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**INSTRUCTIONS**

**MODEL 410A  
HIGH FREQUENCY  
VACUUM TUBE VOLTMETER**

TYPE NO. 3749

**HEWLETT  PACKARD**  
COMPANY  
*Laboratory Instruments for Speed and Accuracy*  
395 PAGE MILL ROAD • PALO ALTO • CALIFORNIA

## C A U T I O N

The gray insulating material of the probe of the Model 410A is polystyrene--a low melting-point material. It is necessary when soldering to the probe to prevent the polystyrene from getting too hot. It is not possible to solder to the contact which is exposed when the probe nose is removed without destroying the polystyrene.

-hp-  
Model 410A

High Frequency  
Vacuum Tube Voltmeter

Specifications

AC Ranges .....	1, 3, 10, 30, 100, and 300 volts rms.
DC Ranges .....	1, 3, 10, 30, 100, 300, and 1000 volts.
Resistance Ranges .....	500, 5000, and 50,000 ohms; 0.5, 5, 50, and 500 megohms.
AC Calibration Accuracy .....	$\pm 3\%$ of full scale for sinusoidal voltages.
Frequency Response .....	$\pm 1$ db from 20 cps to 700 megacycles.
AC Indication .....	Proportional to peak value of applied voltage; instrument is calibrated to read rms value of a sine wave.
AC Input Impedance .....	Equivalent to approximately 6 megohms shunted by 1.3 mmf at low frequencies; the input resistance decreases with increasing frequency owing to dielectric losses.
DC Input Impedance .....	100 megohms.
DC Calibration Accuracy .....	$\pm 3\%$ of full scale.
Power Demand .....	Approximately 40 watts.
Power Source Required .....	Operates from a nominal 115-volt, 50/60 cycle single phase source.

-hp-  
MODEL 410A

HIGH FREQUENCY

VACUUM TUBE VOLTMETER

I N T R O D U C T O R Y

GENERAL

The -hp- Model 410A High Frequency Vacuum Tube Voltmeter has been especially designed as a universal measuring instrument for use in audio, supersonic, broadcast, FM, and television circuits. To this end the input resistance of the instrument has been made extremely high, while the equivalent shunt input capacitance is sufficiently low so that even very high frequency resonant circuits are only moderately detuned. In order to further increase the flexibility and usefulness of this instrument, provision has been made for measuring both DC voltages and resistance.

INITIAL ADJUSTMENTS

No initial adjustments other than those given under OPERATING INSTRUCTIONS are required for this instrument. After first unpacking, however, it is desirable to make a complete inspection for possible damage in transit. If any such damage is found, follow the procedure set out at the back of this manual.

CIRCUIT DESCRIPTION

The circuit of the Model 410A, shown at the back of this manual, includes a shunt diode type rectifier, a dc amplifier, and a power supply. A circuit for neutralizing the effects of "emission velocity current" in the input diode is also included.

Ac voltages applied to the input terminals are rectified by the shunt diode circuit associated with V1. This circuit is located in the probe supplied with the instrument. V1 is a special diode having low anode-cathode capacity, very short electron transit time, and a high resonant frequency.

The output of the rectifier is applied to the dc amplifier which consists of V4a, V5, and V6. The input to the amplifier consists of a 100-megohm voltage divider which acts both as the grid resistor for V4a and, when switched, as range resistors for the instrument. In order to minimize the magnitude of gas current flowing in the grid circuit of V4a, very low plate voltage is applied to the tube.

The output of the cathode-follower V<sup>4a</sup> is amplified by the dc current amplifier V<sup>5</sup> and V<sup>6</sup>. The indicating meter M<sup>1</sup> is connected between the plates of V<sup>5</sup> and V<sup>6</sup> in series with suitable range calibrating resistors.

V<sup>2</sup>, V<sup>4b</sup>, and V<sup>6</sup> operate in the circuit which neutralizes the effect of emission velocity current in V<sup>1</sup>. This current consists of electrons which are emitted from the cathode with sufficient velocity to break through the diode space charge area and pass to the anode with no voltage on the anode. However, the fact that this current does flow through the diode means that the anode is at a potential relative to the cathode, even though no voltage is applied externally. This potential difference, though small, would cause a reading on the indicating meter which would destroy the accuracy of the lower ranges of the instrument.

To counteract this effect, V<sup>2</sup>, a diode of the same type as V<sup>1</sup>, is operated independently in the circuit. V<sup>2</sup> operates merely with heater voltage and with a load resistor. Because diode V<sup>2</sup> is identical to V<sup>1</sup>, a voltage essentially identical to that present at V<sup>1</sup> is also present at V<sup>2</sup>. This voltage is applied to amplifier V<sup>4b</sup> and in turn to V<sup>6</sup>. Thus, the voltage from V<sup>2</sup> counteracts that from V<sup>1</sup> in the dc current amplifier V<sup>5</sup> and V<sup>6</sup>, and only voltages applied externally to V<sup>1</sup> are amplified independently by the current amplifier.

DC voltages to be measured are applied directly to the 100-megohm voltage divider at the input to V<sup>4a</sup>. For dc measurements V<sup>1</sup> and V<sup>2</sup> are switched out of the circuit.

Resistances are measured by means of the voltage generated by two paralleled flashlight type cells. Voltage from the cells is applied to a network consisting of a known resistance in series with the resistance to be measured. That part of the voltage which is thus impressed across the unknown resistance is applied directly to V<sup>4b</sup>, the first tube of the dc amplifier.

The power supply for the Model 410A includes a conventional full-wave rectifier with a resistance-capacity filter.

#### TEST LEADS

At the lower part of the front panel is a knob which permits removal of the access plate for the test lead compartment. In this compartment will be found three single conductor test leads and the diode probe together with its cable. The designations on the front panel indicate the function of each lead.

The probe is provided for use on ac measurements. At low frequencies where relatively high capacities can be tolerated it is not necessary to remove the probe from the compartment. Instead, connections can be made to the binding posts on the front panel if the probe is properly mounted in its brackets at the back of the access plate.

# O P E R A T I O N

## CONTROLS

The controls with their functions are given below:

CONTROL	FUNCTION
Selector	Prepares instrument for various types of measurements.
Range	Determines full scale value of various ranges.
Zero Adj.	Sets meter pointer to zero.
Ohms Adj.	Calibrates ohmmeter circuit for infinite resistance.

In addition to these controls there is an internal screwdriver adjustment reached through the back of the cabinet which may be used to zero-set the a-c ranges. More complete information for this adjustment is given on p. 12.

Plug the power cord into a nominal 115-volt, 50/60 cycle, single phase power source. Turn the SELECTOR switch from the OFF to the - (minus) position, thus applying power to the instrument. Allow the unit to heat for five minutes or more.

