



Increased Operational Simplicity In a New DC-Several Hundred KC Oscilloscope

THE NEW -hp- Model 120A Oscilloscope shown in Fig. 1 provides the engineer a wider equipment choice from which to match instrumentation performance and economy to the measuring problem without sacrificing

SEE ALSO
"New -hp- R & D
Arrangement," p. 6

quality, precision or convenience. The instrument has been designed for the applications that require an oscilloscope with medium-high sensitivity in the vertical amplifier combined with an accurate, high-quality sweep system, but where only medium sensitivity is needed in the horizontal amplifier. Specifically, the 120A has a maximum vertical amplifier sensitivity of 10 millivolts/cm, a maximum horizontal amplifier sensitivity of 100 millivolts/cm, a 5% overall accuracy sweep system, and a response that extends from d-c to several hundred kc (Fig. 2). Further, the instrument has an even simpler sweep arrangement than those on the

Models 130A and 130BR and includes an automatic no-signal base line feature that substantially simplifies set-up adjustments. The excellent phase-shift-measuring characteristics of the Models 130A and 130BR are also present, although the circuitry of the amplifiers in the 120A is not identical as it is in the 130A and 130BR.

AUTOMATIC BASE LINE SWEEP ARRANGEMENT

The automatic no-signal base line is designed to reduce to a large extent or even eliminate the searching with the vertical and horizontal positioning controls that is often necessary when an oscilloscope is first turned on. The arrangement is such that, when no signal is applied to the sweep circuits, a low repetition-rate trace occurs. The position of the base line is thus normally always known. When a signal is applied, the sweep automatically triggers from the signal so that the con-

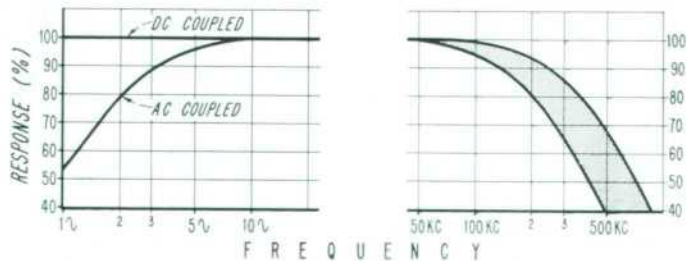


Fig. 2. Typical frequency response characteristic of Model 120A. High-frequency response spread of 20 production instruments is shown by shaded region.

Fig. 1 (at left). New Model 120A Oscilloscope is designed with automatic no-signal base line feature to facilitate initial set-up adjustments. Instrument also has special internal control which can be used to limit range of panel intensity control and thus prevent screen burning if sensitive-phosphor crt's are used.

venience of the *-hp- Preset* feature is obtained. Triggering occurs at the zero-axis crossing on either positive or negative slope as determined by the setting of the *Sync* selector.

Because of the automatic base line feature, the panel control provided on the other *-hp-* oscilloscopes for selecting trigger level is not included. Instead, trigger point selection is provided in the form of a screwdriver control at the lower right of the front panel. This control disables the automatic base line feature and selects the trigger point on displayed waveforms over a range of at least +2 to -2 cm on whichever slope the *Sync* control is set for. On external sync signals the screwdriver control selects the trigger point over a range from +10 to -10 volts on the negative slope. Both external and internal sync signals are a-c coupled to the sweep trigger circuits.

In either automatic or trigger level operation the sweep circuits will trigger from signals over a range from 600 kc to below 5 cps (50 cps for automatic operation). Between 10 cps (50 cps for automatic) and 200 kc the minimum deflection needed for triggering from displayed waveforms is $\frac{1}{2}$ cm peak-to-peak. Beyond this range an increase in this minimum will occur, but at 600 kc, for example, triggering will usually occur on waveforms that give 2 cm deflection. For external trigger signals, a minimum amplitude of $2\frac{1}{2}$ volts peak-to-peak is required for the basic 10/50 cps to 200 kc ranges described above.

SWEEP CIRCUITRY AND EXTRA-SLOW SWEEP CONSIDERATIONS

In keeping with the *-hp-* design philosophy of providing oscilloscopes that are accurate measuring instruments, the sweep generator in the Model 120A, as in the other *-hp-* oscilloscopes, consists of a stabilized, feedback-type sawtooth generator. This circuit generates a sawtooth of

excellent linearity and stability and is essentially insensitive to changes in tube characteristics. The following amplifiers are also carefully controlled to maintain linearity. The result is that the sweep circuits are rated as being accurate within $\pm 5\%$ overall, a rating that includes not only sweep linearity and accuracy of calibration but deflection nonlinearities in the cathode-ray tube itself as well.

