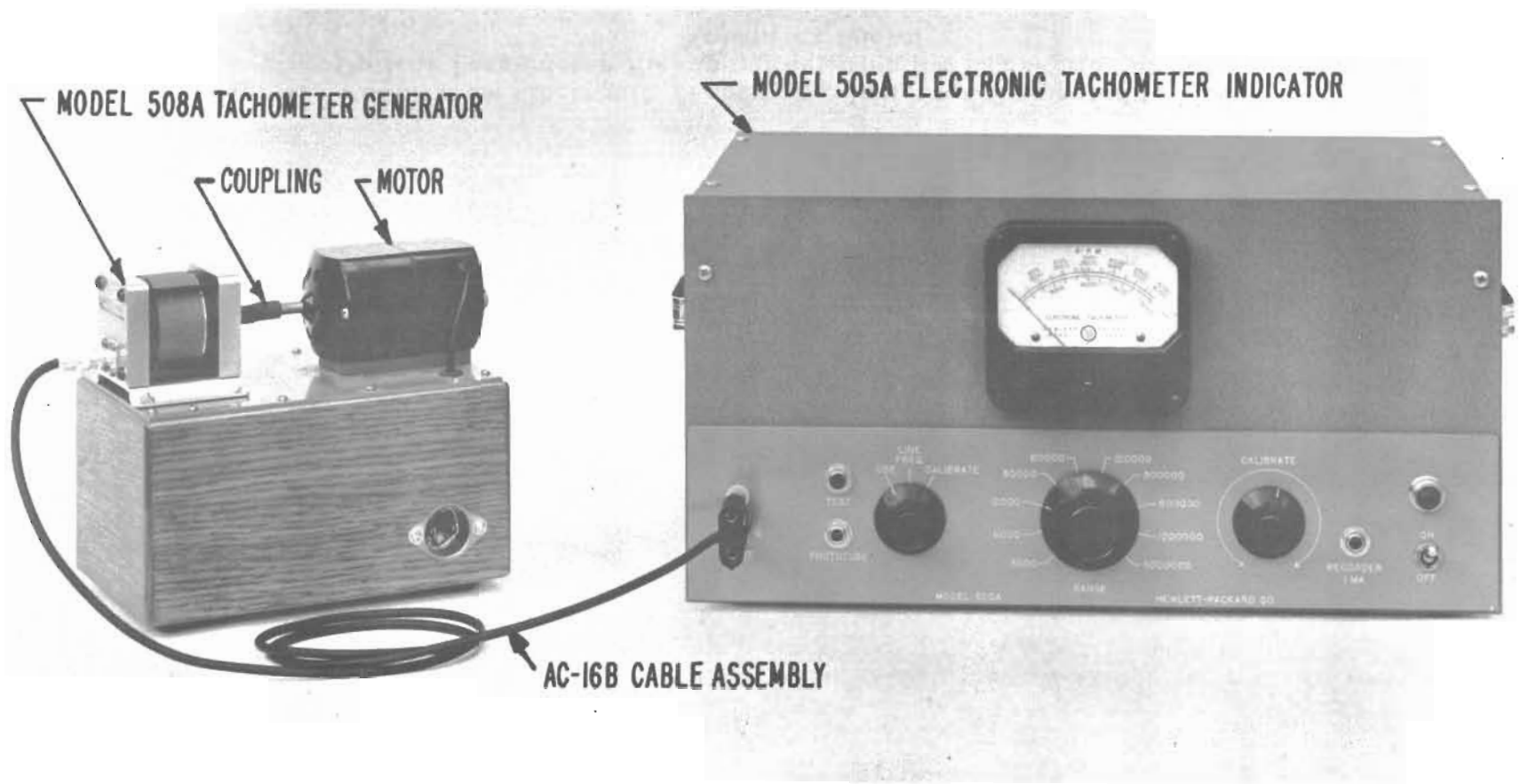


Fig. 2. Model 505A Electronic Tachometer Indicator Connected to Model 508A Tachometer Generator

With Model 506A Optical Tachometer Pickup (Fig. 1)

NOTE: For descriptive information on the Model 506A and on preparation of the light reflecting and absorbing target, see the Accessories section below.

6. Plug the Model 506A power cable (terminated in 2-prong male plug) into a 115 volt 50/1,000 cps power source.

7. Plug the phototube cable (terminated in telephone-type plug) into the PHOTOTUBE jack on the Model 505A (or 505B) control panel.

8. There is a toggle switch on the base of the Model 506A. Turn this switch to the ON position.

9. To position the tachometer head at such angle to and distance from the reflecting surface (target) that maximum voltage will be obtained, it is necessary to measure the voltage the phototube is delivering to the tachometer indicator. A high impedance vacuum tube voltmeter with a measurement range of at least .3 volt to 10 volts (such as a Hewlett Packard Model 400A, 400B, 400C, 400D, 410A, or 410B) should be used. Connect the voltmeter to the Model 505A (or 505B) at the INPUT terminals. (A Hewlett-Packard AC-16A Cable Assembly, terminated at each end with a dual banana plug, may be used for making the connection.)

NOTE: It is desirable to use a voltmeter with at least 10 megohms input impedance when measuring voltages. Under no circumstances should a voltmeter of less than 1 megohm input impedance be used. (A 1 megohm input meter will reduce the voltage from the phototube to about 40% of its normal value.) To obtain maximum voltage from the Model 506A, the voltmeter should be disconnected after the position of the tachometer head has been adjusted.

10. With the shaft (and target) in motion, adjust the angle at which the light strikes the reflecting surface and the distance of the lamp and phototube from the reflecting surface to that position where maximum indication is obtained on the voltmeter. The position-adjusting knob is at the junction of the arm and stand. The knob on the tachometer head is for positioning and holding the head during adjustment. Tighten the adjustment knob until the tachometer head is clamped rigidly in position. The proper distance of the head from the target will be found to be between 3 and 6 inches from the target. (Preparation of the target is discussed under Accessories.)

11. Disconnect the voltmeter from the Model 505A (or 505B).

12. If the approximate rpm (or rps) was not known and the RANGE switch was set for the highest range, change the switch to successively lower ranges until a range is found that produces a readable meter indication.

13. While the meter is indicating the speed of rotation, depress and hold in the TEST button. If the meter indication is changed by not more than 1% by this test, then there is sufficient input voltage for the meter to give an accurate indication. Insufficient input voltage, as shown by a lowered meter indication when

505A, 505B 6/10/54 Serial 2589

the TEST button is depressed, will result in inaccurate measurements. (The input voltage should be at least .5 volt, but should not exceed 200 volts RMS.)

With Model 508A or 508B Tachometer Generator (Fig. 2)

NOTE: For descriptive information on the Models 508A and 508B, see the Accessories section below.

6. The cable assembly for the tachometer generator is not connected to the generator when shipped. Connect the cable assembly at the BNC connector on the rear of the generator.

7. Couple the Model 508A (or 508B) to the shaft of the mechanism under measurement.

8. Connect the tachometer generator to the Model 505A (or 505B) at the INPUT terminals.

NOTE: A Hewlett-Packard AC-16B Cable Assembly (BNC connector at one end, dual banana plug at the other), or cable assembly offering similar connectors, is required for connecting the Model 508A (or 508B) to a Model 505A (or 505B). Normally the tachometer generator is supplied with an AC-16K Cable Assembly (BNC connectors at both terminations), and an AC-16B Cable Assembly should be ordered when the generator is to be used with a Model 505A or 505B.

9. Actuate the mechanism under measurement.

10. If the approximate rpm (or rps) was not known and the RANGE switch was set for the highest range, change the switch to successively lower ranges until a range is found that produces a readable meter indication.

11. While the meter is indicating the speed of rotation, depress and hold in the TEST button. If the meter indication is changed by not more than 1% by this test, then there is sufficient input voltage for the meter to give an accurate indication. Insufficient input voltage, as shown by a lowered meter indication when the TEST button is depressed, will result in inaccurate measurements. (The input voltage should be at least .5 volt, but should not exceed 200 volts RMS.)

12. When the Model 508A is used with a Model 505B, the meter indication is the speed of the shaft in rpm. When the Model 508A is used with a Model 505A or when the Model 508B is used with either a Model 505A or 505B, a conversion is required to obtain the actual speed of the shaft in rpm. The following table gives the conversion factor for each instrument.

Indicating Instrument	CONVERSION TABLE (DBM)	
	Tachometer Generator	
	Model 508A	Model 508B
Model 505A	Meter Indication ÷ 60	Meter Indication ÷ 100
Model 505B	Direct Indication	Meter Indication x .6

Operating Procedure, as a Frequency Meter --

NOTE: The transducer must be disconnected from the Model 505A (or 505B) while making frequency measurements.

The Model 505A (or 505B) may be used as a frequency meter to measure the frequencies of alternating current voltages in the range from 10 cps to 50,000 cps. When a Model 505A is used, the meter indication in rpm should be divided by 60 to obtain the cycles per second. When a Model 505B is used, the meter indication in rps will correspond to the number of cycles per second. The operating procedure is as follows:

1. Plug the instrument into a 115/230 volt, 50/1,000 cycle power source. Turn the ON-OFF switch to ON. To obtain maximum accuracy, allow the instrument to warm up for approximately 30 minutes.
2. Set the USE-LINE FREQ. -CALIBRATE switch to the CALIBRATE position. Adjust the CALIBRATE control so that the meter pointer coincides with the meter scale division labeled "C". On the Model 505A meter, "C" is located at approximately 5100 on the 0-6000 scale; on the Model 505B meter "C" is located at approximately 85 on the 0-100 scale. This step in the procedure calibrates the instrument. The calibration should be rechecked occasionally while making measurements. So long as the current is set at the 5100 rpm (85 rps) mark, overall calibration will be within rated accuracy ($\pm 2\%$ of full scale, or better).
3. If the frequency of the power source is 60 cycles, set the RANGE switch to 6000 on the Model 505A, to 100 on the Model 505B. (If the power source is of a frequency other than 60 cycles, set the RANGE switch to cover the frequency.) Change the USE-LINE FREQ. -CALIBRATE switch to the LINE FREQ. position. For a Model 505A, the meter indication should be 60 times that of the frequency of the power source; for a Model 505B, the meter indication should be the same numerically as the frequency of the power source. This measurement serves as a check on the calibration of the instrument.

CAUTION

No external voltage should be applied to the INPUT terminals when the power line frequency is being measured. Application of external voltage during the measurement may cause an inaccurate line frequency indication.

4. Change the USE-LINE FREQ. -CALIBRATE switch to the USE position.
5. Set the RANGE switch to cover the frequency to be measured. If the approximate frequency is unknown, turn the RANGE switch to the highest frequency range.
6. Apply the voltage to be measured to the INPUT terminals. If the RANGE switch was set at maximum, turn the switch to successively lower ranges until a range is found that produces a readable meter indication.