### Procedure for Measuring AC Voltages.

CAUTION: BEFORE MEASURING VOLTAGES HAVING FREQUENCIES ABOVE 20 OR 30 MEGACYCLES, REFER TO SECTION ON HIGH FREQUENCY USAGE (pp. 7-10)

1. Voltages having rms amplitudes up to 300 volts and frequencies up to 700 megacycles can be measured with the -hp- Model 410A by means of the diode probe provided. Note that it is not necessary to remove the probe from the test lead compartment under certain conditions as explained under "Test Leads" above.
2. Set the SELECTOR switch to AC.
3. Set ZERO ADJ control so that meter pointer reads exactly zero with RANGE switch set to 1v and with the probe lead shorted to its ground lead.
4. Set RANGE switch to a range known to be high enough to include the voltage to be measured.

5. Connect the alligator clip of the probe to the ground side of the voltage to be measured.

CAUTION: The ground clip of the probe should never be connected to any point at a d-c or a-c potential.

6. Connect the probe tip to the point to be measured. This connection can be made either by soldering the probe tip to the circuit or by holding by hand.
7. Reduce RANGE switch as necessary to obtain a large meter pointer deflection.
8. If the RANGE switch is now in the 1-volt position, read voltage on the scale marked 1v ac only. If the RANGE switch is in the 3-volt position, read voltage on the scale marked 3v ac only.

If the RANGE switch is in either the 10-volt or 100-volt positions, read voltage on the top scale of the meter face, using suitable multiplying factor.

If the RANGE switch is in either the 30-volt or 300-volt positions, read voltage on the second scale from the top of the meter face, using suitable multiplying factor.

Note on AC operation: From time to time a small drift may occur between the zero reading of the AC and DC ranges. This drift is most noticeable on the 1vAC range. This condition is normal and as long as the instrument is properly zeroed with the ZERO SET control, the accuracy of the AC readings is not impaired.

#### Procedure for Measuring DC Voltages

1. DC voltages up to 1000 volts of either negative or positive polarity can be measured with the -hp- Model 410A by using the COMMON and DC VOLTS leads.
2. Set the SELECTOR switch to either - or +, depending upon the polarity with respect to ground (chassis) of the voltage to be measured.
3. Set ZERO ADJ control so that meter pointer reads exactly zero on 1v range, if this has not been done previously.
4. Set RANGE switch to a range known to be high enough to include the voltage to be measured.
5. Connect the COMMON lead to the ground side of the voltage to be measured.



6. Connect the DC Volts lead to the high potential side (positive or negative) of the voltage to be measured. Observe usual rules of safety when making this connection.
7. Back off the RANGE switch as necessary to obtain a large meter deflection.
8. The calibration of the range switch indicates the full-scale value of the meter scale. If the RANGE switch is in a position whose full-scale value is a multiple of 10, read the value of the voltage on the top scale of the meter face. Thus, if the RANGE switch is in either the 1, 10, 100, or 1000 positions, read voltage on the top scale, using a suitable multiplying factor.

If the RANGE switch is in a position whose full-scale value is a multiple of 3, read the value of the voltage on the second scale from the top of the meter face. Thus, if the RANGE switch is in either the 3, 30, or 300 positions, read the second scale, using a suitable multiplying factor.

#### Procedure for Measuring Resistance

1. Set SELECTOR switch to OHMS.
2. Unless meter has been zeroed for AC or DC measurements, short ends of COMMON and OHMS leads together and while shorted adjust ZERO ADJ control until meter pointer is exactly at zero. Separate the shorted leads.
3. Adjust OHMS ADJ control until meter pointer reads exactly full-scale on the OHMS scale (lowest scale on face.)
4. Recheck steps 2 and 3.
5. Connect COMMON and OHMS leads to resistance to be measured.
6. Set RANGE switch to a position giving most readable meter pointer deflection.
7. Multiply meter pointer reading on OHMS scale by factor indicated by setting of the RANGE switch resistance calibration. This multiplication gives measured value of the unknown resistance.

## IMPORTANT

### ZERO SETTING

After replacing diodes V1 and V2 or after using the instrument for a period, it may be found that the Model 410A will require zero-setting when switched from the + or - position to the AC position of the SELECTOR switch. This drift is caused by an unbalance in the special diodes V1 and V2. The drift can be corrected by adjusting the ZERO SET control at no loss in accuracy; however, if the drift becomes large, it may be desired to correct this condition according to the following procedure.

1. With the RANGE switch in the 1V position and the SELECTOR switch in either the + or - position, zero-set the meter pointer with the ZERO SET control. Then change SELECTOR switch to AC position.

2. If possible, zero set the meter pointer with R14. R14 can be reached through the access hole located in the lower right-hand side of the back of the instrument case. In earlier types of the Model 410A, R14 is a screwdriver-adjusting potentiometer, while in the later types R14 is provided with a small knob. R14 is located in a high-impedance circuit so that touching it may change the meter reading. Therefore, adjust the setting of R14 slightly and then remove the hand before observing the effect on the meter. A few seconds may be required for the circuit to stabilize after an adjustment of R14.

3. If it is not possible to zero-set the meter pointer with R14, set its contact arm approximately to the center of the arc of rotation.

4. Then zero-set the meter pointer by adjusting R15 with an insulated screwdriver. In instruments having serial numbers higher than approximately Q1750 potentiometer, R15 can be reached after removing the button plug that is located in the upper part of the right side of the instrument case. In older type instruments, the instrument case must be removed in order to reach R15, which is located on a bakelite board together with other potentiometers.

5. Adjust R15 so that the meter pointer reads approximately zero. When making this adjustment, it is necessary to make a slight adjustment and then to wait about one minute for the tubes to stabilize. Then make another adjustment in the setting of R15, etc. However, do not adjust R15 so that its contact arm is outside the central one-third of its arc of rotation.

6. After adjusting R15 so that the meter pointer is close to zero but so that the contact arm is in the central one-third of the arc of rotation, bring the meter pointer to zero by adjusting R14.

7. If it is impossible to set the meter pointer to zero with R14 after following the above procedure, it is necessary to replace the diodes V1 and V2 and to repeat the procedure.

8. Allow the instrument to heat for several hours in order that the tubes may stabilize. With new tubes it may be necessary to repeat the procedure after the tubes have heated an hour or two.

## AC VOLTAGE MEASUREMENTS

The Model 410A has been designed to operate over as wide a frequency range and as wide a voltage range as is possible. To this end the high frequency diode has been designed with careful emphasis upon its application to specific measuring circuits. The cathode is made with a disc seal construction which makes possible very solid grounding of the cathode, while the anode lead has been brought out with the minimum possible inductance. The maximum frequency at which the Model 410A will accurately respond is limited primarily by the physical length of the tube compared with the wave length of the voltage being measured.

In addition to these considerations, care has been taken to keep the input capacitance of the probe as low as possible. This has been done by designing the molded tip on the probe so that the anode circuit, including the blocking condenser and resistor, are located as far as possible from the grounding plane. Furthermore, the probe has been designed so that the input blocking condenser is removable by unscrewing the plastic nose. With an external blocking condenser the lowest possible input capacitance can be realized. This feature also enables the ultimate length of the measuring circuit from cathode to the end of the anode to be considerably reduced so that the frequency at which resonance occurs is extended to the highest possible value.