The slowest calibrated sweep provided on the instrument is $\frac{1}{3}$ second/cm which can be extended with the sweep vernier to at least $\frac{1}{2}$ second/cm or 5 seconds for the full 10 cm sweep. If need occurs for a slower sweep, the range can be extended indefinitely by connecting a pair of external capacitors into the sweep circuits. A pair of 2 mf capacitors, for example, will extend the range another decade, i.e., to 5 seconds/cm or 50 seconds for the full sweep. One of the capacitors should be a high-quality type with high leakage resistance and good recovery characteristics. No loss in sweep linearity occurs if a capacitor with these qualities is used. The second capacitor is connected to the hold-off circuits which do not impose special demand in these respects.

CALIBRATED X5 SWEEP EXPANSION

Also included in the Model 120A is a calibrated sweep expander, which is operated by a toggle switch on the panel. The expansion circuit has two points of special interest. First, it operates in such a way that a known portion of the display (the center 2 cm) is expanded a known amount (5 times). The operator can thus pre-select the portion of the display he wishes to expand. At the same time any 2-cm portion of the original display can be viewed in expanded form by suitably adjusting the horizontal positioning control.

Secondly, expanded sweep operation permits a sweep speed of 1 microsecond/cm to be obtained

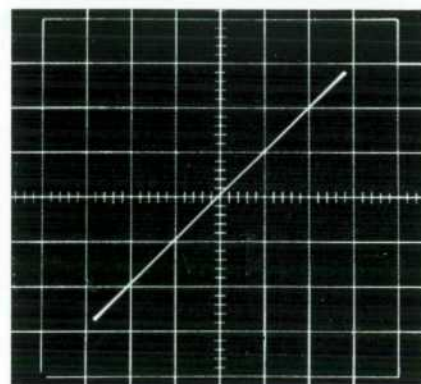


Fig. 3. Typical differential phase characteristic of Model 120A at 50 kc with sensitivity controls at equal settings and verniers in calibrated position. Differential phase is essentially zero.

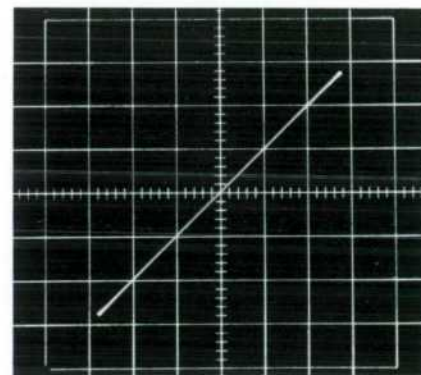


Fig. 4. Typical phase characteristic at 100 kc under same conditions as in Fig. 3.

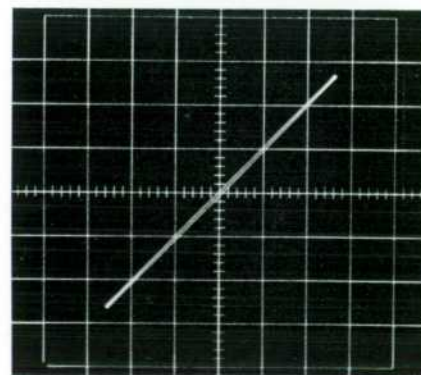


Fig. 5. Typical phase characteristic at 150 kc under same conditions as in Fig. 3. Phase difference shown is about 1° and was made with 1v/cm vertical and horizontal sensitivity settings. Typically, phase difference at this frequency may be 2 to 3 times greater on 10v/cm settings and is usually less on 0.1v/cm settings. Internal adjustment is provided for minimizing phase difference at any one frequency at higher frequencies. Oscillograms made using 100 kc factory setting of this adjustment.

