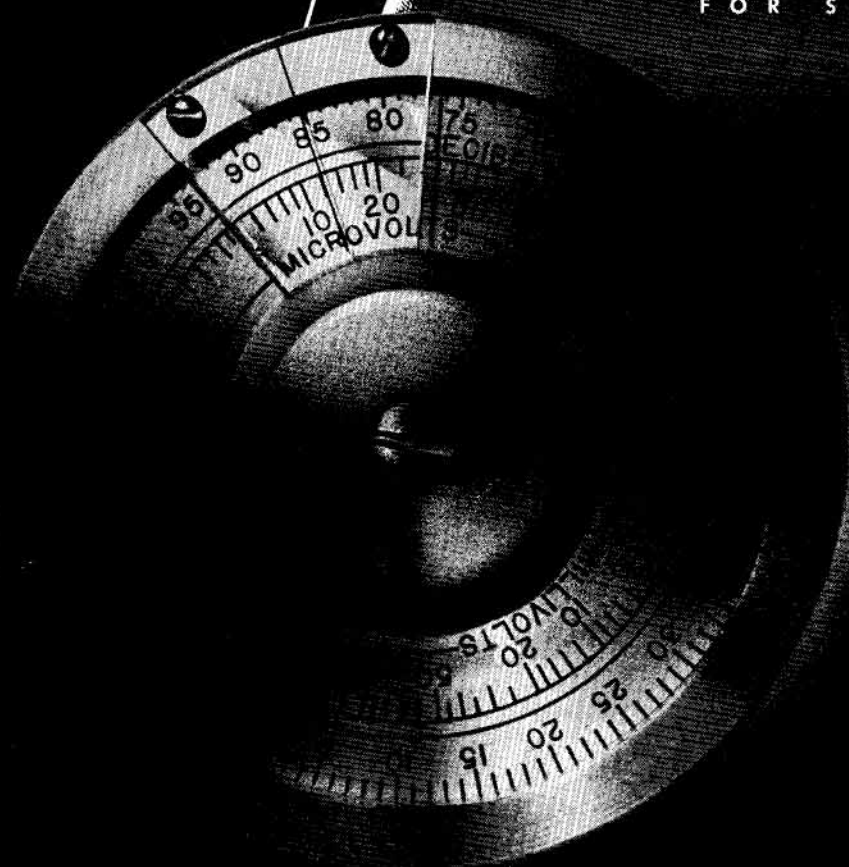


CATALOG 20-A

1950



laboratory instruments
FOR SPEED AND ACCURACY



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

SUGGESTIONS FOR ORDERING

Order by Model Number ... Always order by catalog model number and name of instrument desired. For example, "Model 206A Audio Signal Generator." Whenever possible mention frequency range or other significant specifications to prevent misunderstanding. Also mention features such as special color, special frequency range, non-standard power line voltage, etc., and whether cabinet or rack mounting style is desired.

Most Hewlett-Packard instruments are available in either cabinet or rack mounting. The letter "R" after the model number indicates rack mounting. For example, "206AR". An additional charge of \$5.00 is made for most rack mounting style instruments.

Orders should be sent direct to the factory and addressed to Hewlett-Packard Company, 395 Page Mill Road, Palo Alto, California. All orders are subject to final acceptance by the Hewlett-Packard Company.

Shipments ... Unless specifically requested otherwise, shipments are made by express. This policy is born of experience. Delicate instruments require the careful handling received in express shipment, and over a long period of time this method has proved most satisfactory. On request, shipments will be made by air freight or by truck. We do not recommend shipment by parcel post or by freight, and shipments will not be made by this type of carrier without specific instructions from the customer and the understanding that safe arrival is his entire risk.

Terms ... 30 days net. Unless credit has already been established, shipments will be made c.o.d. All prices are quoted f.o.b. Palo Alto.

Sales Representatives ... Sales representatives are maintained in principal cities as a service to our customers. Customers are invited to contact the nearest representatives at any time. They will gladly supply technical information, help prepare your order and, if desired, forward order to the factory. Orders should be made out to the Hewlett-Packard Company and are subject to final acceptance by the Company in Palo Alto. Sales representatives and their addresses are shown on the back cover. Export sales are made through Frazar and Hansen, Ltd., 301 Clay Street, San Francisco 11, California.

Repairs ... When returning instruments for repairs, recalibration, or any other reason, please contact the Hewlett-Packard Company for shipping instructions. Give model number, type number, and serial number and as much information as possible concerning reason for return.

Repairs are made by the Hewlett-Packard Company at cost of labor and materials plus a small service charge. Customers are invited to make full use of this service to insure maximum benefit from their instruments.

Repair Parts ... When ordering repair parts please describe carefully parts required. Give model number, type number, serial number of the instrument and date of original purchase. Identify parts on the wiring diagram if possible, giving date shown on the circuit wiring diagram.

**WHERE TO FIND THE
INSTRUMENTS YOU NEED
IN THIS CATALOG**

For your convenience, the *-hp-* measuring instruments in this catalog are grouped together according to their uses and applications.

For speedy reference, see listing below, then turn to the section desired for detailed information.

OSCILLATORS for general test signals.

VACUUM TUBE VOLTMETERS and accessories for voltage, current, or power measurements.

AUDIO SIGNAL GENERATORS for measuring gain, frequency response, amplifier characteristics, etc.

PULSE GENERATOR for radar, nuclear and TV circuits.

DISTORTION ANALYZERS for total distortion and wave form measurements.

SQUARE WAVE GENERATORS for transient response determination.

SIGNAL GENERATORS for measuring receiver performance, standing wave ratio, gain, antenna and transmission line characteristics, etc.

MICROWAVE EQUIPMENT. Impedance and power measuring equipment, Low Pass Filters, Detectors.

FREQUENCY MEASURING EQUIPMENT. Frequency Standards for audio, supersonic and rf measurements. FM and TV Broadcast Station Monitors, Direct Reading Electronic Tachometers.

POWER SUPPLIES, regulated, for laboratory and general use.

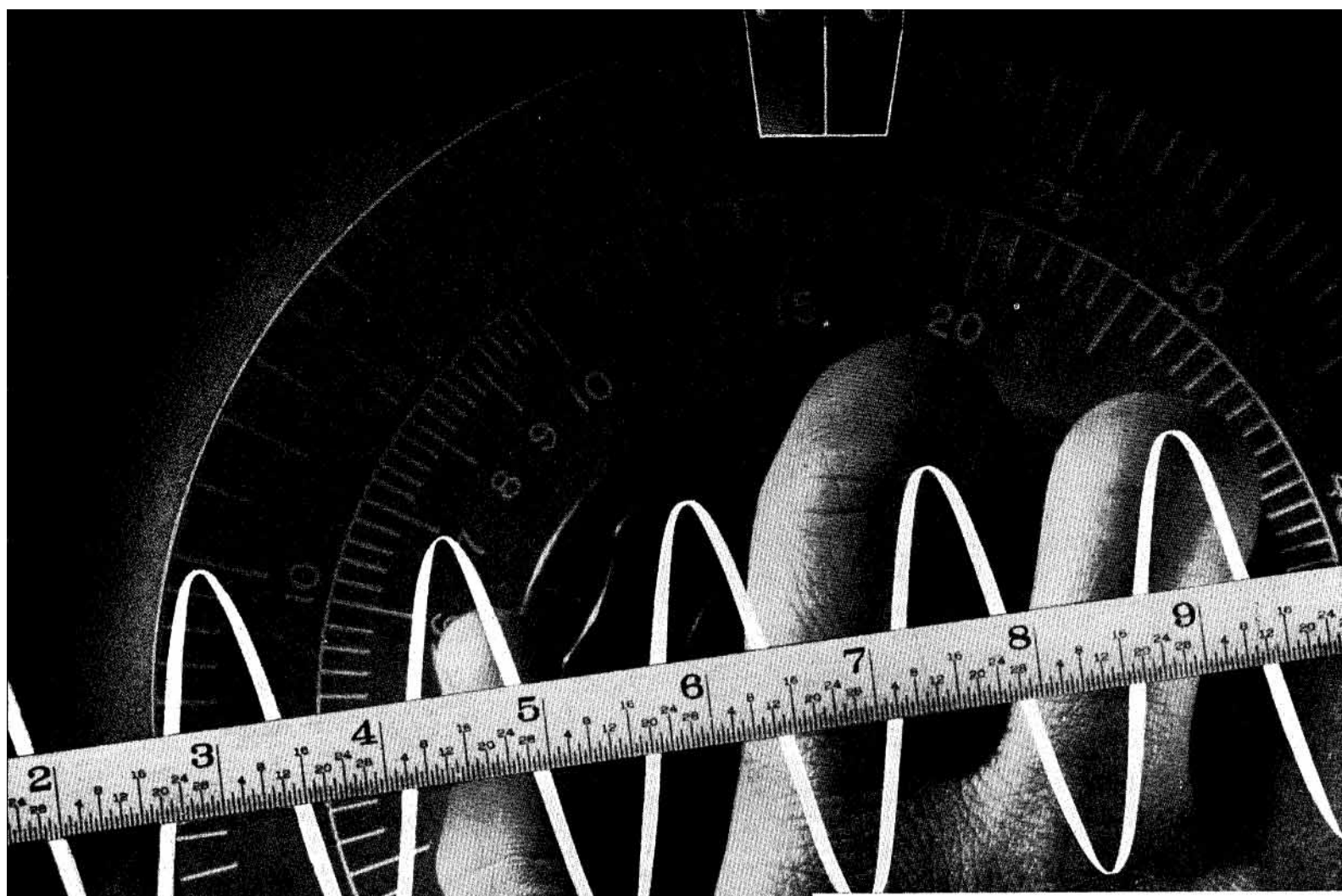
ATTENUATORS for use in measuring gain, frequency response, voltage ratios, etc.

WIDE BAND AMPLIFIERS for faithful pulse amplification, VTVM multipliers, general laboratory use, etc.

ORDERING INFORMATION, RETURNING INSTRUMENTS to *-hp-*. Repair Information.

SALES and **SERVICE** Representatives in your locality.

PRICES: Prices are shown on the table of brief specifications preceding each group of instruments, or in the detailed specifications of individual instruments.



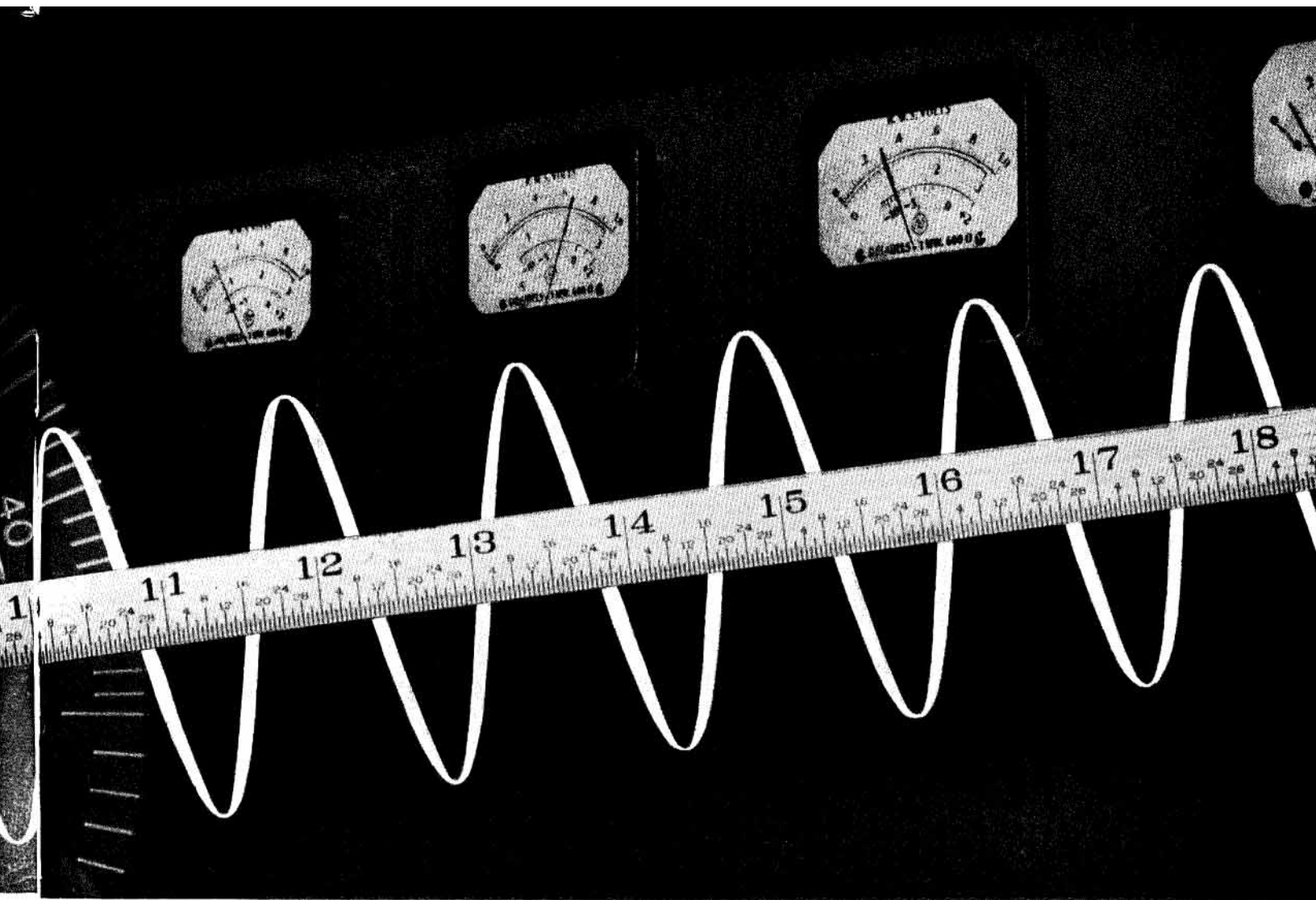
Lord Kelvin

HAD A WORD FOR IT



I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be."

LORD KELVIN
1883



ENGINEERING TIME IS AN EXPENSIVE COMMODITY...

Probably in no other field is proper instrumentation so vitally important as in electronics. Lacking the proper instruments, it is not only difficult to design equipment correctly in the first place, but often impossible to tell whether it is behaving properly when completed.

To describe fully the performance of one of the simplest electronic devices—a single-stage amplifier—requires the measurement of operating voltages and currents, gain, frequency response, overload points, harmonic distortion, and noise level. In more complex apparatus the list would be greatly expanded. Many of these measurements must be made in high-impedance circuits where great care and judgment must

be exercised, not only in making the measurements themselves, but in interpreting the results.

Engineering time is a very expensive commodity. To employ it most efficiently, too much thought cannot be given to the selection of the proper tools. *-hp-* instruments are designed with convenience second only to accuracy in their requirements. By minimizing the time needed for routine measurements, and by guaranteeing the accuracy of the results, *-hp-* instruments render an outstanding service toward the advancement of the science of electronics. On the following pages you will find complete descriptions of a great many *-hp-* instruments. Please feel free to write us for any assistance or further information which you may require.

SPEED AND ACCURACY ARE INTEGRAL PARTS OF EVERY *-hp-* INSTRUMENT



EW ease and sureness in all types of laboratory and production testing are made possible by the use of *-hp-* instruments. Although each is tailored for very specific jobs, *-hp-* laboratory instruments have certain outstanding "family" characteristics. No zero setting, little or no adjustment during operation, virtual independence of line and tube characteristics, full protection against overloads, simple, accurate calibration, and streamlined circuits for clean and trouble-free performance are qualities you will find throughout the *-hp-* line.

-hp- instruments are essential and versatile tools in the fields of television, frequency modulation, radar, industrial heating, communications, carrier current, equipment manufacture, experimental work, broadcasting, industrial testing. Here is a partial list of the measurements that can be made with standard *-hp-* instruments: distortion, frequency, gain, voltage, network response, harmonic analysis, amplifier frequency response. They are also useful to establish standard frequencies, establish standard ratios by attenuation, and provide voltage for bridge measurements. Let *-hp-* instruments, products of sound engineering and precision manufacture, solve your testing and measuring problems.



OSCILLATORS

for general test signals

OSCILLATOR

EQUIPMENT

OUTPUT
INDICATOR

ROM 1/2 cycle to 10 megacycles, there is an *-hp-* resistance-tuned oscillator engineered to your exact need. Ten instruments in all; each with the familiar *-hp-* advantages of high stability, constant output, wide frequency range,

low distortion, and freedom from adjustment during operation.

More details of these instruments are given below, and full information will be found on the pages indicated.

INSTRUMENT	PRIMARY USES	FREQUENCY RANGE	OUTPUT	PRICE	PAGE
<i>-hp-</i> 200A	Audio tests	35 cps to 35 kc	1 watt/22.5v	\$120.00*	6-7-8-9
<i>-hp-</i> 200B	Audio tests	20 cps to 20 kc	1 watt/22.5v	\$120.00*	6-7-8-9
<i>-hp-</i> 200C	Audio and supersonic tests	20 cps to 200 kc	100 mw/10v	\$150.00*	6-7-8-9
<i>-hp-</i> 200D	Audio and supersonic tests	7 cps to 70 kc	100 mw/10v	\$175.00*	6-7-8-9
<i>-hp-</i> 200H	Carrier current, telephone tests	60 cps to 600 kc	10mw/1v	\$350.00*	6-7-8-9
<i>-hp-</i> 200I	Interpolation and frequency measurement	6 cps to 6 kc	100 mw/10v	\$225.00*	6-7-8-9
<i>-hp-</i> 201B	High quality audio tests	20 cps to 20 kc	3 w/42.5v	\$250.00*	10-11
<i>-hp-</i> 202B	Low frequency measurements	1/2 cps to 50 kc	100 mw/10v	\$350.00†	12
<i>-hp-</i> 202D	Low frequency measurements	2 cps to 70 kc	100 mw/10v	\$275.00*	6-7-8-9
<i>-hp-</i> 204A	Portable, battery operated	2 cps to 20 kc	2.5 mw/5v	\$175.00	13
<i>-hp-</i> 650A	Wide range video tests	10 cps to 10 mc	15 mw/3v	\$475.00†	14-15

Data Subject to Change Without Notice. • Prices f.o.b. Palo Alto, California.

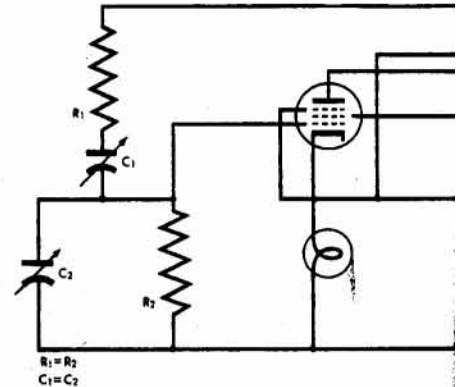
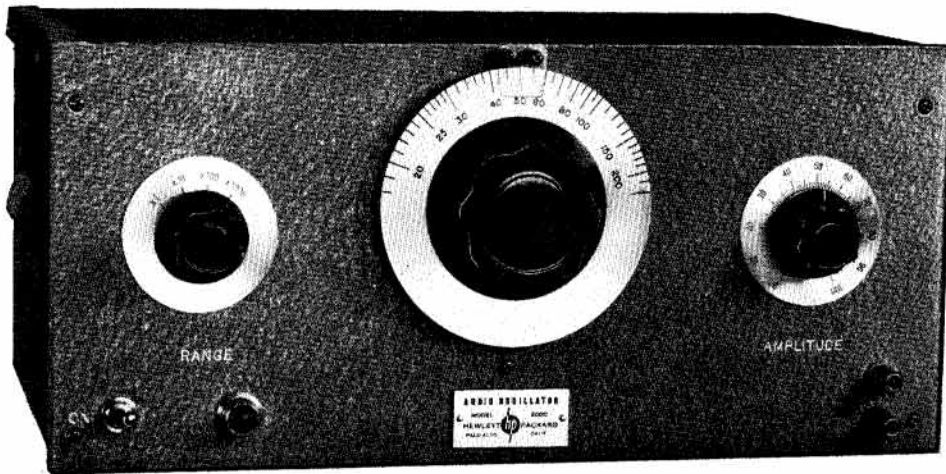
†Rack mounting available at no extra cost.

*Rack mounting available at \$5.00 extra.



MODEL 200

AUDIO OSCILLATOR



ADVANTAGES:

- No zero setting. Great stability
- Constant output
- Wide frequency range
- Logarithmic scale
- Low distortion. Light weight

USE THEM FOR:

- Amplifier testing
- Broadcast transmitter audio response
- Source of voltage for bridge measurements
- Modulating signal generators
- Supersonic voltage source
- Driving mechanical systems
- Synchronizing pulse generators
- Loud speaker resonance tests

RESISTANCE-TUNED PRINCIPLE

HERE is a sound research story behind this revolutionary *-hp-* Resistance-tuned Audio Oscillator. Although audio-frequency oscillators have always been standard equipment throughout the communications and electronics fields, there were many "bugs" in types commonly available. These disadvantages included low stability, especially in the lower frequency ranges; need for constant resetting to insure accuracy; low portability, because of the essential weight and bulk of the instrument. So *-hp-* engineers set out to design and perfect an audio-frequency oscillator which would combine the high stability and very wide range of the coil-condenser type with the flexibility of operation of the beat frequency type. The result is the basically new Resistance-tuned Audio-frequency Oscillator, based on a new fundamental circuit and resulting in new speed and accuracy for electronic tests and measurements.

The fundamental resistance-tuned circuit of *-hp-* Audio Oscillators is shown above. The resonant frequency of this network is inversely proportional to the product of resistance and capacity. Thus the change in resonant frequency of this circuit is three times as great as that of the coil and condenser circuit. A ten to one frequency change is easily possible with the resistance-tuned circuit.

The resistance-capacity (frequency determining) network is operated in conjunction with a stabilized amplifier. Positive feedback is applied to this amplifier through the resistance-tuned network, resulting in a very high effective Q for the circuit. See figure 1. Negative feedback is also used, and operates in conjunction with a non-linear resistor to limit amplitude and decrease distortion. It also helps in providing a constant and extremely stable output over the entire range. See figure 2.

NO ZERO SETTING

The excellent physical layout of *-bp-* Audio Oscillators has much to do with their satisfactory performance. Thermal drift is kept at a minimum by proper placement of components, and by means of low temperature coefficient elements in the resistance network. Furthermore, this thermal drift is not magnified, as is the case with the beat frequency type oscillator. Thus calibration is accurate under all operating conditions, without the inconvenience of constant zero setting, even within the first few minutes of operation. The constant output of these oscillators makes it easy to check the frequency response of the apparatus quickly, easily, accurately.

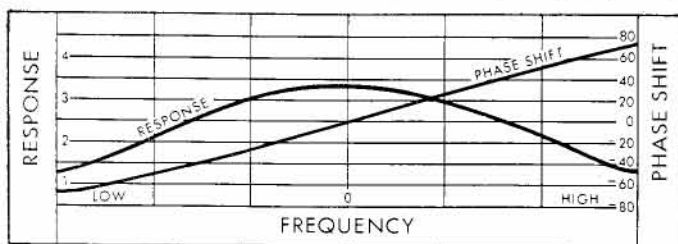


Figure 1

ONLY THREE DIALS

There are only three controls on the panel. They are the main frequency dial which covers a frequency range of 10 to 1; a range switch which selects the desired frequency band, and an amplitude control to vary the output signal level.

USES

The primary function of an audio-frequency oscillator is to generate an accurately controlled signal of known frequency. This signal may be used to check the performance of audio amplifiers, broadcast transmitters, and similar equipment. Although applications in the related fields of electronics are of first importance, the usefulness of the *-bp-* Resistance-tuned Audio Oscillator is by no means limited to the electrical engineering fields. They may be used, for example, to drive mechanical systems, in order to measure resonance and stability. Other measurements of mechanical equipment include measurements of the output frequency of rotating equipment, such as generators and dynamotors.

-bp- Resistance-tuned Audio Oscillators provide an excellent source of voltage for accurate bridge measurements. The output is sufficient to drive signal generators and other equipment requiring considerable power. Certain models are also adapted to work in the supersonic range.

The usefulness of these oscillators is greatly increased because they are small and light in weight; thus easy to carry around. In short, the speed and accuracy of *-bp-* Resistance-tuned Audio Oscillators make them ideal for an almost endless number of exacting jobs.

SPECIFICATIONS

Six standard models are available. The Models 200A and 200B have a transformer-coupled output amplifier which will deliver 1 watt into a matched load and are principally designed for use in audio testing. The Models 200C and 200D have a resistance-coupled output amplifier to provide uniform output voltage over their wide frequency range; they are principally useful when handling a wide range of frequencies, where a smaller amount of power is sufficient. Model 202D is a modification of Model 200D, with the frequency range extended down to 2 cycles per second. It is particularly useful where it is necessary to generate an extremely wide range and where low frequencies are involved, as in mechanical vibration problems. The Model 200I is an oscillator of the band spread type. It is intended for interpolation work and for applications where it is necessary that the frequency of oscillation be known very accurately. These oscillators are supplied in a relay rack mounting, as the 200AR, 200BR, 200CR, 200DR, 202DR, and 200IR.

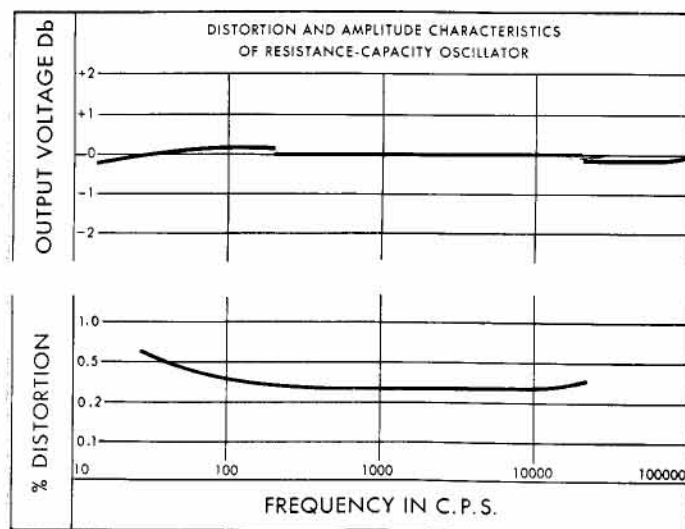
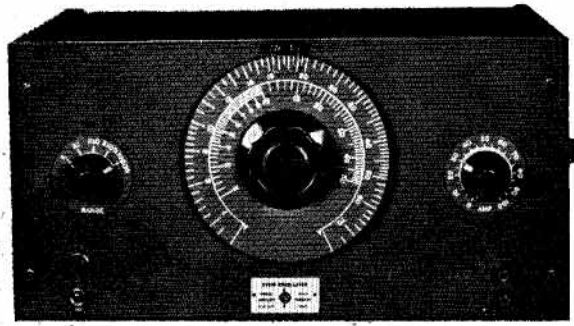


Figure 2



MODEL 202D

FREQUENCY RANGE

Model 200A	. . . . .	35 cps to 35 kc
Model 200B	. . . . .	20 cps to 20 kc
Model 200C	. . . . .	20 cps to 200 kc
Model 200D	. . . . .	7 cps to 70 kc
Model 200H	. . . . .	60 cps to 600 kc
Model 202D	. . . . .	2 cps to 70 kc
Model 200I	. . . . .	6 cps to 6 kc

Calibration: The dial is calibrated directly in cycles for the lowest range. A switch selects the range and indicates the proper multiplying factor. The dial calibration of Models 200A, 200B, and 200C covers approximately 180 degrees, with an equivalent scale length of 20 to 30 inches. Models 200D and 202D have dial calibrations covering approximately 300 degrees with a scale length of about 60 inches. Model 200I is calibrated over approximately 300 degrees, and has a scale length of approximately 90 inches.