These carefully considered features make the Model 410A one of the most useful instruments available to the engineer today. To fully utilize the capabilities of this instrument, a thorough understanding of the considerations involved in making measurements under various conditions is required.

One of the most useful applications of the Model 410A is in the measurement of voltages under normal circuit conditions where the effect of the measuring voltmeter on the operation of the circuit must be minimized. Under these conditions the meter is used with the tip of the probe screwed in place. The lead grounding the cylindrical shell of the probe should be kept as short and as heavy as possible. At the same time it is desirable to keep the molded nose of the probe as far away from the ground plane or from objects at ground potential as can conveniently be done. Care in keeping the molded nose away from grounded points in the circuit will, under typical conditions, keep the input capacitance several tenths of a micromicrofarad lower than will be obtained otherwise. At the higher frequencies, it may be desirable to use an external condenser instead of the condenser which is built into the nose of the probe. One terminal of a small button-type condenser can be soldered to the point of measurement in the circuit. The center conductor of the probe, with the tip removed, can be connected to the other terminal of the condenser for the measurement. At frequencies above 100 kc a capacity of 50 micromicrofarads will be sufficient to obtain an accurate reading with this method.

The condenser which is built into the molded nose is large enough to insure accurate meter reading down to frequencies of 50 cycles or less. The Model 410A can, however, be used to make measurements at lower frequencies. By removing the plastic nose and using a condenser of .25 microfarad in series with the exposed contact of the probe, measurements can be made with good accuracy down to 10 cycles per second or less.

At frequencies above 100 megacycles, it is desirable wherever possible, to use an external button-type condenser with the probe and to keep the distance between the point of voltage measurement and the point of grounding the outside cylinder of the probe as short as possible. This is particularly desirable because in making measurements on typical circuits operating at frequencies above 100 megacycles, considerable voltage may be built up across ground leads or even along various parts of a grounding plane. Consequently, unless the meter is placed as nearly as possible to the point at which voltage is to be measured, erroneous readings may be obtained.

At higher frequencies, it is nearly mandatory that measurements be made on voltages which are confined to transmission line circuits. For applications of this type the Model 410A is particularly suitable because the physical configuration of the diode and probe is that of a concentric transmission line and with a few precautions it can be connected to typical transmission line circuits with little difficulty.

For measurements at the higher frequencies, a special T-joint (-hp- Model 455A) can be supplied for connecting the Model 410A directly across a 50-ohm transmission line using Type N connectors. This T-joint has been designed so that the connection of the Model 410A into a transmission line circuit will not cause an appreciable standing wave. With the aid of this device, measurement of power traveling through a transmission line may be made with good accuracy to 1000 mc. The usual precautions must be taken to provide accurate impedance matching and the elimination of standing waves along the line through which power is flowing. By using a dummy load at the receiving end of this T-joint, power output of various devices can be measured. In many applications, power going into a real load, such as an antenna, can be conveniently measured up to frequencies as high as 1000 megacycles with good accuracy.

In other transmission line applications, it may be desirable to connect the Model 410A into an existing transmission line. This can be done by cutting the line away so that the center conductor of the line is exposed through a hole large enough to clear the body of the Model 410A probe. The nose of the probe should be removed. A button-type capacitor of approximately 200 micro-microfarads should be fastened to the center conductor of the transmission line so that one terminal of the condenser contacts the center conductor of the transmission line and the other terminal of the condenser contacts the anode connection of the probe. A

close fitting metal shield or bushing should be arranged to ground the outer cylinder of the probe to the outer conductor of the transmission line. Unless some impedance matching modifications are also made on the line, this type of a connection is likely to cause some increase at higher frequencies in the standing wave ratio of the line being measured. It is desirable, where the frequency is high and where good accuracy is required, to make some compensating adjustments on the transmission line and minimize reflected power from the point of measurement.

If two general precautions are kept in mind when using the Model 410A, very satisfactory accuracy will be obtained over the entire rated frequency range of the instrument. First, take every precaution to make sure that the outer shell of the probe is well grounded at the point from which a measurement is desired. Second, connect the voltmeter into the circuit so that the distance from the anode connection on the diode to the point at which the voltage is to be measured is as short as possible.

As an additional precaution in maintaining accuracy of measurement, it must be kept in mind that the instrument is a peak-reading device. Although the calibration on the face of the instrument is marked "RMS Volts", this simply means that the meter will read the rms value of a true sine wave. If the wave form of the voltage being measured contains appreciable harmonic voltages or other spurious voltages, errors in measurement will be encountered of a magnitude indicated by the following table:

% Harmonic	True RMS Value	Peak Meter Indication
0	100	100
10% 2nd.	100.5	90 to 110
20% 2nd.	102	80 to 120
50% 2nd.	112	75 to 150
10% 3rd.	100.5	90 to 110
20% 3rd.	102	80 to 120
50% 3rd.	112	108 to 150

Wave form errors are often very troublesome at frequencies in the neighborhood of 500 megacycles and above. Quite often parasitic circuits or leads will resonate at a frequency which is two, three, or four times the frequency of the voltage being measured. These harmonic frequencies may cause serious errors in the meter reading. It is desirable to keep in mind that the sensitivity of the Model 410A increases above a thousand megacycles owing to the resonant rise in the probe circuit, and so in the higher frequency regions the meter itself is more sensitive to harmonics than at lower frequencies.

## MAINTENANCE

### Tube Replacement

When a tube is replaced in the Model 410A, it is desirable to check the accuracy of calibration of the instrument and also the change in calibration caused by line voltage variations. Adjustments are provided in the instrument for correction of calibration changes which may arise owing to the variation of a replacement tube from its average type characteristic.

Replacing tubes V4, V5, and V6 may cause a shift in the line voltage characteristics of the instrument. Hence, if any of these tubes are changed it is desirable to connect the Model 410A to the power line through an adjustable autotransformer monitored by an ac voltmeter.

After the new tube has heated for 15 minutes or more, adjust the autotransformer for a 115-volt line voltage. The SELECTOR switch should be in the  $\dagger$  or - position with the dc leads shorted together. Allow three or four minutes for the instrument to stabilize and then zero-set the meter with the ZERO ADJ control. Next, set the line voltage to 105 and 125 volts respectively, allowing three or four minutes at each setting. If the zero reading changes more than  $\pm 2\%$ , potentiometer R45 should be reset until line voltage effects are within the specified tolerance. (R45 is marked "6" on the terminal board located behind the upper right side of the instrument cabinet.) Make certain that ZERO SET control will zero the meter; under some conditions it may be necessary to select another replacement tube and to repeat the procedure.