CAUTION

THE MAXIMUM VOLTAGE (SUM OF THE DC VOLTAGE AND THE AC PEAK VOLTAGE) APPLIED TO THE INPUT TERMINALS OF THIS INSTRUMENT MUST NOT EXCEED 600 VOLTS. HIGHER VOLTAGES WILL BREAK DOWN THE CAPACITOR IN THE INPUT CIRCUIT OF THIS INSTRUMENT.

7. While the meter is indicating the frequency of the voltage being measured, depress and hold in the TEST button. If the meter indication is changed by not more than 1% by this test, then there is sufficient input voltage for the instrument to produce an accurate measurement. Insufficient input voltage, as shown by a lowered meter indication when the TEST button is depressed, will result in inaccurate measurements. (The input voltage should be at least .5 volt, but should not exceed 200 volts RMS.)

Connecting a Recorder to the Model 505A (or 505B) --

The RECORDER jack connections include a variable resistor (R56) by means of which the output resistance of the Model 505A (or 505B) may be matched, within the ± 100 ohms, to the input resistance of the recorder. The adjustment is made as follows:

1. Perform steps 1 through 3 of the Operating Procedure, and note the meter indication when the power line frequency is measured.
2. Leave the USE-LINE FREQ. -CALIBRATE at LINE FREQ., and plug the lead from the recorder into the RECORDER jack. If the meter indication is not the same as noted in step 1, adjust resistor R56 (see Fig. 8) to obtain the same indication as in step 1.

NOTE: When the RECORDER jack is at normal (no plug in the jack), fixed resistor R53 is connected into the circuit and resistor R56 is disconnected. Thus a change in the setting of resistor R56 has no effect on the circuit of the Model 505A (or 505B) while the RECORDER jack is at normal.

Circuit Description

The Model 505A (or 505B) Electronic Tachometer Indicator consists of a limiting amplifier, an electronic switch, a pulse counter circuit, a constant current regulator, and a power supply.

The incoming voltage of unknown frequency is applied to the grid of V1, the first stage of the limiting amplifier (tubes V1, V2, V3). Tubes V1 and V2 amplify and flatten the peaks of the incoming voltage. Tube V3 is a phase inverter.

The square waves obtained from the plate circuits of tubes V2 and V3, opposite in phase, are applied to the grids of tubes V4 and V5, which comprise the electronic switch.

The space current for the two switching tubes is obtained from the constant current regulator. The proper pair of pulse-counter capacitors for the desired range is selected by the RANGE switch, which at the same time selects the proper shunt resistor for the meter. When the square wave from V2 is in the positive half of the cycle, switching tube V4 is biased to conduct, and current from the regulator flows through V4 to charge one of the capacitors in the C9-C18 group. When the voltage on the grid of V4 becomes negative, the wave from phase inverter V3, applied to the grid of V5, is in the positive half of the cycle. Switching tube V5 in turn conducts, and current from the regulator flows through V5 to charge one of the capacitors in the C19-C28 group. The time constants of the two RC combinations (load resistor R33/capacitor from C9-C18 group and load resistor R32/capacitor from C19-C28 group) are equal. The resistor and capacitor values are such that, at the highest frequency to be counted, the capacitor will be fully charged before the end of the half cycle. The accurately controlled pulses from the pair of capacitors are converted to unidirectional pulses by crystal-rectifiers CR1-CR4, and the resultant current flows through the meter. The meter indication is proportional to the number of pulses per unit of time and therefore to the frequency of the voltage applied to the input of the instrument. Resistors R34 to R43 are shunts, one of which (selected by the RANGE switch) is connected across the meter to adjust the current through the meter to the correct value for the selected frequency range.

Two resistors (R53 and R56) are connected to contacts of the RECORDER jack, but only one resistor is in the circuit at any one time. With the jack at normal, variable resistor R56 is shunted, and resistor R53 is connected into the meter circuit. Resistor R53 constitutes a dummy load approximately equivalent to the load a recorder presents, and is inserted in the circuit when no recorder is connected to the instrument. With a plug in the RECORDER jack, resistor R53 is disconnected from the circuit, and resistor R56 is inserted. Adjustment of the Model 505A (or 505B) recorder circuit to that of the recorder within a 1400 ± 100 ohms limit is made by means of variable resistor R56.

The constant current regulator consists of tubes V7, V8. Tube V8 is a voltage regulator tube which maintains a constant voltage on the screen grid of tube V7. A voltage divider (R48, R49, R50) is connected between the screen grid and ground. The variable resistor (R49) in this divider is provided so that the voltage applied to the grid of V7 may be adjusted to produce the desired constant current for the switching tubes. This current is measured by switching the meter (M1) across resistor R27 in the plate circuit of tube V7.

Accessories

Transducers are available for converting mechanical energy into electrical impulses. Such accessories are not supplied with the instrument but may be purchased from the Hewlett-Packard Co. These transducers, together with their specifications and information pertinent to their use with the Model 505A (or 505B), are described below.

Model 506A Optical Tachometer Pickup --

Specifications -

Shaft Speed Range (with target consisting of one light-reflecting and one light-absorbing surface):

With Model 505A: 600 to 300,000 rpm

With Model 505B: 10 to 5,000 rps

Measurement of speeds above 300,000 rpm is made possible by insertion of an amplifier, such as a Hewlett-Packard 450A Stabilized Laboratory Amplifier, between the Model 506A and the Model 505A (or 505B).

Measurement of speeds below 600 rpm is made possible by the use of additional reflecting and absorbing segments on the target.

Voltage Output: At least .5 volt RMS, 600 to 300,000 rpm (10 to 5,000 rps) (into high impedance) with light reflecting and absorbing surfaces 3/4" square.

Bias Voltage for Phototube: +70 to +90 volts DC (supplied by Model 505A [or 505B]).

Power Supply for Lamp: 115 volts $\pm 10\%$, 50/1000 cps, 25 watts.

Description (Fig. 3) - The tachometer head assembly includes (1) a 21 candle-power, 6 volt incandescent lamp and condensing lens mounted in a shielded tube, and (2) a type 1P41 phototube and condensing lens mounted in the same size shielded tube. The mounting stand for the lamp-phototube head is equipped with an adjusting mechanism which permits the head to be adjusted both as to angle and as to height. A step-down transformer for the lamp circuit is housed in the base of the mounting stand. A toggle switch, designated ON-OFF, on the base, controls the power for the light circuit.

The Model 506A has two cables, one for connecting the light circuit to a source of 115 volt, 50/1000 cycle AC, and the other for connecting the phototube to an instrument which includes an indicating meter, such as the Model 505A (or 505B). The phototube cable is a 3 foot shielded cable terminated in a telephone-type plug. When the plug is inserted in the PHOTOTUBE jack of a Model 505A (or 505B), the center conductor, connected to the tip, transmits 70-90 volts DC from the Model 505A (or 505B) power supply to the plate of the phototube, and also transmits the signal voltage from the phototube to the Model 505A (or 505B). The shield conductor, connected to the ring, connects the cathode of the phototube to ground on the PHOTOTUBE jack.

PHOTOTUBE
ASSEMBLY

ADJUSTMENT
KNOB

LAMP
ASSEMBLY

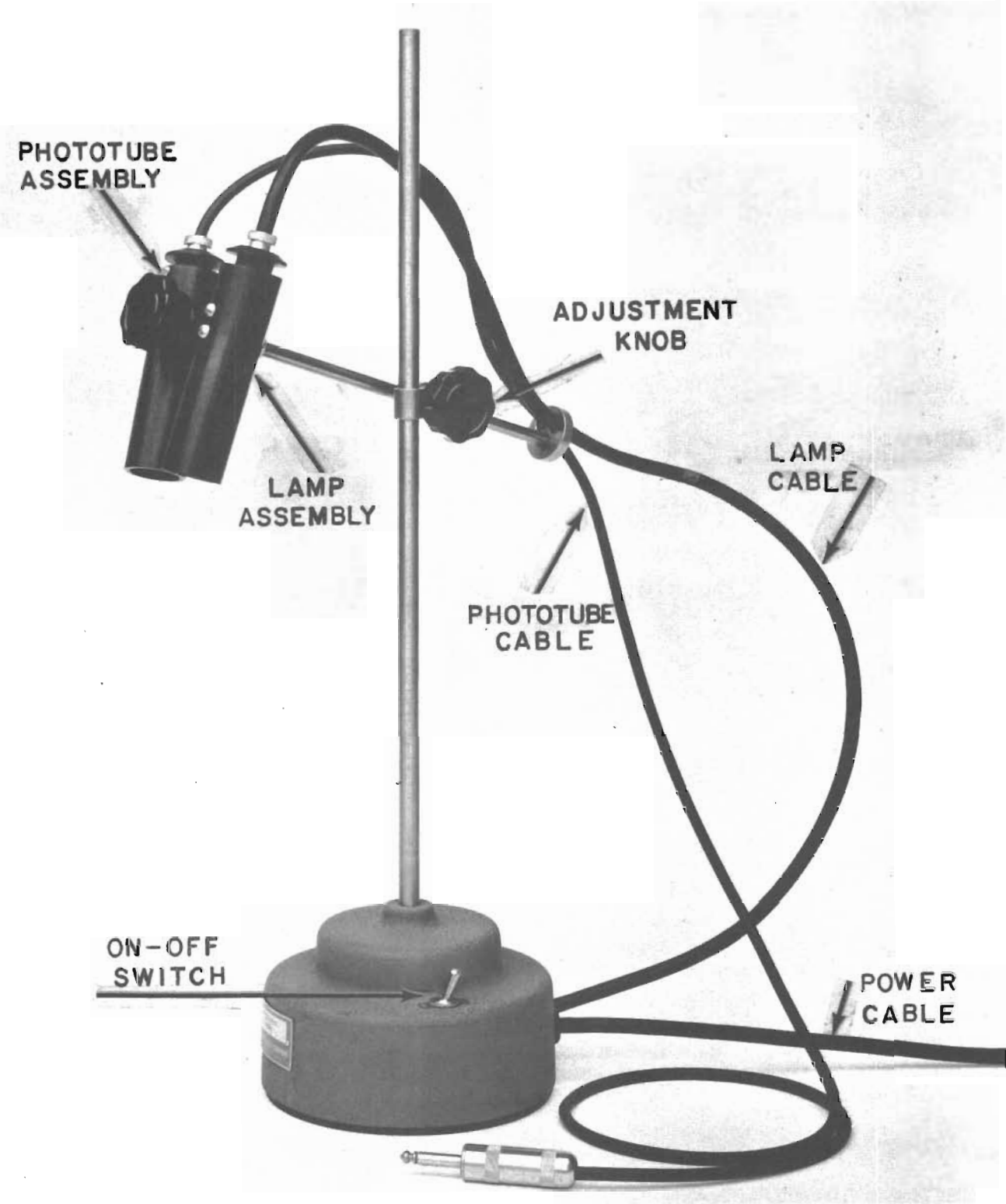
LAMP
CABLE

PHOTOTUBE
CABLE

ON-OFF
SWITCH

POWER
CABLE

Fig. 3. Model 506A Optical Tachometer Pickup



Construction of the Model 506A Optical Tachometer Pickup is such that the light is concentrated by the lamp lens into a focal point approximately 3/4" wide, and when focused on a light-reflecting surface, the reflected light is picked up by the phototube lens, and focused on the phototube. With the rotating part prepared with alternate reflecting and absorbing surfaces, an interrupted reflected light is focused on the phototube; the electrical impulses generated thereby are transmitted to the Model 505A (or 505B).