	200A	200B
Range 1	. . . 35 - 350 cps	20 - 200 cps
Range 2	. . . 350 - 3500 cps	200 - 2000 cps
Range 3	. . . 3500 cps - 35 kc	2000 cps - 20 kc

	200C	200D	200H
Range 1	. . . 20 - 200 cps	7 - 70 cps	60 - 600 cps
Range 2	. . . 200 - 2000 cps	70 - 700 cps	6 - 6 kc
Range 3	. . . 2000 cps - 20 kc	700 - 7000 cps	6 - 60 kc
Range 4	. . . 20 - 200 kc	7000 cps - 70 kc	60 - 600 kc

Model 202D is similar to Model 200D, with the addition of a 2-50 cps band covering approximately 200 degrees on the main tuning dial.

	200I	
Ax1	6 - 20 cps Bx10	200 - 600 cps
Bx1	20 - 60 cps Ax100	600 - 2000 cps
Ax10	60 - 200 cps Bx100	2000 - 6000 cps

Stability: Under normal conditions the frequency drift is less than $\pm 2\%$ or 0.2 cps (whichever is greater) including initial warm-ups. Plus or minus 10 volt line voltage variations change the frequency less than $\pm 0.2\%$ at 1 kc. No zero setting is necessary on these oscillators. On Model 200I, if the ranges are standardized against a suitable frequency standard from time to time, accuracy better than 1% can be maintained.

Output: The Models 200A and 200B will supply one watt or 22.5 volts output into a matched resistance load of 500 ohms, and 25 volts on open circuit. Models 200C, 200D, 202D, and 200I will deliver 100 milliwatts or 10 volts into a 1000 ohm load. The internal impedance of the output amplifier is in the order of 50 ohms at 1000 cps. Model 200H, 10 milliwatts to a 100 ohm load.

Frequency Response: The output voltages of Models 200A and 200B are constant within plus or minus one decibel from 20 cps to 15 kc. The output voltage of the Model 200C is constant within plus or minus one decibel from 20 cps to 150 kc. The output voltages of the Models 200D and 202D are constant within plus or minus one decibel from 7 cps to 70 kc. The Model 202D will be within plus or minus 2 decibels from 2 cps to 7 cps. The frequency response of the 200I is plus or minus one decibel from 6 cps to 6,000 cps; 200H, plus or minus one db, 60 cps to 600 kc.

Distortion: The total rms distortion contained in the waveform of the various models is within the following limits: Models 200A and 200B, less than 1% distortion from 35 cps to 15 kc. Model 200C, less than 1% distortion from 20 cps to 100 kc. Model 200D, less than 1% distortion from 10 cps to 70 kc. Model 202D, less than 2% at rated output voltage from 10 cps to 70 kc. Model 200I, distortion less than 1% above 10 cps, and only slightly more than this at lower frequencies. Model 200H, 1% distortion to 100 kc, 3%, 100 kc to 600 kc.

Hum Voltage: On all models, the hum voltage is less than 0.1% of maximum output voltages.

Power Supply: 115 volts, 50/60 cycles, 60 watts.

Mounting: The cabinet models are mounted in an attractive steel cabinet finished in wrinkle gray.

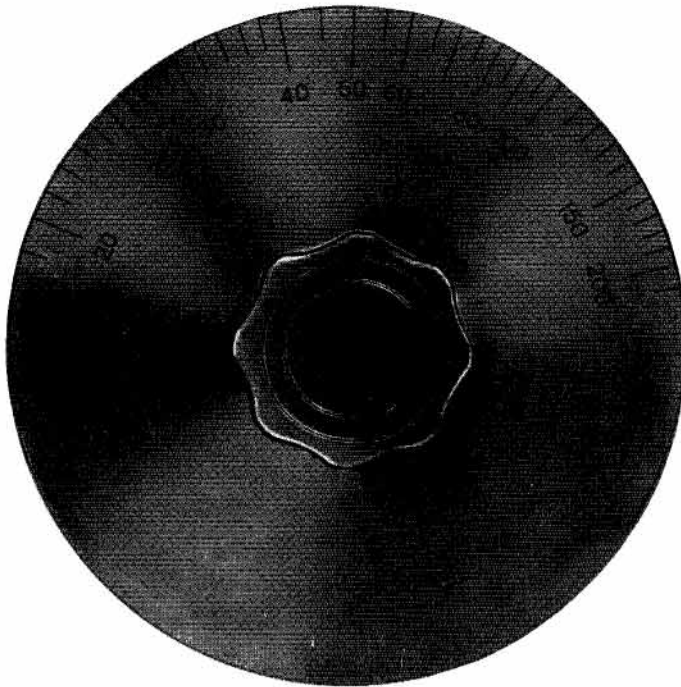
The relay rack mounting fits the standard 19" relay rack with 3/4" spacing. The dust cover mounts on the chassis and is removable from the rear.

Model	Mounting*	Length	Height	Depth	Weight
200A	Cabinet	16"	7"	9"	32 lbs.
200B	Cabinet	16"	7"	9"	32 lbs.
200C	Cabinet	16"	7"	9"	30 lbs.
200D	Cabinet	17"	8 3/4"	11"	32 lbs.
202D	Cabinet	17"	8 3/4"	11"	32 lbs.
200H	Cabinet	17"	8 1/2"	10 3/8"	32 lbs.
200I	Cabinet	17"	8 1/2"	10 3/8"	32 lbs.

Average shipping weight 42 lbs.

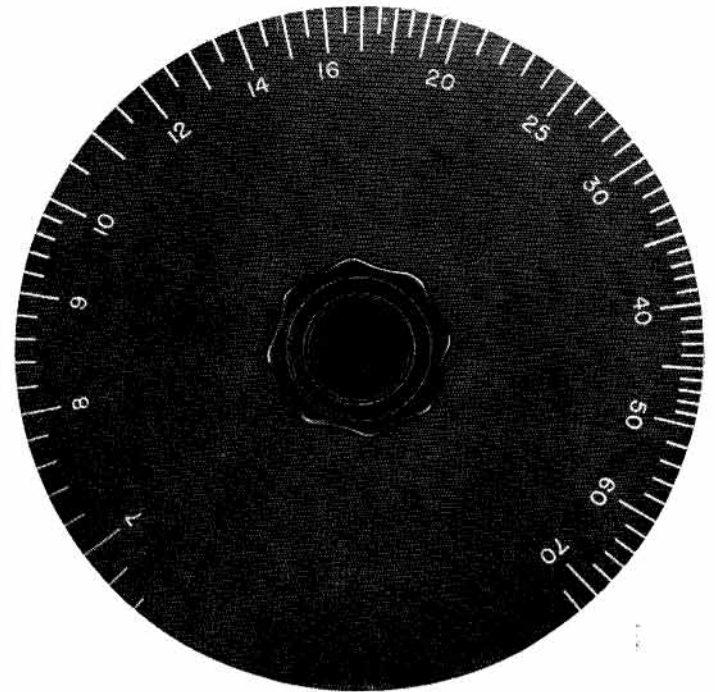
*These instruments available for rack mounting with 19" long panel.

Data subject to change without notice.



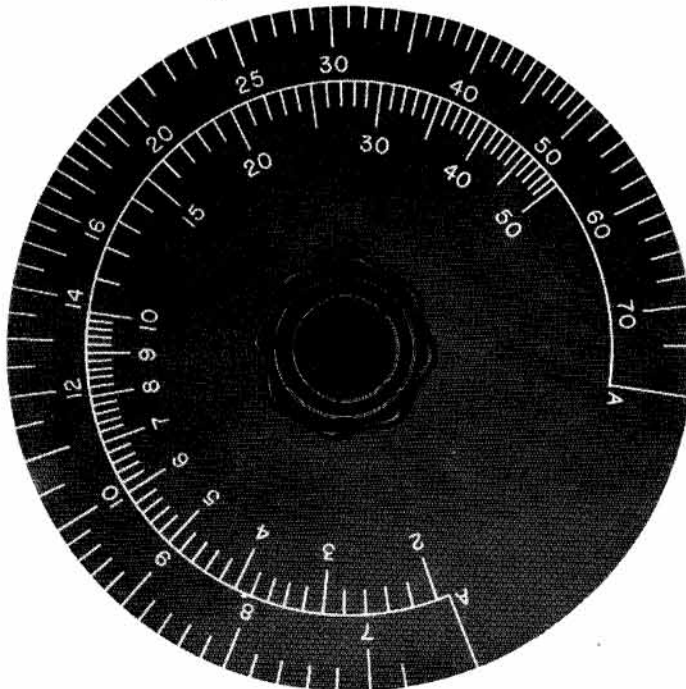
200B AND 200C

Here is the main tuning dial of *-hp-* Models 200B and 200C Audio Oscillators. Range is 20 cps to 20 kc on 200B, with dial calibrated over approximately 180° and effective scale length of about 20"; 200C has range of 20 cps to 200 kc and effective scale length of about 26".



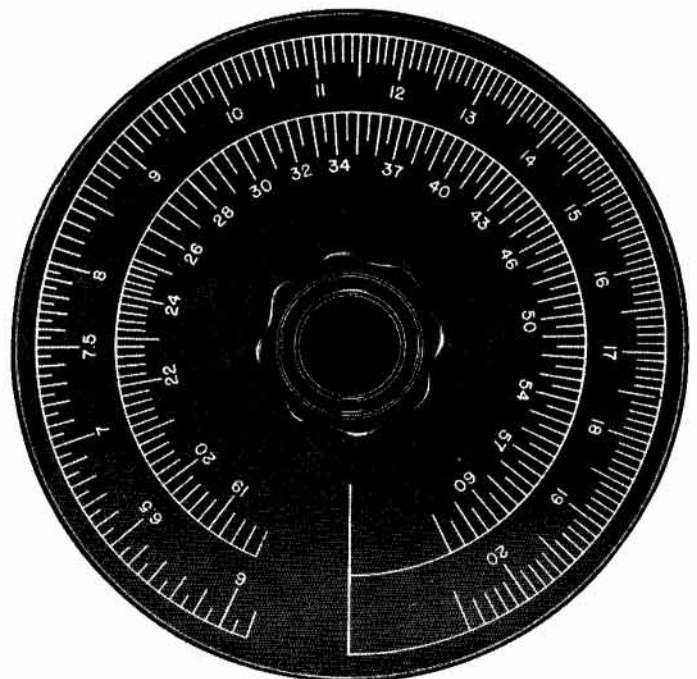
200D

Main tuning dial of *-hp-* Model 200D is calibrated over approximately 300° and has an effective scale length of about 60". This wide range instrument (from 7 cps to 70 kc) owes much of its speed and accuracy of operation to the precisely calibrated and easily controlled tuning dial pictured above.



202D

The *-hp-* Model 202D is a modification of the 200D, which extends the range down to 2 cps. The tuning dial is calibrated over approximately 300°; the effective scale length is about 75". Before calibration, all *-hp-* Audio Oscillators are operated for a long period so as to be completely stabilized.



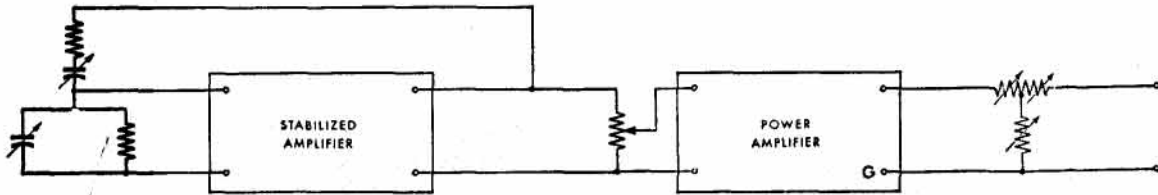
200I

Main tuning dial of the 200I, which is an oscillator of the band-spread type, intended for comparison work. The dial is calibrated over approximately 300° with effective scale length about 90" and range of 6 cps to 6 kc. Each Model 200I is carefully hand calibrated to insure maximum accuracy.



MODEL 201B

AUDIO OSCILLATOR



CHECK THE ADVANTAGES OF THIS FINE, NEW OSCILLATOR

ADVANTAGES:

- 3 watts output
- Distortion less than 1/2%
- Low hum level
- New dial with ball-bearing drive
- Accurate expanded frequency calibration
- Improved control of output level

USE IT FOR:

- High fidelity amplifier testing
- Transmission line measurement
- Loud speaker testing
- Frequency comparison

In FM and other fields where high fidelity is important, this new *hp*- Model 201B Audio Frequency Oscillator will meet every requirement for speed, ease of operation, accuracy and purity of wave form. The product of 6 years of *hp*- oscillator development, this new oscillator has many brand new features, in addition to the revolutionary resistance-tuned circuit which has made *hp*- a by-word in engineering circles.

The 201B has an accurate, convenient method of frequency control. The 6" dial, with smooth ball-bearing action, may be tuned by a directly controlled knob, or for still greater accuracy, may be set by the vernier which has a ratio of 6 to 1 to the main dial. The illuminated main dial is designed so that parallax is eliminated. It is calibrated over 300 degrees with approximately 95 calibration points and has an effective scale length of about 47 inches. Frequency range is 20 cps to 20 kc.

INCREASED POWER OUTPUT

The amplifier delivers up to 3 watts of power into a 600 ohm resistance load, with distortion held to 1%. Thus there is sufficient power available for driving almost any kind of laboratory or production equipment. Harmonic distortion may be kept to less than 1/2 of 1%, if the output of the amplifier is limited to 1 watt.

Another important feature of this oscillator is the provision which is made for standardizing each frequency range against a reliable standard, such as *h-p*'s Model 100C Secondary Frequency Standard. By standardizing the instrument regularly, frequencies can be depended upon to be better than 1% accurate.

DUAL CONTROL FOR OUTPUT LEVEL

A new departure in oscillator design is the dual method for controlling output level. A volume control which is ahead of the amplifier controls the voltage at which the amplifier operates. An output attenuator is provided to attenuate the signal delivered by the amplifier. Attenuation is approximately linear from zero to 40 db. Both hum level and output voltage are thus attenuated together. As a result, hum level may be kept 60 db or more below the signal level, a special advantage in cases where small test signals are used.

The impedance looking back into the output circuit is about 50 ohms; thus the voltage regulation for varying loads is extremely good. For measurements where it is desirable to have impedance looking back into the instrument of 600 ohms, as in transmission measurements, the attenuator may be used to give about 10 db or more of attenuation, making the reflected impedance of the instrument about 600 ohms.

IMPORTANT DETAILS

Care has been taken to perfect every detail of this new oscillator. Improved chassis layout and placement of component parts minimizes thermal drift. The voltage on the oscillator is maintained constant with an electronic voltage regulator. The entire instrument is characterized by greater mechanical rigidity; the tuning assembly is mounted on a sturdy cast aluminum frame. The chassis itself is made of aluminum; the oscillator is light in weight and easy to handle.

SPECIFICATIONS, MODEL 201B AF OSCILLATOR

Frequency Range: The frequency range is from 20 cps to 20,000 cps covered in three bands.

Band	Frequency Coverage
x1	20 - 200 cps
x10	200 - 2,000 cps
x100	2,000 - 20,000 cps

Frequency Calibration: The calibration is direct in cycles per second for the lowest band. Approximately 95 calibration points are provided over a 300-degree arc. The dial is 6 inches in diameter, illuminated and driven by a vernier knob having 6:1 ratio. The effective scale length for the three bands is 47 inches.

Stability: Under normal temperature conditions the frequency stability is better than $\pm 2\%$, including the initial warm-up drift. Plus or minus 10 volt line voltage variations will result in no change in the output frequency. Adjustments are provided on each band to standardize the calibration against an accurately known frequency. With standardization the accuracy may be maintained better than $\pm 1\%$.

Output: The instrument is rated at a maximum of 3 watts or 42.5 volts into a 600 ohm resistive load. One terminal is at ground potential. Maximum no load voltage is at least 50 volts. The impedance looking back into the output circuit (zero attenuator setting) is in the order of 75 ohms. With attenuator set at a value of 10 db or more the impedance looking back into the output is 600 ohms.

Frequency Response: The output voltage is constant within ± 1 db over the frequency range of 20 cps to 20,000 cps.

Distortion: The total rms distortion of the output wave over the range of 20 cps to 20,000 cps is less than the following limits:

3 watts output	1% distortion
1 watt output	.5% distortion*
*Down to 50 cps, at 20 cps 1% distortion.	

Volume Control: Two controls are provided for varying the output of the instrument:

1. An "Amplitude Control" adjusts the amount of oscillator voltage fed to the output amplifier.
2. An "Attenuator" attenuates the output of the amplifier. It is a variable T Pad having an attenuation range of 0 to infinity. Approximately linear in region 0 to 40 db.

Hum Voltage: The hum voltage is less 0.1% of maximum output voltage. If the output attenuator is used to control the output (with Amplitude control set for maximum rated power output) the hum level will be less than .1% below any signal level.

Power Supply: 115 volts ± 10 volts, 50/60 cycles. Power consumption: 75 watts. Plate supply voltage to oscillator section is electronically regulated.

Mounting: Cabinet Models are mounted in an aluminum cabinet finished in wrinkle gray. Size: 17 in. long x 8 1/2 in. high x 11 in. deep. Weight: 32 pounds. Shipping Weight: 46 pounds.

Data subject to change without notice.

LOW FREQUENCY OSCILLATOR



HIGH ACCURACY FOR LOW FREQUENCY MEASUREMENTS — 1/2 CPS TO 50,000 CPS

Now you can make low frequency measurements with all the precision and stability associated with audio frequency work. This *hp*-202B oscillator blankets the low-frequency spectrum from 1/2 to 50,000 cps. Throughout this range it provides better wave form, higher stability and greater measuring accuracy than any instrument ever manufactured for industrial, field or laboratory use.

USES

The *hp*-202B gives maximum measuring speed and accuracy for these important tests: Vibration or stability characteristics of mechanical systems, electrical simulation of mechanical phenomena, electro-cardiograph and electro-encephalograph performance, seismograph response, vibration checks of structural components, performance of geophysical prospecting equipment.

SPECIFICATIONS

Frequency Range: 1/2 cps to 50 kc in 5 ranges

Range	Frequency
x1	1/2—5 cps
x10	5—50 cps
x100	50—500 cps
x1K	500—5,000 cps
x10K	5,000—50,000 cps

Frequency Dial: 6" diameter. Reads directly in cps for the lowest range. Dial is back of panel, illuminated, and is controlled by direct drive as well as a 6 to 1 vernier.

Accuracy of Calibrations: ±2%.

Frequency Stability: ±2% under normal temperature conditions (including warm-up drift). Less than ±1% for power voltage changes of ±10%.

Output: 10 volts into a 1000 ohm resistive load over the entire frequency range. Internal impedance approximately 25 ohms at 10 cps.

Frequency Response: ±1 db 10 to 50,000 cps.
±2 db 1 to 50,000 cps.

Distortion: Less than 1% total distortion, 2 to 50,000 cps.

Hum Voltage: Less than 0.1% of rated output voltage.

Recovery Time: Less than 20 seconds on lowest frequencies.

Power: 115 volts ±10 volts, 50/60 cps.

Size: 17" long, 12 3/4" deep, 10 1/2" high.

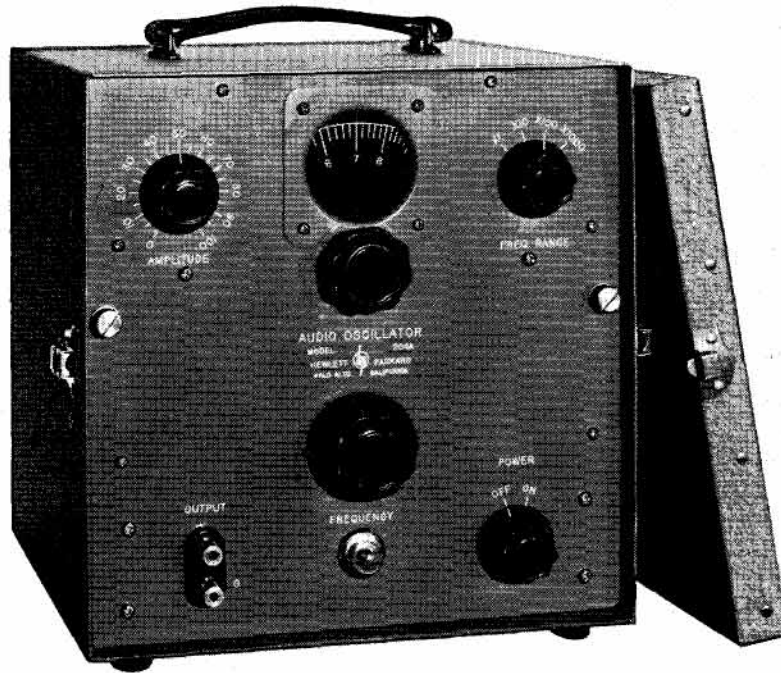
Mounting: Smooth gray panel, oak cabinet.

Net Weight: 50 pounds. **Shipping Weight:** 92 pounds.

Data subject to change without notice.



MODEL 204A



AUDIO OSCILLATOR (PORTABLE)

BATTERY-OPERATED PORTABLE FOR FREQUENCIES FROM 2 CPS TO 20 KC

HIS new *-hp-* oscillator is a compact, light-weight, precision instrument designed for use where ac power supplies are not available. It is particularly useful in checking telephone or remote broadcast lines; in strain gauge applications or checking telemetering systems in aircraft, for geophysical field parties; or in the laboratory when a completely hum-free audio signal is desired. The instrument operates from standard flashlight and 45 volt batteries, and is completely enclosed by a sturdy, splash-proof dural case.

STABLE, EASY TO OPERATE

Model 204A has the familiar *-hp-* characteristics of simple operation, rugged construction, and freedom from zero setting during use. The frequency range of 2 cps to 20 kc is covered in 4 decade ranges instantly selected by a front panel switch. Frequencies are set and read directly on the 6" tuning dial. Vernier control is provided for precise frequency settings. Output is stable and constant over the entire frequency range, and the instrument is relatively unaffected by temperature or humidity changes.

SPECIFICATIONS

Frequency Range: 2 cps to 20 kc in 4 decade ranges. Directly calibrated, 2 cps to 20 cps, on the lowest range.

Stability: $\pm 3\%$ including changes due to temperature, tube and battery aging.

Output: 5 v maximum into 10,000 ohm load. Output level continuously variable, zero to maximum.

Frequency Response: Flat within 1 db, 2 cps to 20 kc.

Distortion: Less than 1%, 20 cps to 10 kc. Not over 2%, up to 20 kc.

Battery Life: 60 hours total, when used at rate of 4 hours per day, continuous.

Batteries Required: Filament: 5 No. 2 flashlight cells.
Plate: 3 Burgess No. 5308 45 v. or equal.

Size: 10 $\frac{1}{2}$ " x 10 $\frac{1}{2}$ " x 11" deep. Net weight, incl. batteries, approximately 24 lbs. Shipping weight 37 lbs.

Mounting: Welded dural case, gasketed splash cover.

Data subject to change without notice.



MODEL 650A

TEST OSCILLATOR



ADVANTAGES:

- No zero set
- Wide frequency range
- No adjustments during operation
- Output voltage attenuator
- Self-contained vacuum tube voltmeter
- High stability
- Ease of operation

USE IT FOR:

- Testing television amplifiers
- Wide-band systems
- Filter transmission characteristics
- Tuned circuit response
- Determining receiver alignment
- Telephone carrier measurements
- Bridge measurements

FAST, ACCURATE TESTS 10 CPS TO 10 MC

His *-hp-* Model 650A Oscillator is the newest and finest of the famous *-hp-* resistance-tuned oscillators. It is the first *-hp-* instrument of its kind to bring audio frequency speed, accuracy and ease of operation to higher frequency fields. Its unique frequency range, 10 cps to 10 mc, makes it ideal for a wide variety of measurements in audio, supersonic, video and r-f bands. It is a wide-band, highly-stable precision instrument which provides output flat within 1 db throughout its frequency range. Its voltage range is .00003 volts to 3 volts. Output impedance is 600 ohms. And, for measurements where low source impedance is desired, a 6 ohm impedance is provided by means of an output voltage divider.

DECADE RANGES, OUTPUT VOLTMETER

Like other *-hp-* resistance tuned oscillators, the new Model 650A is fast and easy to operate. Six decade frequency ranges provide an effective scale length of 94 inches. The tuning dial is controlled directly, or with a 6 to 1 vernier micro-drive

for hair-line adjustment. Frequencies are read through a no-parallax illuminated window.

The output voltage is monitored by a vacuum tube voltmeter which measures the voltage at the input to the attenuator system. The VTVM is calibrated in volts and decibels and reads actual output voltage when the attenuators are set for zero attenuation. For other attenuator settings true output voltage is obtained by subtracting the attenuator reading from the output voltmeter reading. The output attenuator is adjustable in 10 db steps and maximum attenuation is 50 db. The voltage applied to the vacuum tube voltmeter and thus to the output attenuator is set by means of an amplitude control. The attenuated output voltage is correct only when the output terminals are loaded with 600 ohms, resistive.

OUTPUT VOLTAGE DIVIDER

Where small test signals or a low source impedance is required, a voltage divider is provided (shown connected to instrument in Figure 1). The divider consists of a cable and terminating connector which may be extended to the actual point of measurement. Two sets of voltages are obtainable from this divider. One voltage is one one-hundredth of the normal output voltage from the 650A and is delivered from a source impedance of only 6 ohms. True voltage is obtained at these terminals when they are connected to a load resistance large compared to 6 ohms. The second voltage is the actual output voltage of the Model 650A and is delivered from a source impedance of 300 ohms. Proper voltage is obtained at these terminals when working into a load resistance large compared to 300 ohms.

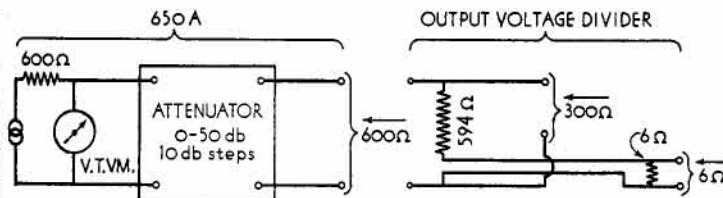


Figure 1

Circuits of the *-hp-* Model 650A have been carefully proportioned and low temperature coefficient components have been employed to assure highest frequency stability. Output voltage will remain constant over long periods of time, despite wide variations in temperature. Distortion over the low frequency bands is kept at a minimum to increase the usefulness of the instrument for audio measurements.

USES

Employing essentially the same resistance-tuned circuit as *-hp-* audio oscillators (see page 6 for description of the *-hp-* resistance-tuned principle) this wide-band, stable *-hp-* Model 650A is ideally suited for laboratory and production jobs where fast, accurate wide band measurements are required. It is specifically designed for the testing of television amplifiers, audio amplifiers, filter networks, tuned circuits and telephonic and telegraphic carrier equipment. It serves admirably as a power supply for a-f and r-f bridge measurements.

SPECIFICATIONS

Frequency Range: 10 cps. to 10 mc. Six bands.

Frequency Calibration: 1 to 10.

MF	Frequency Range
x10 cps	10 to 100 cps
x100 cps	100 to 1000 cps
x1 kc	1000 to 10,000 cps
x10 kc	10 to 100 kc
x100 kc	100 to 1000 kc
x1 mc	1 to 10 mc

Stability: $\pm 2\%$, 10 cps to 100 kc; $\pm 3\%$, 100 kc to 10 mc including warmup, line voltage, and tube changes.

Output: 15 milliwatts or 3 volts into 600 ohm resistive load. Open circuit voltage is at least 6 volts. 600 ohm source impedance. Source impedance of 6 ohms is available when voltage divider is used.

Frequency Response: Flat within ± 1 db, 10 cps to 10 mc into 600 ohm resistive load.

Distortion: Less than 1% from 20 cps to 100 kc. Approximately 5% from 100 kc to 10 mc.

Output Monitor: Vacuum tube voltmeter monitors level at input to attenuator, in volts or db at 600 ohm level. Zero db = 1 mw in 600 ohms. Accuracy $\pm 5\%$ of full scale reading.