Also, when amplifier tubes V4, V5, or V6, are replaced, the calibration of the instrument should be checked by measuring standard or accurately-known sources of one volt dc with the instrument properly zeroed. If the reading of the Model 410A is not within 3% of full scale, adjust potentiometer R35 (marked "4" on terminal board) until an accuracy of better than 3% is obtained. After calibrating the one-volt range, check the calibration of the other dc ranges by measuring accurately-known or standard dc voltage sources. It may be necessary to readjust R35 to obtain an overall accuracy of 3% for all dc ranges.

Diodes V1 and V2 should be replaced as matched pairs. When the tubes have been replaced, it is desirable to check the line voltage effects on ac readings and also to check the adjustment of the diode balancing circuit. Line voltage checks should be made as before except that the SELECTOR switch should be set on AC. If necessary adjust R15 (marked "5" on terminal board) for minimum line voltage variations.

Next, adjust R14 so that no difference in the zero reading is discernible when changing the SELECTOR switch from the two dc positions to the AC position\* with the RANGE switch on lv. A hole is provided at the rear of the cabinet in order to allow access to R14. R14 is in a high impedance circuit, so that touching it with a screwdriver causes a change in the meter setting. Therefore, it is necessary to adjust the control slightly and then remove the screwdriver before observing the effect on the meter.

If diodes V1 and V2 are changed and potentiometer R14 thus adjusted, it is desirable to check the calibration of the ac ranges of the instrument: If necessary, zero the meter and calibrate the full scale reading by means of R24 ("1" on terminal board) for the lvAC range, R25 ("2" on terminal board) for the 3vAC range, and R26 ("3" on terminal board) for the best overall accuracy of the 10, 30, 100, and 300 vAC ranges. The higher ac ranges seldom require further adjustment, but if necessary the fixed resistors R25, R28, and R48 can be replaced with the values necessary to correct the calibration of the 30 to 300vAC ranges respectively.

\* From time to time it may be found desirable to adjust R14 as above, even if no tubes are changed. The criterion for adjustment of R14 is that the meter pointer should have the same zero reading when the SELECTOR switch is switched from - to + to AC (on all ranges). Also see note on page 4 at end of "Procedure for Measuring AC Voltages."



## PULSE MEASUREMENT

The Model 410A is a peak-reading type voltmeter and is so designed that it measures the positive peak value of the applied voltage. This property allows the Model 410A to be used to measure the positive voltage rise in a pulse, provided the reading obtained is multiplied by the factor

$$1.4 (1 + t_1/t_2 + K/PRF)$$

where  $t_1$  is the duration of the positive portion of the voltage,

$t_2$  is the duration of the negative portion of the voltage,

K is a factor which is a function of the source impedance of the pulse generator and of  $t_1$ ,

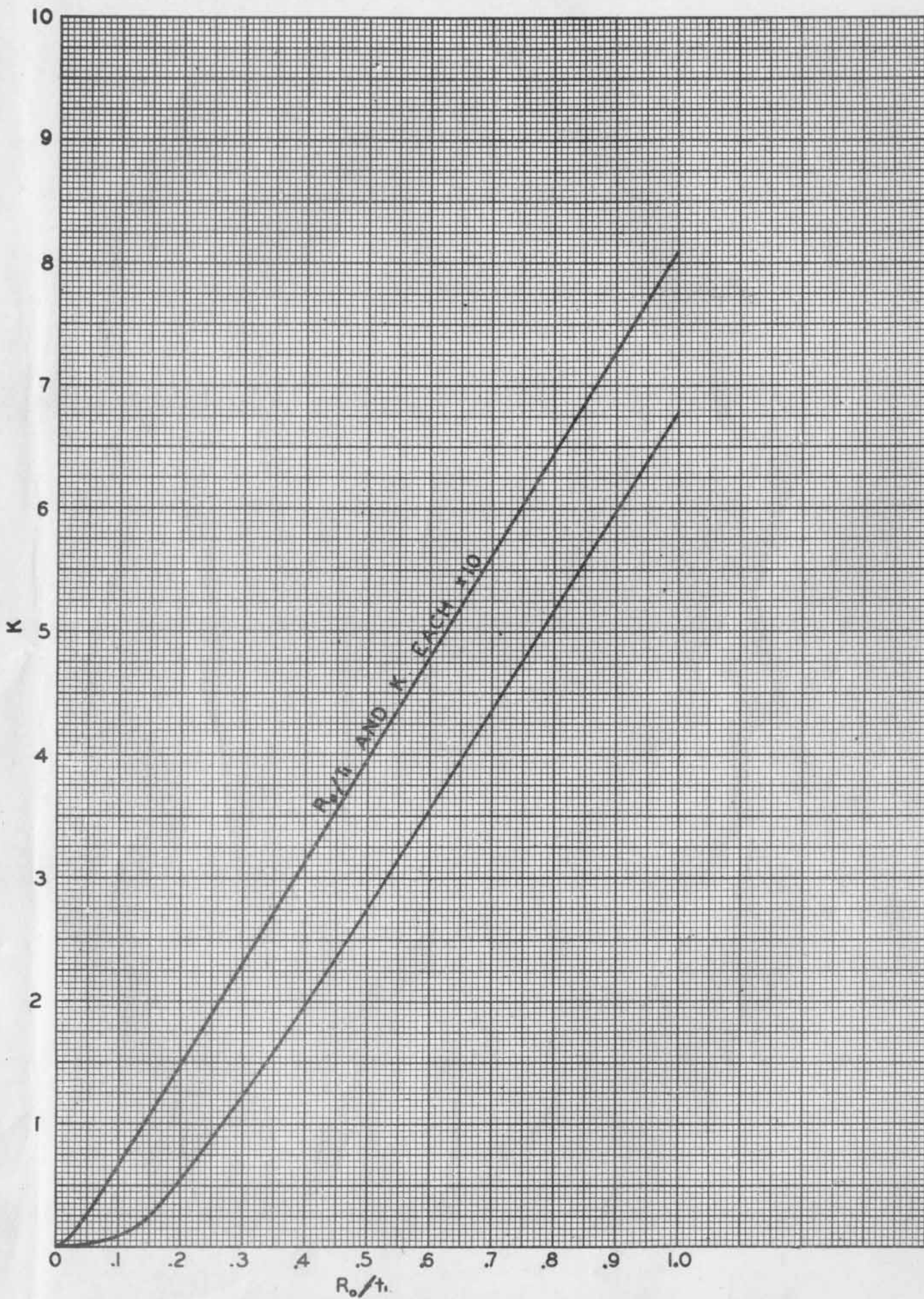
PRF is the pulse repetition frequency in pulses per second.