Several factors determine the amount of voltage the phototube can deliver to the Model 505A (or 505B). (1) The angle at which the light from the source hits the target. The focal point, which will appear as a narrow concentration of light about 3/4 inch long, should be as nearly parallel as possible to the dividing line between the reflecting and absorbing segments. (2) The distance of the tachometer head (lamp and phototube) from the light-reflecting surface. (The proper angle to and distance from the target are determined by measuring the voltage delivered by the phototube to the Model 505A [or 505B], as described in step 10 of the operating procedure.) (3) The size of the reflecting area. The amount of light picked up by the lens and focused on the phototube is a factor in the amount of voltage the phototube can deliver. The light reflecting surface should have approximately the area of a square 3/4 inch by 3/4 inch. (4) The degree of reflection. The more intense the light picked up by the phototube lens, the higher the voltage the phototube can deliver. The intensity of the light source and the quality of the reflecting surface both contribute to the amount of light the phototube lens can pick up. (5) The speed at which the target is rotating. A rapidly rotating target will result in a high-frequency voltage from the phototube. Some of the factors introduced at higher frequencies are discussed briefly below under High Speed Rotation.

The Model 506A in conjunction with a Model 505A (or 505B) is capable of measuring very high speeds of moving parts which have small energy or which for other mechanical reasons cannot be mechanically connected to any measuring device.

Preparation of Target (Figs. 4 and 5) - When using a Model 506A Optical Tachometer Pickup, the rotating part under measurement must be prepared by suitable means to have alternating light-reflecting and light-absorbing surfaces of approximately equal size. For best results, the reflecting and absorbing surfaces each should have an area of at least 3/4 inch by 3/4 inch square.

The reflecting area should be treated by paint or other means to provide very high reflection. The absorbing area should be treated to absorb as much light as possible. When the speed of rotation is above 600 rpm, the rotating part may be prepared to present a half white and half black target; when the speed of rotation is below 600 rpm, the target should have two or more reflecting and absorbing surfaces. Since operation of the phototube involves reception of light followed by absence of light, it is desirable that an area of high reflection be followed by an area of nearly total absorption of light. The nearer the target comes to meeting this requirement, the more efficient will be the operation of the phototube.

The location of the target on the moving part generally will be governed by (1) availability of space suitable for preparation of a target, (2) accessibility, and (3) sufficiency of space for setting up the Model 506A for use with the target. The target may be prepared either on the flat surface of the rotating part as shown in Fig. 4, or on the curved surface as shown in Fig. 5. To measure speeds up to 300,000 rpm, when the target is prepared on the curved surface of the shaft, the diameter of the shaft must be at least 1/2 inch. Speeds of shafts of less than 1/2 inch diameter may be measured, but over a narrower speed range.

Small Diameter Shafts - To measure speeds up to 300,000 rpm, shafts of less than 1/2 inch diameter may be fitted (1) with a sleeve at least 3/4 inch long and 1/2 inch in diameter, or (2) with a rotating surface at right angles to the axis of the shaft, the surface to be of such size that it provides reflecting and absorbing surfaces each approximately the area of a 3/4 inch square.

Low Speed Rotation - With a Model 505A (or 505B), the lowest speed which can be measured with a half white, half black target is about 600 rpm (10 rps). Slower speeds may be measured, however, by marking off the target into a larger number of segments. If, for example, two reflecting and two absorbing segments are provided, speeds as low as 300 rpm (5 rps) may be measured. With such a target, at 300 rpm the meter will indicate 600 rpm (10 rps). To obtain the actual rpm (or rps), the meter indication must be divided by the number of light reflecting segments, in this case two.

Division of the rotating part into a greater number of segments permits the measurement of much lower speeds. For example, if the shaft is rotating at about 120 rpm (2 rps), the target may be divided into eight light-reflecting and eight light-absorbing segments. At 120 rpm, the meter indication will be 960 on a Model 505A or 16 on a Model 505B. Since there are eight light reflecting surfaces, division by eight gives the actual shaft speed in rpm or rps. To determine the number of segments which will be required when the shaft is rotating at a low rate of speed, divide the minimum rotations required by the indicating instrument by the estimated speed of the shaft under test. This will be the number of light absorbing segments required. For example, if measuring the speed of rotation of a turntable (78 rpm), with the tachometer head assembly delivering impulses to a Model 505A, divide 600 by 70 (estimated speed of the turntable). The closest whole number is 9. Therefore the surface of the turntable should be marked off into nine light-reflecting and nine light-absorbing segments. Since the turntable actually is turning at 78 rpm, 9×78 impulses per minute will be transmitted to the Model 505A, and its meter will indicate 702 rpm. To obtain the speed of the turntable, divide 702 by the number of light-reflecting segments: 702 divided by 9 is 78 rpm, the speed of the turntable.

High Speed Rotation - The highest speed it is practical to measure is limited by the amount of attenuation introduced at the higher frequencies. The response of the phototube is down approximately 3 db at 600,000 rpm, and the shunting capacities of the interconnecting cable, sockets, tubes, etc. of the tachometer head at the higher frequencies greatly reduces the signal voltage available at the phototube plug.