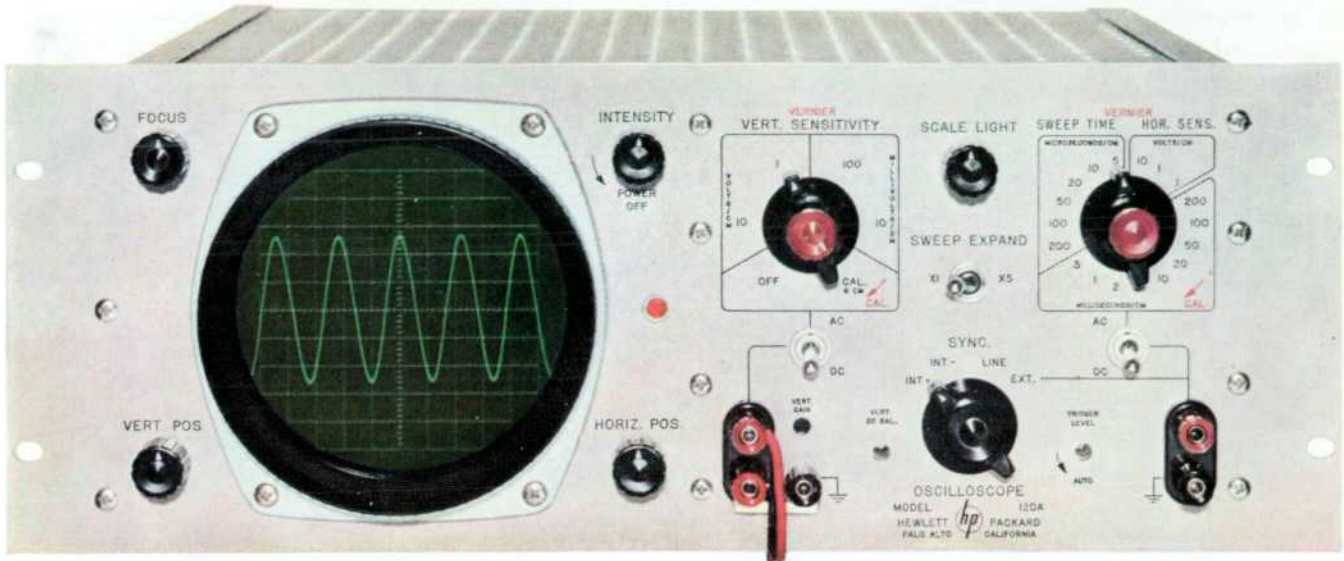


Fig. 6. Rack mount version of Model 120A is designed with panel height of only 7" to conserve frontal rack area. Number of panel controls has been minimized through use of only two major controls — one for vertical system and one for both sweep and amplifier functions of horizontal system.

where the fastest unexpanded sweep is 5 microseconds/cm. The accuracy of the expanded sweep is 10% as compared with the 5% accuracy of unexpanded sweeps.

VERTICAL AMPLIFIER H-F RESPONSE

Although vertical amplifier response is rated as being down no more than 3 db at 200 kc, this rating was intentionally established to be conservative and all experience to date bears this out. Fig. 2, for example, shows the high-frequency response spread of 20 production instruments selected in production sequence. For the 20 instruments the average response at 200 kc was 86.6% or $-1\frac{1}{4}$ db and the lowest response of the 20 was 81%. From these data it can be seen that the instrument is usable in many if not most cases to view waveforms up to at least 500 kc. The instrument thus has considerably more flexibility than might be implied by simply stating that the 3 db point is rated at 200 kc. Coupled with this response characteristic is the fact that the sweep circuits are designed to trigger from frequencies up to 600 kc, as described earlier.

DIFFERENTIAL PHASE CHARACTERISTICS

Even though the circuitry of the vertical and horizontal amplifiers is not identical, the bandshapes and phase characteristics are, at least to well above 100 kc, as demonstrated by the oscillograms in Figs. 3 to 5. As a result the instrument is rated as having not more than 2° differential phase shift below 100 kc and is thus well suited to phase difference measurements. In fact, because the horizontal amplifier has basically an even wider response than the vertical, an adjustment is provided in the horizontal amplifier so that phase differences can, if desired, be minimized at individual frequencies above 100 kc, a feature not present in the other *hp* oscilloscopes. The adjustment consists of a small variable capacitor which acts to set the first high-frequency corner of the horizontal amplifier for optimum agreement with that of the vertical. At the factory this adjustment is set for optimum agreement at 100 kc.