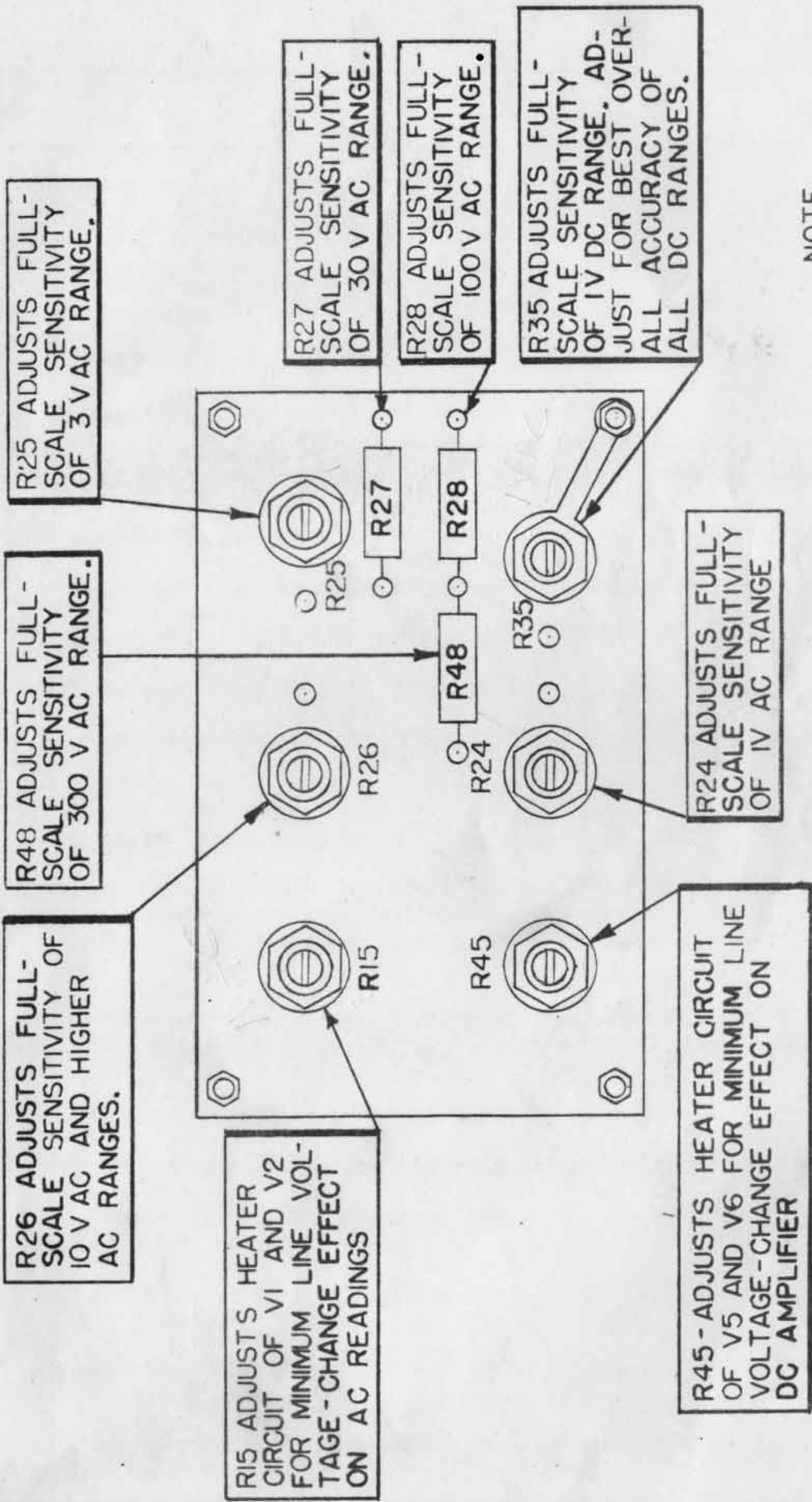
In general if the pulse repetition frequency is greater than approximately 400 or 500 pps, the above factor reduces to

$$1.4 (1 + t_1/t_2)$$

K can be found by use of the curves on the next page when the impedance of the pulse generator  $R_0$  in kilohms and the duration of the positive portion of the pulse  $t_1$  in microseconds are known. For example, in the case of a positive pulse of 1 microsecond and a PRF of 1000, and assuming  $R = 2$  kilohms,  $R_0/t_1 = 2$ ,  $K = 15.1$  and the multiplying factor would then be  $1.4 (1 + 1/999 + 15.1/100)$ .

For the case of a 1 microsecond negative pulse and a PRF of 1000,  $t_1$  would equal 999 microseconds and  $t_2$  would equal 1 microsecond. Thus,  $R_0/t_1$  would be approximately 0 and therefore (from curves) K would also be approximately 0. The multiplying factor would then be  $1/4 (1 + 999/1)$ . Hence, it may be seen that in the case of negative pulses of short duration, much smaller meter readings will be obtained than for an equivalent positive pulse, and unless the pulse voltage is large, these measurements may be impractical.





NOTE  
SEE TEXT FOR  
DETAILS

LOCATION AND FUNCTION  
OF MODEL 410A CALIBRATION RESISTORS

LIST OF COMPONENTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. and Type No.
C1	Capacitor: silver mica; .0026 mf; molded in nose of probe; for replacement order Hewlett-Packard part 42A-84		
C2	Capacitor: silver mica; 500 mmf; part of rf probe 42A-25		
C3	Capacitor: paper; .01 mf, 600 vdcw	16-11	Aerovox: 684
C4	Capacitor: paper; .01 mf, 600 vdcw	16-11	Aerovox: 684
C5	Capacitor: paper; 1 mf, 600 vdcw	17-2	General Elec: 23F467G103
C6	Capacitor: mica; .005 mf, 500 vdcw	14-5000	Micamold: type W
C7	Capacitor: mica; .005 mf, 500 vdcw	14-5000	Micamold: type W
C8	Capacitor: mica; 500 mmf, 500 vdcw	14-500	Micamold: OXM
C9	Capacitor: mica; .005 mf, 500 vdcw	14-5000	Micamold: type W
C10	Capacitor: mica; 560 mmf, 500 vdcw	15-11	Sangamo: type J
C11	Capacitor: mica; .0005 mf, 500 vdcw	14-500	Micamold: OXM
C12	Capacitor: mica; .005 mf, 500 vdcw	14-5000	Micamold: type W
C13	Capacitor: electrolytic; 50 mf; 50 vdcw	4A-65	Mallory: TC-39
C14	Capacitor: mica; 003 mf, .500 vdcw	14-16	Micamold: Type W
F1	Fuse: 3AG size cartridge type; 1 ampere rating	211-1	Littelfuse: 1040
I1	Pilot lamp: min bay base; 6-8v, 0.15 amp	211-47	GE: 47
M1	Meter: 0-1 ma	112-15	
R1	Resistor: composition; 22 megohms; 1 watt	24-22M	Allen-Bradley: GB
R2	Resistor: composition; 22 megohms; $\frac{1}{2}$ watt	23-22M	IRC: BTS- $\frac{1}{2}$
R3	Resistor: precision composition type; 0.1 megohm	31-100K	Wilkor: CP-1
R4	Resistor: precision composition type; 216.3K ohms	31-216.3K	Wilkor: CP-1
R5	Resistor: precision composition type; 683.7K ohms	31-683.7	Wilkor: CP-1
R6	Resistor: precision composition type; 2.163 megohms	31-2.163M	Wilkor: CP-1