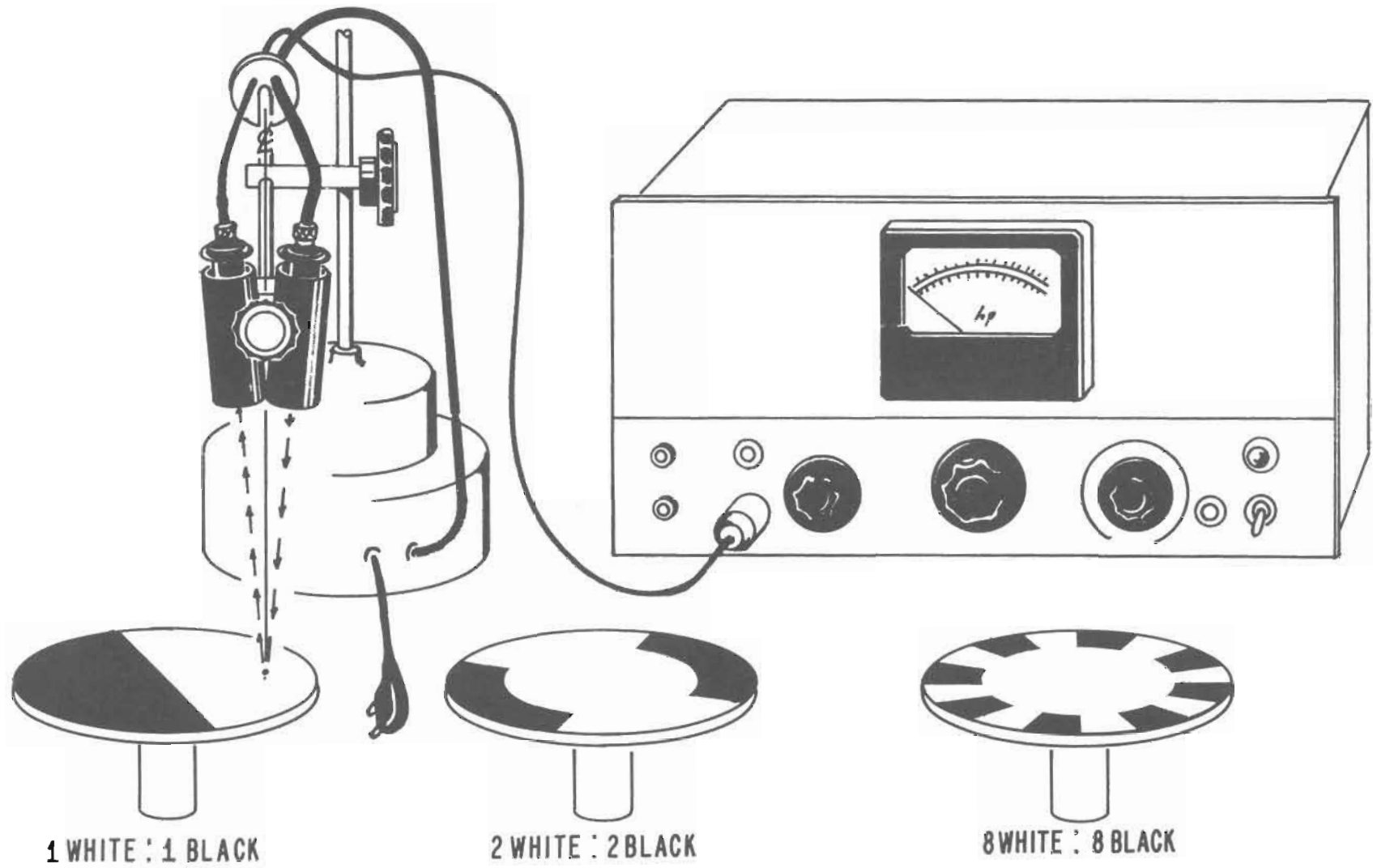


Fig. 4. Model 506A and Target Prepared on Flat Surface

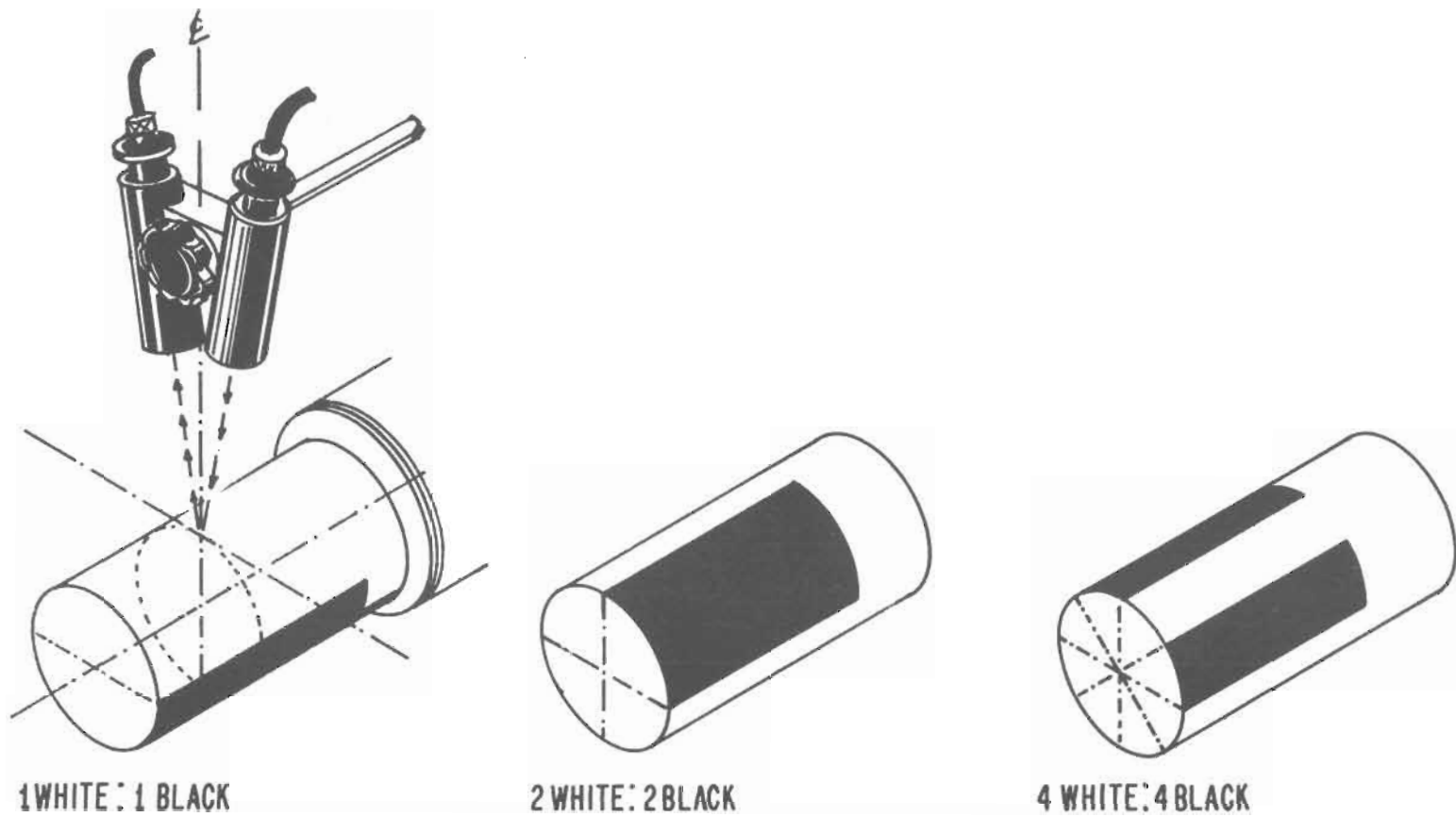


Fig. 5. Model 506A and Target Prepared on Curved Surface of Rotating Part

To compensate for the higher losses inherent in the system at higher frequencies, the output from the Model 506A may be amplified, the intensity of the light may be increased, or the reflecting quality of the light-reflecting areas may be improved.

To amplify the output of the Model 506A, an amplifier such as the Hewlett-Packard Model 450A Stabilized Laboratory Amplifier may be inserted between the Model 506A and the Model 505A (or 505B). With amplification, the measurement range may be extended to approximately 600,000 rpm (10,000 rps).

When measuring speeds above 300,000 rpm, an increase in light intensity is required if the Model 506A is to be used without an amplifier. Where greatly increased light intensity is required, an external light source may be used.

Models 508A and 508B Tachometer Generators --

Specifications -

Shaft Speed Range: 30 to 30,000 rpm
(Into Model 505A or
505B Electronic
Tachometer
Indicator)

Measurement of speeds above and below rated limits is made possible by insertion of an amplifier, such as a Hewlett-Packard 450A Stabilized Laboratory Amplifier, between the Model 508A (or 508B) and the Model 505A (or 505B). With an amplifier, the Model 508A may be used in the measurement of speeds within a range of from 15 to 40,000 rpm, and the Model 508B may be used within a range of from 15 to 30,000 rpm.

Output Voltage: At least .5 volt RMS at 30 rpm and at 25,000 rpm (into Model 505A or 505B).

Drive Shaft: 1/4" diameter, projects 19/32".

Torque: Approximately 1/4 in. -oz. at 200 rpm; 1/2 in. -oz. at 1,500 rpm.

Peak Starting Torque: Approximately 4 in. -oz.

Moment of Inertia: Calculated value, approximately 22 gm. cm.².

Mounting Dimensions: Four 3/16" diameter mounting holes on 2" centers front-to-back, 3" centers side-to-side.

Description (Fig. 6) - The Model 508A (or 508B) Tachometer Generator consists of an alnico magnet arranged in a closed magnetic loop which is interrupted when the generator shaft is turned. The Model 508A is so arranged that the loop is interrupted 60 times per revolution, and the Model 508B, 100 times per revolution. Thus the Model 508A delivers an output voltage of 60 cycles per revolution, and the Model 508B delivers an output voltage of 100 cycles per revolution. A pick-up coil couples the induced voltage to a coaxial type output connector. The closed-loop design enables the generator to be used in the presence of relatively strong external fields without effect on measurements. Because of its low driving torque, the Model 508A (or 508B) may be used with all but small energy devices without constituting a significant load.

The rotor is mounted in permanently-lubricated ball bearings, and may be rotated either in a clockwise or counterclockwise direction. The rotor drive shaft projects more than a half inch, thus providing sufficient exposed shaft to permit a firm coupling arrangement. The tachometer generator cannot be used in the measurement of rotary speeds unless the mechanism under measurement offers an exposed shaft to which the generator may be coupled.

Connection between the generator and the Model 505A (or 505B) Electronic Tachometer Indicator is completed by means of an auxiliary cable assembly furnished with the tachometer generator. Normally an AC-16K Cable Assembly is furnished with the generator. When the Model 508A (or 508B) is to be used with an electronic tachometer indicator, a Hewlett-Packard AC-16B Cable Assembly should be ordered. This assembly provides the dual banana plug required to complete the connection to the Model 505A (or 505B).

The specified range limits were obtained with a Model 508A (or 508B) operating into a Model 505A (or 505B), which offers an input impedance of at least 300,000 ohms shunted by 37 $\mu\mu\text{f}$.

Maintenance - Models 505A & 505B

Cover and Bottom Plate Removal --

The bottom plate is removed by unscrewing the four screws, one in each corner of the bottom plate, which fasten the plate to the chassis.

The cover is removed by unscrewing the eight screws which fasten the cover to the back and top of the instrument.

Tube Replacement --

Any tube having RETMA standard characteristics may be used for replacement purposes in this instrument.

Meter Zero Adjustment --

The meter zero adjust screw should be set for the best tracking of the meter. The screw is not sealed. If the meter pointer does not indicate exactly on zero, the accuracy of the meter need not be doubted.

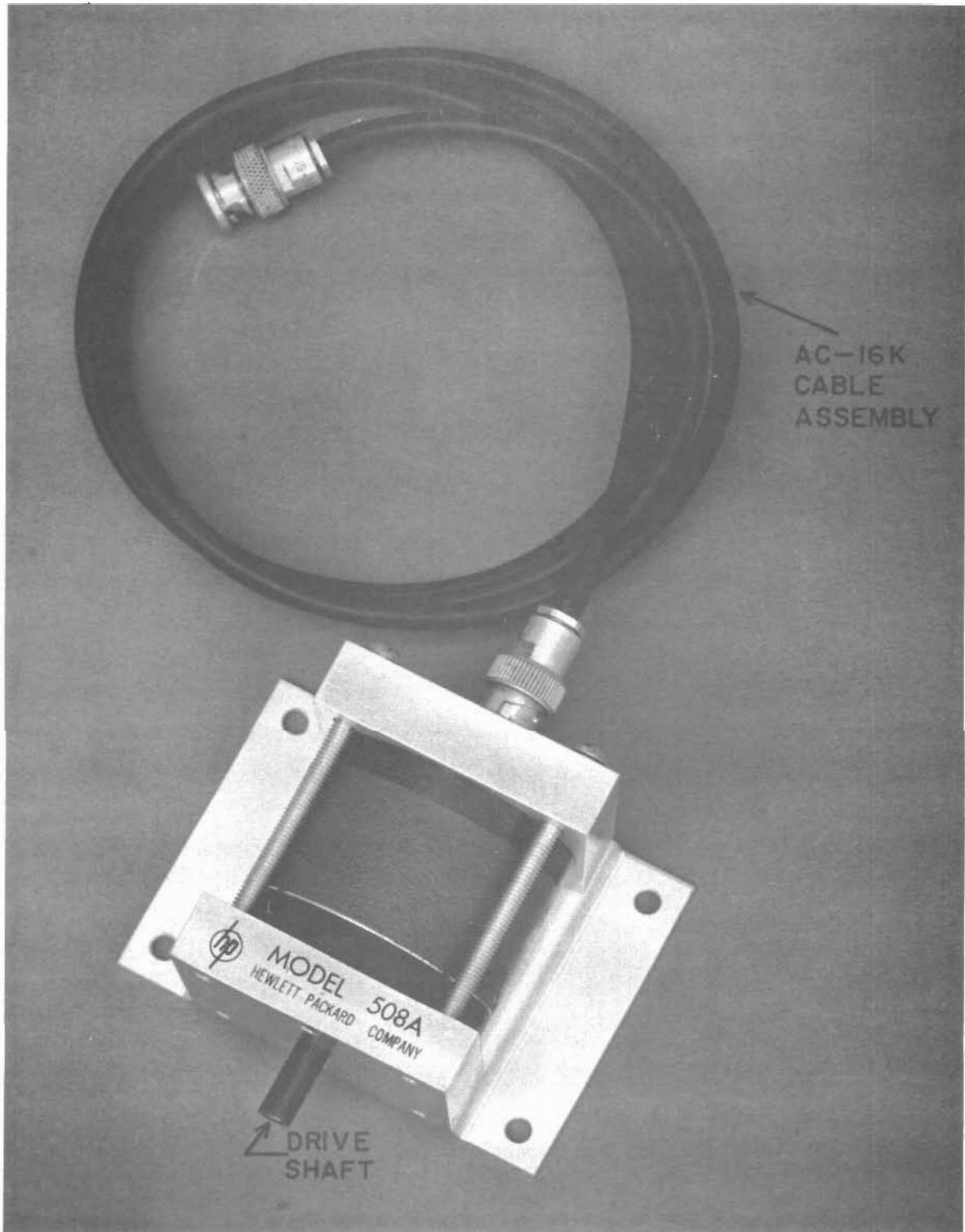


Fig. 6. Model 508A Tachometer Generator and AC-16K Cable Assembly

Hum Balance Adjustment (R55) --

The adjustment for balancing out the unwanted line current is as follows:

1. Measure the power line frequency (Operating Procedure, step 3), and note the meter indication. Shield the INPUT terminals of the instrument. A shielded banana plug is satisfactory.
2. Set the USE-LINE FREQ. -CALIBRATE switch to USE and the RANGE switch at 3000 (Model 505A) or 50 (Model 505B).
3. Adjust variable resistor R55 for minimum meter indication. Resistor R55 (Fig. 9) is located underneath the chassis and reached by removing the bottom plate.
4. Again measure the line frequency and compare with the previous line frequency measurement. If they are not the same, readjust R55 slightly to one side to obtain the same meter indication as in step 1.