BALANCED VERTICAL INPUT

For cases where it is desired to view a balanced signal such as provided by some transducers, the

instrument is arranged to accept balanced signals on the 10 mv/cm position of the vertical amplifier. Thus, balanced sine-wave signals of 3.5 millivolt rms will give 1 cm peak-to-peak deflection, while by using the 10:1 vernier on the vertical sensitivity control, balanced sine-wave signals as large as 350 mv rms can be viewed without external attenuation.

Common mode voltages on balanced inputs will be suppressed by at least 40 db. Such voltages can have a maximum peak amplitude of + or -3 volts to ground.

HORIZONTAL AMPLIFIER

As described earlier the horizontal amplifier is adjusted to have response that is essentially identical in shape to that of the vertical amplifier. The maximum sensitivity of the amplifier is one-tenth that of the vertical amplifier or 100 millivolts/cm. Two additional sensitivity positions of 1 volt/cm and 10 volts/cm are provided, so that the maximum viewable signal can be as large as 100 volts peak-to-peak for 10 cm deflection without using the vernier or 1000 volts peak-to-peak using the vernier.

In the illustrations that picture the front panel it can be seen that the sensitivity vernier for the horizontal amplifier also operates as the vernier for the sweep circuits. This control is coupled to dual potentiometers, however, so that it acts as a 10:1 vernier for amplifier sensitivity but as a 2.5:1 vernier for sweep selection.

The calibrated control for the horizontal amplifier is also the calibrated sweep time selector. The operator thus has the convenience of only two major controls on the instrument—one for the vertical system and one for the horizontal.

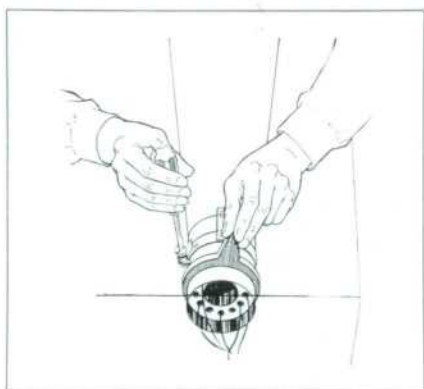


Fig. 7. Model 120A includes *hp*-developed crt lever for quick alignment of crt axis.

CALIBRATOR

An internal square-wave calibrator with an accuracy of $\pm 2\%$ and a nominal frequency of 400 cps is provided for checking amplifier calibration accuracy when desired. Because of the inherent stability and medium sensitivity of the horizontal amplifier, no provision is made for internal connection between that amplifier and the calibrator. Consequently, the calibrator is arranged to be used only with the vertical amplifier.

Horizontal amplifier calibration can easily be checked, however, since an external signal can be measured on the vertical amplifier and then applied to the horizontal as a check. Little adjustment of the horizontal amplifier is necessary and the hori-

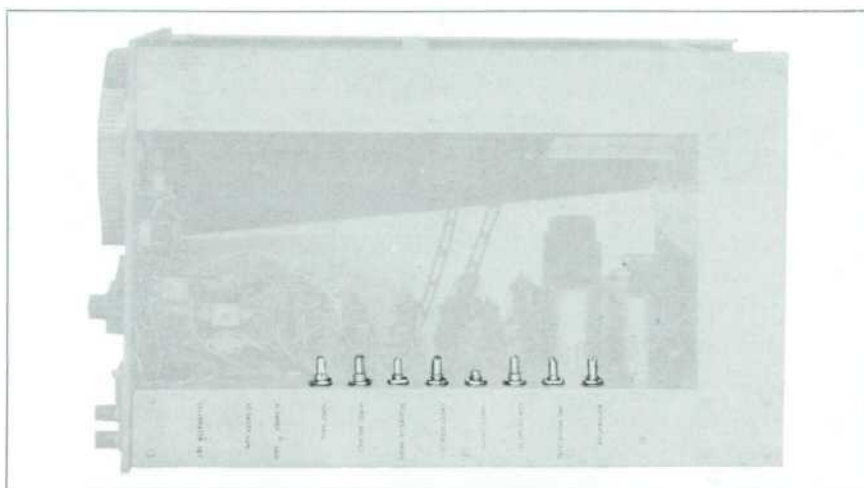


Fig. 8. Most internal calibration controls are located in easily-reached row along side of chassis.

zontal gain control is thus located internally. A special position at the clockwise end of the vertical amplifier control automatically applies the calibrator waveform to the vertical system without need for removing a signal applied at the input terminals. The calibrator voltage is such (60 mv) that it produces 6 cm of vertical deflection. A screwdriver control is provided at the front panel for adjusting vertical amplifier gain if desired.