LIST OF COMPONENTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. and Type No.
R7	Resistor: precision composition type; 6.837 megohms	31-6.837M	Wilkor: CP-1
R8	Resistor: precision composition type; 21.63 megohms; 1 watt	31-21.63M	Wilkor: CP-1
R9	Resistor: precision composition type; 68.37 megohms; 2 watts	31-68.37M	Wilkor: CP-2
R10	Resistor: precision composition type; 479,000 ohms; 1 watt	31-479K	Wilkor: CP-1
R11	Resistor: precision composition type; 1.031 megohms; 1 watt	31-1.031M	Wilkor: CP-1
R12	Resistor: precision composition type; 3.28 megohms; 1 watt	31-3.28M	Wilkor: CP-1
R13	Resistor: precision composition type; 10.31 megohms; 1 watt	31-10.31M	Wilkor: CP-1
R14	Potentiometer: composition; 10 megohms	210-455	Centralab
R15	Potentiometer: wirewound; 5 ohms	<del>42A-15A</del> 210-56	Centralab Urban. MP-3
R16	Resistor: composition; 33 ohms, 1 watt	24-33	Allen-Bradley: GB
R17	Resistor: composition; 680 ohms, 2 watts	25-680	Allen-Bradley: HB
R18	Resistor: composition; 680 ohms, 2 watts	25-680	Allen-Bradley: HB
R19	Resistor: composition; 56000 ohms; 1 watt	24-56K	Allen-Bradley: GB
R20	Resistor: composition; 8200 ohms, 1 watt	24-8.2K	Allen-Bradley: GB
R21	Resistor: composition; 8200 ohms, 1 watt	24-8.2K	Allen-Bradley: GB
R22	Resistor: composition; 56000 ohms	24-56K	Allen-Bradley: GB
R23	Resistor: wirewound; 10,000 ohms, 10 watts	26-10K	Lectrohm: 1-3/4E
R24	Potentiometer: wirewound; 5000 ohms	42A-150X	CENTRALAB: 21-010-357 Clarostat: 43
R25	Potentiometer: wirewound; 5000 ohms	42A-150X	CENTRALAB: 21-010-357 Clarostat: 43-
R26	Potentiometer: wirewound; 10,000 ohms	42A-15D	Clarostat: 43
R27	Resistor: composition; 1 watt; value selected during factory adjustment		

## LIST OF COMPONENTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. and Type No.
R28	Resistor: composition; 1 watt; value selected during factory adjustment		
R29	Resistor: composition; 4.7 megohms; $\frac{1}{2}$ watt	23-4.7M	Allen-Bradley: EB
R30	Resistor: composition; 5.6 megohm; $\frac{1}{2}$ watt	23-5.6M	Allen-Bradley: EB
R31	Resistor: composition; 5.6 megohm; $\frac{1}{2}$ watt	23-5.6M	Allen-Bradley: EB
R32	Resistor: composition; 10,000 ohms; 2 watts	25-10K	Allen-Bradley: HP
R33	Potentiometer: wirewound; 2000 ohms	42A-15F	Clarostat: 58
R34	Resistor: composition; 10,000 ohms, 2 watts	25-10K	Allen-Bradley: HP
R35	Potentiometer: wirewound; 5000 ohms	42A-15B	Clarostat: 58
R36	Potentiometer: wirewound; 25000 ohms	42A-15H	Clarostat: 58
R37	Resistor: precision composition type; 9 megohms	31-9M	Wilkor: CP-1
R38	Resistor: precision composition type; 0.9 megohms	31-900K	Wilkor: CP-1
R39	Resistor: precision composition type; 90,000 ohms	31-90K	Wilkor: CP-1
R40	Resistor: composition; 9000 ohms; 1 watt	31-9000	Wilkor: CP-1
R41	Resistor: composition; 900 ohms; 1 watt	31-900	Wilkor: CP-1
R42	Resistor: composition; 90 ohms; 1 watt	31-90	Wilkor: CP-1
R43	Resistor: wirewound; 9.5 ohms	42A-55D	Hewlett-Packard
R44	Resistor: composition; 200 ohms, 1 watt	24-200	Allen-Bradley: GB
R45	Potentiometer: wirewound; 3 ohms	42A-15A	Utah: MP-3
R46	Resistor: composition; 200 ohms; 1 watt	24-200	Allen-Bradley: GB
R47	This reference not assigned		
R48	Resistor: composition; 1 watt; value selected during factory calibration		