Output Attenuator: Output level attenuated 50 db in 10 db steps, providing continuously variable output voltage from +12 dbm to -50 dbm, 3 volts to 3 millivolts, or down to 30 microvolts with voltage divider. Accuracy ± 1 db, into resistive load of 600 ohms.

Hum Voltage: Less than 0.5% of maximum attenuated signal level.

Power Supply: 115/230 volts 50/60 cps. Consumption 165 watts. Plate supply and h-f oscillator tube filaments electronically regulated.

Mounting: Cabinet or relay rack. Panel size 19" x 10 1/2", Depth 13". Smooth gray finish.

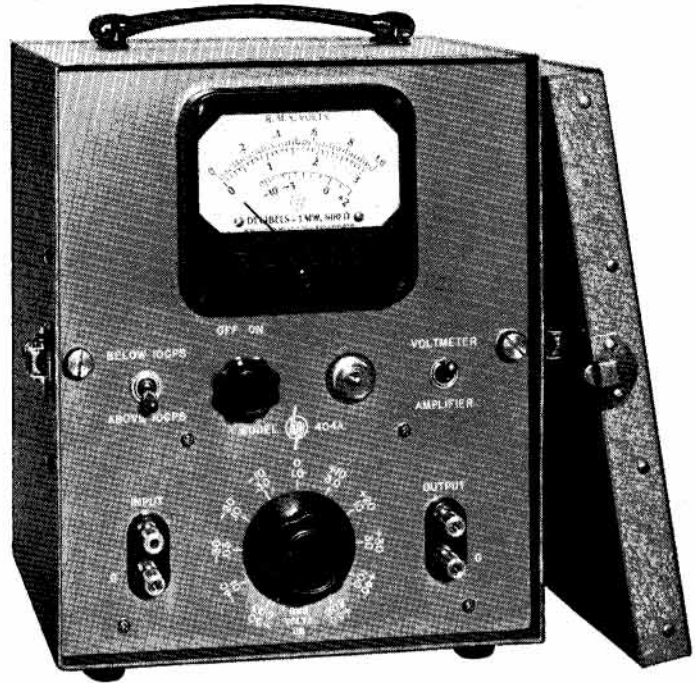
Net Weight: 46 pounds. Shipping Weight: 100 pounds.

Data subject to change without notice.



MODEL 404 A

VACUUM TUBE VOLTMETER (PORTABLE)



FOR GENERAL VOLTAGE MEASUREMENTS WHERE AC POWER IS NOT AVAILABLE

BETWEEN the frequencies of 2 cps and 50 kc, this light, easy to handle *-hp-* portable voltmeter provides highly accurate measurements in applications where an ac power source is not available. The voltage range is 0.001 to 300 volts, amply broad for a wide variety of measurements including remote broadcast line and carrier current checks, strain gauge system tests, geophysical and telemetering circuit measurements, and many others. In the laboratory it also offers completely hum-free measurements of very low noise level, and may be used as a standard amplifier of 60 db gain.

BATTERY-OPERATED

This convenient new *-hp-* portable voltmeter operates from standard flashlight and 45 volt batteries. It is simple to operate, requiring no adjustment during use. Voltage ranges are selected with a single switch and no precautions are required. The voltmeter is well protected against overloads up to 100 times normal. The meter responds to the average value of a full wave. Waveform errors are minimized and there is no turnover. Operation is virtually independent of tube or battery aging, or external conditions.

SPECIFICATIONS

Voltage Range: 11 ranges: .003, .01, .03, .1, .3, 1, 3, 10, 30, 100 and 300 volts full scale.

Calibration: Meter calibrated to read rms value of sine wave. Linear voltage scale, also db scale reading from -62 to $+52$ dbm.

Frequency Range: 2 cps to 50 kc.

Accuracy: $\pm 3\%$ between 2 cps and 20 kc.
 $\pm 7\%$ from 20 kc to 50 kc.

Input Impedance: 10 megohms, all ranges, shunted by approximately $20 \mu\mu\text{f}$.

Meter Switch: Provides a large capacity across meter to prevent needle flutter at low frequencies.

Amplifier: Switch removes meter from circuit, allowing balance of instrument to be used as a 60 db, ± 5 db gain amplifier. Maximum output voltage to open circuit, 15 volts.

Batteries: Filament: 5 No. 2 flashlight cells.
Plate: 3 No. Z30NX Burgess or equal.

Battery Life: 60 hours total, when used at rate of 4 hours per day continuously.

Mounting: Welded dural case, gasketed cover.

Size: $7\frac{1}{2}$ " x $10\frac{1}{2}$ " x 9" deep. Net weight, including batteries, approximately 14 lbs. Shipping weight 30 lbs.

Data subject to change without notice.



VACUUM TUBE VOLTMETERS

and accessories for voltage, current, or power measurements

SIGNAL SOURCE

EQUIPMENT

VACUUM TUBE VOLTMETER

From 2 cycles to 700 megacycles, there's an accurate, easy-to-use *-hp-* voltmeter to fit every voltage or current measuring requirement. You can choose from 5 precision voltmeters (including a battery-operated portable instrument) the one which precisely fills your measuring need. Each will give you the familiar *-hp-* characteristics of high sensitivity, wide range, compact size, versatility and time-

saving ease of operation. These *-hp-* voltmeters are used by radio stations, manufacturers, research institutions and scientific laboratories the world over.

A complete *-hp-* line of voltmeter accessories is also provided to appreciably extend the useful range of these instruments and to facilitate the measurement of current.

VOLTMETERS

INSTRUMENT	PRIMARY USES	FREQUENCY RANGE	VOLTAGE RANGE	INPUT IMPEDANCE	PRICE	PAGE
<i>-hp-</i> 400A	General purpose measurement	10 cps to 1 mc	.005 to 300 v 9 ranges	1 megohm 24 μ f shunt	\$185.00*	18-19
<i>-hp-</i> 400B	Low frequency measurements	2 cps to 100 kc	.005 to 300 v 9 ranges	10 megohms 24 μ f shunt	\$195.00	18-19
<i>-hp-</i> 400C	Wide range measurements High sensitivity	20 cps to 2 mc	.0001 to 300 v 12 ranges	10 megohms 15 μ f shunt	\$200.00*	18-19
<i>-hp-</i> 404A	Portable, battery operated	2 cps to 50 kc	.0005 to 300 v 11 ranges	10 megohms 20 μ f shunt	\$185.00	16
<i>-hp-</i> 410A	Audio rf, VHF measurements; dc voltages; resistances	20 cps to 700 mc	0.1 to 300 v 7 ranges	10 megohms 1.3 μ f shunt	\$245.00	20-21

ACCESSORIES

Extend usefulness of *-hp-* Models 400A, B, C or 410A voltmeters

INSTRUMENT	FEATURES	PRICE	PAGE
<i>-hp-</i> 452A Capacitive Voltage Divider	For all <i>-hp-</i> ac VTVM. 25 cps to 20 mc. Division 1000:1	\$75.00	22
<i>-hp-</i> 453A Capacitive Voltage Divider	For <i>-hp-</i> 410A VTVM only. Division 100:1	\$20.00	22
<i>-hp-</i> 454A Capacitive Voltage Divider	For <i>-hp-</i> 400C VTVM only. Division 100:1	\$20.00	22
<i>-hp-</i> 455A Probe Coaxial "T" Connector	For <i>-hp-</i> 410A VTVM. Measures voltages between conductor and sheath of 50 ohm transmission line.	\$35.00	22
<i>-hp-</i> 458A Probe Coaxial "N" Connector	For <i>-hp-</i> 410A VTVM. Measures volts at open end of 50 ohm transmission line.	\$17.50	22
<i>-hp-</i> 459A DC Resistive Voltage Multiplier	For <i>-hp-</i> 410A VTVM. For measuring high dc voltages safely. Multiplies 1:100	\$20.00	22
<i>-hp-</i> 470 A-F Shunt Resistors	For 400A, B, or C VTVM. For Measurement of current.	470A—\$7.50 470B thru F—\$6.00	22

*Available in rack mounting at \$10.00 extra.

Data Subject to Change Without Notice. • Prices f.o.b. Palo Alto, California.



MODEL 400C

VACUUM TUBE VOLTMETER



ADVANTAGES:

- Wide voltage range. High sensitivity
- Hairline accuracy. Time saving stability
- High input impedance
- Large overvoltage capacity
- Waveform errors minimized
- Measurements up to 2 mc
- Small and light

USE IT TO MEASURE:

- Voltage in audio, supersonic, and lower RF region
- Amplifier gain. Network response
- Output level. Hum level
- Power circuit voltages
- Video voltages. Carrier current voltages
- Capacity. Coil figure of merit

**FAST, ACCURATE MEASUREMENTS
BETWEEN 20 CPS AND 2 MC**

ODAY, the vacuum tube voltmeter is the most important basic tool of electronic research, development or production work . . . and the *hp*- Model 400C is one of the most versatile and widely used of all vacuum tube voltmeters.

This ruggedly built precision instrument will measure any voltage from 0.1 millivolts to 300 volts. It covers every frequency from 20 cps to 2 mc. It has a high input impedance of 10 megohms, effectively preventing disturbance to circuits under test. It is extremely simple to operate, and gives direct voltage and dbm readings. It is protected against overloads 100 times normal, and no precautions are necessary.

HIGH GAIN AMPLIFIER

Model 400C voltmeter includes a high gain, broad band amplifier. This amplifier employs a new circuit and component arrangement that makes possible both high stability and wide band coverage. The output is applied to a full wave rectifier actuating a meter movement. This 1 milliamper meter is exceptionally rugged, guaranteeing maximum accuracy throughout years of service despite electrical abuse, or

mechanical impacts. Inverse feedback is employed over the entire system, insuring a high degree of accuracy and providing meter readings that are independent of line voltage changes, tube characteristics or other external effects.

EASY TO USE

The simple operation typical of all *-hp-* instruments is particularly apparent in the Model 400C voltmeter. Ranges are quickly selected on a front panel switch which changes sensitivity by accurate 10 db intervals. This, combined with the direct db calibration of the meter makes it possible to read dbm directly, without calculation, from -72 to $+52$. (0 dbm = 1 milliwatt into 600 ohms.) Turnover effect and waveform errors are virtually eliminated because the meter responds to the average value of a full sine wave. There are no adjustments to make during operation. The large, clear 4" linear meter face is sloped for maximum readability. Meter movement has uniform damping throughout the entire scale.

USES

The measuring speed and accuracy of this voltmeter makes it valuable for laboratory work in measuring amplifier gain, network response and output level. The wide frequency range makes it suitable for audio, video or rf measurements. In many cases, its sensitivity is sufficient to measure hum and noise level directly. The high voltage ranges mean the instrument can be used for measuring power circuit or high frequency voltages in broadcast equipment. The model 400C also serves as a VU meter, measures coil "Q", compares capacities and resistances, and detects nulls. It may also be used as a high gain, broad band amplifier to increase sensitivity of oscilloscopes, bridges and other equipment requiring additional sensitivity.

-hp- 400A VACUUM TUBE VOLTMETER

Long a standard unit of equipment wherever precision voltage measurements are required, the *-hp-* Model 400A Vacuum Tube Voltmeter offers direct readings between 10 cps and 1 mc. Sensitivity is 30 millivolts full scale, and accuracy is within $\pm 3\%$ up to 100 kc; $\pm 5\%$ up to 1 mc. The instrument has a voltage range from 0.005 to 300 volts, covered in 9 decade ranges. Input impedance is 1 megohm shunted by $24 \mu\mu\text{f}$.

-hp- 400B VACUUM TUBE VOLTMETER

The Model 400B is a vacuum tube voltmeter designed to give precision voltage readings at very low frequencies. Input impedance is 9 megohms shunted by $24 \mu\mu\text{f}$. Maximum sensitivity is 30 millivolts full scale. Accuracy is $\pm 3\%$, 10 cps to 100 kc; $\pm 1\frac{1}{2}$ db, 3 cps to 10 cps; ± 1 db, 2 cps to 3 cps. The instrument has 9 decade ranges and provides full scale readings from 0.030 volts to 300 volts. Output terminals provided so instrument may be used as a stabilized amplifier.

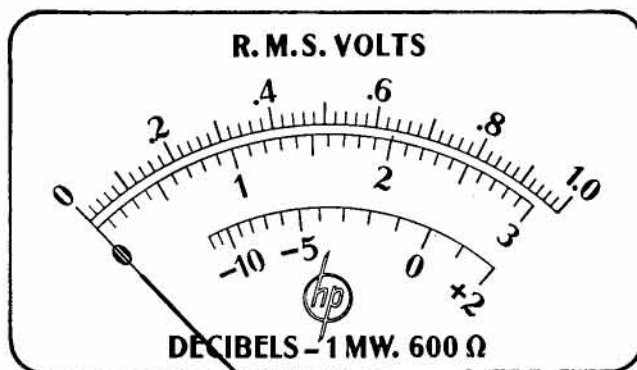


Fig. 1. Detail of sloping meter face, Models 400A, B and C, showing easy readability of linear voltage scale and direct-reading dbm scale.

SPECIFICATIONS

-hp- Model 400C Vacuum Tube Voltmeter

Voltage Range: 12 ranges, selected on front panel switch. Full scale readings of:

0.001 v.	.100 v.	10.0 v.
.003 v.	.300 v.	30.0 v.
.010 v.	1.00 v.	100.0 v.
.030 v.	3.00 v.	300.0 v.

Frequency Range: 20 cps to 2 mc.

Accuracy: The over-all accuracy of the meter is within $\pm 3\%$ below 100 kc and $\pm 5\%$ from 100 kc to 2 mc. Line voltage variations from 105 to 125 volts or changing tubes will affect the reading by less than 3% at all frequencies below 100 kc.

Calibration: Calibrated to read rms value of sine wave. Voltage indication proportional to average value of full sine wave. Linear voltage scale with db calibration from -12 to $+2$ dbm. 10 db intervals between voltage ranges.

Input Impedance: 10 megohms shunted by $15 \mu\mu\text{f}$ on ranges 1.0 v. to 300 v.; $24 \mu\mu\text{f}$ on ranges 0.001 v. to 0.3 v.

Output Circuit: Maximum output 0.5 v. corresponding to full scale deflection of meter. Internal impedance 1,000 ohms. Gain 500 when instrument is on the 0.001 volt range.

Power Supply: 115 volts, 50/60 cps, 45 watts.

Size: $7\frac{1}{2}$ " wide, $8\frac{1}{2}$ " high, $9\frac{1}{2}$ " deep. Wrinkle grey steel cabinet. Weight 15 lbs. Shipping weight 22 lbs.

Data Subject to Change Without Notice



HIGH FREQUENCY VACUUM TUBE VOLTMETER



ADVANTAGES:

- Range: 20 cps to 700 mc
- Input capacity, approximately 1.3 μmfd
- High input impedance
- Few controls. High stability
- Rugged meter movement
- Excellent overload protection

USE IT TO MEASURE:

- Audio frequency, supersonic, r-f, and VHF voltages
- Antenna voltage, current, and power
- Transmission line characteristics
- Standing waves
- Audio, video and VHF amplifiers
- DC voltage in high impedance circuits

ALL-PURPOSE TEST INSTRUMENT MEASURES TO 700 MC

BECAUSE of the tremendous number of tasks it will perform, the 410A High Frequency Vacuum Tube Voltmeter can play a uniquely valuable role in any laboratory, broadcast station, or production test department. It combines in one instrument an ac voltmeter covering the frequency range from audio to radar frequencies, a dc voltmeter with 100 megohms input impedance, and an ohmmeter capable of measuring resistance from 0.2 ohms to 500 megohms. In addition, it is easy to use, compact, portable, and light in weight.

A special probe, employing a new, radically different diode especially designed by Eimac for Hewlett-Packard, is used for making ac measurements. The resonant frequency of the diode is approximately 2000 mc, and the shunt capacity is extremely low. Mounted in the probe, it places a capacity of

approximately 1.3 μmfd across the circuit under test. Total input impedance at low frequencies for ac measurements is 10 megohms shunted by this capacity.

The 410A employs a high impedance dc voltmeter having a special circuit developed by *-hp-* engineers. Its outstanding feature is low drift and maintenance of calibration over long periods of time. Only one zero adjustment is necessary for all voltage ranges, and once set it rarely needs readjustment. This circuit permits the use of a 1 ma meter movement which together with certain features of the circuit itself makes it impossible to damage the meter by overloads. Input impedance for dc measurements is 100 megohms for all ranges.

USES

The versatility of the 410A is so great that the number of uses to which it may be put is almost endless. As an ohmmeter it will accurately measure resistance over a much wider range than is ever ordinarily encountered. As a dc voltmeter, its extremely high input impedance permits its use on almost any equipment without any appreciable loading of the circuit.

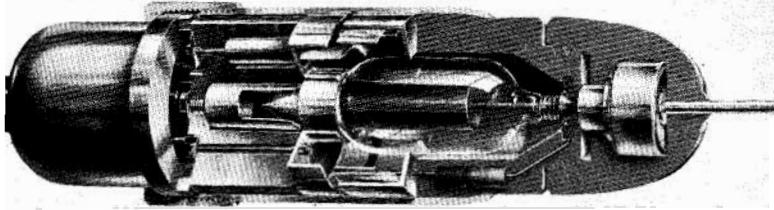


Figure 1. Construction details of new *-hp-* diode probe

As an ac voltmeter, its combination of high input impedance with great frequency range sets altogether new standards of performance. The probe can be inserted in almost any audio, supersonic, radio, or VHF amplifier without detectable loading of the circuit. It can be used to measure antenna and transmission-line voltage, current, and power with as much ease and convenience as if the circuits carried dc. Special adaptors can be supplied for use with the probe to connect to standard transmission lines.

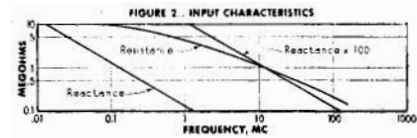
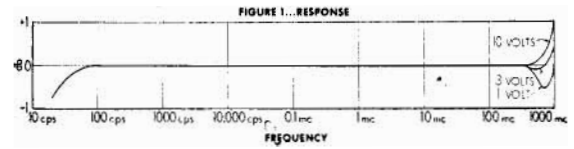
Finally, the fact that all these functions are combined in one instrument means that where previously a whole battery of equipment might be required to test a given piece of apparatus, the 410A, in one small, convenient, and highly portable instrument, does the whole job. Leads are provided for all functions so that to change from one to another it is necessary only to throw a switch.

SPECIFICATIONS

Ranges: 1 to 300 volts in 6 ranges full scale: 1, 3, 10, 30, 100, and 300 volts ac or dc and 0-1000 volt range dc. Resistance 0.2 ohm to 500 megohms in seven ranges. Mid-scale reading of 10, 100, 1000, 10,000, 100,000 ohms, 1 megohm, and 10 megohms.

Accuracy: $\pm 3\%$ of full scale on all ranges on sinusoidal ac voltages and on dc voltages. The ac portion of the instrument is a peak-reading device, calibrated in rms volts.

Frequency Response: Frequency response is flat within ± 1 db up to 700 mc and drops off less than 1 db at 20 cps. Probe resonant frequency is about 2000 mc, and an indication can be obtained up to 3000 mc. See Fig. 2.



Input Impedance: Input capacity is 1.3 μmfd ; input resistance is 10 megohms at low frequencies. At high frequencies resistance drops off due to dielectric losses. (See Fig. 3.) Dc input resistance is 100 megohms for all ranges.

Probe: The probe is approximately 1" diameter and 4 1/2" long. It is equipped with a ground clip, and the connector may be soldered to the point under test. For operation at lower frequencies the probe can be mounted in the storage compartment and connections made to binding posts on the panel. Adapting connectors are available to measure voltages in coaxial transmission lines.

Power Supply: 115 volts, 50/60 cycles, 40 watts. Two 1 1/2 volt flashlight cells provide ohmmeter circuit voltage.

Mounting: Gray panel. Wrinkle gray finished metal case. Size 12 1/8" x 7 5/8" x 6 1/4".

Net Weight: 16 pounds. Shipping Weight: 23 pounds.

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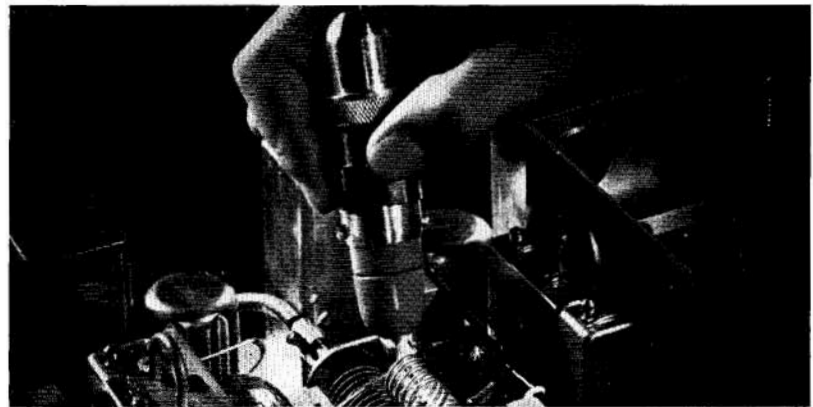
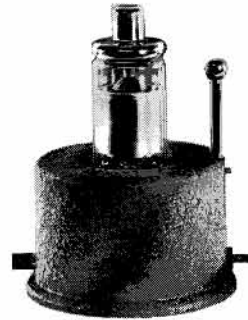


Figure 4. Probe is compact for greater ease in reaching components



VOLTMETER ACCESSORIES

XTEND the usefulness of your present *-hp-* voltmeters with these new precision built *-hp-* accessories. Custom-designed for use with *-hp-* Models 400A, 400C or 410A Vacuum Tube Voltmeters. Save time and work, simplify tedious jobs. Make fast, accurate measurements far beyond the original range of your instruments.



-hp- 452A Capacitive Voltage Divider

For *-hp-* 400C and 410A VTM's. Safely measures power voltages to 25 kv. Accuracy $\pm 3\%$. Division ratio 1000:1. Input capacity 15 μf ± 1 . Max. voltage ratings at 60 cps, 25 kv; 100 kc, 22 kv; 1 mc, 20 kv; 10 mc, 15 kv; 20 mc, 7 kv. Usable for dielectric heating, power and supersonic voltages.



-hp- 453A Capacitive Voltage Divider

For *-hp-* 410A Voltmeter. Increases range so transmitter voltages can be measured quickly, easily. Accuracy $\pm 1\%$. Division ratio, 100:1. Input capacity approx. 2 μf . Max. voltage 2,000 v. For frequencies 10 kc and above.

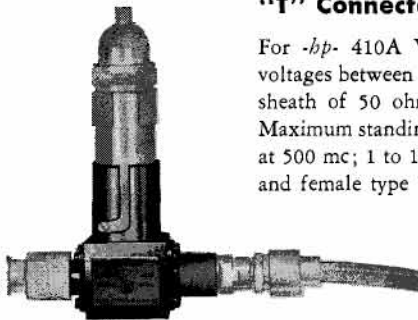


-hp- 458A Probe Coaxial "N" Connector

For *-hp-* 410A Voltmeter. Measures volts at open end of 50 ohm transmission line. (No terminating resistor.) Uses female Type "N" fitting.

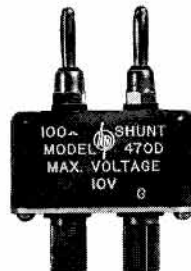
-hp- 455A Probe Coaxial "T" Connector

For *-hp-* 410A Voltmeter. Measures voltages between center conductor and sheath of 50 ohm transmission line. Maximum standing wave ratio 1 to 1.1 at 500 mc; 1 to 1.2 at 1,000 mc. Male and female type "N" fittings.



-hp- 470A-470F Shunt Resistors

For *-hp-* 400A or 400C Voltmeters, to measure currents as small as 1 μa full scale. Accuracy $\pm 1\%$ to 100 kc, $\pm 5\%$ to 2 mc (470A, $\pm 5\%$ to 1 mc) Max. power dissipation 1 watt.



Instrument	Value
<i>-hp-</i> 470A	0.1 Ω
<i>-hp-</i> 470B	1.0 Ω
<i>-hp-</i> 470C	10.0 Ω
<i>-hp-</i> 470D	100 Ω
<i>-hp-</i> 470E	600 Ω
<i>-hp-</i> 470F	1,000 Ω

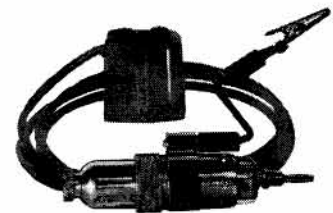


-hp- 459A DC Resistive Voltage Multiplier

For *-hp-* 410A Voltmeter. Gives maximum safety and convenience for measuring high voltages as in television receivers, etc. Accuracy $\pm 5\%$. Multiplication ratio 100:1. Input impedance 12,000 megohms. Max. voltage 30 kv. Max. current drain 2.5 microamperes.

-hp- 454A Capacitive Voltage Divider

For *-hp-* 400C Voltmeters. Safely measure power, audio, supersonic and rf voltages. Accuracy $\pm 3\%$. Division ratio, 100:1. Input impedance 50 megohms, resistive shunted with 2.75 μf capacity. Max. voltage, 1,500 v.



Data subject to change without notice.



AUDIO SIGNAL GENERATORS

for measuring gain, frequency, response, amplifier characteristics, etc.

AUDIO
SIGNAL
GENERATOR

AMPLIFIER

LOAD

VTVM

EWLETT-PACKARD audio signal generators are designed to provide exact voltages with specific impedances at precisely known frequencies across the audio spectrum. These instruments are particularly useful in making amplifier gain measurements, determining network

frequency or transmitter response, in production testing or general laboratory work where an accurate, quickly-obtained signal is necessary.

Brief details of these instruments appear below, and detailed information will be found on pages indicated.

INSTRUMENT	PRIMARY USES	FREQUENCY RANGE	CHARACTERISTICS	PRICE	PAGE
-hp- 205A	General purpose. High power for audio tests.	20 cps to 20 kc	5 watts output, 1% distortion, output VTVM, 110 db attenuator.	\$390.00†	24-25
-hp- 205AG	Same as above. Makes gain measurements without extra equipment.	20 cps to 20 kc	Same as above, but has separate VTVM for measurement of external level.	\$425.00†	24-25
-hp- 205AH	General purpose. High power for supersonic tests.	1 to 100 kc	5 watts output, 1% distortion, output VTVM, 110 db attenuator.	\$550.00†	24-25
-hp- 206A	High quality, high accuracy and low level audio tests.	20 cps to 20 kc	Output +15 dbm. Less than 0.1% distortion. Output VTVM and 111 db attenuator. 0.1 db steps.	\$550.00†	26-27

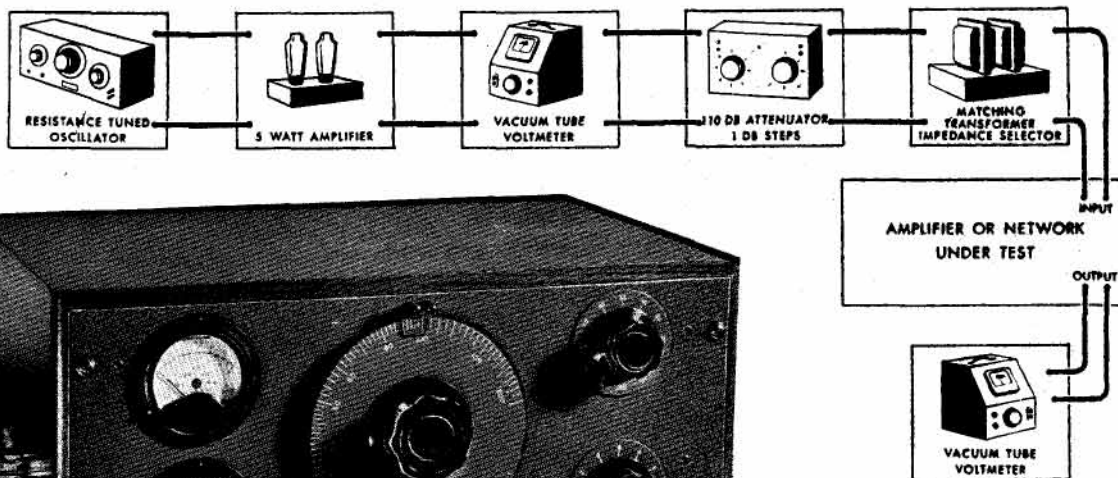
†Rack mounting available at no extra cost.