TRANSISTOR-REGULATED HEATER SUPPLIES

One of the factors that gives high stability to the Models 130A and 130BR is the fact that, in addition to regulation of the plate supply, the heater supplies of the low-level vertical and horizontal amplifier stages are carefully regulated. In the Model 120A important tube heaters are also regulated, despite the somewhat lower sensitivity of the instrument. The result is that stability of the Model 120A is of the same order as that of the 130A and 130BR. Specifically, the instrument is rated that a line voltage change of $\pm 10\%$ from a 115-volt center will cause not more than $\pm \frac{1}{2}$ cm of shift on any range. Efficiency and simplicity considerations have resulted in the use of transistors for the control elements in the heater regulator circuit.

CRT CONSIDERATIONS

A further instance in which care has been taken to maintain the integrity of the design is in the choice of the cathode-ray tube and in the conditions under which it is operated. The tube chosen is the type 5AQP-, the same tube used in the Models 130A and 130BR. It is a mono-accelerator type which has been selected for its basic advantages over the less expensive post-accelerator types. One of these is that the focus is constant to a substantially greater degree over the face of the tube, because deflection occurs only after full acceleration of the beam and lens action at the deflecting plates is thus minimized. Further, the blooming that occurs with intensity changes in post-accelerator types is greatly reduced in the 5AQP-. These factors account for the crisp appearance of the trace which is characteristic in *hp*-oscilloscopes.

Operationally, the tube is supplied from a regulated source so that intensity changes do not alter supply voltages and thus affect the deflection factor of the tube. Consequently, the display does not grow or shrink with changes in intensity settings. The tube is operated at an accelerating voltage of 2,500 volts which, in agreement with tube

manufacturer's ratings, gives the same light output as 20% more voltage with post-accelerator types. Blanking voltage is direct-coupled to the crt so that intensity will be independent of duty cycle.

P1 phosphors are standard for the instrument, but P7 and P11 phosphors are also available.

INTENSITY LIMIT CONTROL

A special internal control has been included in the Model 120A for assistance in those applications that require the use of sensitive phosphors such as P7's. This control is arranged so that it limits the beam current that can be obtained with the *Intensity* control on the panel. When sensitive phosphors are installed, the internal limit control can be adjusted so that accidental screen burning through oversetting of the panel control is virtually impossible.

INTENSITY MODULATION

High-impedance terminals are provided at the rear of the instrument for intensity-modulating the trace when desired. At typical operating intensities, an applied voltage of +20 volts will blank the trace.

7" RACK MOUNT

As a convenience to users of rack-mounting instruments, the rack style instrument (Model 120AR) has been arranged with a front panel height of only 7" to minimize rack space consumption.

Vertical and horizontal amplifier terminals at the back of the rack style instrument, although not standard, can be obtained on special request.

GENERAL

The design also includes a number of mechanical conveniences. The bezel is designed to serve directly as a mount for a standard oscilloscope camera and is arranged with the tube shield and behind-the-panel guard ring to be light proof. The bezel itself can be removed quickly

for tube or filter changes by means of four screws accessible from the front.

The crt positioning lever (Fig. 7) first introduced by *-hp-* on the 130A is also included in the Model 120A to permit quick and accurate alignment of the crt.

As a special convenience for maintenance, all but four of the internal controls have been located in a single row along the side of the chassis (Fig. 8). Two of the other

controls are associated with the crt circuitry and are located near the crt socket. One is the intensity limit control described earlier, and the second is the astigmatism control. The third is a hum balance control, while the fourth sets trigger sensitivity. Both are located on the chassis.

Finally, the cabinet is provided with a tilting bail which can be used to elevate the front of the instrument for convenient viewing in bench use. —Duane Dunwoodie

SPECIFICATIONS

-hp- MODEL 120A

OSCILLOSCOPE

SWEEP

Sweep Range: 1 μ sec/cm to at least 0.5 sec/cm. 15 Calibrated sweeps in a 1-2-5-10 sequence from 5 μ sec/cm to 200 millsec/cm, accurate to within $\pm 5\%$. Vernier permits continuous adjustment of sweep time between calibrated steps and extends 200 millsec/cm step to at least 0.5 sec/cm.