R50

Resistor: 3/8 ohm; consists of  
two 3/4 ohm resistors in parallel

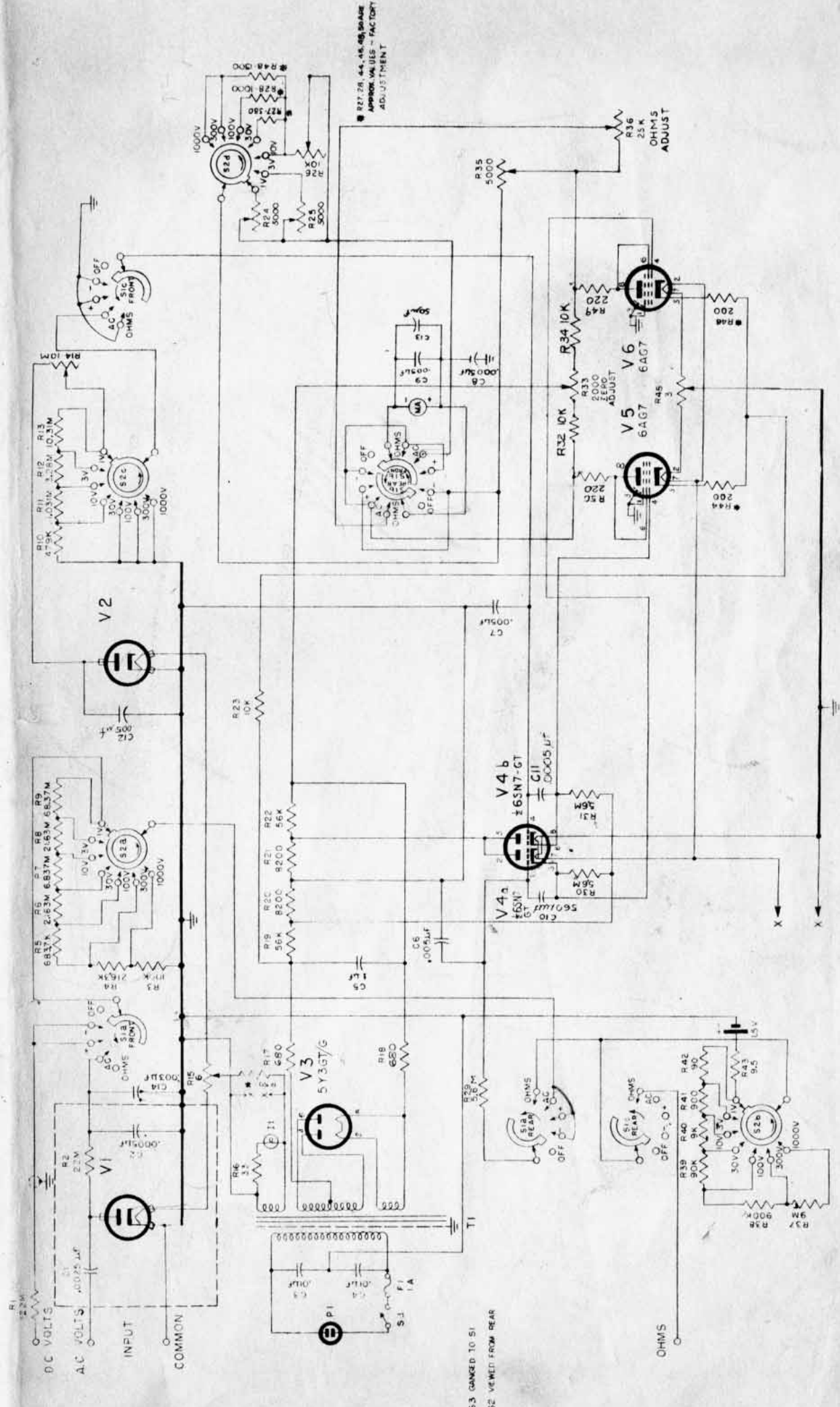
## LIST OF COMPONENTS

Circuit Ref.	Description	-hp- Stock No.	Manufacturer and Type
R49	Resistor: composition; 220 ohms, 1 watt	24-220	Allen-Bradley GB
R50	Resistor: wirewound; 3/4 meg-ohms, 2 watts $\pm$ 10%	26-20	Clarostat: Type FYG
S1	Switch: rotary; 3 sections, five position; ceramic insulation	310-19	
S2	Range Switch Assembly: 7 sections 7 position rotary switch with resistors R3 to R9, R10 to R13, and R37 to R43 mounted thereon	42A-19W	Hewlett-Packard 42A-19W
S3	Switch: toggle: SPST (part of S2)		
T1	Power transformer	910-22	Excel: 910-410
V1	Tube: UHF diode: supplied with V2 as a matched pair	42A-73A E-01C	Eimac:
V2	See V1		
V3	Tube: RMA type 5Y3GT/G	212-5Y3GT- /G	
V4	Tube: RMA type 6SN7GT	212-6SN7GT	
V5	Tube: RMA type 6AG7	212-6AG7	
V6	Tube: RMA type 6AG7	212-6AG7	
	Tube Socket: standard octal; molded mica filled phenolic	38-22	Cinch: 9880
	Tube Socket: for V2	42A-48	Hewlett-Packard
	Pilot Lamp Socket: for min bay base lamps; red jewel	312-10	Signal Ind. 807BS
	Binding Post: ferrule thumbscrew type	312-3	Hewlett-Packard
	Knob: molded black phenolic: 1 1/2" diam	37-5	Kurz-Kash: S-380-64L
	Knob: molded black phenolic: 1-1/8" diam	M-59	Hewlett-Packard
	"Ohms" Test Lead	816-18R & 38-89R	Hewlett-Packard

## LIST OF COMPONENTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. and Type No.
	"Common" Test Lead	816-18B & 38-60	Hewlett-Packard
	"DC Volts" Test Lead	42A-16B	Hewlett-Packard
	"AC Volts" Test Lead & Probe	42A-25 Type 2	Hewlett-Packard
	Flashlight cell	312-112	
	Power Cord	812-55	
	Handle	312-5	
	Probe Head (Part 1): consists of 22 megohm $\frac{1}{2}$ watt composition resistor and contact molded in gray polystyrene	42A-83	Hewlett-Packard. 42A-83
	Probe Head (Part 2): consists of 2600 mmf silver mica capacitor molded in gray polystyrene	42A-84	Hewlett-Packard. 42A-84





SCHEMATIC DIAGRAM OF -hp-MODEL 410A HIGH FREQUENCY VTVM

## 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 instructions or shipping data.
2. On receipt of shipping instructions, 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, CALIF.



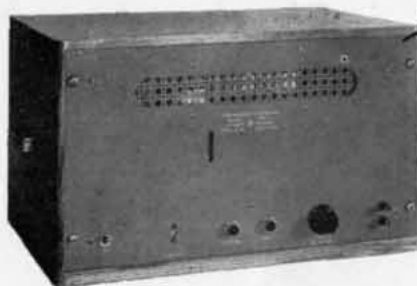


# LABORATORY INSTRUMENTS OF SPEED AND ACCURACY



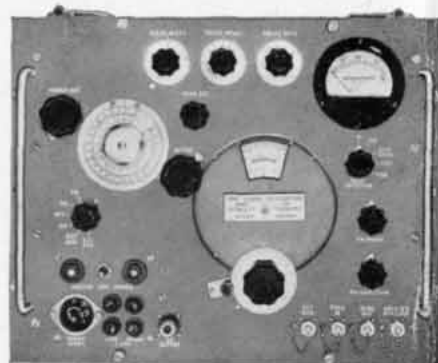
## SQUARE WAVE GENERATOR

*hp* Model 210 Square Wave Generator provides a new approach to the problem of measuring the characteristics of audio-frequency equipment. One or two observations with this generator will check the frequency response of apparatus where heretofore a large number of observations were necessary. It will show up phase shift and transient effects, both of which are rather difficult to study by other methods.



## SECONDARY FREQUENCY STANDARD

*hp* Model 100 Low Frequency Standard provides a convenient and extremely useful source of four standard frequencies (100 cps, 1 kc, 10 kc, 100 kc) for accurate measurement purposes, for calibrating audio equipment and for various other work where great accuracy is required. It is useful in making accurate interpolation measurements at high frequencies.



## UHF SIGNAL GENERATOR

*hp* Model 616A UHF Signal Generator is the first instrument developed commercially which combines great operational speed, accuracy and ease of operation with a frequency range of 1800 mc to 4000 mc. R-f power is generated by a reflex klystron oscillator, and voltage adjustments during operation are eliminated by special *hp* automatic coupling device which causes oscillator repeller voltage to track frequency changes. The *hp* 616A features direct frequency and voltage control; c-w, f-m or pulsed output; plus wide variety of input and output delay and synchronization features.



## ATTENUATORS AND VOLTAGE DIVIDERS

*hp* Model 350 is a bridged-T attenuator consisting of one 100 db attenuator with 10 db steps and a 10 db attenuator having 1 db steps. Special construction is used to assure high frequency response. Inquiries pertaining to your particular attenuator or voltage divider problems will be given careful attention. The Model 350A operates on a 500-ohm impedance level while the 350B operates at a 600-ohm impedance level.