Data Subject to Change Without Notice. • Prices f.o.b. Palo Alto, California.



MODEL 205 AG

AUDIO SIGNAL GENERATOR



ADVANTAGES:

- No auxiliary equipment needed
- Range—20 to 20,000 cps
- 5 watts output, less than 1% distortion
- No zero setting
- Supplies known voltage
- Output meter calibrated in volts and decibels
- Standardized frequencies instantly available
- Separate input meter for gain measurements
- Wide range of output impedances

USE IT FOR:

- Amplifier gain measurements
- Network frequency response
- Source of voltage for distortion measurements
- Broadcast transmitter audio response
- Loudspeaker response
- General laboratory applications
- Production testing

SIX BASIC INSTRUMENTS COMBINED TO SPEED GAIN MEASUREMENTS

ALL THE necessary instruments for accurate gain or frequency response measurements have been assembled by *hp* engineers in one compact unit. (See block diagram.) No auxiliary equipment is required.

This Audio Signal Generator brings new speed and ease to testing jobs. Any desired frequency within the range of 20 to 20,000 cps is made available by the resistance-tuned audio oscillator. These frequencies are developed at any desired voltage between 150 volts and 50 micro-volts.

To make amplifier or network gain measurements with the *hp* Model 205 AG Audio Signal Generator, the operator simply connects input and output leads to the binding posts.

Two vacuum tube voltmeters are provided, one to measure input and the second to measure output of the device under test. The input meter has a range of minus 5 db to plus 49 db, with an input impedance of 5,000 ohms. The attenuator sets the output voltage. The output impedance can be instantly changed by means of a selector switch (line matching transformer in the block diagram) to the commonly used impedances of 50, 200, 600, and 5,000 ohms, a convenience in

matching various types of networks. The Model 205AG will supply 5 watts output with less than 1% distortion, and thus is useful where sizeable amounts of power are required. Feedback is used for improved frequency response and lower distortion.

The *-hp-* Model 205AG is well adapted to measuring frequency response and gain or loss of any network. The frequency remains accurate, without the necessity of zero setting. *-hp-* Audio Signal Generators are built for heavy duty and long, hard service.

AUDIO AND SUPERSONIC MODELS AVAILABLE

There are three models of signal generators. The *-hp-* Model 205AG provides all of the basic components to make a complete gain measurement in one unit. The *-hp-* Model 205A is similar to the 205AG except that the input vacuum tube voltmeter is eliminated. For supersonic measurements the *-hp-* Model 205 AH Signal Generator is available. This instrument is similar to the *-hp-* Model 205A but covers a frequency range of 1 kc to 100 kc.

SPECIFICATIONS, MODELS 205AG AND 205A

Frequency Range: The frequency coverage is 20 cps to 20,000 cps, in three ranges.

Calibration: The dial is calibrated directly in cycles for the lowest range, 20 cps to 200 cps. A switch selects the desired range and indicates the proper multiplying factor. Each range covers approximately 270 degrees on the 6½" main dial. Range 1 covers 20 cps to 200 cps; Range 2 covers 200 cps to 2,000 cps; and Range 3 covers 2,000 cps to 20,000 cps.

Stability: Under normal temperature conditions the frequency will drift less than 2% over long periods of time. Each range is provided with an internal adjustment so that 1% accuracy may be maintained if required.

Output: Five watts output will be delivered to a matched resistance load.

Load Impedances: A switch selects transformer taps for use with loads of 50, 200, 600 and 5,000 ohm resistive loads. The output circuit is balanced and center tapped and any terminal may be grounded. The internal impedance is approximately 1/6 of the load impedance with zero attenuator setting. The internal impedance approaches the load impedance with attenuator settings of 20 db or more.

Frequency Response: The frequency response of the system beyond output meter is down 2.0 db at 20 cps and 1 db at 20,000 cps (at levels from +37 to -10 dbm). Drop in response exceeds these limits at levels lower than -10 dbm.

Distortion: The distortion is less than 1% at rated output at all frequencies above 30 cps.

Hum Level: The hum level is 60 db below the output voltage or 90 db below zero level, whichever is the larger.

Output Meter: The output meter is calibrated directly in volts at 600 ohms and in db above a 1 mw level (54.7 volts and plus 37 db full scale).

Input Meter:* The input meter has a range of minus 5 db to plus 48 db based on a 1 mw level in 600 ohms. The meter scale is calibrated from minus 5 db to plus 8 db and a multiplier switch adds from zero to 40 db to the reading in 5 db steps. The meter has an input impedance of 5,000 ohms.

*Not included in Model 205A.

Input Meter Response: The frequency response of the input meter is within ± 0.2 db over range from 20-20,000 cps.

Output Attenuator: The output attenuator provides 110 db in 1 db steps. It consists of a 100 db attenuator with 10 db steps and a 10 db attenuator with 1 db steps.

Power Supply: 115 volts ± 10 volts, 50/60 cycles. Power consumption: 125 watts.

Mounting: Available in either relay rack or cabinet mounting. Panel size on either instrument, 19" x 10½". Cabinet models are mounted in oak cabinets. Panels are finished in wrinkle gray enamel with machine engraved designations.

Net Weight: 73 pounds. Shipping Weight: 116 pounds.

MODEL 205AH SUPERSONIC SIGNAL GENERATOR

Frequency Range: 1 kc to 100 kc, in two ranges.

Power Output: 5 watts at 1% distortion, 1 watt at ½% distortion.

Load Impedances: 50, 200, 500 and 5,000 ohm resistive. The output circuit is balanced and center tapped and any terminal may be grounded. The internal impedance is approximately 1/7 of the load impedance with zero attenuator setting. The internal impedance approaches the load impedance with attenuator settings of 20 db or more.

Frequency Response: ± 1 db from 10 kc reference.

Hum Level: The hum level is at least 65 db below output voltage or 65 db below 1 milliwatt into 500 ohms, whichever is greater.

Output Attenuator: Range: 0 to 110 in 1 db steps. Accuracy: ½ db in first 80 db, 3 db in last 30 db.

Power Supply: 115 volts, 50-60 cycles, 125 watts.

Accuracy of Frequency: $\pm 2\%$.

Stability of Frequency: $\pm 1/2\%$ after ½ hour warm up. Line voltage changes of ± 10 volts have negligible effect on frequency as power supply to oscillator is regulated.

Output Meter: The output meter is calibrated directly in volts at 500 ohms and in db above 1 milliwatt level (50 volts and +37 db, full scale).

Mounting: Same as 205 AG.

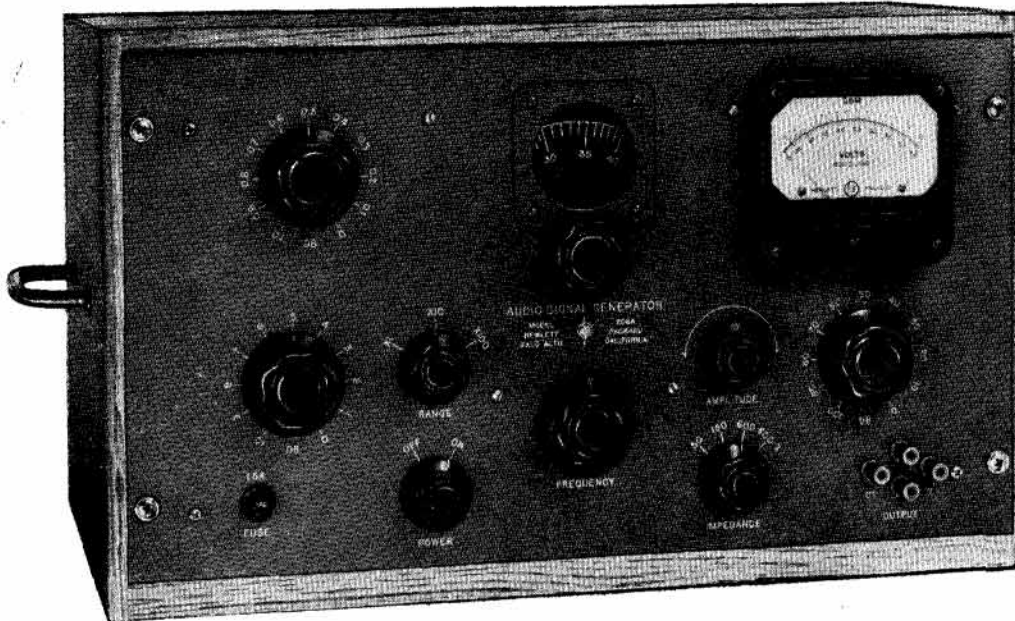
Net Weight: 63 pounds. Shipping Weight: 110 pounds.

Data subject to change without notice.



MODEL 206A

AUDIO SIGNAL GENERATOR



ADVANTAGES:

- Continuously variable a-f voltage
- Accuracy 0.2 db, any level
- High stability
- Harmonic distortion less than 0.1 %
- 111 db attenuator, 0.1 db steps

USE IT FOR:

- A-f voltage source
- Checking FM transmitter response and distortion
- Checking broadcast studio performance
- High-quality amplifier testing
- Transmission measurements

CONTINUOUSLY VARIABLE AUDIO SIGNALS LESS THAN 0.1% DISTORTION

THE newly-developed *hp*-Model 206A Audio Signal Generator provides a source of continuously variable audio frequency voltage at a total distortion level of less than 0.1%. This unique feature, coupled with simple, straight-forward circuitry, rugged construction and typical *hp*-ease of operation, makes this new signal generator ideal for use in the maintenance of FM broadcasting units and high fidelity audio systems.

CIRCUIT DESCRIPTION

The circuit arrangement of the Model 206A is shown in the block diagram, Figure 1. The oscillator section is followed by a tuned amplifier, automatically tracked with the oscillator. High selectivity of the amplifier reduces the harmonic voltages generated by the oscillator section. This serves to reduce the percentage of harmonic distortion in the voltage reaching the instrument's output terminals.

The selective amplifier is followed by an output amplifier, a vacuum tube voltmeter, an attenuator and finally an output matching transformer. An electronic voltage regulator supplies plate voltage for the complete circuit.

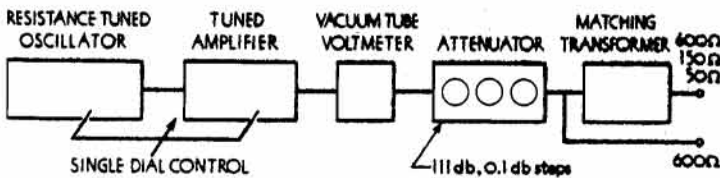
FREQUENCY DETERMINING NETWORK

The frequency determining network in the instrument's oscillator section is composed of low temperature coefficient elements, so that the instrument will have good stability over long periods of time. The frequency calibration of the instrument is accurate within 1%. Frequencies from 20 cps to 20 kc are continuously available. Three decade frequency ranges provide an effective scale length of 47". Tuning dial is controlled directly or with a 6 to 1 vernier micro drive for hair-line adjustments. Dial is read through a no-parallax illuminated window.

The output of the amplifier is measured by a vacuum tube voltmeter. Indications can be read in either volts or dbm to an accuracy of 0.2 dbm. Following the vacuum tube voltmeter is a 111 db attenuator which allows the power output to be varied in 0.1 db steps.

OUTPUT SYSTEM

The new -hp- 206A generator includes an output matching transformer which allows it to be matched to resistive loads of 50, 150 and 600 ohms. This output system is balanced to ground and each winding is center-tapped. The internal impedance matches the load impedance.



A single ended 600 ohm output is provided which bypasses the line-matching transformer. This output connection results in superior distortion and frequency response characteristics.

USES

This instrument is specifically designed for testing high quality audio circuits. It is suitable for FM transmitter maintenance, studio amplifier and console testing, a low distortion source for bridge measurements, for use as a transmission measuring set, and for any application requiring a low-distortion, accurately-known audio test signal.

SPECIFICATIONS

Frequency Range: The frequency coverage is from 20 cps to 20 kc in 3 ranges.

Calibration: The dial is calibrated directly in cycles for the lowest range, from 20 to 200 cps. Each range covers approximately 270 degrees of the 6" dial. The dial is located behind the panel and is illuminated. A six to one rim drive enables the equipment to be easily and quickly set to any desired frequency.

Stability: The frequency is calibrated to within better than 1% when the instrument leaves the factory. The circuit elements in the frequency determining network have low temperature coefficients and good stability so that better than 2% accuracy will be maintained over long periods of time.

Output: The equipment will deliver an output level of +15 dbm above 1 mw into impedance of 50, 150 and 600 ohms. Approximately 10 volts are available into an open circuit.

Output Impedances: The generator has a matched internal impedance and the selection of output impedances includes 50, 150 and 600 ohms center-tapped and balanced and 600 ohms single ended.

Frequency Response: The frequency response of the system beyond the output meter is better than 0.2 db at all levels, 30 cps to 15 kc.

Distortion: The total harmonic distortion in the output voltage is less than 0.1% at frequencies above 50 cps and less than 0.25% from 20 cps to 50 cps.

Hum Level: The residual hum and noise in the output signal is at least 70 db below the output signal or more than 100 db below zero level, whichever is the larger.

Output Meter: The output voltage is measured ahead of the attenuators by a 4" square meter calibrated in dbm and also in volts. The meter has a scale which can be read to at least 0.2 db at all points above a 50% scale reading. (Zero dbm equals 1 mw in 600 ohms.)

Output Attenuators: Output attenuators provide a range of 111 db in 0.1 db steps. The individual resistors in the attenuators are adjusted to better than 0.2% and the accuracy of the attenuators is approximately 0.1 db.

Mounting: The Model 206A is mounted on a standard relay rack size panel 10½" by 19". The depth behind the panel is approximately 13". Either cabinet or relay rack mounting can be supplied. The panel is finished in smooth gray enamel, or special colors to match transmitter installations.

Power Supply: 115 volts, 50/60 cycles.

Net Weight: 65 pounds. Shipping Weight: 110 pounds.

—Data subject to change without notice.



MODEL 212A

PULSE GENERATOR



SPECIFICATIONS

Pulse Length: Continuously variable 0.07 to 10.0 μ sec. Direct reading panel control.

Pulse Amplitude: 50 v. into 50 Ω load. Positive and negative pulses. Peak output power 50 watts.

Amplitude Control: Continuous throughout range. 50 db in 10 db steps. 10 db fine adjustment.

Internal Impedance: 50 Ω or less.

Pulse Shape: Rise and decay time approx. 0.02 μ sec. (10% to 90% amplitude.)

Repetition Rate: 50 to 5,000 pps internally or externally controlled.

Sync In: Positive or negative trigger of 5.0 v. up to 5,000 pps.

Sync Out: 40 v. positive or 25 v. negative into 200 Ω load approx. 2 μ sec long. Approx. 0.25 μ sec rise time.

Pulse Delay: Main pulse delayable 0 to 100 0 - 10 μ sec from sync out pulse. Delay and advance controlled by a single knob.

Pulse Advance: Main pulse can be advanced 0 - 10 μ sec from sync out pulse.

Size: 10 $\frac{1}{2}$ " x 19" x 12" deep. Weight 56 lbs. Shipping weight 75 lbs. Rack mounting only. Detachable end pieces with hinged handles for table use, \$5.00 per pair.

PRICE: \$550.00 f.o.b. Palo Alto, Calif.

Data subject to change without notice.

BASIC TEST INSTRUMENT FOR RADAR, NUCLEAR, TV AND OTHER "FAST" CIRCUITS

ODEL 212A PULSE GENERATOR is designed for versatility and time-saving convenience. It offers positive or negative pulses, and may be synchronized to other equipment through built-in delay and advance sync out circuits. It offers continuously variable pulses from 0.07 to 10 μ sec. It has a direct-reading pulse length control, and 50 watts of pulse power. It offers high quality pulses with very fast rise and decay time, "flat" top, and minimum overshoot. The instrument permits accurate pulses to be delivered to the end of a long transmission line, if line is correctly terminated. Pulse shape is independent of frequency, load, sync condition, input voltage or output attenuator setting.

USES

In addition to radar, TV and nuclear work, the generator is useful for testing response of rf amplifiers, filters, band pass circuits, oscilloscopes; as a noise generator, to check peak measuring equipment, modulate rf carriers, or pulse modulate UHF signal generators.



Fig. 1. Tracing of actual photograph showing 0.07 μ sec pulse delivered by Model 212A.

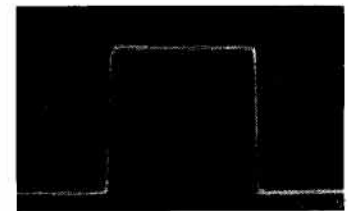


Fig. 2. Tracing of actual photograph showing 1.0 μ sec pulse delivered by Model 212A.



DISTORTION ANALYZERS

for total distortion and wave form measurements. SQUARE WAVE GENERATORS for transient response determination

SIGNAL SOURCE

EQUIPMENT

ANALYZER

EVEN instruments operating at variable and fixed audio frequencies are manufactured by *-hp-* for the study of distortion and wave form, and the generating of square waves.

Each of these instruments gives you traditional *-hp-* ease of operation, durable construction and simple, "clean" circuitry. Each is designed for maximum convenience, to save engineer-

ing time in making distortion and wave form studies. The instruments as a group have broad applicability, but each has specific characteristics that make it particularly adapted to certain types of measurement.

More details of these instruments appear below, and complete information will be found on the pages indicated.

ANALYZER	PRIMARY USES	FREQUENCY RANGE	CHARACTERISTICS	PRICE	PAGE
-hp- 300A	Wave form analysis.	30 cps to 16 kc	Variable selectivity; measuring range 1 mv to 500 v. 5% accuracy.	\$625.00†	32-33
-hp- 320A	Measures total harmonic distortion at 2 fixed frequencies.	400 cps and 5 kc	Requires separate detector.	\$75.00*	35
-hp- 320B	Measures total harmonic distortion at 6 fixed frequencies.	50, 100, 400 cps; 1, 5 and 7.5 kc	Same as above.	\$150.00*	35
-hp- 330B	Measures total distortion, frequency tunable.	20 cps to 20 kc	Includes input amplifier and VTVM.	\$395.00†	30-31
-hp- 330C	Similar to 330B. For FM broadcast measurements.	20 cps to 20 kc	VTVM has special characteristics to meet F.C.C. requirements.	\$425.00†	30-31
-hp- 330D	Similar to 330B. For AM and FM broadcast measurements.	20 cps to 20 kc	Includes AM detector and special meter to meet F.C.C. requirements.	\$440.00†	30-31
SQUARE WAVE GENERATOR					
-hp- 210A	For rapid determination of transient and frequency response.	20 cps to 10 kc	Output 50 v. peak-to-peak. 1,000 ohm impedance.	\$150.00*	34

*Rack mounting available at \$5.00 extra cost.

†Rack mounting available at no extra cost.

Data Subject to Change Without Notice. • Prices f.o.b. Palo Alto, California.



MODEL 330B

DISTORTION ANALYZER



ACCURATE DISTORTION MEASUREMENTS 20 CPS TO 20,000 CPS

ADVANTAGES:

- Blankets audio spectrum
- Measures noise as small as 100 microvolts
- Terminals for oscilloscope
- Micro-drive tuning control
- High accuracy, stability

USE IT FOR:

- Measuring total audio distortion
- Measuring voltage level, power output, amplifier gain
- Measuring total distortion of audio-modulated r-f carrier
- Measuring noise and hum level directly
- Determining audio signal frequency
- High-gain, wide-band stabilized amplifier

The *hp*-Model 330B Distortion Analyzer 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 possible measurements of these characteristics direct from a modulated r-f carrier. The convenience of operation, high sensitivity, accuracy, stability and light weight of the *hp*-330B make it an uniquely valuable instrument for broadcast, laboratory and production measurements.

The circuit of the Model 330B consists of a frequency-selective amplifier, a vacuum tube voltmeter, and a regulated power supply.

The r-f detector includes a diode rectifier operating in conjunction with a resonant circuit which is tuned to the carrier frequency under measurement. The detector covers a range of 500 kc to 60 mc, and is varied by means of a tuning condenser and range switch which selects one of six bands. The detector may be switched out of the circuit when audio frequencies are used.

ALMOST INFINITE ATTENUATION

The 20 db amplifier operates in conjunction with the *-hp-* resistance-tuned circuit to provide infinite attenuation at one frequency while allowing all other frequencies to be passed at the normal gain of the amplifier. (See Fig. 1.) Negative feedback is employed in the amplifier to minimize distortion, give a uniform response over a wide range of frequencies, and to provide a high order of stability. Frequency response is from 10 cps to 100,000 cps; thus even the 5th harmonic of 20 kc is passed by the amplifier without appreciable attenuation.

The voltmeter section of the instrument consists of a two-stage high-gain amplifier, a rectifier, and an indicating meter. A large amount of negative feedback is employed to insure stability and a uniform response from 10 cps to 100,000 cps. It responds proportionally to the average value of the applied voltage wave and is calibrated in rms values of a sine wave.

OTHER *-hp-* DISTORTION ANALYZERS

Model 330C Distortion Analyzer

The *-hp-* 330C Distortion Analyzer is a special modification of the *-hp-* 330B. It is identical in all respects, except that the indicating meter movement is provided with VU ballistic characteristics to meet F.C.C. requirements for FM broadcasting. Like the 330B, the Model 330C provides almost infinite attenuation at any one frequency, and makes possible "total" audio distortion measurements at any frequency from 20 to 20,000 cps.

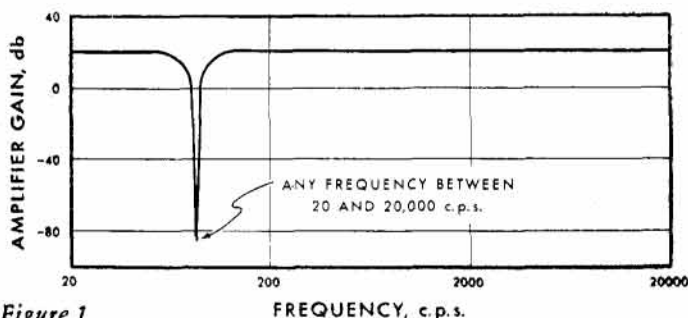


Figure 1

Model 330D Distortion Analyzer

The Model 330D Distortion Analyzer is designed for radio stations and other installations where both AM and FM measurements are required. This instrument includes an AM detector for rectification of the AM carrier, plus the special vacuum tube voltmeter employed in the Model 330C. Other characteristics are similar to Model 330B.

SPECIFICATIONS

Range: 20 cps to 20,000 cps. Frequency of measurement is selected on a directly calibrated dial having its lowest range calibrated directly in cps. Range switch selects operating band.

Accuracy: Circuit will eliminate fundamental by more than 60 db and will attenuate second and higher harmonics by less than 10%. Distortion measurements are accurate within $\pm 3\%$ of full scale reading for distortion levels as low as 0.5%. Meter indicates in proportion to the average value of the residual components. Residual distortion introduced by instrument is less than 0.1%.

Sensitivity: Distortion levels of 0.3% are measured full scale. Levels of 0.1% can be read with good accuracy at approximately 25% scale reading.

Voltmeter Range: Nine ranges. Full scale sensitivities of .03, .1, .3, 1.0, 3.0, 10, 30, 100, 300. Calibration $+2$ to -12 db is also provided. Ranges are related to each other in 10 db steps. Range switch indicates db level as well as voltage range. Zero level 1 milliwatt in 600 ohms.

Voltmeter Accuracy: $\pm 3\%$ of full scale; unaffected by changing of tubes or line voltage variations from 105 to 125 volts. Reading is proportional to average value of the applied wave, and is calibrated in rms value of a sine wave. This meter provides the most practical method of measuring distortion even though it does not indicate true rms values. It is stable, accurate and cannot be damaged by overloads.

Voltmeter Frequency Response: Flat within 3% over range of 10 to 100,000 cps. 330 C/D flat within 3%, 10 to 20,000 cps and 6% to 60,000 cps.

Noise Measurement: When used to measure hum or noise meter will give a full scale deflection on a signal of 300 microvolts. Satisfactory readings may be made to 75 db below 1 milliwatt in 600 ohms.

R. F. Detector: Linear r-f detector is provided to rectify the transmitted carrier. Input circuits of this rectifier are tunable from 500 kc to 60 mc, in 5 bands (330D only).

A. F. Input Impedance: Input impedance at the audio frequency input terminals is approximately 200,000 ohms shunted by 40 uuf. Input impedance at the vacuum tube voltmeter terminals is 1 megohm shunted by 37 uuf.

Oscilloscope Terminals: Terminals are provided for connection to an oscilloscope to observe the wave shapes of the original signal and the residual distortion components. Maximum gain from the a-f input is 75 db.

Power Supply: 115 volt 50/60 cycles. Power consumption is 90 watts. Plate supply electronically regulated.

Mounting: Oak cabinet or relay rack. Panel size, 19" x 10 $\frac{1}{2}$ "; depth 13". Panel finish wrinkle gray.

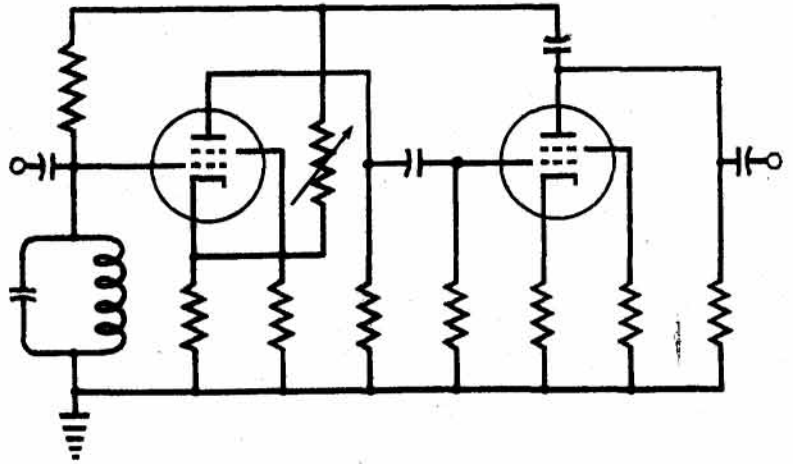
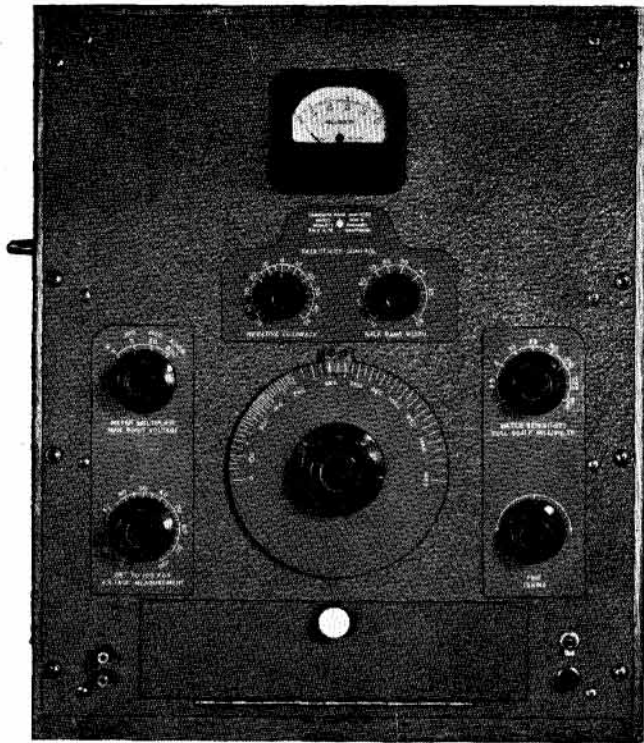
Net Weight: 50 pounds. Shipping Weight: 80 pounds.