Adjustment of Current Regulator --

The procedure for adjusting the current regulator is as follows:

1. Warm up the instrument using 115V (230V) line voltage. Set the USE-LINE FREQ. -CALIBRATE switch to CALIBRATE. Adjust the CALIBRATE control so that the meter indicates exactly 4800 on the 0-to-6000 scale (Model 505A) or exactly 80 on the 0-to-100 scale (Model 505B).
 2. Change the line voltage to 105 (210) volts, and note the meter indication. Repeat at 125 (250) volts line voltage. If the meter indication does not change more than $\pm 1\%$ full scale (4750 to 4850, Model 505A; 79 to 81, Model 505B), then the regulator circuit is functioning satisfactorily.
 3. If the meter indication is not within the specified limits, then a new OD3 tube (V8) and/or a new 6L6 tube (V7) should be tried. The OD3 tube should be aged by operating it for eight hours with 150 volts applied across its terminals. The easiest way to age the tube is to put it in its socket in the instrument and let the instrument operate for eight hours.
- If changing tubes does not restore the regulator circuit to normal, then additional adjustments will be necessary.
4. With the line voltage at 115 (230) volts, set the USE-LINE FREQ. -CALIBRATE switch at CALIBRATE. Set the CALIBRATE control to produce a meter indication of 4800 (Model 505A) or 80 (Model 505B), then change the USE-CALIBRATE switch to USE and apply a 50,000 cycles/sec. voltage to the INPUT terminals. Note the meter indication.

5. Adjust R61 (See Resistor Board Detail RB1, Fig. 10) by connecting a resistor in parallel with R61 or by substituting a new resistor of a higher value, so that the meter does not vary more than $\pm 1\%$ of full scale when the power line voltage is varied from 105 to 125 volts (210 to 250 volts).

6. Without changing the CALIBRATE control, change the RANGE switch and input frequency to 1000 cycles/sec. Note the meter indication with 115 (230) volts power line voltage. Change the power line voltage to 105 and 125 volts (210 and 250 volts), and note any variations from the indication obtained at 115 (230) volts. If the variation is $\pm 1\%$ or less, the circuit is correctly adjusted.

However, if the variation is more than $\pm 1\%$ then the value of R61 should be changed so as to obtain the best compromise between the 1000 and 50,000 cycles/sec. adjustments.

Calibration Adjustment --

The only calibration adjustment that should be performed in the field is the adjustment of the meter shunt resistors, R34 to R43. If any of the coupling capacitors, C9 to C28, are affecting the calibration, the instrument should be returned to the factory for adjustment.

The procedure for adjusting the shunt resistors is as follows:

1. Warm up the instrument and set the controls for USE (Operating Procedure, steps 1 through 4).

2. Starting with the RANGE switch at the 3000 (Model 505A) or the 50 (Model 505B) position, apply a 50 ν voltage to the INPUT terminals of the instrument. This voltage should be obtained from a secondary frequency standard or some other source of accurate frequencies. If the meter does not indicate exactly full scale, then adjust the value of shunt resistor R34 by substituting another resistor or by connecting a high resistance in parallel with R34.

3. Repeat step 2 for each range. The frequencies of the various calibration voltages are listed in the following table.

If the meter does not indicate exactly full scale, adjust the shunt resistor for the range being calibrated.

Calibration Voltage	Range & Full Scale Indication		Shunt Resistor
	Model 505A	Model 505B	
50 ν	3000 RPM	50 RPS	R34
100 ν	6000 RPM	100 RPS	R35
200 ν	12000 RPM	200 RPS	R36
500 ν	30000 RPM	500 RPS	R37
1 KC	60000 RPM	1000 RPS	R38
2 KC	120000 RPM	2000 RPS	R39
5 KC	300000 RPM	5000 RPS	R40
10 KC	600000 RPM	10000 RPS	R41
20 KC	1200000 RPM	20000 RPS	R42
50 KC	3000000 RPM	50000 RPS	R43

505A, 505B 6/10/54 Serial 2589 and Above

Trouble Shooting --

The following information is designed to aid in trouble shooting a defective instrument:

<u>Symptoms</u>	<u>Possible Cause</u>	<u>Test Procedure</u>	<u>Remedies</u>
Instrument NOT operating, pilot light NOT on.	Line fuse blown due to defective fuse or overload in power supply section of instrument.	Replace fuse, if this fuse blows remove V6 (5Y3GT) and again replace the fuse. If this fuse blows it indicates: 1. Short circuit in wiring associated with power transformer. 2. Short circuit in filament wiring. 3. Tube with an internal short circuit. 4. Defective power transformer. If the fuse does not blow with V6 removed, it indicates: 1. Defective filter capacitor C31, C7AB. DC resistance between pin 8 on V6 socket and ground is normally 17,000 ohms (approximate) and should be measured with the instrument disconnected from the power line. 2. Short in direct current wiring.	1. Locate and clear short circuit. 2. Locate and clear short circuit. 3. Replace defective tube. 4. Replace power transformer. 1. Replace C31, C7AB if proven defective. 2. Locate and clear short circuit.
Instrument NOT operating, pilot light ON.		1. Defective tube. 2. Measure DC voltages. Should agree with those indicated on schematic diagram within $\pm 10\%$.	1. Replace defective tube. 2. Replace component causing incorrect DC voltage.
Low meter indication on all ranges.	Defective crystal rectifier.	Measure the back resistance of each crystal rectifier. CR1 - CR4. Back resistance must be 30,000 ohms or greater.	Replace defective rectifier.