## ELECTRONIC FREQUENCY METER

*hp* Model 500A Frequency Meter is designed to measure the frequency of an alternating voltage from 5 cps to 50 kc. It can be used to measure difference between two h-f signals. It is particularly suited to crystal grinding work where it can be used to measure the frequency deviation from the standard, quickly and accurately.



## POWER SUPPLY UNIT

*hp* Model 710A Power Supply is an excellent source of d-c power for every laboratory and production department use. The power pack is designed for the utmost in flexibility, compactness, portability and economy. Output is continuously variable between 180 and 360 volts. The output voltage varies approximately 1 per cent with changes in load current up to 75 ma and with normal line variations. Noise and hum level is exceptionally low, and output unusually stable over a long period of time. Also contains auxiliary center-tapped 6.3 volt source providing 5 amperes of a-c.



## WIDE-BAND OSCILLATOR

*hp* Model 650A Resistance-tuned Oscillator is the first instrument of its kind that not only covers a frequency range of 10 cps to 10 mc, but brings to the r-f and video fields all the speed, ease and accuracy traditional in *hp* audio oscillators. This highly-stable, precision instrument provides output flat within  $\pm 1$  db from 10 cps to 10 mc, and a voltage range of .00003 to 3 volts. Output impedance is 600 ohms, or 6 ohms with 100 to 1 output voltage divider. Instrument includes built-in vacuum tube voltmeter and 50 db output attenuator.



## PRECISION OSCILLATORS

*hp* Model 201B and *hp* Model 2001 are precision measuring instruments of utmost accuracy and latest design. The 201B spans a range from 20 cps to 20 kc in three bands; the 2001, a spread-scale oscillator, covers frequencies from 6 to 6000 cps in six bands. Both include a 6" main frequency tuning dial calibrated over 300 degrees, controlled directly or by 6-1 micro-drive. Both meet all requirements for measurement speed, accuracy, and purity of wave form. And both instruments incorporate *hp* family characteristics of no zero set, constant output, and great stability.



## AUDIO SIGNAL GENERATOR

*hp* Model 206A Audio Signal Generator provides a highly-stable source of continuously variable a-f having a total distortion of less than 0.1% between 50 cps and 20 kc. Output meter monitors output voltage signal with accuracy of at least 0.2 db. Precision attenuators vary output signal level in 0.1 db steps over 111 db range. Flat frequency response and great accuracy of output voltage make this instrument ideal for FM transmitter and station maintenance work.

**hp laboratory instruments**  
FOR SPEED AND ACCURACY

**HEWLETT-PACKARD COMPANY**

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# LABORATORY INSTRUMENTS OF SPEED AND ACCURACY

*Standard -hp- instruments shown here are adaptable for making nearly every electronic measurement in the electronic field. Following is a brief description of a few of these instruments. Complete technical information will be sent—without obligation—on request. In addition, -hp- engineers are at your service to help solve special problems.*



### VACUUM TUBE VOLTMETER

-hp- Model 400A Vacuum Tube Voltmeter sets a new standard of performance for voltage measurements in the audio, supersonic, and lower radio frequency region. Measurements up to 1 megacycle with this instrument are as simple as measurements with the usual multi-range meter at d-c. Nine ranges give full-scale sensitivities from .030 to 300 volts. Ordinarily no precautions whatsoever are required; turn-over effect and waveform errors are minimized; there are no adjustments to make during operation; a large overload will not damage the instrument. The input impedance is 1 megohm so that most circuits will not be disturbed when their voltage is measured.



### H-F VACUUM TUBE VOLTMETER

-hp- 410A High Frequency Vacuum Tube Voltmeter combines in one instrument an ac voltmeter covering frequencies from 20 cps to 700 mc, a dc voltmeter with 100 megohms input impedance, and an ohmmeter capable of measuring resistances from .2 ohms to 500 megohms. The special probe places a capacity of 1.3 uufd across the circuit under test. Input resistance for ac measurements is 6 megohms. Six voltage ranges provide full-scale sensitivities from 1 to 300 volts.



### WIDE-BAND AMPLIFIER

-hp- 450A Amplifier is a new, versatile, wide-band amplifier designed for general laboratory or production use. It provides exceptional stability at 40 or 20 db gain, and gives new freedom from spurious responses. Low phase shift is assured by a straight-forward, resistance-coupled amplifier design, together with inverse feedback. Frequency response is flat within 1/2 db between 10 and 1,000,000 cps. Varying tube voltages or aging tubes have no appreciable effect on the gain or other characteristics. When used in conjunction with -hp- 400A Vacuum Tube Voltmeter, it increases voltmeter sensitivity 100 times.



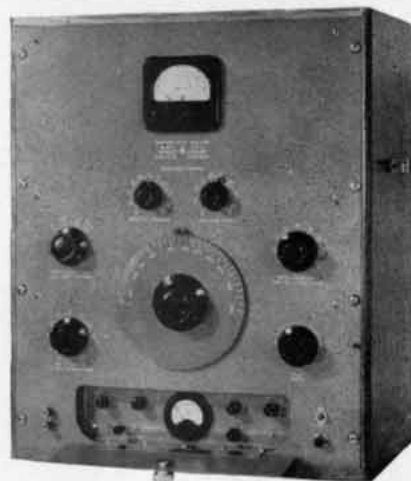
### AUDIO SIGNAL GENERATORS

-hp- Audio Signal Generators are designed for time-saving performance. They are excellent for general laboratory applications because they supply a known voltage as well as a known frequency at the commonly used impedance levels. They are particularly suitable for gain measurements because no auxiliary apparatus is required. They provide an excellent source of voltage for distortion measurements because their waveform distortion is very small.



### RESISTANCE-TUNED AUDIO OSCILLATORS

-hp- Resistance-Tuned Oscillators are suitable for almost every type of work. Their low distortion makes them particularly valuable in making distortion measurements on audio amplifiers, broadcast transmitters and other equipment. They provide an excellent source of voltage for accurate bridge measurements. The output is sufficient to drive signal generators and other equipment requiring considerable power. Their wide frequency range also makes them suitable for work in the supersonic region.



### HARMONIC WAVE ANALYZER

-hp- Model 300A Harmonic Wave Analyzer is an excellent instrument for both laboratory and production work where accurate and rapid measurement of individual components of a complex wave is required. The maximum selectivity is sufficient for measurement of harmonics of frequencies as low as 30 cycles and it can be varied over a wide range. With this variable selectivity feature, measurements at higher frequencies can be made more rapidly, yet with no sacrifice in accuracy.



### DISTORTION ANALYZER

This Model 330B Distortion Analyzer is -hp-'s newest, finest distortion measuring instrument. It is capable of measuring distortion at any frequency between 20 cps and 20,000 cps. It will make noise measurements of voltages as small as 100 microvolts. A linear r-f detector makes it possible to measure these characteristics directly from a modulated r-f carrier. The high sensitivity, stable accuracy and compactness of the 330B make it extremely valuable for broadcast, laboratory and production measurements.

ADDITIONAL INSTRUMENTS ON REVERSE SIDE OF PAGE