Data subject to change without notice.



MODEL 300A

HARMONIC WAVE ANALYZER



VARIABLE SELECTIVITY PROVIDES RAPID, ACCURATE WAVE ANALYSIS

THIS *-hp-* Model 300A Harmonic Wave Analyzer is a selective voltmeter designed to measure the individual components of complex waves. The selectivity can be varied by means of a unique selective amplifier. Where the harmonics are close together the high selectivity easily separates the wave components. Yet, where the components are spaced far apart, the selectivity may be widened to increase the speed of operation without sacrificing essential accuracy. This feature is also valuable where it is necessary to measure distortion of waves containing a small amount of frequency modulation, such as in sound tracks, and may be used conveniently to integrate a small portion of the audio spectrum in noise measurements and the like. Maximum selectivity is sufficient to separate harmonic components spaced 30 cycles apart. See figure 1.

DIRECT READING

The *-hp-* Model 300A Harmonic Wave Analyzer covers the audio spectrum from 30 cps to 16,000 cps. The wide voltage range covers the values encountered in nearly every application. Full scale voltmeter readings may be obtained with inputs of .001 to 500 volts so that the instrument may be used

ADVANTAGES:

- Direct reading
- Simplified operation
- Variable selectivity
- Wide voltage range
- Linear meter scale

USE IT TO ANALYZE:

- Noise characteristics
- Broadcast amplifier characteristics
- Modulating amplifier distortion
- Recording devices
- Rotating machinery harmonic voltages
- Film sound track distortion
- Recording distortion
- Hum
- Network characteristics

with equal success with low output transducers and high power modulating amplifiers. Other features which make it unexcelled for both laboratory and production testing are the linear meter scales fully protected against overloads, and the built-in calibrating system to standardize voltage measurements.

THEORY

The circuit of the Model 300A consists of a variable local oscillator, a balanced modulator, a selective amplifier, and an indicating meter. The variable local oscillator modulates the unknown frequency to produce a constant difference frequency. This difference frequency is applied to the selective amplifier, the output of which is then proportional to the magnitude of the unknown voltage. A meter in the output of the selective amplifier indicates the magnitude of the voltage.

The local oscillator is of the resistance-tuned type, providing a very stable, accurate voltage. A balanced modulator is used to eliminate the local oscillator frequency and to keep cross-modulation products very low. The selective amplifier consists of four tuned circuits in which the effective Q is controlled by positive feedback. Negative feedback is also used to stabilize the amplifier.

This amplifier has the unique characteristic that its selectivity may be varied over a wide range without appreciably affecting the gain of the amplifier.

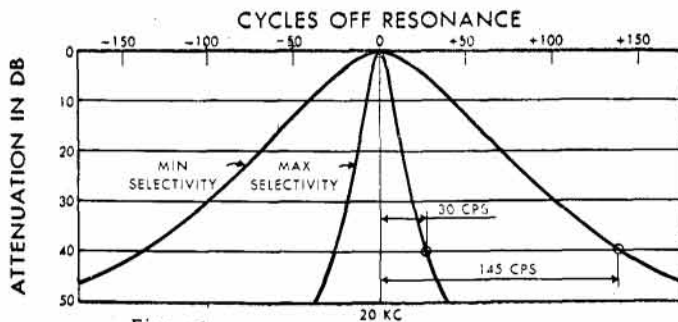


Figure 1

USES

The Model 300A is well adapted to the measurement of the harmonic distortion in audio frequency equipment of all kinds, broadcast receivers, transmitters; to determine the harmonic components in a-c machinery and power systems; to the study of induced voltages on telephone lines; to measurement of hum components in rectifier circuits.

Other uses include the study of noise by integrating portions of the spectrum with the selectivity control adjusted for a wide pass band and the checking of wave filter characteristics with maximum selectivity.

The Model 300A is also useful as a device to measure the amount of cross- or inter-modulation products generated by the simultaneous transmission of two frequencies by an audio system or to measure demodulation of a modulated wave applied through an audio system.

SPECIFICATIONS

Frequency Range: The frequency range is from 30 to 16,000 cps and the frequency calibration is within 3%. The frequency is controlled by a 7" diameter dial located on the panel. The entire range is covered in approximately a 200° sweep of the dial.

Voltage Range: There are four input voltage ranges having maximum values of 0.5 volts, 5 volts, 50 volts, and 500 volts. In addition, a meter multiplier divides each voltage range into full scale meter readings of 500, 250, 100, 50, 25, 10, 5, 2.5, and 1. Thus full scale meter readings can be obtained on from 1 mv to 500 v. Two controls select the input range and meter multiplier. The linear meter is fully protected against overloads.

Selectivity: The selectivity can be varied by means of a control on the front panel. At the maximum selectivity setting, the response is down approximately 3 db at 3.5 cycles, 10 db at 8 cycles, 40 db at 30 cycles, and 60 db at 53 cycles from maximum response. At minimum selectivity the response is down approximately 3 db at 14 cycles, 10 db at 37 cycles, 40 db at 145 cycles, and 60 db at 280 cycles from maximum response. Selectivity may be varied continuously between these limits. The variable selectivity control is calibrated in the half band width at which the response is down 40 db.

Voltage Accuracy: The over-all voltage accuracy is $\pm 5\%$, provided adjacent harmonics are within limits determined by the selectivity. This accuracy can be maintained provided that unwanted voltages are attenuated by the selectivity of the instrument to less than $\frac{1}{3}$ of the voltage being measured. Thus, with maximum selectivity a 3% second harmonic of a 30 cycle voltage may be measured with 5% accuracy.

The residual modulation products are suppressed by at least 65 db. Hum is at least 75 db below maximum input voltage on any of the four input ranges.

Input Impedance: The input impedance is 200,000 ohms. The input circuit includes a potentiometer which is set to maximum for voltage measurements.

Power Supply: The instrument contains a voltage regulated power supply which operates from 115 volts, 50/60 cycles. Power required is 105 watts.

Mounting: The Model 300A is mounted in an attractive oak cabinet to harmonize with the panel which is finished in wrinkle gray with machine engraved designations. A relay rack model is also available and is designated as the Model 300AR.

Physical: Over-all dimensions of the Model 300A are 24" high, 21 $\frac{5}{8}$ " wide, and 14 $\frac{1}{8}$ " deep.

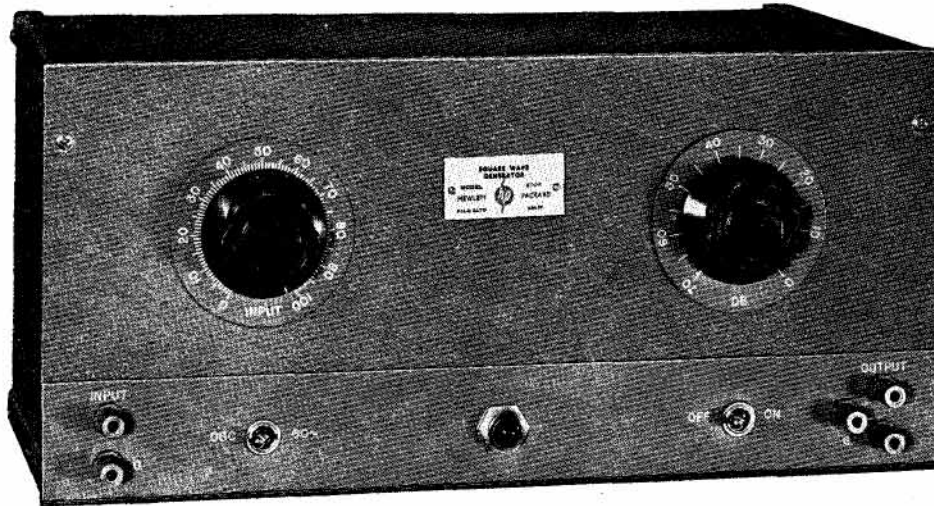
Net Weight: 78 pounds. Shipping Weight: 150 pounds.

Data subject to change without notice.



MODEL 210A

SQUARE WAVE GENERATOR



SQUARE WAVES FOR RAPID TESTING 20 CPS TO 100 KC

The *hp*-Model 210A Square Wave Generator provides an excellent source of square waves for production tests and experimental purposes. The fundamental frequency range is 20 cps to 10,000 cps. A reasonably square wave may be obtained at frequencies as high as 100 kc. The square wave frequency is synchronized from an external source of 2 or more volts. Output can be attenuated 70 db from a maximum voltage of 50 volts, peak to peak. Output voltages balanced to ground.

USES

The *hp*-210A is ideal for testing receivers, video amplifiers, networks and transmitters; to measure time constants or provide a time base, check cathode ray sweep circuits, generate harmonics for frequency multiplication or control an electronic switcher. It may also be used to indicate phase shift, frequency response, or transient effects.

SPECIFICATIONS

Frequency Range: 20 cps to 10,000 cps. Voltage rise time: Approximately 1 microsecond to 90% of maximum. Flat top of wave decays less than 1%.

Output Voltage: Approximately 50 volts, peak to peak, open circuit. The output impedance is 1,000 ohms, balanced to the ground.

Output Attenuator: 70 db in 5 db steps.

Driving Voltage: 3 volts required. Input impedance 25,000 ohms. May be internally driven with a-c power supply voltage.

Mounting: Steel Cabinet: 15" long, 7" high, 9" deep. Relay Rack: 19" long, 7" high, 8" deep.

Power Supply: Built-in. Operates from 115 volt 50/60 cycle. Requires approximately 115 watts.

Net Weight: 30 pounds. **Shipping Weight:** 39 pounds.

Data subject to change without notice.

1. Square wave distortion from poor high frequency response.



2. Square wave distortion from poor response at both high and low frequencies.



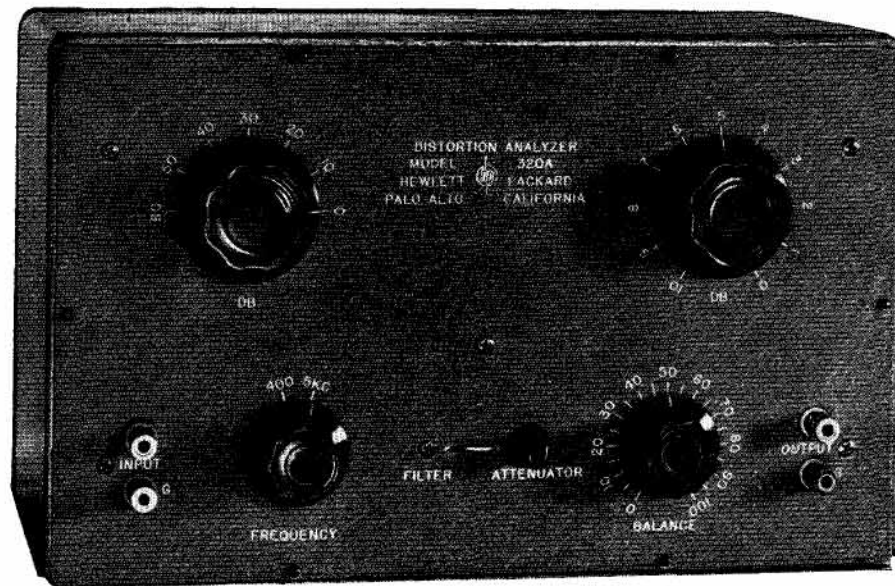
3. Square wave test on feedback amplifier showing peak at 9 times square wave frequency.





MODEL 320

DISTORTION ANALYZER



QUICKLY DETERMINES TYPE AND AMOUNT OF DISTORTION

The *-hp-* Model 320 Distortion Analyzer is a simple and convenient device for studying and measuring the total harmonic distortion in audio frequency apparatus. The character and type of distortion can also be determined.

The Model 320 contains a 70 db attenuator set and sharply tuned filters. Distortion measurements are made by eliminating the fundamental from the applied voltage with the filter and noting the amplitude of remaining distortion on an external detector or voltmeter such as the *-hp-* 400A. The filters are then switched out and the original wave attenuated on the self-contained attenuators until an identical reading is obtained on the external detector. The setting of the attenuator then indicates the distortion level in db below the applied wave. An oscilloscope also may be used to aid in determining the character of distortion or as a detector.

The Model 320 is available as the *-hp-* 320A, for measurements at 400 and 5000 cps; or as the *-hp-* 320B for frequencies of 50, 100, 400, 1000, 5000 and 7500 cps. Filters for other frequencies available on special order.

USES

These time-saving instruments are designed to quickly compare wave distortion with fundamental voltage, observe type as well as amount of distortion, obtain speed production testing. They will also attenuate voltages and signals through a range of 0 to 70 db.

SPECIFICATIONS

Frequency Range: Model 320A: 400 and 5000 cps. Model 320B: 50, 100, 400, 1,000, 5,000, 7,500 cps. (Filters for other frequencies on special order.)

Input Impedance: Minimum, 20,000 ohms.

Attenuator: 70 db adjustable in 1 db steps.

Distortion Range: Distortion as low as 0.1% of fundamental may be measured with sensitive detector.

Mounting: Wrinkle gray panel, oak cabinet: 13" long, 9" high, 8" deep. Relay-rack: 19" long, 9" high, 8" deep.

Net Weight: 17 pounds. Shipping Weight: 29 pounds.

... Data subject to change without notice.

UHF SIGNAL GENERATOR



GENERAL PURPOSE UHF SIGNAL GENERATOR, 450 TO 1200 MC

SPECIFICATIONS

Frequency Range: 450-1200 mc directly calibrated.

Attenuator: Mutual inductance piston type, directly calibrated in db below 0.1 volts in 50 ohms; 120 db maximum attenuation.

Output: Accurately known voltages from 0.1 microvolt to 0.1 volt supplied through 50-ohm coaxial cable terminated in type "N" connector. Internal impedance 50 ohms. Accuracy better than ± 1 db over entire range.

Modulation: Internal pulse, external pulse, external square wave, external amplitude.

Internal Pulser: Pulse length variable 2 to 50 microseconds. Repetition rate variable 60 to 3000 cps. Pulse delay variable 3 to 300 microseconds (between externally supplied synchronizing pulse and beginning of r-f pulse).

Leakage: Sufficiently low to permit measurement of sensitivities as low as 1 microvolt.

Size: Panel 8" x 11"; depth 22".

Net Weight: 44 pounds. Shipping Weight: 85 pounds.

Data subject to change without notice.

HE *-hp-* Model 610B Signal Generator provides a general purpose laboratory standard for measurements between 450 and 1200 mc. It supplies an accurately known voltage throughout this range, from 0.1 microvolt to 0.1 volt. Output voltage and frequency are directly selected and read without reference to calibration charts.

The *-hp-* 610B includes a high-frequency oscillator, and an attenuator for accurately controlling output beyond a measured level. Also included is an internal pulser and modulator, and a regulated power supply to provide oscillator plate voltage. The oscillator employed is of the concentric type, utilizing a "lighthouse" tube, and is adjusted by the positioning of the shorting plungers in the concentric lines. Output voltage is derived through a mutual inductance type attenuator, coupled to the oscillator cavity. R-f voltage at attenuator input is measured by a thermistor bolometer.

Internal pulsing circuits provide rectangular, r-f, pulsed output of variable lengths and repetition rates. The pulse rate may be synchronized from an outside source. An external synchronizing pulse is provided. R-f signal may also be externally amplitude modulated.



SIGNAL GENERATORS

for measuring receiver performance, standing wave ratio, gain, antenna and transmission line characteristics, etc.

SIGNAL GENERATOR

RECEIVER

OUTPUT INDICATOR

AT ANY frequency between 10 mcs and 4,000 mcs, you can get accurately known voltages and a multitude of time-saving conveniences from any of four *-hp-* UHF signal generators. Each of these instruments features directly read and directly set frequency controls, wide applicability for secondary purposes, and traditional *-hp-* precision accu-

racy. Several of the instruments offer many different types of pulsing, modulation and delay characteristics, synchronized and unsynchronized.

The table below lists frequencies and brief details of the various generators. Detailed specifications will be found on the pages indicated.

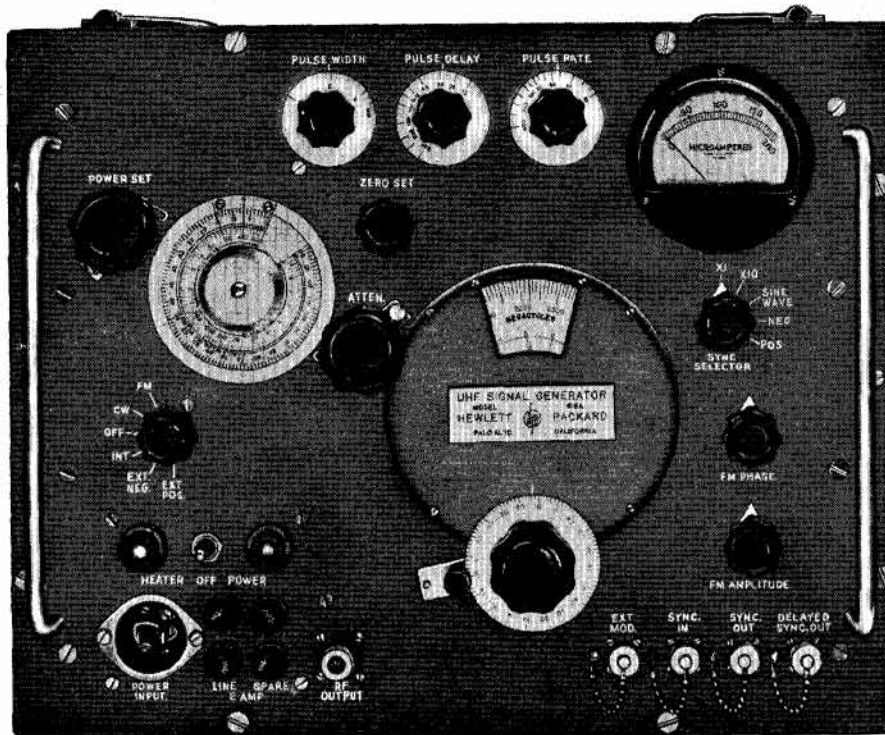
INSTRUMENT	FREQUENCY	CHARACTERISTICS	PRICE	PAGES
<i>-hp-</i> 608A	10-500 mc	Output 1.0 v. to 0.1 μ v. Amplitude, pulsed and CW output. Direct reading.	\$850.00	40-41
<i>-hp-</i> 610B	450-1,200 mc	Calibrated output 0.1 μ v to 0.1 v. Internal pulse modulation. Direct calibration.	\$925.00	36
<i>-hp-</i> 614A	800-2,100 mc	Direct reading. Pulse modulation, CW & FM. Output 1 mw or .223 v. to 0.1 μ v.	\$1,950.00	42
<i>-hp-</i> 616A	1,800 to 4,000 mc	Direct reading. Pulse modulation, CW & FM. Calibrated output .223 v. to 0.1 μ v.	\$1,950.00	38-39

Data Subject to Change Without Notice. • Prices f.o.b. Palo Alto, California.



MODEL 616A

UHF SIGNAL GENERATOR



ADVANTAGES:

- Direct frequency control
- Direct voltage readings
- C-w, f-m, or pulsed output
- Variable pulse rate
- Synchronized pulsing
- Wide frequency range
- Great stability
- Rugged, compact

USE IT TO MEASURE:

- Receiver sensitivity
- Signal-noise ratio
- Conversion gain
- Standing wave ratios
- Antenna gain
- Transmission line characteristics

FAST DIRECT READINGS 1800 TO 4000 MC

ASE of operation, direct reading without reference to calibration charts, one-dial frequency control, great stability, and precision accuracy between 1800 and 4000 mc—those are but a few of the advantages of this new -hp- Model 616A Signal Generator.

Operation of the new -hp- 616A is extremely simple. For example, carrier frequency in mc may be directly set and read on the large tuning dial. No voltage adjustments are necessary during operation, because the unique, -hp- developed coupling device causes oscillator repeller voltage to automatically track frequency changes. R-f output from the reflex klystron oscillator is directly set and read on a simplified output dial. It may be continuous or pulsed, or frequency modulated at power supply frequency. Pulse modulation may be provided externally or supplied internally. Internal pulsing may be synchronized with either positive or negative external pulses, or sine waves. R-f pulse may be delayed 3 to 300 microseconds with respect to external synchronizing pulse.

The oscillator portion of the new *-hp-* 616A Signal Generator is of the reflex klystron type, with an external resonant cavity. Frequency of oscillation is determined by a movable plunger which varies the parameter of the cavity. Oscillator output is monitored by a temperature-compensated thermistor bridge circuit which operates virtually unaffected by ambient temperature conditions. Voltage beyond the monitored output level is passed through a piston attenuator which is so designed that attenuation is linear over a range of 120 db or more. Voltage output is directly read on the scale.

Because of its wide range and great stability, the *-hp-* 616A UHF Generator is ideal for almost any precision uhf application. It is easy to use, compact to save bench space, and ruggedly-built of finest components for long, trouble-free service.

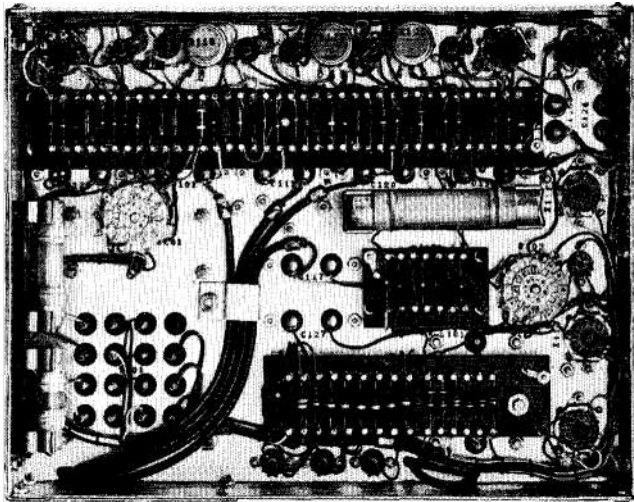


Fig. 1 — Rear view of *-hp-* 616A UHF Signal Generator, showing compact arrangement and ready accessibility of all components.

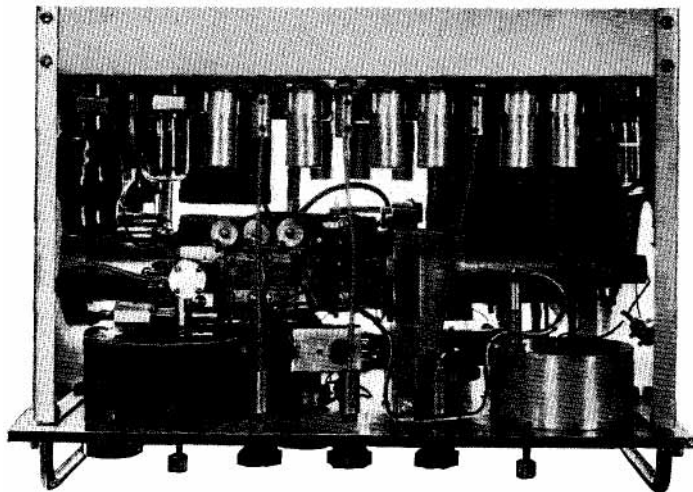


Fig. 2 — Top view of signal generator showing klystron oscillator cavity and bolometer circuits. Aperture at right permits easy replacement of oscillator tube.

SPECIFICATIONS

Frequency Range: 1800 to 4000 megacycles.

Selection is made by means of a single directly-calibrated control covering the entire range. No charts are necessary.

Frequency Calibration Accuracy: $\pm 1\%$.

Frequency Stability: 0.005% per degree centigrade change in ambient temperature; line voltage changes of ± 10 volts cause less than 0.01% frequency change.

Output Range: 1 milliwatt or .223 volts to 0.1 microvolt (0 dbm to -127 dbm). Directly calibrated in microvolts and db; continuously monitored.

Attenuator Accuracy: Within ± 1 db without correction charts. A correction chart is provided when greater accuracy is desired.

Output Impedance: 50 ohms, nominal.

Modulation: Internal or external pulse or f-m.

Internal Pulse Modulation: Repetition rate variable from 40 to 4000 per second; pulse length variable from 1 to 10 microseconds; and delay variable from 3 to 300 microseconds (between synchronizing signal and r-f pulse).

Trigger Pulses Out:

1. Simultaneous with r-f pulse.
2. In advance of r-f pulse, variable 3 to 300 microseconds. (Both approximately 0.5 microsecond rise time, height 25-50 volts.)

External Sync Pulse Required: Amplitude from 10 to 50 volts of either positive or negative polarity and 1 to 20 microseconds width. May also be synchronized with sine waves.

FM Modulation: Oscillator frequency sweeps at power line frequency. Phasing and sweep range controls provided. Maximum deviation approximately ± 5 mc.

Power Source: The instrument operates from a 105-125 volt 50/60 cycle, single phase source.

Approximate Size: 17" long, 13 $\frac{1}{4}$ " high and 13 $\frac{1}{2}$ " deep.

Data subject to change without notice.



MODEL 608A



VHF SIGNAL GENERATOR

ADVANTAGES

- High power output
- Constant internal impedance
- Wide frequency range
- Broad modulation capabilities
- Master oscillator power amplifier circuit
- Microsecond pulsing
- Small residual FM
- CW, AM or pulsed output
- Direct calibration

USES

- Measure gain, selectivity, sensitivity or image rejection of receivers, I-F amplifiers, broad band amplifiers, etc.
- Drive bridges, slotted lines, antennas, filter networks, etc.

NEW BASIC MEASURING TOOL FOR 10 TO 500 MC BAND

HERE at last is a general purpose laboratory generator of broadest application in the important 10 to 500 megacycle band — an instrument which has high power broad modulation capabilities because of its master oscillator power amplifier design.

This new instrument offers a directly calibrated output from 0.1 microvolt to 1.0 volt for measurements of gain, selectivity, sensitivity or image rejection of receivers, I-F amplifiers, broad band amplifiers and other VHF equipment. It also provides a 1 volt output into a 50 ohm load (over entire frequency range) suitable for driving bridges, slotted lines, transmission lines, antennas, filter networks, etc.

DIRECT CALIBRATION

Both output and frequency are calibrated directly, for fast reading without charts. The output circuit is calibrated in both volts and dbm. Frequencies from 10 to 500 mc are covered in 5 bands, and calibrated directly in megacycles on a drum-type dial having a total effective scale length of 84 inches. This single-dial ball bearing frequency control insures maximum convenience and accuracy in tuning and re-setting. There is virtually no backlash and the resetability is better than 1 megacycle even at the high frequency end of the band.

HIGH POWER

One of the most valuable features of this new *-bp-* signal generator is its high power output of 1 volt into a 50 ohm load. This output is available throughout the entire frequency range, and is adjustable down to 0.1 microvolt. This enables the generator to serve for very low level applications as well as antenna, SWR and other measurements requiring high power output. The output level is controlled by means of a mutual inductance type attenuator which has been designed and adjusted to provide a 50 ohm source impedance over the entire band. There are no spurious responses to cause error in the output voltage.

MODULATED POWER AMPLIFIER

Unusually good amplitude modulation is obtainable because a master oscillator power amplifier circuit is employed. Ninety percent modulation can be obtained with low distortion. A range of audio, carrier current and video modulations may be employed since circuitry has flat response from 50 cps to 1 megacycle. The percentage modulation is measured by demodulating a portion of the radio frequency carrier, and is read directly on the large front panel meter.

The instrument also provides excellent pulse modulation, and good pulse shape is obtainable from square waves to 1 microsecond length. The incidental frequency modulation accompanying amplitude modulation is held to an extremely low value.

CIRCUITS

The master oscillator and power amplifier circuits are identically designed to insure tracking over a wide frequency range. These circuits employ an unique combination of transmission line and lumped constant techniques to successfully bridge the 10 to 500 megacycle spectrum. The amplifier is of the grounded grid variety, and provides good isolation of the

output circuitry from the master oscillator. The output level is adjusted by varying the bias voltage on the final amplifier. Rf voltages ahead of the piston-type attenuator are continuously monitored.