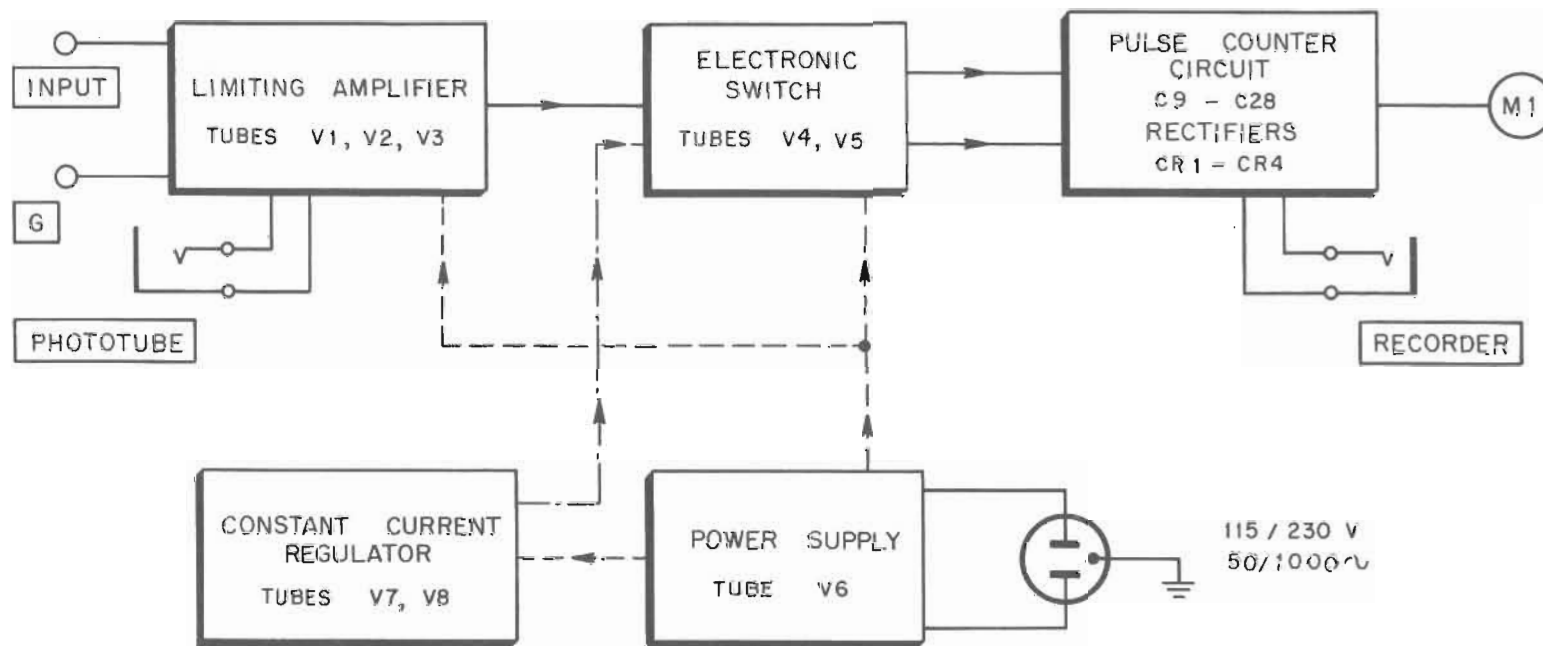


Fig. 7. Model 505A (or 505B) Block Diagram

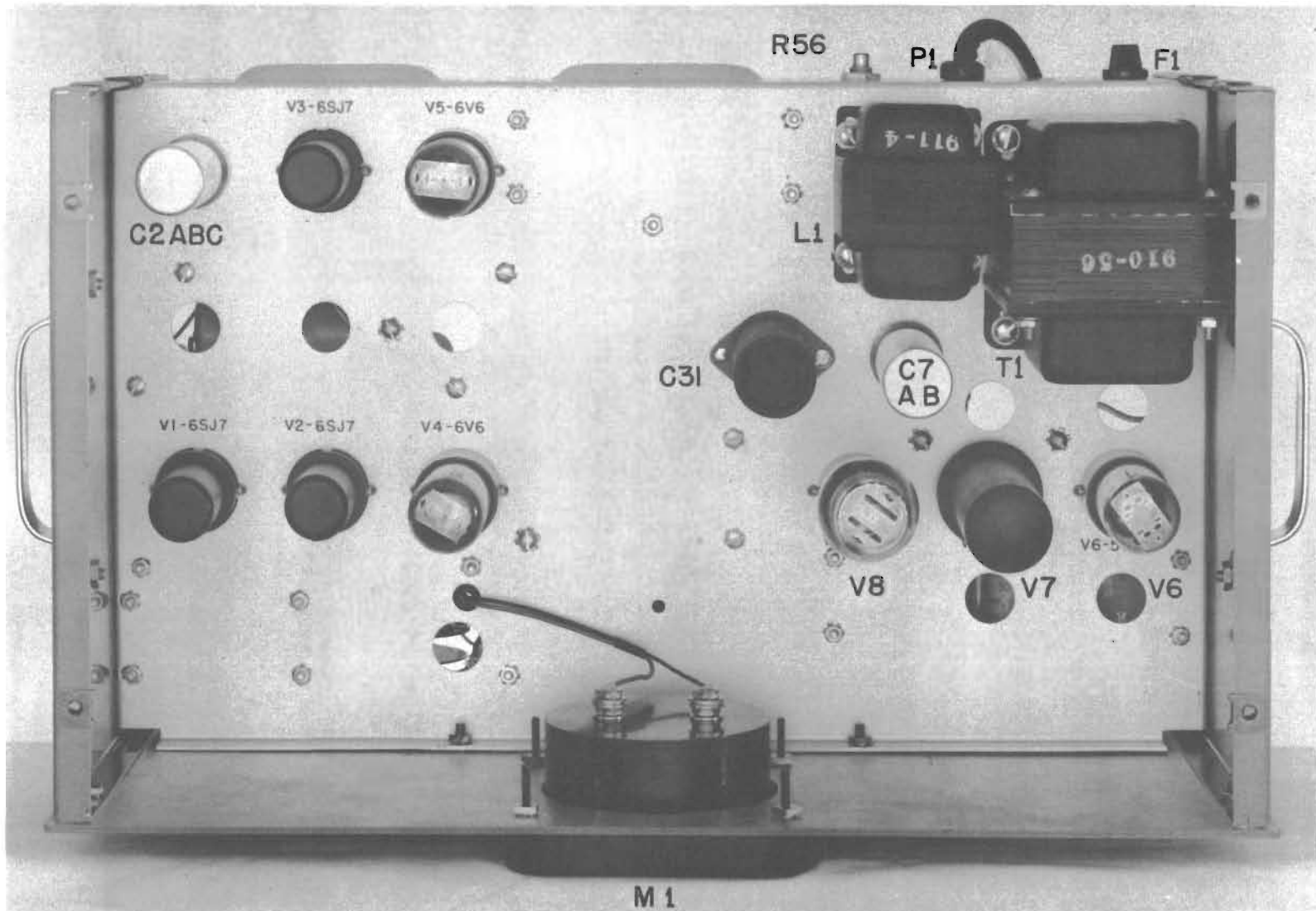


Fig. 8. Model 505A (or 505B) Top View Cover Removed

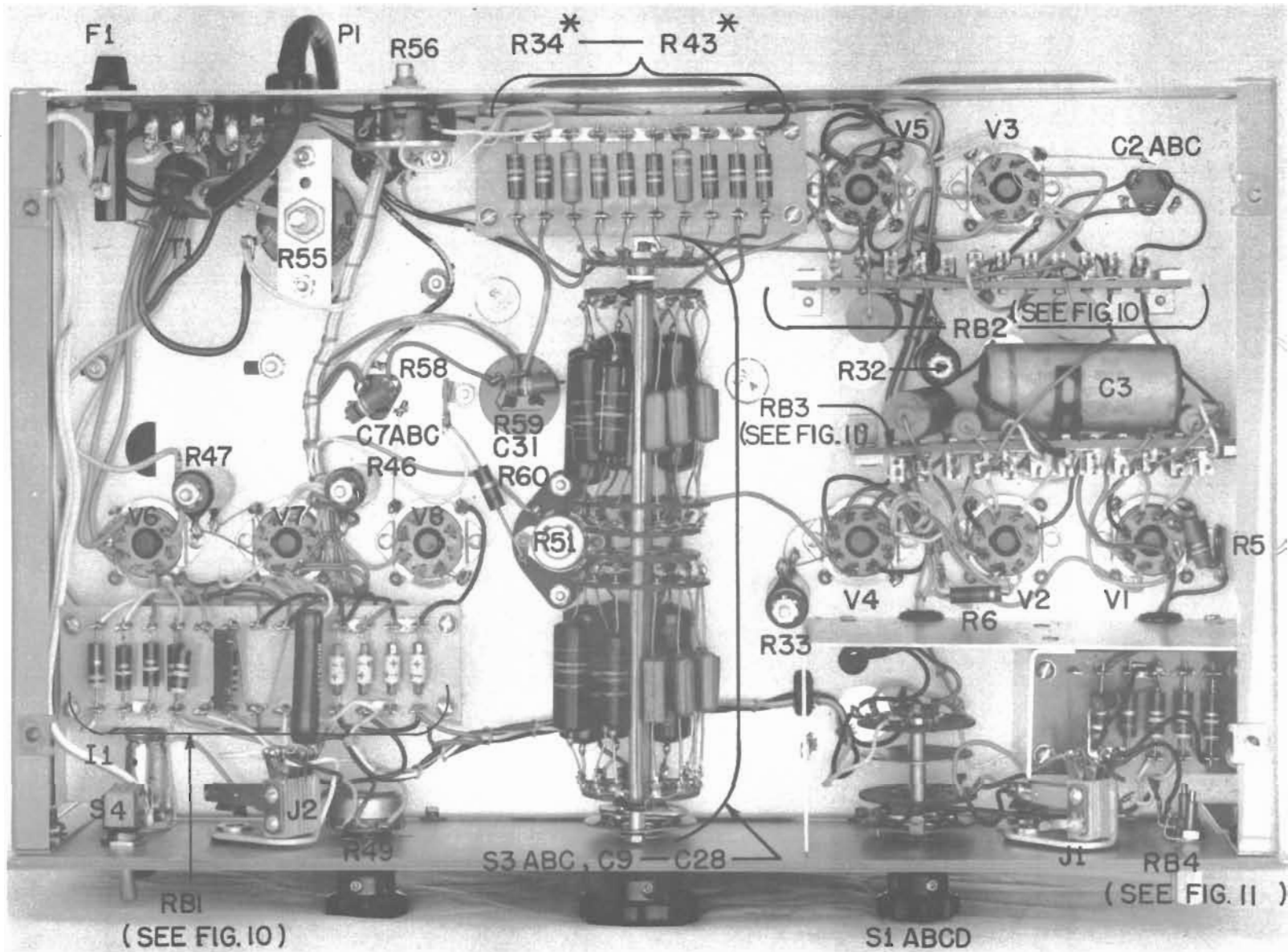
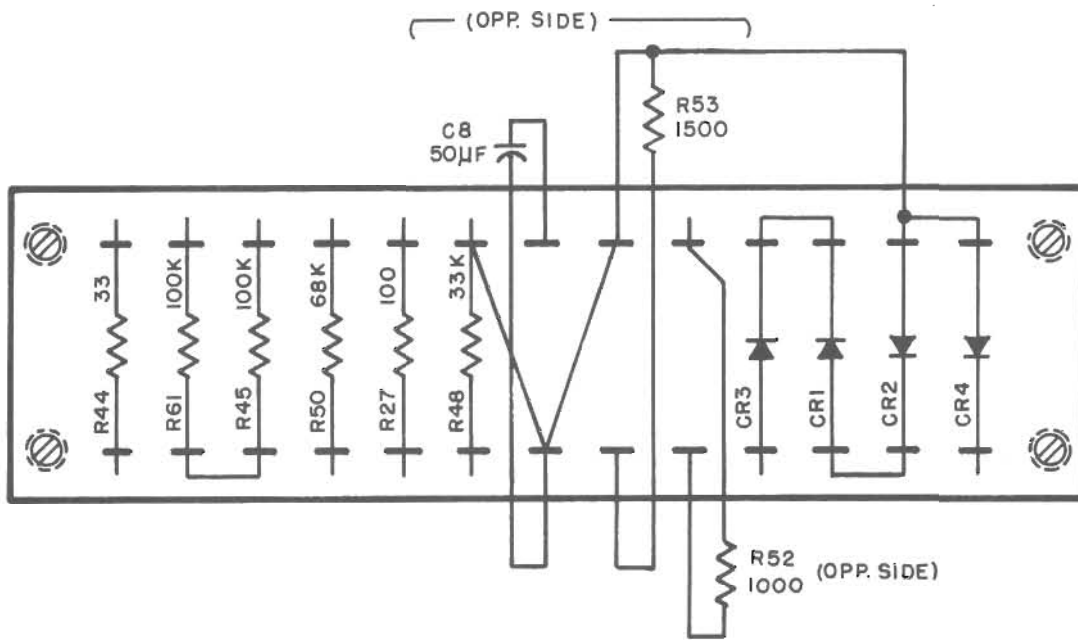
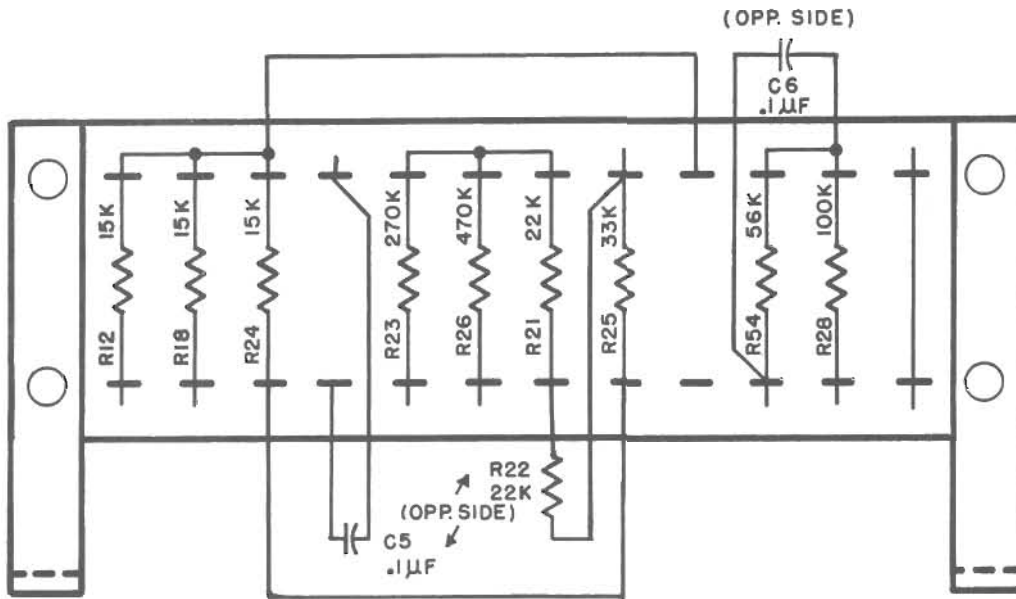


Fig. 9. Model 505A (or 505B) Bottom View Bottom Plate Removed



RB1



RB2

Fig. 10. Model 505A (or 505B) Resistor Board Detail

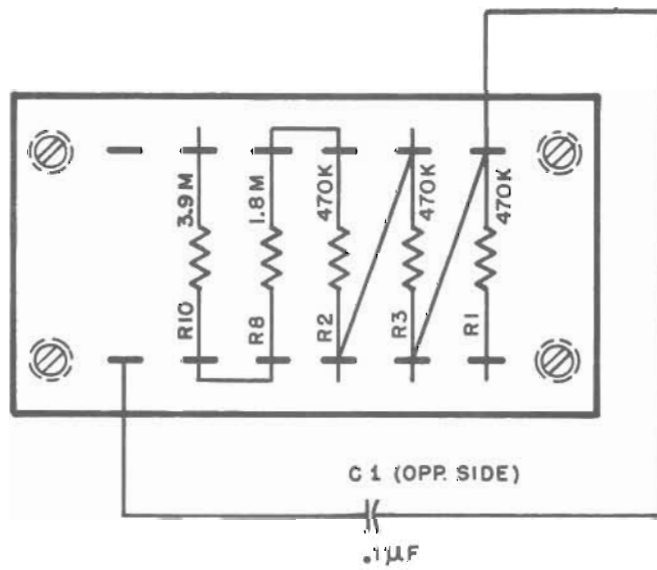
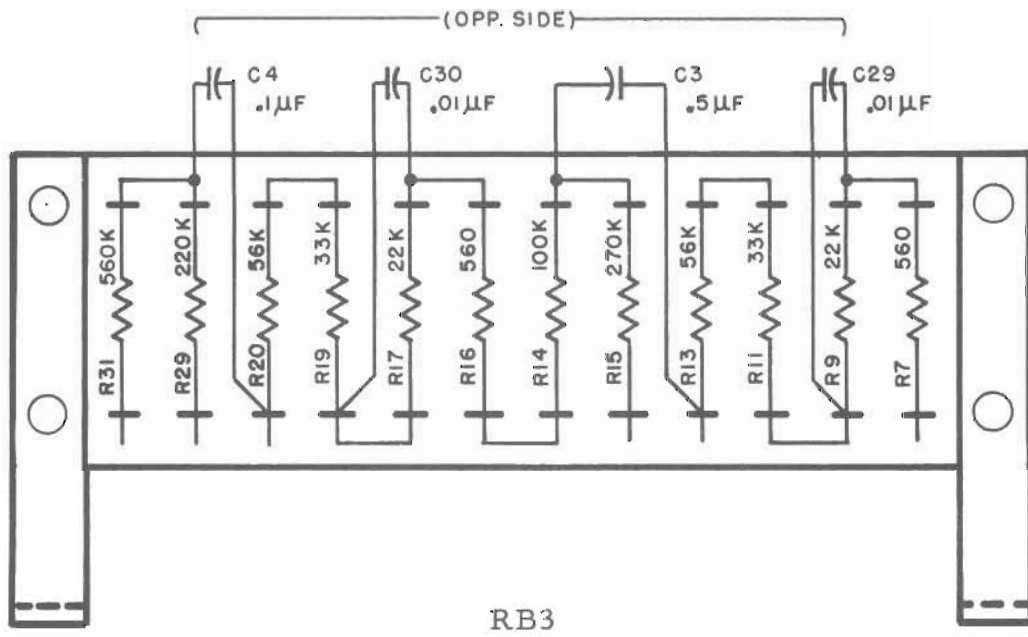
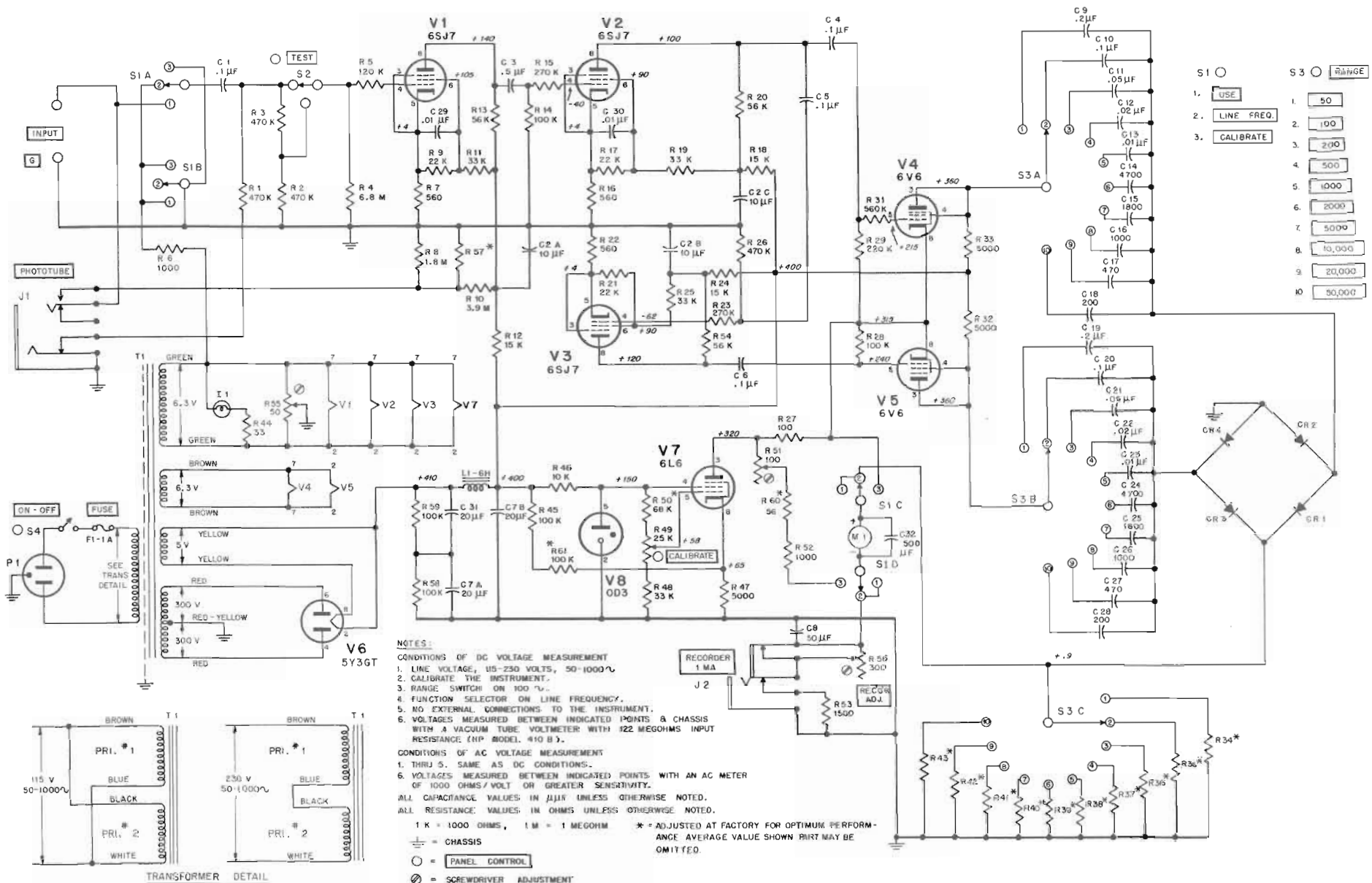


Fig. 11. Model 505A (or 505B) Resistor Board Detail



NOTES:

CONDITIONS OF DC VOLTAGE MEASUREMENT

1. LINE VOLTAGE, 115-230 VOLTS, 50-1000 \sim
2. CALIBRATE THE INSTRUMENT.
3. RANGE SWITCH ON 100 \sim .
4. FUNCTION SELECTOR ON LINE FREQUENCY.
5. NO EXTERNAL CONNECTIONS TO THE INSTRUMENT.
6. VOLTAGES MEASURED BETWEEN INDICATED POINTS & CHASSIS WITH A VACUUM TUBE VOLTMETER WITH 122 MEGOHMS INPUT RESISTANCE (HP MODEL 410 B).

CONDITIONS OF AC VOLTAGE MEASUREMENT

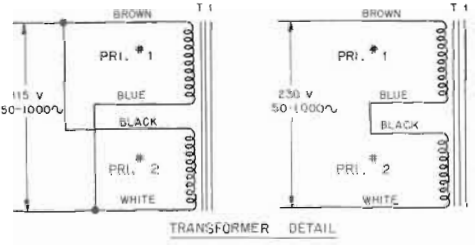
1. THRU 5. SAME AS DC CONDITIONS.
6. VOLTAGES MEASURED BETWEEN INDICATED POINTS WITH AN AC METER OF 1000 OHMS/VOLT OR GREATER SENSITIVITY.

ALL CAPACITANCE VALUES IN μ F UNLESS OTHERWISE NOTED.
 ALL RESISTANCE VALUES IN OHMS UNLESS OTHERWISE NOTED.

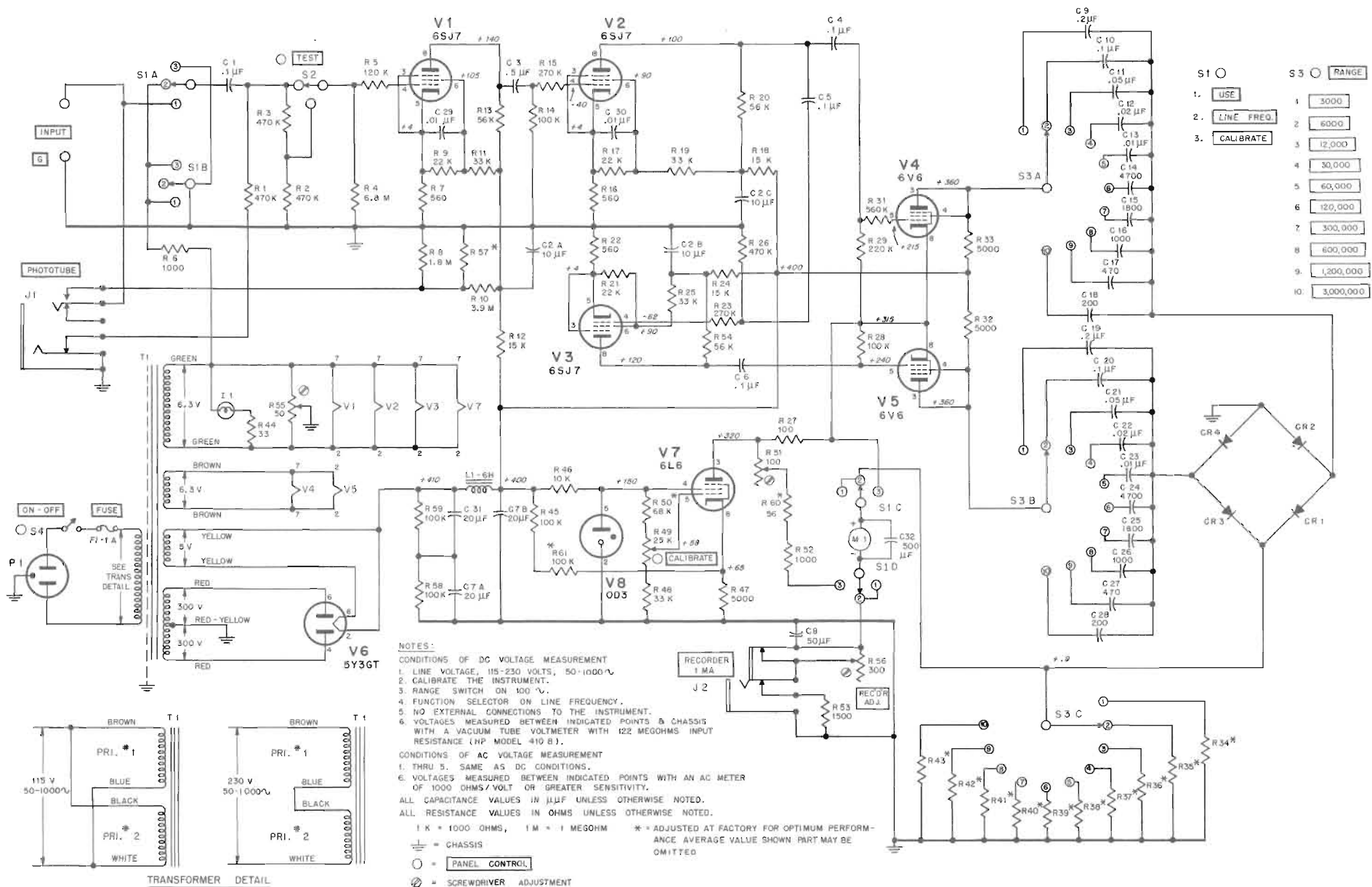
1 K = 1000 OHMS, 1 M = 1 MEGOHM * = ADJUSTED AT FACTORY FOR OPTIMUM PERFORMANCE AVERAGE VALUE SHOWN PART MAY BE OMITTED.