The radio frequency circuits are completely enclosed in a heavy cast aluminum shield, and both tuning condensers are made from silver-plated Invar steel plates, thus insuring the highest possible degree of mechanical and thermal stability. Castings are also silver-plated and are carefully designed to prevent electrical leakage. The power supply and modulation circuits are mounted on a vertical chassis revealing the circuitry for easy servicing. Only the highest quality components are employed to insure the utmost in stability and long, trouble-free service.

SPECIFICATIONS

Frequency Range: 10 to 500 mc in 5 bands.

Accuracy: Calibration $\pm 1\%$. Re-setability better than 1 mc at high frequencies. Total scale length approximately 90".

Output: 0.1 μ v to 1.0 v, continuously variable. Calibrated in volts and dbm.

Impedance: 50 Ω . Maximum VSWR 1.2.

Accuracy: ± 1 db entire range.

Modulation:

Amplitude: From 0 to 90% indicated by front panel meter.

Envelope Distortion: 1% at 30% modulation.

Internal: Fixed modulation frequencies, 400 and 1,000 cps.

External: Any frequency 50 cps to 1 mc. 4.0 v. input.

External Pulse: Positive or negative, 4 v. peak. Good pulse shape at 1 μ sec length.

Leakage: Negligible; permits receiver sensitivity measurement down to at least 0.1 μ v.

Residual FM: Not over .0025% at 30% modulation.

Power: 115/230 v. 50/60 cps. 150 watts.

Size: 12" x 14" x 18" deep. *-bp-* grey finish. Cabinet mounting. Weight 55 lbs. Shipping weight 75 lbs.

- Data Subject to Change Without Notice

UHF SIGNAL GENERATOR



DIRECT READING, DIRECT CONTROL GENERATOR, 800 TO 2,100 MC

SPECIFICATIONS

Frequency Range: 800-2,100 mc directly calibrated. Accurate within $\pm 1\%$.

Output Range: 1 milliwatt or .223 v to 0.1 μ v. (0 dbm to -127 dbm) Directly calibrated in μ v and db; continuously monitored.

Output Impedance: 50 ohms. SWR 3 db (VSWR 1.4).

External Modulation: By external pulses, pos. or neg. peak amplitude 40 to 70 v., 0.5 microseconds to square wave.

FM Modulation: Oscillator frequency sweeps at power line frequency. Phasing and sweep range controls provided. Max. deviation approx. ± 5 mc or more.

Internal Modulation: Pulse repetition rate variable from 40 to 4,000 per second; pulse length variable from 1 to 10 μ sec. Pulse rise and decay approx. 0.1 μ sec.

Trigger Pulses Out: (1) Simultaneous with rf pulse. (2) In advance of rf pulse, variable 3 to 300 μ sec. (Both approx. 1 μ sec. rise time, height 10 to 40 v.)

External SYNC Pulse Needed: Amplitude from 10 to 50 v. of either pos. or neg. polarity; and 1 to 20 μ sec width. May also be synchronized with sine waves.

Size: 17" long; 13 $\frac{1}{4}$ " high; 13 $\frac{1}{2}$ " deep.
Net Weight: 65 lbs. Shipping weight: 115 lbs.
Data subject to change without notice.

HIS new *-hp-* UHF Signal Generator is similar in design to the *-hp-* 616A generator, but offers such additional advantages as faster rise time of pulsed output, more constant internal impedance and higher output accuracy.

Like the 616A, the new 614A can save hours of time and work in making UHF measurements. It offers direct reading output and accuracy of ± 1 db; constant internal impedance with a standing wave ratio of 3 db; external modulation of half-microsecond pulses to square waves; a choice of CW, FM or pulsed output, and many other time-saving conveniences.

For example, carrier frequency in mc can be set and read directly on the large central tuning dial. Rf output from the klystron oscillator is also directly set and read, in microvolts or db. No calibration charts or tedious interpolations are necessary; and no voltage adjustments are required during operation. Output may be continuous, pulsed, or frequency modulated at power supply frequency. The instrument can be modulated internally or externally; and may be synchronized with positive or negative pulses or sine waves.

With this instrument you can quickly, easily and accurately measure receiver sensitivity and alignment, signal-to-noise ratio, conversion gain, standing wave ratios, antenna gain, and transmission line characteristics—to name but a few readings essential to UHF work.



MICROWAVE EQUIPMENT

Impedance and power measuring equipment, Low Pass Filters, Detectors

SIGNAL
GENERATOR

FILTER

SLOTTED
LINE

LOAD

ERE -hp- presents a broad new line of microwave measuring equipment—forerunner of complete -hp- instrumentation throughout the microwave field. In addition to the basic equipment shown here, -hp- has still other, newer instruments in the laboratory; precision equip-

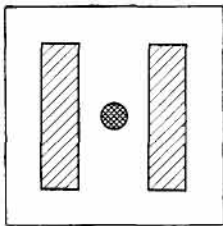
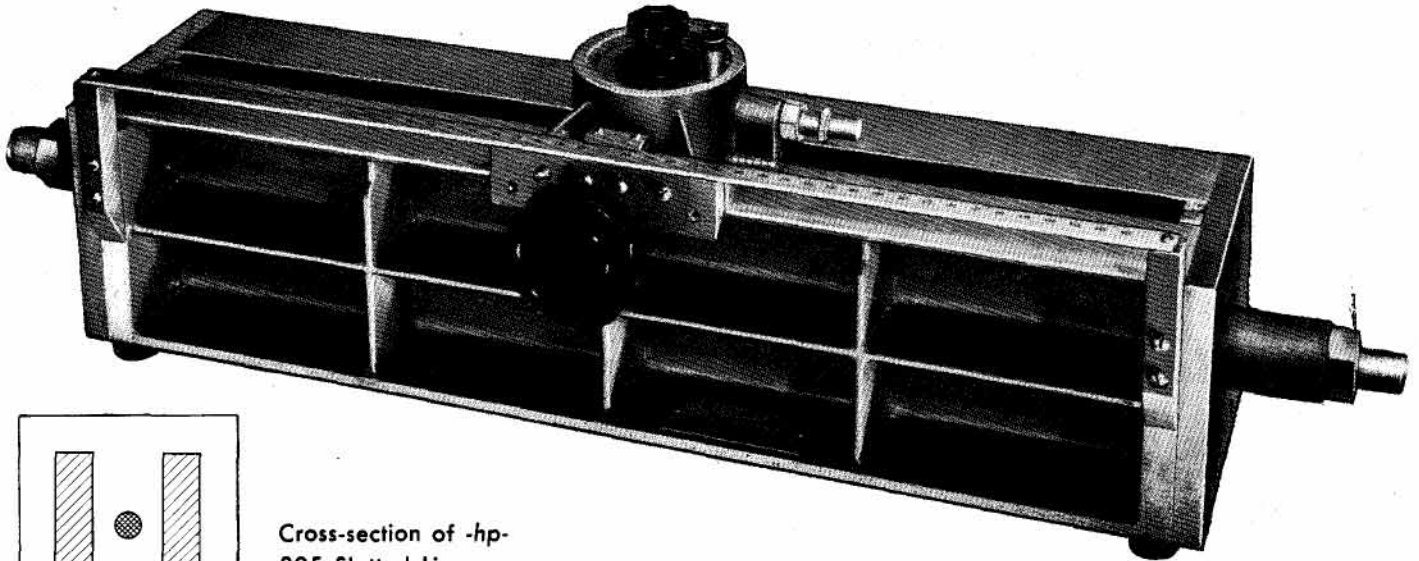
ment that will give you the utmost in speed and accuracy for every type of microwave measurements.

Brief details of these instruments appear below. Complete data will be found on the pages indicated.

INSTRUMENT	PRIMARY USES	FREQUENCY RANGE	CHARACTERISTICS	PRICE	PAGES
-hp- 430A Power Meter	Measures VHF, UHF, SHF power in bolometer element.	Depends on bolometer mount.	Reads .1, .3, 1, 3 and 10 mw full scale. Reads dbm from -20 to +10. Accuracy 5% full scale.	\$250.00	50
-hp- 803A VHF Bridge	Measures VHF impedance.	50 to 500 mc.	Direct reading. Accuracy $\pm 5\%$. Useful 5 mc to 1,000 mc.	\$495.00	46
-hp- 805A Slotted Line	Measures UHF impedance, transmission line characteristics.	500 to 4,000 mc.	Negligible slope, 50 ohms impedance, residual VSWR 1.04. Calibrated in cm and mm. For use with flexible cables and Type N connector.	\$475.00	44-45
-hp- 805B	Same as 805A. For $\frac{7}{8}$ " rigid coaxial conductor.	500 to 4,000 mc.	Same as above except impedance 46.3 ohms and residual VSWR only 1.02. For use with $\frac{7}{8}$ " rigid coax, RG44/U.	\$475.00	44-45
-hp- 415A Standing Wave Indicator	With 805A & 805B to read VSWR directly. As null indicator.	1,000 cps normally supplied. Other frequencies, 300 to 2,000 cps available.	Sensitivity 0.3 μ v. 60 db calibrated attenuator.	\$200.00	45
-hp- 417A VHF Detector	With Model 803A.	10 to 500 mc.	Sensitivity 5 μ v. Frequency directly calibrated.	\$200.00	47
-hp- 360A-D Low Pass Filters	Eliminates harmonic voltages from UHF systems.	Cutoff frequencies: 700, 1,200, 2,200 and 4,100 mc.	50 db attenuation at 1.2 x cutoff frequency. 50 ohms impedance.	\$50.00	48
-hp- 475A Bolometer Mount	With Model 430A. Couples bolometer to microwave system. Tunable transformer.	300 to 1,000 mc.	Tunable. Matches 50 ohm line to bolometer of 100 or 200 ohms.	\$200.00	49
-hp- 475B Bolometer Mount	Same as Model 475A.	1,000 to 4,000 mc.	Same as above.	\$200.00	49

Data subject to change without notice. Prices f.o.b. Palo Alto, California.

SLOTTED LINE



Cross-section of -hp-
805 Slotted Line

ADVANTAGES:

Parallel plane design: provides higher accuracy, greater stability, negligible slope, rigid central conductor. Ball-bearing probe carriage. Low residual VSWR.

USE IT TO MEASURE:

Load Impedance
System Flatness
Connector Reflection
Antenna Match
% of Reflected Power
Standing Wave Magnitude
Standing Wave Phase

NEW "PARALLEL-PLANE" DESIGN GIVES UTMOST ELECTRICAL STABILITY

THE new -hp- 805 Slotted Line incorporates a radically new structural design with precision manufacture, resulting in an instrument of unvarying accuracy for the measurement of microwave circuits.

GREATER INHERENT ACCURACY

This new instrument employs two parallel planes and a rigid central conductor in place of the conventional co-axial arrangement. This configuration has several important advantages over the standard slotted section.

For example, it permits the parallel planes to be made mechanically rigid; thus insuring greater accuracy and providing a rigid probe carriage. The central conductor is proportionately larger and more rigid, with less tendency to bow. Depth of probe penetration is inherently less critical, and therefore carriage inaccuracies are minimized. Leakage is also low because the effective slot opening is small. This new design permits VSWR of the basic section to be held to less than 1.02.

In the construction of the *-hp-* 805 Slotted Line, every effort has been made to achieve complete mechanical stability. The flat sections or planes are of cast, normalized aluminum alloy, ribbed to combine strength and light weight. The central conductor is a selected brass rod, centerless ground and silver plated.

CALIBRATION

Calibration of the scale is in millimeters and centimeters, and the probe position can be read to 0.1 millimeters. The probe carriage traverses the slot length on ball bearings, and is free-moving to facilitate quick setting of the probe position. Close setting is made by means of a vernier control knob. The probe circuit is tunable over the instrument's entire frequency range, 500 to 4,000 megacycles. Depth of probe penetration can be quickly and easily adjusted by means of a knob on top of the probe carriage.

The *-hp-* 805 Slotted Line is supplied complete with a specially designed steel-and-dural carrying case. The case includes sponge rubber shock-mountings to guard the instrument against damage, and is fitted with steel snap fastenings and carrying handle.

SPECIFICATIONS

-hp- 805A Slotted Line

Frequency Range: 500 mc to 4,000 mc (minimum frequency determined by usable length of $17\frac{1}{2}$ inches).

Characteristic Impedance: 50 ohms. (For use with such flexible coaxial cables as RG: 8/U, 9/U, 10/U, 14/U, 17/U, 18/U, 21/U.)

Connections: TYPE N. (One male; one female). Special fittings designed to mate with Type N connectors provide a minimum VSWR. Connectors compensated so that either end may be connected to the load. Also included are shorting connectors, male and female, for use in making phase measurements.

Residual VSWR: 1.04.

Slope: Negligible.

Calibration: Metric, calibrated in cm and mm. Vernier permits reading to 0.1 mm.

Detector: Circuit tunable, uses standard crystal (1N21B or 1N23); Sperry Barretter Model 821; or 1/100 ampere instrument fuse.

Size: Length 27". Height 8". Width 6". Weight 18 lbs. In case: Length 28". Height $9\frac{1}{4}$ ". Width $9\frac{3}{4}$ ". Weight 33 lbs. Shipping weight 75 lbs.

-hp- 805B Slotted Line

Characteristic Impedance: 46.3 ohms. For use with RG 44/U stub supported coaxial cable. $\frac{7}{8}$ " outside diameter.

Connections: (One male, one female UG 45/U and UG 46/U.)

Residual VSWR: 1.02.

(Other specifications same as *-hp-* 805A)

Data subject to change without notice.



-hp- Model 415A

STANDING WAVE INDICATOR

The new *-hp-* 415A Standing Wave Indicator is designed for use with the *-hp-* 805A Slotted Line. It may also be used as a null indicator, or for bridge measurements, and provides a 75,000 ohm input circuit for this application.

The *-hp-* 415A consists of a high gain amplifier with very low noise level, operating at a fixed audio frequency. Amplifier output is measured with a Square-Law calibrated vacuum tube voltmeter. This meter reads direct in VSWR and in db, eliminating the need for laborious computations. A 60 db attenuator adjustable in 10 db steps provides a calibrated range of 70 db for readings of SWR. A gain control adjusts the instrument to a convenient level. Input circuits are provided both for use with a crystal rectifier or bolometer.

SPECIFICATIONS

Frequency: Normally 1,000 cps $\pm 2\%$. Plug-in units for other frequencies, 300 to 2,000 cps are available. Request unit 41A-42, and specify frequency. Amplifier "Q" is 20 ± 5 .

Sensitivity: 0.3 μ v. gives full scale deflection. Equivalent noise level referred to input is 0.04 μ v.

Calibration: For use with Square-Law detector. 60 db level covered in 6 ranges. Accuracy ± 0.1 db per 10 db step.

Gain Control: Adjusts meter to convenient level. Range is approx. 30 db.

Input: Connects to crystal rectifier or bolometer. Bias of 8 v. $\pm .5$ v. delivers approx. 8.75 ma. to a 200 ohm bolometer or 1/100 ampere instrument fuse. 75,000 ohms for null measurement. One terminal at ground.

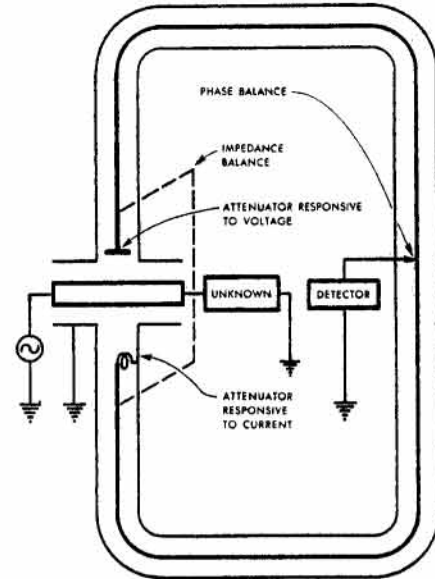
Size: 12" long, 9" wide, 9" high. Weight 17 lbs. Shipping weight 30 lbs.

Data subject to change without notice.



MODEL 803A

VHF BRIDGE



ADVANTAGES

- Direct reading,
 - 2 to 2,000 ohm impedances
 - 90° to +90° phase angle
- Wide range,
 - 50 to 500 megacycles
 - Useful 5 to 1,000 mc
- Simple, easy operation
- Faster than slotted lines
- Compact size

USES

- Determines characteristics of:
 - Antennas
 - Transmission Lines
 - rf chokes
 - Resistors
 - Condensers
- Measures:
 - Connector impedances
 - Standing wave ratios
 - % reflected power
 - VHF system flatness

READS ANY IMPEDANCE DIRECT BETWEEN 50 AND 500 MC

MODEL 803A VHF BRIDGE is the first commercial equipment built to provide direct impedance measurements in the VHF range. It is based on a new principle originated by Mr. John Byrne of the Airborne Instruments Laboratory. Development of this principle into commercial equipment was achieved by Hewlett-Packard engineers.

The equipment measures impedance by sampling the electric and magnetic fields in a transmission line. Two attenuator systems are controlled simultaneously. One responds to the electric field in the transmission line, and the other responds only to the magnetic field in the transmission line. The combination is adjusted for equal output from each attenuator. These two signals are applied to opposite ends of a transmission line. Phase is determined by finding their point of cancellation. (See diagram.) This method effectively overcomes the narrow frequency limitations of conventional bridges, and permits *hp* Model 803A to make readings at frequencies up to 1,000 mc and down to 5 mc.

SIMPLE TO OPERATE, DIRECT READING

In operation, the instrument is similar to a standard bridge, much simpler to use and more compact than a slotted line. Two controls are simultaneously tuned until a sharp null is obtained. At the null, one dial reads unknown impedance direct in ohms, and the other dial shows phase angle.

Impedances between 2 and 2,000 ohms are read directly, and higher or lower values may be quickly determined by using a transmission line of known length as an impedance transformer. Phase angles up to $\pm 90^\circ$ can be measured at frequencies as low as 50 mc. Calibration of phase angle is direct in degrees at 100 mc, and angles at other frequencies can be readily determined by multiplying angle read by frequency in mc, and dividing by 100.

BROAD USEFULNESS

Virtually all measurements which can be made with a slotted line can be made more easily and swiftly with the compact Model 803A VHF Bridge. The instrument is extremely useful for determining rf resistance—even at frequencies as low as 5 mc or high as 1,000 mc. It also offers fast, accurate determination of antenna and transmission line characteristics and impedances, capacity, inductance, etc. Its broad usefulness makes this equipment a real time saver to engineers working in the VHF band.

-hp- MODEL 417A

VHF DETECTOR



This new *-hp-* instrument is a super-regenerative (AM) receiver covering all frequencies between 10 and 500 mc in 5 bands. It is designed for use with the *-hp-* 803A Bridge. It offers a high sensitivity of 5 microvolts over the entire frequency band. It is designed for fast, simple operation, and has a single, convenient frequency control directly calibrated in megacycles.

SPECIFICATIONS

Measurement Range: Impedance magnitude, 2 to 2,000 Ω . Higher and lower values may be measured by using a known length of transmission line as an impedance transformer.

Phase angle from -90° to $+90^\circ$ at 50 mc and above.

Calibration: Impedance: Directly in ohms. Phase angle: Directly in degrees at 100 mc. May be readily computed at other frequencies. \odot (actual) = \odot (read) x Frequency, mc/100.

Accuracy: Impedance magnitude, better than $\pm 5\%$. Phase angle better than ± 3 degrees (over range 50 to 500 mc). Resetability better than 1%.

Frequency Range: Maximum accuracy 50 to 500 mc. Useful down to 5 mc and up to 1,000 mc. Maximum measurable phase angle at 5 mc is -9° to $+9^\circ$.

External rf Generator: Requires an AM signal source of at least 1 mw. High signal level is desirable. (*-hp-* Model 608A VHF Signal Generator is ideal for this purpose.)

rf Detector: Requires a well-shielded VHF receiver of good sensitivity. (*-hp-* Model 417A VHF Detector is designed for this use.)

Size: 14" x 14" x 8" deep. Weight 24 lbs. Shipping weight 37 lbs. *-hp-* grey finish. Cabinet mounting.

Data Subject to Change Without Notice

The instrument is thoroughly shielded and is suitable for general laboratory use, including the determination of approximate frequency, noise, interference, etc. It is light weight for portability, sturdily built, and compact to occupy a minimum of bench space.

SPECIFICATIONS

Frequency Range: 10 to 500 mc, continuous coverage, 5 bands. Directly calibrated in mc.

Sensitivity: Approximately 5 microvolts over entire band.

Power: 115 volts 50/60 cps 30 watts

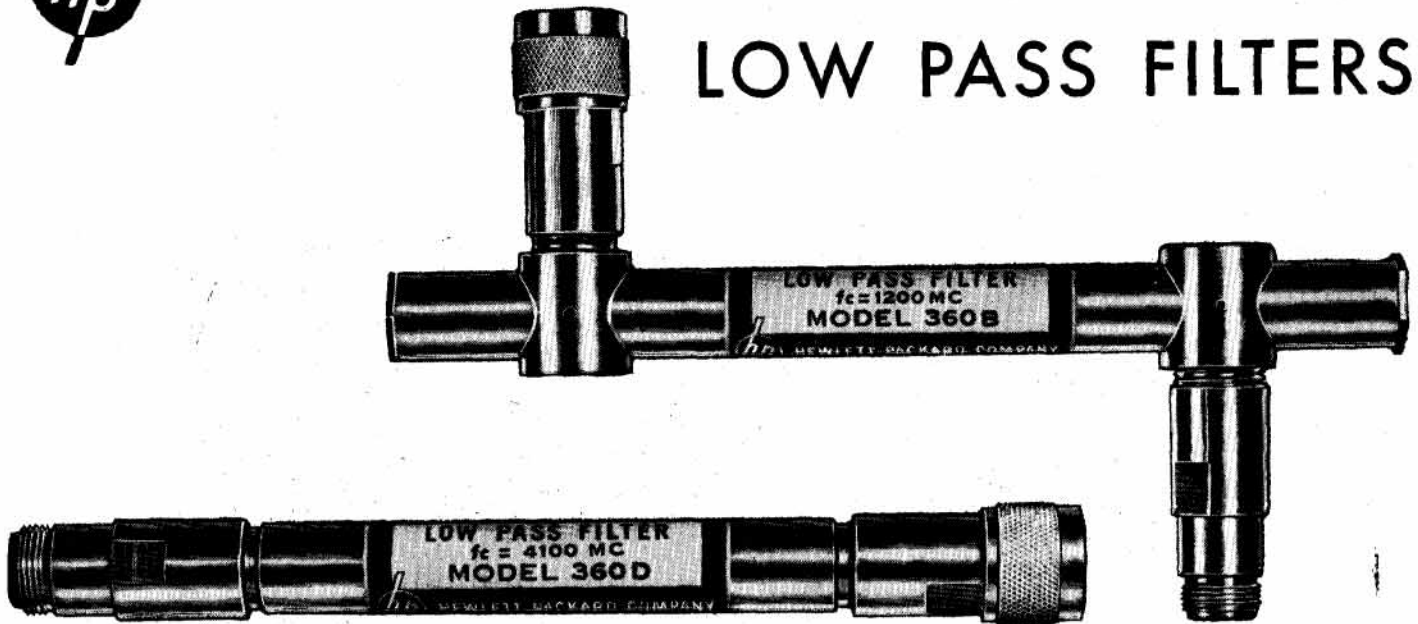
Size: 9" x 10 $\frac{1}{2}$ " x 8" deep. Weight 15 lbs. Shipping weight 23 lbs.

Data Subject to Change Without Notice



MODEL 360

LOW PASS FILTERS



SPECIFICATIONS

Cut-off Frequency:

Model	Cut-off
-hp- 360A	700 mc
-hp- 360B	1,200 mc
-hp- 360C	2,200 mc
-hp- 360D	4,100 mc

Insertion Loss: Not over 3 db throughout pass band.

Rejection: 50 db or more attenuation at 1.2 x (Cut-off Frequency).

Nominal Impedance: 50 ohms through pass band. Should be matched for optimum performance.

Fittings: 1 Type N Male (UG 21/U)
1 Type N Female (UG 23/U)

Data subject to change without notice.

ELIMINATE HARMONICS. TRANSMIT ENERGY AT A SINGLE MICROWAVE FREQUENCY

HE -hp- Model 360 Low Pass Filters are designed to facilitate microwave measurements by eliminating harmonics and permitting the transmission of energy at a single known frequency. Such isolation of a single frequency is of particular importance in the making of slotted line measurements, in checking filter characteristics, in determining receiver response and other applications where harmonics are objectionable.

NO SPURIOUS RESPONSES

The new -hp- filters consist of brass tubes fitted with a multi-section coaxial type filter. The ends are terminated in Type N fittings, one male and one female. Attenuation in the pass bands less than 3 db; and attenuation in the rejection band is more than 50 db. There are no spurious responses up to 3 times cutoff frequency.

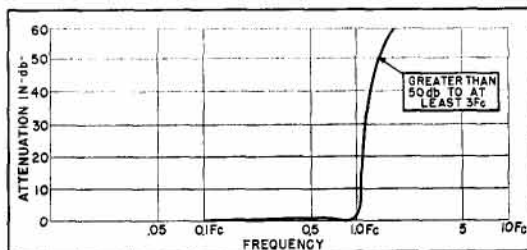


Fig. 1. Typical rejection characteristics.

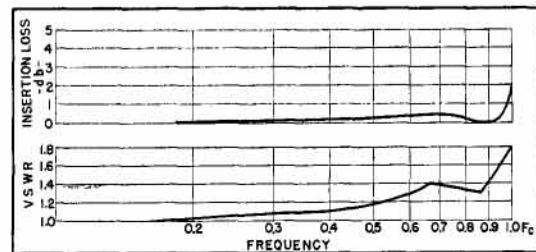
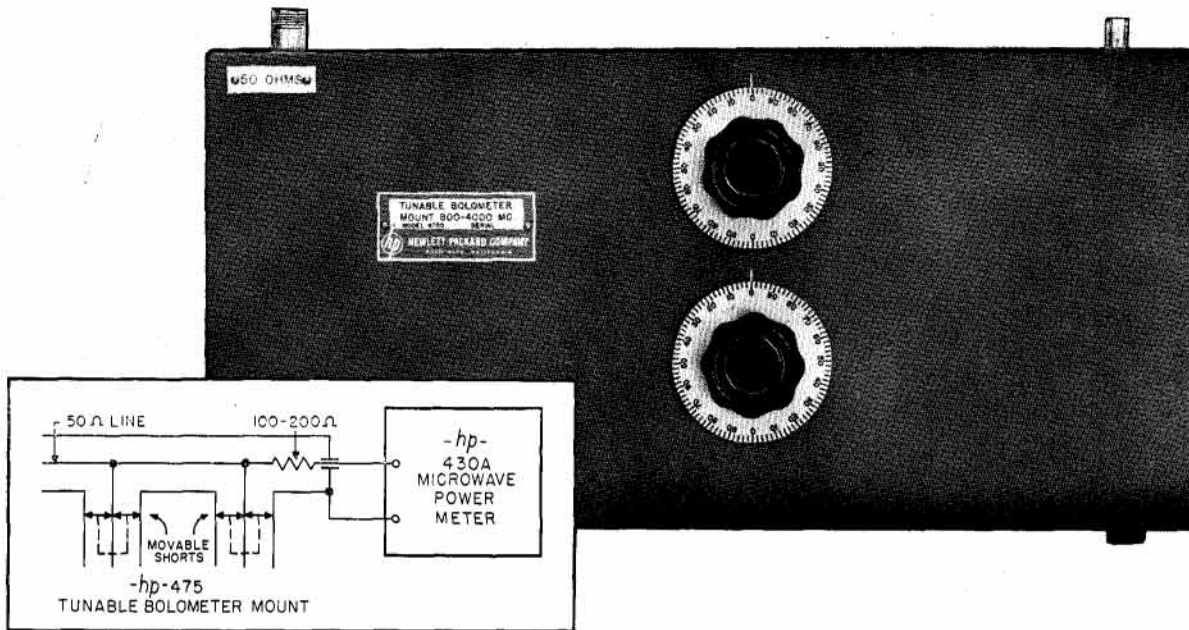


Fig. 2. Typical band pass characteristics.

TUNABLE BOLOMETER MOUNTS



SPECIFICATIONS

-hp- 475A Tunable Bolometer Mount

Frequency: Approx. 300 to 1,000 mc. (Varies with VSWR, phase of source and value of bolometer load.)

Fittings: Type N female (UG23/U) (Incoming power) BNC Type (UG89/U) bolometer dc connection. Output will accept Type N connector fitting so mount may be used as a conventional double-stub transformer.

Power Range: 0.1 mw to 10 mw full scale (with -hp- 430A).

Power Sensitive Element: 1/100 ampere instrument fuse, Sperry Barretter 821, Western Electric Type D166382 Thermistor*
(*Not usable with -hp- 430A.)

Size: 10" x 36" x 2 1/4" deep.

-hp- 475B Tunable Bolometer Mount

Frequency: Approx. 1,000 to 4,000 mc. (Varies with VSWR, phase of source and value of bolometer load.)

Size: 7 1/4" x 18" x 2 1/2" deep.

(Other specifications same as -hp- 475A.)

Data subject to change without notice.

NEW WIDE-BAND MATCHING SYSTEM FOR MEASUREMENT OF MICROWAVE POWER

THESE new -hp- tunable bolometer mounts set a new standard of accuracy and convenience for making microwave power measurements. Since these mounts are *tunable* over a broad band, they have universal application.

Both the -hp- 475A and 475B are essentially double stub tuners, designed to couple energy from a 50 ohm coaxial microwave system into a 200 ohm bolometer. The rf energy absorbed by the bolometer is measured by means of a bolometer bridge; or by using a self-balancing bridge such as the -hp- 430A Microwave Power Meter. With this combination of equipment, microwave power may be measured directly at frequencies from 300 to 1,000 mc (-hp- 475A) or 1,000 to 4,000 mc (-hp- 475B).

Both instruments are similar in construction. Two shorting stubs are rigidly positioned in shunt with a transmission line section, and are spaced 1/2 wave apart at a frequency above the transmission range. Shorting stubs are varied by two controls actuating sliding contact fingers. The transmission line section terminates in a power-sensitive element which may have resistance values ranging from 100 to 200 ohms.

MICROWAVE POWER METER



DIRECT, AUTOMATIC, INSTANTANEOUS POWER READINGS IN MW OR DBM!

ODEL 430A is a microwave power meter that offers you completely automatic, instantaneous power readings direct in decibels or milliwatts. There are no tedious calculations, no troublesome adjustments. The instrument can be used at any microwave frequency for which there are bolometer mounts.

The *hp*-430A consists of an audio bridge, one arm of which is a power sensitive element. The bridge is initially balanced with no rf power in the element. As rf power is applied, an equivalent in audio power is automatically removed, so that the bridge remains in balance. The change in audio power level indicates directly on the front panel vacuum tube voltmeter. This meter, calibrated in milliwatts and dbm, then gives direct indication of the rf power in the sensitive bridge arm.

The outstanding feature of this new *hp*-instrument is its automatic operation. Measuring an unknown rf is as simple as connecting the *hp*-430A to the 200-ohm bolometer in your system. After initial balancing, the instrument does the rest. Power can be read directly in milliwatts from .02 to 10 mw, or dbm from -20 to +10 dbm. Higher powers can be measured by adding attenuators or directional couplers to the microwave system. Any of 5 ranges are quickly selected on a front panel switch.

SPECIFICATIONS

Power Range: Full scale readings of: .1, .3, 1, 3 and 10 mw. Also calibrated in db to give continuous reading from -20 dbm to +10 dbm. (0 dbm = .001 watt). Power range can be extended with attenuators or directional couplers in microwave system.

External Bolometer: Frequency Range depends on bolometer mount. Bolometer must be 200 ohms at power level of approximately 15.3 mw and have positive temperature coefficient. Suitable bolometers include: 1/100 ampere instrument fuse; Sperry barretter 821. (Bolometer and mount not supplied.)

Accuracy: $\pm 5\%$ of full scale reading.

Size: 12" wide, 9" deep, 9" high. 4" meter.

Weight: 17 lbs. Shipping weight 32 lbs.

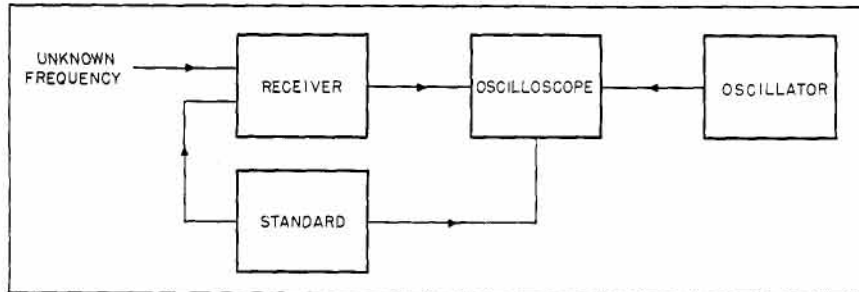
Power: 115 v., 50/60 cps, 60 watts.

Data subject to change without notice.



FREQUENCY MEASURING EQUIPMENT

Frequency Standards for audio, supersonic and rf measurements. FM and TV Broadcast Station Monitors. Direct Reading Electronic Tachometers.



THE problem of measuring frequencies and of standardizing frequency measuring equipment confronts nearly every electronics and communications facility today. To help make these measurements more quickly, more accurately and with less effort, *-hp-* presents a group of instru-

ments which, singly or together, can answer nearly every comparison or frequency determining problem.

Brief details of these instruments appear below, and complete information will be found on pages indicated.

INSTRUMENT	PRIMARY USES	FREQUENCY RANGE	CHARACTERISTICS	PRICE	PAGE
-hp- 100D Secondary Frequency Standard	High accuracy frequency and time measurements	100 kc, 10 kc, 1 kc, 100 cps, 10 cps	Stability 1/1,000,000 Sine or rectangular output. Marker pips. Internal oscilloscope.	\$600.00†	52-53
-hp- 100C Secondary Frequency Standard	Audio and supersonic oscillator calibration	100 kc, 10 kc, 1 kc, 100 cps	Accurate within ±.001%. Sine waves only.	\$450.00†	52-53
-hp- 335B FM Monitor	FM broadcast monitoring	88 to 108 mc	F.C.C. approved. Monitors carrier frequency and modulation. High fidelity output for aural monitoring.	\$935.00†	54-55
-hp- 335C FM Monitor	TV aural broadcast monitoring	59.75 to 87.75 mc	Same as 335B. For TV channels 2 to 6.	\$935.00†	54-55
-hp- 335D FM Monitor	Same as above	179.75 to 215.75 mc	Same as 335B. For TV channels 7 to 13.	\$935.00†	54-55
-hp- 500A Frequency Meter	Rapid measurement of frequency	5 cps to 50 kc	10 ranges, ± 2% accuracy. Input 0.5 to 200 volts.	\$210.00*	56-57
-hp- 505A Tachometer	Measurement of high speed or very low power machinery	300 to 3,000,000 r.p.m.	10 ranges, ± 2% accuracy.	\$300.00*	57
-hp- 505B Tachometer	Same as above	5 to 50,000 rps	Same as 505A except calibrated in rps.	\$300.00*	57

†Rack mounting available at no extra cost.

*Rack mounting available at \$5.00 extra.

Data subject to change without notice. Prices f.a.b. Palo Alto, California.

SECONDARY FREQUENCY STANDARDS

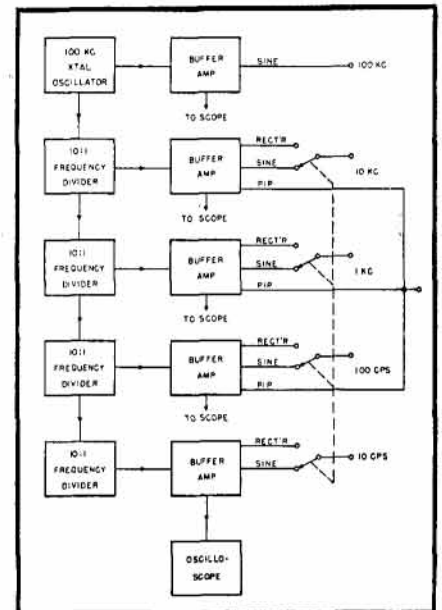
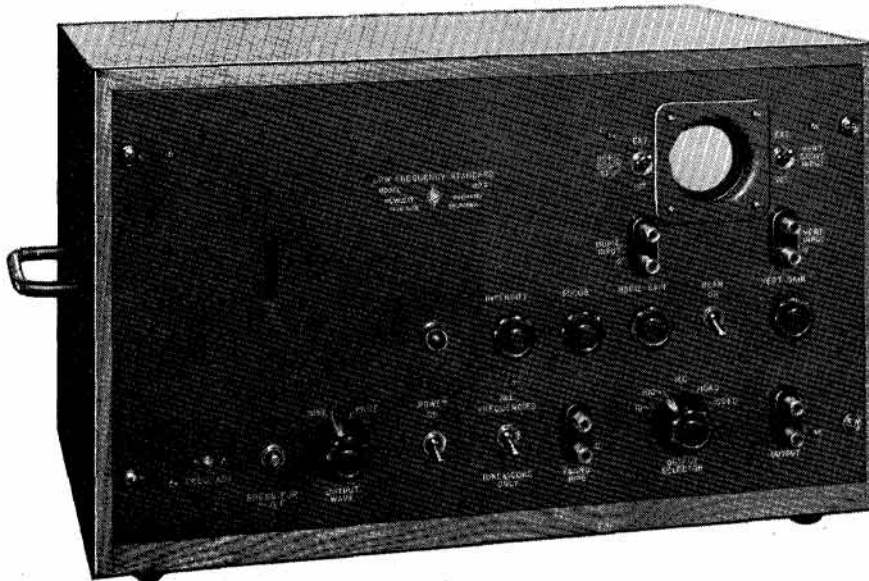


Fig. 1. Block diagram of circuit, Model 100D.

ADVANTAGES

- Sine or rectangular waves
- 100 μ sec time markers
- Built-in oscilloscope
- Stability 1/1,000,000
- Low output impedance
- New improved circuits
- Controlled frequencies: 100 kc, 10 kc, 1 kc, 100 cps, 10 cps

USE IT TO

- Perform most functions of expensive primary standards
- Establish standard frequencies
- Calibrate audio oscillators
- Calibrate supersonic or rf oscillators
- Check transmitter stability
- Check oscillator stability
- Measure short time intervals
- Provide time standard

GENERATES 5 STANDARD FREQUENCIES FOR SWIFT, SURE COMPARISON

ODAY, nearly every electronics or communication establishment is confronted with the problem of obtaining standardized, precisely-known frequencies for use in determining unknown frequencies. Until recently, this problem has been solved by the use of elaborate and expensive primary frequency standards whose frequency is established by constant checks against standard time. However, the reliability and convenience of standardizing with Bureau of Standards transmissions (Station WWV) have resulted in the recent widespread use of more economical secondary standards as a source of accurate frequencies.

The Model 100D Secondary Frequency Standard has been developed with this trend in mind. The instrument may be standardized against Station WWV without the use of additional equipment other than a standard audio oscillator and a communications receiver. Thus the instrument provides most of the advantages of a primary standard, at much lower cost.

SINE OR RECTANGULAR FREQUENCIES

Five sinusoidal standard frequencies—100 kc, 10 kc, 1 kc, 100 cps and 10 cps—are generated by Model 100D. In addition, the equipment also generates rectangular waves at all the above frequencies except 100 kc. Harmonics as high as 5 mc can be obtained from these rectangular waves for measurement purposes.

In addition, the instrument also provides marker pips at 100, 1,000 and 10,000 microsecond intervals. (See Figure 2.) A self-contained oscilloscope further contributes to convenience in standardizing the instrument. It provides a visual check of the division ratio and is useful in calibrating audio oscillators and other supersonic or rf equipment by means of Lissajous figures.

CIRCUIT DESCRIPTION

The block diagram in Figure 1 shows the circuit arrangement of this Secondary Frequency Standard. A crystal-controlled oscillator operating at 100 kc controls the stability of all frequencies generated by the instrument. The frequencies of 10 kc, 1 kc, 100 cps and 10 cps are obtained from four 10:1 cascaded frequency dividers driven by the 100 kc crystal-controlled oscillator. Each divider operates its own isolating amplifier so that all sine waves and rectangular waves generated are available for external use simultaneously!

CRYSTAL OSCILLATOR

The oscillator is a modified Pierce circuit using a very low-temperature coefficient crystal. Housing for the crystal is a double-chamber oven, temperature controlled by a mercury thermostat having a differential of 0.1°C. Control of the oven and stability of the crystal are such that an over-all accuracy within approximately 2/1,000,000 is provided over an interval of one week.

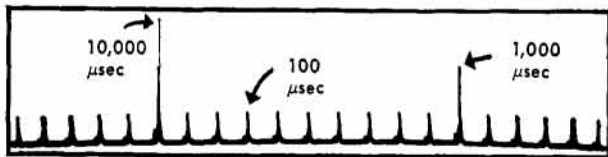


Fig. 2. Timing comb, -hp- Model 100D.

-hp- MODEL 100C

Model 100C Secondary Frequency Standard is a simplified instrument providing the basic operating features of Model 100D. It is for use where somewhat less accuracy is acceptable. It provides 4 sinusoidal frequencies, has an accuracy of $\pm 0.001\%$ at normal room temperature. Like the Model 100D, it operates from a fully contained regulated 115 volt ac power supply.

The Model 100C does not include a built-in oscilloscope

or frequency shift circuit; nor does it supply timing markers and rectangular waves.

Accuracy: Within $\pm 0.001\%$, normal room temperature.

Output: Controlled frequencies of 100 kc, 10 kc, 1 kc, and 100 cps. Internal impedance approximately 200 ohms.

Data Subject to Change Without Notice

SPECIFICATIONS

Model 100D

Accuracy: About 2 parts per million per week, at normal room temperatures.

Stability: About 1 part per million over short intervals.

Panel Control: Panel trimmer allows oscillator frequency to be varied over a range of approximately $\frac{1}{2}$ cps for correction purposes.

Voltage Output: Sinusoidal output 5 volts into 5,000 ohms or higher load. Internal impedance approximately 200 ohms.

Distortion: Less than 4% when operating into 5,000 ohms or higher load.

Frequency Output: Controlled frequencies: 100 kc, 10 kc, 1 kc, 100 cps, 10 cps. Sine or rectangular waves.

Marker Pips: Generated at intervals of 100 μsec . A pip of double amplitude is generated every 1,000 μsec ; and a pip of triple amplitude every 10,000 μsec .

Oscilloscope: Integral with circuit. Establishes 10:1 Lissajous figures to show division ratio. May be used independently of standard.

Frequency Shifting Circuit: Panel push-button lowers oscillator frequency by approximately 1 cps at 100 kc (50 cps at 5 mc) to aid in frequency measurements.

Rectangular Waves: 4 waves, generated corresponding to 10 kc, 1 kc, 100 cps and 10 cps. Harmonics up to 5 mc obtainable from 10 kc waves. Corresponding harmonics obtainable from other waves.

Power Supply: 115 v, 50/60 cps, regulated to minimize line voltage fluctuations. Power drawn approximately 150 watts.

Mounting: Cabinet or relay rack.

Size: 19" x 10 $\frac{1}{2}$ " x 12" deep. Net weight 65 lbs. Shipping weight 90 pounds.

Data Subject to Change Without Notice



MODEL 335

FREQUENCY MONITORS AND MODULATION METERS



HIS NEW *-hp-* 335B Frequency and Modulation Meter monitors FM transmitters reliably, accurately, over long periods of time. No adjustments are necessary during operation, and because the instrument does not depend on a tuned circuit, it is not necessary to re-set the carrier level or re-align circuits. The instrument is specifically designed to operate without adjustment week after week. It gives continuous indication of broadcast frequency and of modulation level at all times, and has F.C.C. type approval.

A low-temperature coefficient crystal, oscillating inside a temperature-controlled oven, provides a reference standard of approximately 5 mc. The output of this crystal oscillator is multiplied 20 times, and mixed with the transmitter frequency to form a 200 kc intermediate frequency. This frequency is fed into electronic counter circuits, which measure the intermediate frequency and thereby indicate the carrier deviation. The linear counter circuits also provide a measurement of percentage modulation as well as an audio output signal for measurement and monitoring purposes. *See block diagram.*

The electronic counter circuits are unusually stable, are independent of signal level, tube characteristics and tube

voltages, and require no adjustment except at long intervals. To check the accuracy of the counter circuits, a crystal-controlled oscillator at 200 kc is provided. This check is operated by a front-panel switch, and is usually only required at one-week intervals.

The *-hp-* 335B includes provision for operation of a remote modulation meter, as well as a remote peak modulation indicator lamp. The percentage modulation at which the lamp flashes a warning is adjusted on the front panel.

TELEVISION TRANSMITTER MONITORS

-hp- Models 335C and 335D are similar to Model 335B Monitor, but are designed for use in checking the aural carrier of television transmitters. Both are adaptations of the Model 335B, with similar operating characteristics and advantages. They have been modified to meet frequency and deviation requirements of television service.

Model 335C is designed for operation on TV Channels 2 through 6. Model 335D is designed for use on Channels 7 through 13. Both are supplied complete with proper reference crystal matching frequency of customer's transmitter.

SPECIFICATIONS

-hp- MODEL 335B MONITOR

FREQUENCY MONITOR

Frequency Range: Any frequency, 88 mc to 108 mc. Supplied with crystal of frequency matching customer's transmitter.

Deviation Range: +3 kc to -3 kc mean frequency deviation.

Accuracy: Deviation indicator accuracy better than ± 1000 cps. ($\pm .001\%$).

Power Required: Approximately 2 watts. Operates satisfactorily at levels above and below 2 watts.

MODULATION METER

Modulation Range: Meter reads full scale on modulation swing of 100 kc. Scale calibrated to 100% at 75 kc; 133% at 100 kc.

Accuracy: Within 5% modulation percentage over entire scale.

Meter Characteristics: Meter damped in accordance F.C.C. requirements. Reads peak value of modulation peak of duration between 40 and 90 milliseconds. Meter returns from full reading to 10% of full value within 500 to 800 milliseconds.

Frequency Response: Flat within $\pm 1/2$ db from 50 to 15,000 cps.

External Meters: Provision is made for installation of remote meter having full scale sensitivity of 400 microamperes. Scale should indicate 100% modulation at 300 microamperes. Extra meters can be supplied with unit.

PEAK LIMIT INDICATOR

Peak Limit Range: From 50% to 120% modulation (75 kc = 100%). Provision for external peak limit indicators.

AUDIO OUTPUT

Frequency Range: 20 cps to 20 kc. Response flat within $\pm 1/2$ db. Equipped with standard 75 microsecond de-emphasis circuit.

Distortion: Less than 0.25% at 100% modulation.

Output Voltage: 10 volts into 20,000 ohms, at low frequencies. (At 100% modulation.)

Noise: At least 75 db below audio output level resulting from 100% modulation at low frequencies.

Monitoring Output: 1.0 mw into 600 ohms, balanced, at 100% modulation. (At low frequencies.)

Size: Front panel 10 1/2" x 19". 13" deep.

Power: 115 volts 50/60 cps primary power. Requires approximately 150 watts.

-hp- MODEL 335C MONITOR

Frequency Range: 59.75 mc to 87.75 mc. Channels 2 to 6 inclusive.

Deviation Range: +3 kc to -3kc mean frequency deviation.

Modulation Meter: Meter reads full scale on modulation swings of 33.3 kc. Scale calibrated at 100% at 25 kc swing; 133% at 33.3 kc swing.

Noise: Residual noise is 70 db below output level corresponding to 100% modulation.

Other specifications same as Model 335B

-hp- MODEL 335D MONITOR

Frequency Range: 179.75 mc to 215.75 mc. Channels 7 to 13 inclusive.

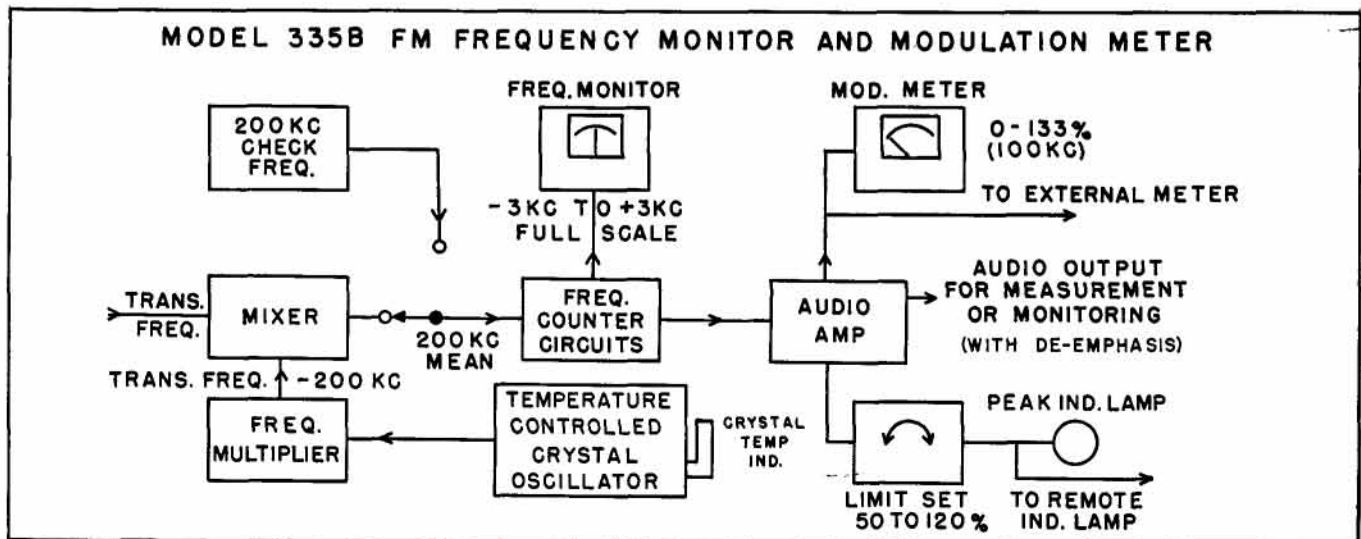
Deviation Range: +6 kc to -6 kc mean frequency deviation.

Modulation Meter: Same as Model 335C.

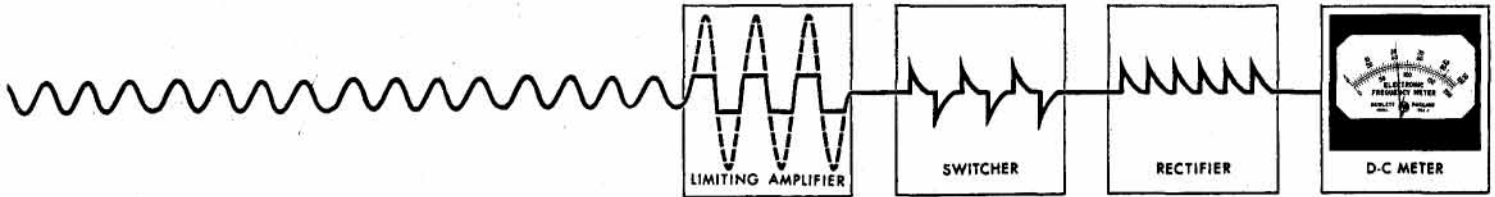
Noise: Same as Model 335C.

Other specifications same as Models 335B and 335C

Data subject to change without notice.



ELECTRONIC FREQUENCY METER



MEASURES FREQUENCY OF A-C VOLTAGES AS HIGH AS 50 KC

ADVANTAGES

- Wide frequency range
- Accurate
- Good sensitivity
- Accuracy independent of line voltage changes and tube characteristics
- Ten convenient scale ranges

USE IT TO MEASURE:

- Beat frequency between two rf signals
- Crystal frequency deviation
- Audio frequencies
- Speed of rotating machinery
- Oscillator stability

The *hp*-Model 500A directly measures the frequency of an alternating voltage from 5 cps to 50 kc. It is suitable for laboratory and production measurements of audio and supersonic frequencies.

The frequency meter consists of a wide band amplifier with a limiting circuit, an electronic switch, a constant current supply, a frequency discriminating circuit, and an output meter and rectifier. The input signal is amplified and used to switch the constant current source to alternate load resistors. The voltage developed across these resistors is applied to a condenser, and the output meter indicates the average value of the rectified charging current. (See diagram above.) The circuit is designed so that each pulse of charging current has the same average value, making the meter reading proportional to the number of pulses per second, and hence proportional to the frequency of the input signal.

INDEPENDENT OF SIGNAL VOLTAGE VARIATIONS

The reading is practically independent of the input voltage waveform, as normal waveform errors cannot affect the electronic switching operation. The regulated current source makes the reading independent of variations in input signal voltage, line voltage, and vacuum tube characteristics. A multiplier switch in the meter circuit provides ten convenient scale ranges. Provision is made for checking the calibration against power line frequency.

USES

The *-hp-* 500A will measure directly and without any precautions the frequency of any source in the audio and supersonic range. In frequency measurement work at higher frequencies, with the aid of a detector it can be used to measure the frequency difference between two radio frequency 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. Similarly it may be used to measure oscillator and transmitter frequency stability. With the aid of a magnetic pickup it may be used to measure speed of machinery and rate of vibration. Provision is made to operate an Esterline-Angus 1 ma recorder with the Model 500A for a continuous record of frequency.

SPECIFICATIONS

Frequency Range: 5 cycles to 50 kc, in ten ranges having full scale values of 50, 100, 200, and 500 cycles, and 1, 2, 5, 10, 20, and 50 kc.

Input: An input voltage of at least 0.5 volts is required and the input impedance is 200,000 ohms. Variation of the input voltage from 0.5 volts to 200 volts will affect the reading of the meter by not more than plus or minus 1%. A push-button panel switch is provided to insure that sufficient signal voltage is present for proper operation.

Accuracy: The overall accuracy of the meter is plus or minus 2% of full scale value. A line voltage variation of from 105 volts to 125 volts will affect the meter reading by not more than plus or minus 1% of full scale.

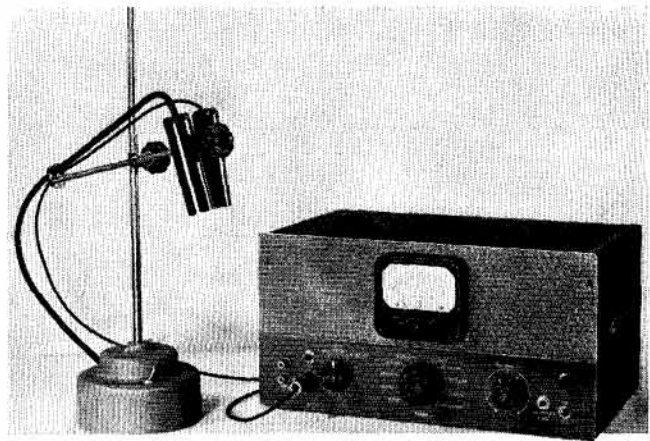
Recorder Output: Jack provided on right-hand side of panel for use with 1 milliamper, 1400 ohm \pm 100 ohm Esterline-Angus Automatic Recorder.

Power Supply: 115 volts, 50/60 cycles, 65 watts.

Mounting: The instrument is available in either cabinet or relay rack mounting. The panel size is 8 $\frac{3}{4}$ " x 19" and the depth is 12".

Net Weight: 28 pounds. Shipping Weight: 44 pounds.

Data subject to change without notice.