⊕ = CHASSIS
 ○ = PANEL CONTROL
 ⊗ = SCREWDRIVER ADJUSTMENT

S1 ○	S3 ○ RANGE
1. USE	1. 50
2. LINE FREQ.	2. 100
3. CALIBRATE	3. 200
	4. 500
	5. 1000
	6. 2000
	7. 5000
	8. 10,000
	9. 20,000
	10. 30,000



**SCHEMATIC DIAGRAM OF MODEL 505B
 SERIAL 2589 & ABOVE**



**SCHEMATIC DIAGRAM OF MODEL 505A
 SERIAL 2589 & ABOVE**

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
C1	Capacitor: fixed, paper, .1 μ f, $\pm 10\%$, 600 vdcw	16-1	CC #73P10496
C2	Capacitor: fixed, electrolytic, 10, 10, 10 μ f, 450 vdcw	18-31	X FPT-389
C3	Capacitor: fixed, paper, .5 μ f, $\pm 10\%$, 400 vdcw	16-58	CC #4TM-P5
C4, C5, C6	Capacitor: fixed, paper, .1 μ f, $\pm 10\%$, 600 vdcw	16-1	CC #73P10496
C7 AB	Capacitor: fixed, electrolytic, 20, 20 μ f, 450 vdcw	18-22	A AEF-"1X3"
C8	Capacitor: fixed, electrolytic, 50 μ f, +200%, -10%, 50 vdcw	18-50	X TC-39
C9 - C28	Part of Range Switch Assembly		
C29, C30	Capacitor: fixed, paper, .01 μ f, $\pm 10\%$, 600 vdcw	16-11	A Type P688
C31	Capacitor: fixed, electrolytic, 20 μ f, 450 vdcw	18-20	X FPS-144
C32	Capacitor, fixed, electrolytic, 500 μ f, 15 vdcw	18-5	X TC-1505
R1, R2, R3	Resistor: fixed, composition, 470,000 ohms, $\pm 10\%$, 1 W	24-470K	B GB 4741
R4	Resistor: fixed, composition, 6.8 megohms, $\pm 10\%$, 1 W	24-6.8M	B GB 6851
R5	Resistor: fixed, composition, 120,000 ohms, $\pm 10\%$, 1 W	24-120K	B GB 1241
R6	Resistor: fixed, composition, 1000 ohms, $\pm 10\%$, 1 W	24-1000	B GB 1021
R7	Resistor: fixed, composition, 560 ohms, $\pm 10\%$, 1 W	24-560	B GB 5611
R8	Resistor: fixed, composition, 1.8 megohms, $\pm 10\%$, 1 W	24-1.8M	B GB 1851
R9	Resistor: fixed, composition, 22,000 ohms, $\pm 10\%$, 1 W	24-22K	B GB 2231
R10	Resistor: fixed, composition, 3.9 megohms, $\pm 10\%$, 1 W	24-3.9M	B GB 3951

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

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
R11	Resistor: fixed, composition, 33,000 ohms, $\pm 10\%$, 1 W	24-33K	B GB 3331
R12	Resistor: fixed, composition, 15,000 ohms, $\pm 10\%$, 1 W	24-15K	B GB 1531
R13	Resistor: fixed, composition, 56,000 ohms, $\pm 10\%$, 1 W	24-56K	B GB 5631
R14	Resistor: fixed, composition, 100,000 ohms, $\pm 10\%$, 1 W	24-100K	B GB 1041
R15	Resistor: fixed, composition, 270,000 ohms, $\pm 10\%$, 1 W	24-270K	B GB 2741
R16	Resistor: fixed, composition, 560 ohms, $\pm 10\%$, 1 W	24-560	B GB 5611
R17	Resistor: fixed, composition, 22,000 ohms, $\pm 10\%$, 1 W	24-22K	B GB 2231
R18	Resistor: fixed, composition, 15,000 ohms, $\pm 10\%$, 1 W	24-15K	B GB 1531
R19	Resistor: fixed, composition, 33,000 ohms, $\pm 10\%$, 1 W	24-33K	B GB 3331
R20	Resistor: fixed, composition, 56,000 ohms, $\pm 10\%$, 1 W	24-56K	B GB 5631
R21	Resistor: fixed, composition, 22,000 ohms, $\pm 10\%$, 1 W	24-22K	B GB 2231
R22	Resistor: fixed, composition, 560 ohms, $\pm 10\%$, 1 W	24-560	B GB 5611
R23	Resistor: fixed, composition, 270,000 ohms, $\pm 10\%$, 1 W	24-270K	B GB 2741
R24	Resistor: fixed, composition, 15,000 ohms, $\pm 10\%$, 1 W	24-15K	B GB 1531
R25	Resistor: fixed, composition, 33,000 ohms, $\pm 10\%$, 1 W	24-33K	B GB 3331
R26	Resistor: fixed, composition, 470,000 ohms, $\pm 10\%$, 1 W	24-470K	B GB 4741
R27	Resistor: fixed, wirewound, 100 ohms	5A-26	HP
R28	Resistor: fixed, composition, 100,000 ohms, $\pm 10\%$, 1 W	24-100K	B GB 1041

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

5A, 505B 6/10/54 Serial 2589 and Above

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
R29	Resistor: fixed, composition, 220,000 ohms, $\pm 10\%$, 1 W	24-220K	B GB 2241
R30	This circuit reference not assigned.		
R31	Resistor: fixed, composition, 560,000 ohms, $\pm 10\%$, 1 W	24-560K	B GB 5641
R32, R33	Resistor: fixed, wirewound, 5000 ohms, $\pm 10\%$, 20 W	27-3	S Type 2R
R34-R43	Electrical value adjusted at factory.		
R44	Resistor: fixed, composition, 33 ohms, $\pm 10\%$, 1 W	24-33	B GB 3301
R45	Resistor: fixed, composition, 100,000 ohms, $\pm 10\%$, 1 W	24-100K	B GB 1041
R46	Resistor: fixed, wirewound, 10,000 ohms, $\pm 10\%$, 27 W	27-4	S Type 2R
R47	Resistor: fixed, wirewound, 5000 ohms, $\pm 10\%$, 20 W	27-3	S Type 2R
R48	Resistor: fixed, composition, 33,000 ohms, $\pm 10\%$, 1 W	24-33K	B GB 3331
R49	Resistor: variable, composition, 25,000 ohms, linear taper	210-54	B
R50	Resistor: fixed, composition, 68,000 ohms, $\pm 10\%$, 1 W Electrical value adjusted at factory.	24-68K	B GB 6831
R51	Resistor: variable, wirewound, 100 ohms, linear taper	M-80	HP
R52	Resistor: fixed, wirewound, 1000 ohms, $\pm 10\%$, 1 W	26-15	R Type BW-1
R53	Resistor: fixed, composition, 1500 ohms, $\pm 1\%$, 1 W	31-1500	GG Type CP-1
R54	Resistor: fixed, composition, 56,000 ohms, $\pm 10\%$, 1 W	24-56K	B GB 5631
R55	Resistor: variable, wirewound, 50 ohms, $\pm 10\%$, 3 W	210-2	G #21-010-067
R56	Resistor: variable, wirewound, 300 ohms, linear taper	210-53	G #21-010-358

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

505A, 505B 6/10/54 Serial 258

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
R57	Electrical value adjusted at factory		
R58, R59	Resistor: fixed, composition, 100,000 ohms, ±10%, 1 W	24-100K	B GB 1041
R60	Resistor: fixed, composition, 56 ohms, ±5%, 1 W	24-56-5	B GB 5605
R61	Resistor: fixed, composition, 100,000 ohms, ±10%, 1 W Electrical value adjusted at factory	24-100K	B GB 1041
	Binding Post:	10A	HP
CR1-CR4	Crystal Rectifier:	212-G11B	HP
F1	Fuse: 1A, Withstands 200% overload for 25 seconds - for 115V operation	211-18	E, MDL-1
F1	Fuse: 1/2A, Withstands 200% overload for 25 seconds - for 230V operation	211-20	E, MDL-1/2
	Fuseholder:	140-18	E
	Indicator Lamp Assembly:	145-2	BB, #807BS
	Knob: 1-1/2" diam.	37-11	HP
	Knob: 2" diam.	37-13	HP
I1	Lamp:	211-47	O, Mazda #47
J1	Telephone Jack:	124-5	X, #706
J2	Telephone Jack:	124-6	Switchcraft, Inc.
M1	Meter: Model 505A Model 505B	55A-81 55B-81	HP HP
P1	Power Cable:	812-56	HP
L1	Reactor: 6 H @ 125 MA, 240 ohms	911-4	HP
S1 AB	Rotary Switch:	310-69	HP
S2	Push Button Switch:	310-53	Switchcraft #1003
S3 ABC, C9-C28	Range Switch Assembly:	5A-19W	HP
S4	Toggle Switch:	310-11	D, 20994NV
T1	Power Transformer:	910-56	HP

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

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
V1, V2 V3	Tube: 6SJ7	212-6SJ7	ZZ
V4, V5	Tube: 6V6	212-6V6	ZZ
V6	Tube: 5Y3GT	212-5Y3GT	ZZ
V7	Tube: 6L6	212-6L6	ZZ
V8	Tube: OD3	212-OD3	ZZ

505A, 505B 6/10/54 Serial 258

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

LIST OF MANUFACTURERS CODE LETTERS
FOR REPLACEABLE PARTS TABLE

<u>Code Letter</u>	<u>Manufacturer</u>
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.
HP	Hewlett-Packard
I	Clarostat Manufacturing Co.
J	Cornell Dubilier Electric Co.
K	Hi-Q Division of Aerovox Corp.
L	Erie Resistor Corp.
M	Federal Telephone and Radio Corp.
N	General Electric Co.
O	General Electric Supply Corp.
P	Girard-Hopkins
R	International Resistance Co.
S	Lectrohm, Inc.
T	Littelfuse, Inc.
V	Micamold Radio Corp.
X	P. R. Mallory Co., Inc.
Z	Sangamo Electric Co.
AA	Sarkes Tarzian
CC	Sprague Electric Co.
DD	Stackpole Carbon Co.
EE	Sylvania Electric Products, Inc.
FF	Western Electric Co.
HH	Amphenol
II	Dial Light Co. of America
KK	Switchcraft, Inc.
LL	Gremer Mfg. Co.
MM	Carad Corp.
ZZ	Any tube having RETMA 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

395 PAGE MILL ROAD  PALO ALTO, CALIFORNIA