ELECTRONIC TACHOMETER

How to Count RPM Without External Loading

-hp- Models 505A and 505B Electronic Tachometers are a natural development from the 500A Electronic Frequency Meter. By connecting a photocell pickup in combination with a light source to this basic instrument, it becomes an electronic tachometer, capable of counting speeds or revolutions over a wide range, from about 300 rpm (5 cps) to 3,000,000 rpm (50,000 cps). The light illuminates the moving part to be measured, which is prepared with alternate reflecting and absorbing surfaces. The interrupted reflected light is picked up by the photocell; the electrical impulses generated thereby are transmitted to the frequency meter. The *-hp-* Electronic Tachometer 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. The danger of fractional or multiple errors, inherent in other measuring methods, is eliminated.

SPECIFICATIONS

The Electronic Tachometer consists of a photocell and a light source mounted on a stand and an electronic frequency counter which is similar to the *-hp-* Model 500A. Two tachometer models are supplied. The *-hp-* Model 505A is calibrated in rpm and the *-hp-* Model 505B is calibrated in rps.

Speed Range: Model 505A: 300 rpm to 3,000,000 rpm full scale reading, in ten ranges. Model 505B: 50 rps to 50,000 rps full scale reading in ten ranges.

Circuit and Construction: Similar to *-hp-* Model 500A except for calibration.

Photocell: Type 1P41 phototube. Mounted in shielded tube same size as light source and provided with condensing lens to focus reflected light on phototube. Three-foot cable connects photocell to frequency meter.

Light Source: 21 candle power, 6 volt automotive bulb, mounted in shielded tube. Condensing lens concentrates light.
Net Weight: 38 pounds. Shipping Weight: 50 pounds.



POWER SUPPLY UNIT



HIGH-STABILITY REGULATED DC OR AC POWER SUPPLY

The *hp*-Model 710A Power Supply is an excellent source of dc power for every laboratory and production department use. It has been designed to give the ultimate in flexibility, compactness, portability, and economy. Output is continuously variable between 180 and 360 volts, and is practically independent of either line voltage or applied load for any setting. The noise and hum level is very low for any condition of operation. The output is stable over long periods of time. Its small size requires a minimum of bench space when in use, and little storage space when idle. Since many set-ups which call for a source of well-regulated dc also require an ac source for supplying filaments, a center-tapped, 6.3 volt source which will supply 5 amps ac has been included. The low cost makes it practical and economical to employ several of these instruments simultaneously.

USES

Because of its stability and low noise level, the *hp*-Model 710A Power Supply can be used in place of batteries in many applications. In such service its long life, dependability, and portability result in real savings, both in time and money. It

may be used to power low-level amplifiers, constant frequency oscillators, and any equipment requiring a voltage source of high stability. One of its outstanding uses is in supplying power for temporary set-ups, "breadboard" layouts, and the like, where its exceptional flexibility makes it applicable in countless ways.

SPECIFICATIONS

Voltage Range: Output continuously variable from 180 to 360 volts. Either positive or negative output terminal may be grounded. 6.3 volts ac, center-tapped, also provided.

Regulation: Output constant to approximately 1% for loads of from 0 to 75 ma, and line voltage variations of ± 10 volts for any setting. A maximum of 100 milliamperes can be drawn.

Noise and Hum: Total noise and hum is less than 0.005 volts for any condition of operation.

Input Power: 115 volts 50/60 cycles. 90 watts full load.

Mounting: Wrinkle gray finish. Panel size, $7\frac{1}{4}$ " x 8". Cabinet depth, $11\frac{3}{4}$ ".

Price: \$85.00 f.o.b. Palo Alto.

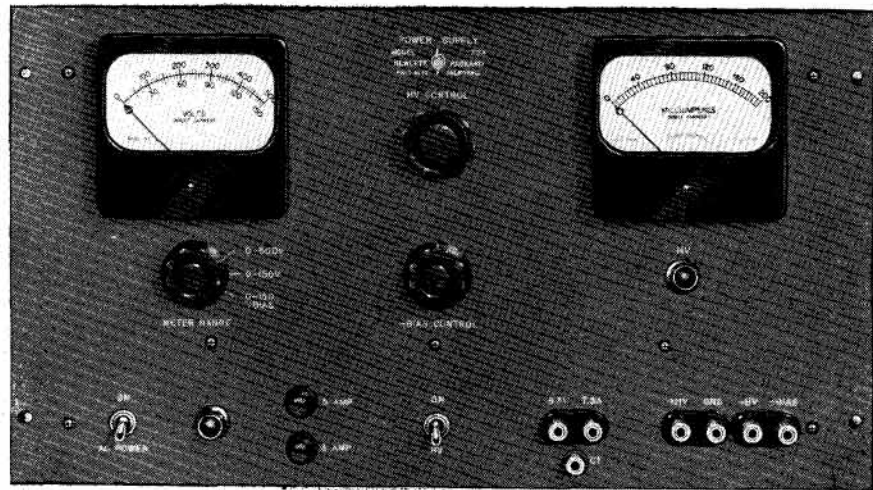
Weight: 18 pounds. Shipping Weight: 25 pounds.

Data subject to change without notice.



MODEL 712A

POWER SUPPLY



SPECIFICATIONS

Output Voltages:

- DC. *High voltage.* 0-500 volts (without switching) 200 ma. maximum load.
- DC. *Bias voltage.* 0-150 volts, 5 ma. maximum load.
- AC. *Unregulated.* 6.3 volts at 10 amps maximum load.

Regulation:

- H.V. Better than 1/2% from no load to full load, 20 to 500 volts; or for line voltage, 105 to 125 volts.
- Bias. Better than 1% from no load to full load at maximum output voltage. Regulation at any other voltage depends on setting of voltage control. Internal impedance may be as high as 25,000 ohms.

Meters:

- Current Meter.* 0-200 ma. (High voltage only.)
- Voltmeter.* 2 ranges—0-500 and 0-150 volts. Meter range may be switched to facilitate reading of high voltage output. 0-150 volt range may be switched to read bias output voltage.

Hum: Less than 8 mv.

Terminals: Either positive or negative high voltage terminal may be grounded. Positive terminal of bias supply is permanently connected to negative high voltage terminal.

Input Power: Approximately 400 watts maximum at 105-125 volts, 50/60 cycles.

Overload Protection: Load and line separately fused. Fuses available on front panel.

Mounting: Relay Rack Panel. Finish, -hp- grey. Detachable end pieces with hinged handles for table use, \$5.00 per pair.

Size: 10 1/2" x 19", 13" deep. Weight 60 lbs. Shipping weight 85 lbs.

Price: \$250.00 f.o.b. Palo Alto, California.

Data Subject to Change Without Notice.

LOW COST POWER SUPPLY PROVIDES UP TO 500 VOLTS AT 200 MA

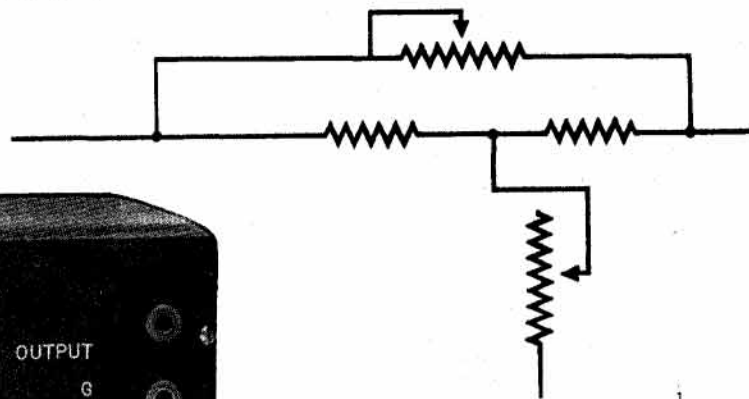
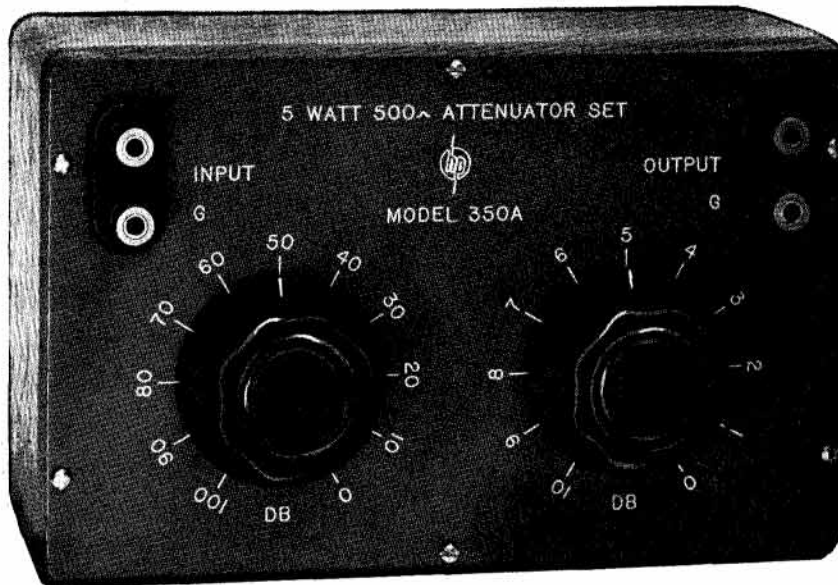
EW MODEL 712A POWER SUPPLY provides variable plate and bias supply voltages as well as ac filament voltage for general laboratory, production and industrial use. The instrument is similar in design to the -hp- Model 710A Power Supply, but is designed for use in the next higher power range. It provides variable dc voltage from 0 to 500 volts at 200 milliamperes, with 0.5% regulation. The instrument also makes available 0 to 150 volts for bias use, plus a 10 ampere ac current at 6.3 volts. Meters are provided to monitor both voltages and currents.

This new power supply is designed to give maximum flexibility, compactness and portability. It requires little bench space, and is available for relay rack mounting. It is an extremely versatile instrument providing an economical solution to a wide range of power supply problems.



MODEL 350

ATTENUATORS



ADVANTAGES:

- Large power handling capacity
- Wide frequency response
- Smooth operation
- Convenient controls

USE IT TO:

- Attenuate the output of supersonic and audio oscillators
- Measure gain and frequency response of amplifiers
- Measure transmission loss
- Increase usefulness of other laboratory instruments

A SMALL INSTRUMENT WITH MANY USES

OR measurement work where accuracy, wide frequency response, large power handling capacity, or other special features are desired, *-hp-* attenuators are extremely valuable. Typical of these highly specialized instruments is the *-hp-* Model 350 Attenuator Set.

The schematic diagram above shows the basic bridged-T circuit, two of which make up the *-hp-* 350 Attenuator Set. One is a 100 db attenuator, calibrated in 10 db steps, and one is a 10 db attenuator, calibrated in 1 db steps.

A special design assures a response that is substantially flat to frequencies as high as 100 kc. See figure 1. Calibration is accurate because the individual resistors are adjusted to $\pm 1/2\%$.

USES

The *-hp-* Model 350 can be used wherever a decade attenuator is required.

In conjunction with an *-hp-* oscillator and one voltmeter, this *-hp-* Model 350 Attenuator may be used to make exact measurements of power gain. See figure 2.

The 350 may also be used to augment an *-hp-* audio oscillator and a vacuum tube voltmeter (*-hp-* 400A) to form a signal generator. See figure 3.

The 350 is built with a large power handling capacity—5 watts continuous duty. It is particularly adapted to work in the supersonic field, and for other work in measurements above the range of the conventional a-f attenuator. It may also be used for work down to zero frequency.

The 350, like all *-hp-* instruments, is held to a minimum size for convenience in use. Actual dimensions are 5" x 8" x 4½". Input and output binding posts are available on the front panel. The unit is completely shielded from moderate fields.

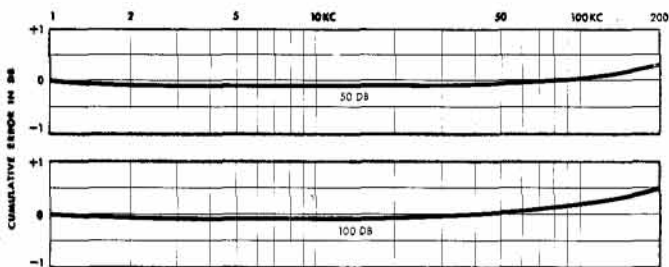


Figure 1. Typical Frequency Response

SPECIAL PROBLEMS

Attenuators, voltage dividers, matching networks, and precision resistors accurate for frequencies as high as one megacycle can be supplied. Inquiries pertaining to your particular measurement problem will be given prompt attention.

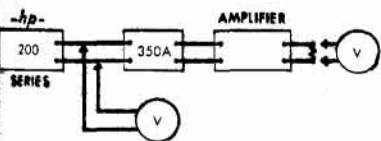


Figure 2

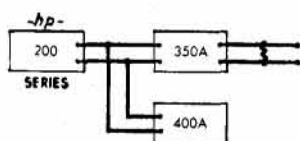


Figure 3

SPECIFICATIONS

Two models are available. The *-hp-* 350A matches a 500 ohm impedance and the *-hp-* 350B matches a 600 ohm impedance (one side grounded).

Attenuation: The attenuation is 110 db in 1 db steps.

Accuracy: Each individual resistor is adjusted to $\pm 1/2\%$.

Frequency Response: Accumulative error at 100 kc less than 1 db in 50 db.

Power Capacity: 5 watts, continuous duty.

Mounting: Gray panel. Oak cabinet: 5" x 8" x 4½".

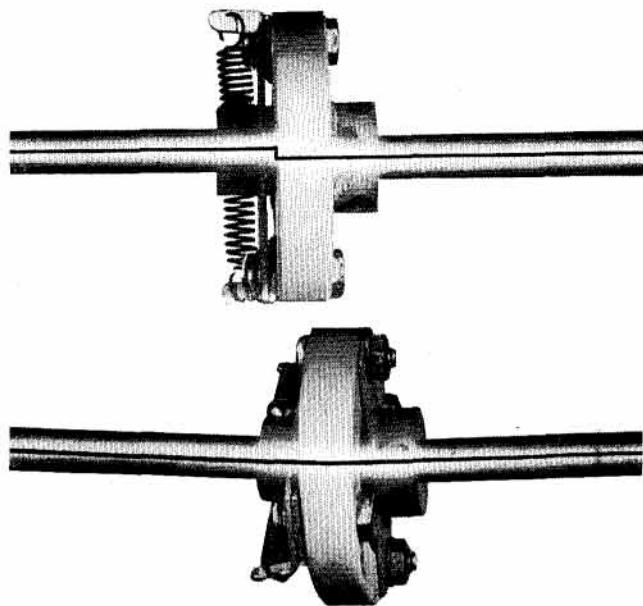
Price: \$50.00 f.o.b. Palo Alto. (Rack mounting \$5.00 extra.)

Net Weight: 4 pounds. Shipping Weight: 8 pounds.

Data subject to change without notice.

SPECIAL *-hp-* HARDWARE

Precision multi-tap switches and other hardware for use in equipment for measuring work are also available. Two typical examples of this special-purpose hardware are shown below.



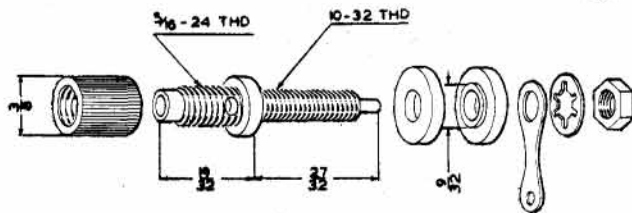
FLEXIBLE COUPLER

The *-hp-* No. 14 flexible coupler permits the accurate, positive transmission of motion from one shaft to another when the two shafts are not accurately aligned. Misalignments of as much as ½" and/or 5° are permissible. At the same time, the two shafts are insulated from each other, each shaft being connected to a different point on the ceramic body of the coupler. The coupler is spring-loaded to prevent backlash.

Price: \$1.50 ea. Quantity discounts on request.

BINDING POSTS

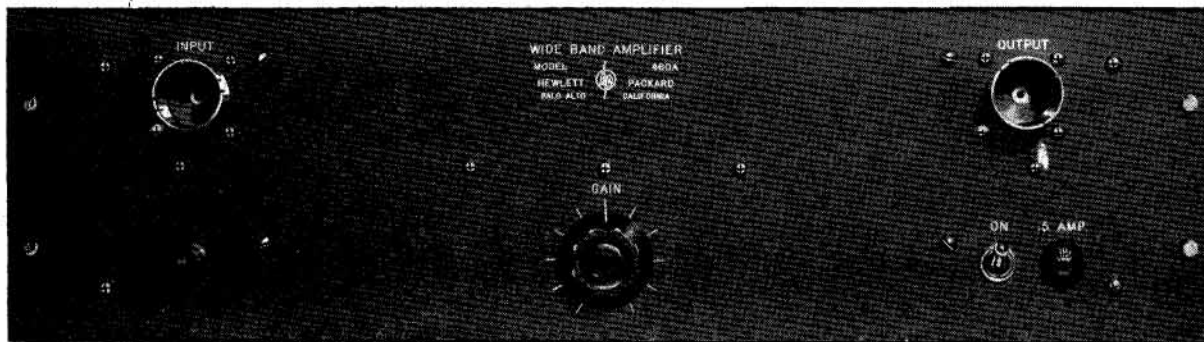
The *-hp-* No. 10 binding posts shown, were designed to provide a positive connection that could be changed frequently. The recess for the "Banana" plug is in the main body



of the post, a feature which eliminates excessive contact resistance. The cross-hole for permanent connection can be used even when the "Banana" plug is inserted. The screw thread will not damage the thread. The long, axially-knurled ferrule is 10-32 and the tip is undercut so that a soldered connection provides a wide surface for ease of handling.

Price: \$.20 ea. (Quantities 1 to 99).
 .15 ea. (100 or more).

WIDE BAND AMPLIFIER



ADVANTAGES

- True amplification of very short pulses
- Rise time .0026 μ sec
- No ringing or overshoot
- Response matches Gaussian curve
- 20 db gain; can be cascaded
- Increases VTVM sensitivity 10 times
- Flat response to 200 mc

USES

- Amplify extremely short pulses
- Increase voltmeter sensitivity
- Accurately measure small outputs
- General laboratory amplifier
- Increase oscilloscope gain
- For TV, UHF or nuclear work

SETTING A NEW STANDARD FOR FAITHFUL PULSE AMPLIFICATION

HIS new *hp*-460A Wide Band Amplifier is the first instrument of its kind to offer you *faithful amplification* of extremely short pulses without objectionable ringing or overshoot. The rise time of the amplifier itself is only .0026 microseconds; and the high frequency response matches the Gaussian curve (established ideal of pulse transmission) more closely than any other instrument offered.

OPERATION

The *hp*-460A is a new type of amplifier with a very wide transmission band (approximately 200 mc). It has two stages with 5 and 7 tubes respectively. Tube grids are connected along one transmission line to form the input circuit. Tube plates are connected along a second transmission line, forming the output circuit. A wave, travelling along the input line, excites the grids in succession; and half of the corresponding wave (generated in the plate circuit) travels down the plate line toward the output. This wave is reinforced at each successive plate.

The part of the wave in the plate line which travels in the reverse direction is absorbed by a termination at the opposite end of the line. By the time the wave in the plate line reaches the output, it has been amplified by about 10 db. The second stage of the amplifier also increases the gain by approximately

10 db, making a total approximate gain of 20 db for the unit. Several amplifiers can be cascaded to achieve a stable, flat gain up to 100 db.

TRUE AMPLIFICATION

The precise accuracy with which the new *-hp-* 460A amplifies very short pulses can be seen in Figure 1. The top view shows a .01 microsecond pulse applied direct to the plates of a 5XP11A cathode ray tube. At bottom in Figure 1, the same pulse after passing through the *-hp-* 460A. Note the very short rise time (less than .003 μ sec) and the complete absence of ringing or overshoot.

The response of the new *-hp-* 460A is shown in Figure 2. Note how closely the curve of the *-hp-* 460A follows the Gaussian ideal, even to a point beyond 200 mc. Figure 2 also shows graphically how this new *-hp-* instrument can be combined with the *-hp-* 410A Vacuum Tube Voltmeter to increase the voltmeter's sensitivity up to 10 times. In this combination, accurate readings of voltages as small as .01 volts from 200 kc to 200 mc are quickly and easily made.

200 OHM COAXIAL SYSTEM

Since the optimum interconnecting impedance level for this amplifier is 200 ohms, *-hp-* has designed a complete 200 ohm coaxial system of connectors and cables. These include leads with fittings, panel jacks and plugs, adapters to connect a 50 ohm Type N system into the amplifier; and a special adapter for use with the *-hp-* 410A Vacuum Tube Voltmeter. (See Specifications for details.)

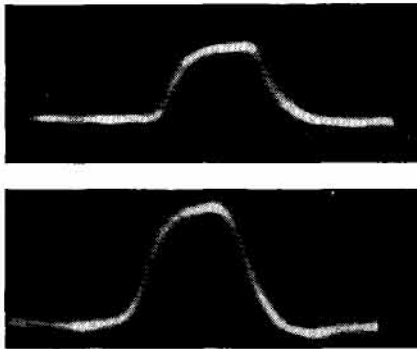


Fig. 1. Actual photo of oscillograph trace showing 0.01 μ sec pulse (above) applied direct to plates of cathode ray tube; and (below) same trace applied through *-hp-* 460A Amplifier.

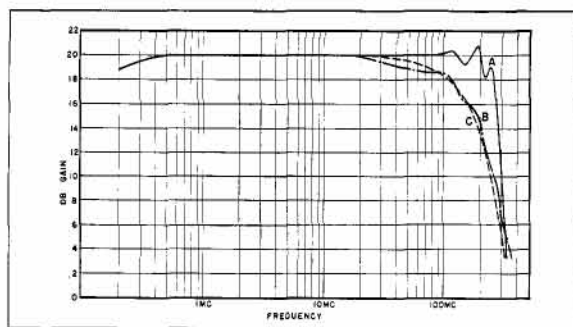


Fig. 2. Typical response of *-hp-* 460A Amplifier working into (B) resistive load (A) using *-hp-* 410A Voltmeter (C) Gaussian curve.

SPECIFICATIONS

Frequency Response: *High frequency*—closely matches Gaussian curve when operating into a 200 ohm resistive load. 3 db point is 140 mc.

Low frequency—when operating from a 200 ohm source and .01 blocking condenser, response off 3 db at 3 kc into an open circuit or succeeding amplifier. When operating into a 200 ohm load, off 3 db at 100 kc.

With *-hp-* 410A VTVM: ± 1 db, 200 kc to 200 mc.

Gain: Approximately 20 db into 200 ohm load. Gain control has range of 6 db. 5 amplifiers may be cascaded.

Output: Approx.: 8 v. peak open circuit.
Output impedance, 330 ohms.

Input Impedance: 200 ohms.

Noise Factor: Less than 10 db.

Delay Characteristics: Approx. .012 μ sec.

Rise Time: Approx. .0026 μ sec (10% to 90% amplitude).
No appreciable overshoot.

Mounting: Relay rack. 5 $\frac{1}{4}$ " x 19", panel 6" deep.

Weight: 11 lbs. Shipping weight 22 lbs.

Power Supply: 115 v. 50/60 cps, self-contained.

Price: \$185.00 f.o.b. Palo Alto.

ACCESSORIES

-hp- 46A-16A Patch Cord: 2-foot length, 200 ohm cable, with plugs, for interconnecting two *-hp-* 460A Amplifiers. \$18.50.

-hp- 46A-16B Patch Cord: Like but 6' long. \$25.50.

-hp- 46A-95A Panel Jack: Low capacitance jack designed for 200 ohm cables. Mates with other accessories. Requires 1 $\frac{1}{8}$ " dia. mounting hole. \$7.50.

-hp- 46A-95B Cable Plug: Low capacitance plug designed for use with 200 ohm system. Mates with other accessories. \$7.50.

-hp- 812-52 Cable: 200 ohm cable available in lengths to your requirements. \$1.75 per foot.

-hp- 46A-95C 50 ohm Adapter: Provides Type N connection for coupling 50 ohm transmission line to input of *-hp-* 460A Amplifier. Includes terminating resistor. \$15.00.

-hp- 46A-95D Adapter for -hp 410A Voltmeter Probe: Comprising bayonet type sleeve fitting directly to diode probe of *-hp-* 410A Voltmeter. Includes proper compensating LC components. \$15.00.

-hp- 46A-95E Connector Sleeve: For joining two *-hp-* 46A-95B Cable Plugs to interconnect two lengths of 200 ohm cable. \$7.50.

Data subject to change without notice.

Prices f.o.b. Palo Alto.



MODEL 450A

AMPLIFIER



GENERAL-PURPOSE AMPLIFIER 20 DB OR 40 DB GAIN

The *-hp-* Model 450A Amplifier is ideal as a general purpose instrument wherever wide frequency range and stable gain are essential. The instrument has an extremely stable 20 db or 40 db gain over a continuous frequency range of 10 cps to 1,000,000 cps. Either gain may be quickly selected with a toggle switch on the front panel.

The amplifier is resistance-coupled and does not use peaking or compensating networks. Optimum performance is obtained entirely from a straightforward amplifier design in combination with inverse feedback. Phase shift is negligible, and there are no spurious oscillations or resonances.

USES

The *-hp-* 450A Amplifier may be used separately for almost any amplification job or in conjunction with the *-hp-* 400A Vacuum Tube Voltmeter.

When used with the 400A Voltmeter, the 450A Amplifier increases voltmeter sensitivity 100 times at 40 db gain (300 microvolts full scale). At 20 db gain, the voltmeter's sensitivity is multiplied 10 times (3 millivolts full scale). Both amplifier and voltmeter have identical base sizes.

SPECIFICATIONS

Gain: 40 db $\pm 1/8$ db (100X) or 20 db $\pm 1/8$ db (10X) (Panel Switch).

Frequency Response: At 40 db gain: within $\pm 1/2$ db between 10 and 1,000,000 cps; within ± 1 db between 5 and 2,000,000 cps. At 20 db gain: within $\pm 1/2$ db between 5 and 1,000,000 cps; within ± 1 db between 2 and 1,200,000 cps.

Stability: $\pm 2\%$ with approximate line voltage variation 105-125 volts and normal change in tube characteristics.

Input Impedance: 1 megohm shunted by approx. 15 uuf.

Output: 10 volts maximum to 3,000 ohms or higher resistive load.

Internal Impedance: Less than 150 ohms over entire range.

Distortion: Less than 1% at max. output and rated load.

Equivalent Input Noise Level: 40 db gain, 40 microvolts approximate; 20 db gain, 250 microvolts approximate.

Power Supply: 115 volts 50/60 cycles 40 watts.

Mounting: Metal case, leather carrying handle.

Size: 7 1/2" wide, 5 1/4" high, 9 1/2" deep.

Price: \$140.00 f.o.b. Palo Alto (Rack mounting \$5.00 extra).

Net Weight: 10 pounds. Shipping Weight: 18 pounds.

Data subject to change without notice.

Warranty

Hewlett-Packard Company warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this Warranty is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to making good at our factory any part or parts thereof except tubes, fuses or batteries which shall, within one year after making delivery to the original purchaser, be returned to us with transportation charges prepaid, and which on our examination shall disclose to our satisfaction to have been thus defective.

Hewlett-Packard reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This Warranty is expressly in lieu of all other obligations or liabilities on the part of Hewlett-Packard, and Hewlett-Packard neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of Hewlett-Packard instruments.

CALL THE NEAREST *-hp-* SALES AND SERVICE REPRESENTATIVE FOR PERSONAL HELP WITH YOUR MEASURING PROBLEMS

The Hewlett-Packard Company has selected the best independent organizations in the United States to provide you with personal attention to your measuring problems. Technical men representing these organizations have complete information about *-hp-* instruments, and can be of great help to you in selecting the correct measuring equipment for your needs.

These men that comprise the *-hp-* field service force can save you time, just as the familiar *-hp-* direct-to-you sales policy saves expense. Whenever or *wherever* you require personal assistance with your measuring problems, call the nearest *-hp-* field representative. Or, write direct to our factory, and we will see that you get prompt attention to your problem.

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