Sweep Expand: X5 sweep expansion may be used on all ranges and expands fastest sweep to 1 μ sec/cm. Expansion is about the center of the CRT and expanded sweep accuracy is $\pm 10\%$.

Synchronization: Internally from vertical deflection signals causing 1/2 cm or more vertical deflection, from line voltage, and from external signals at least 2.5 volts peak-to-peak.

Trigger Point: Automatic: Zero crossing, negative slope of external sync signals, zero crossing, positive or negative slope of vertical deflection signals. Screwdriver control overrides automatic and permits trigger point to be set between -10 to +10 volts. Turning fully counter-clockwise restores automatic operation.

VERTICAL AMPLIFIER

Bandwidth: Dc coupled: dc to 200 kc. Ac coupled: 2 cps to 200 kc. Bandwidth is independent of sensitivity setting.

Sensitivity: 10 millivolts/cm to 100 volts/cm in 4 calibrated steps (10 mv/cm, 100 mv/cm, 1 v/cm, and 10 v/cm) accurate within $\pm 5\%$. Vernier permits continuous adjustment of sensitivity between steps and extends 10 v/cm step to at least 100 v/cm.

Internal Calibrator: Calibrating signal automatically connected to vertical amplifier for standardizing of gain, accuracy $\pm 2\%$.

Input Connectors: Banana jacks, spaced 3/4".

Input Impedance: 1 megohm, less than 50 μ mf shunt.

Balanced Input: On 10 mv/cm range. Input impedance, 2 megohms shunted by less than 25 μ mf.

Common Mode Rejection: Rejection at least 40 db. Common mode signal must not exceed ± 3 volts peak.

Phase Shift: Vertical and horizontal amplifiers have some phase characteristics within $\pm 2^\circ$ to 100 kc when verniers are fully cw.

HORIZONTAL AMPLIFIER

Bandwidth: Dc coupled: dc to 200 kc. Ac coupled: 2 cps to 200 kc. Bandwidth is independent of attenuator setting.

Sensitivity: 0.1 volt/cm to 100 volts/cm in 3 calibrated steps (.1 v/cm, 1 v/cm, and 10 v/cm) accurate within $\pm 5\%$. Vernier permits continuous adjustment of sensitivity between steps and extends 10 v/cm step to at least 100 v/cm.

Input Connector: 2 banana plugs, spaced 3/4".

Input Impedance: 1 megohm, nominal, shunted by less than 50 μ mf.

Phase Shift: Horizontal and vertical amplifiers have same phase characteristics within $\pm 2^\circ$ to 100 kc.

GENERAL

Cathode Ray Tube: 5AQP1 mono-accelerator normally supplied; 2500 volt accelerating potential. P7 and P11 phosphors are also available. P2 is available if desired for special applications.

CRT Bezel: Light proof bezel provides firm mount for oscilloscope camera and is removed easily for quick change of filter.

CRT Plates: Direct connection to deflection plates via terminals on rear. Sensitivity approximately 20 v/cm.

Intensity Modulated: Terminals on rear. +20 v to blank trace of normal intensity.

Filter Supplied: Color of filter compatible with CRT phosphor supplied; Green with P1; Blue and amber with P7; Blue with P11.

Illuminated Graticule: Edge lighted with controlled illumination, 10 cm x 10 cm, marked in cm squares. Major horizontal and vertical axes have 2 mm subdivisions.

Dimensions: Cabinet Mount: 9 3/4" wide, 15" high, 21 1/4" deep. Rack Mount: 19" wide, 7" high, 21 1/4" deep. 19 1/2" deep behind panel.

Weight: Cabinet Mount: Net 34 lbs., shipping 50 lbs. Rack Mount: Net 32 lbs., shipping 47 lbs.

Power: 115/230 volts $\pm 10\%$, 50-1000 cps; 130 watts.

Equipment Slides: Can be installed at the factory on special order for easy withdrawal of Rack Mount from Equipment rack. Specification No. 12001, Price: \$70.00.

Accessories Available: AC-83A Viewing Hood; face-fitting molded rubber, Price: \$4.50.

Price: Model 120A Cabinet Mount: \$435.00. Model 120AR Rack Mount: \$435.00. Normally supplied with P1 phosphor. When ordering P7 or P11, specify by adding phosphor number after model.

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

NEW -hp- R & D DIVISIONS



Bernard M. Oliver



Alan S. Bagley



E. F. Barnett



Brunton Bauer



John M. Cage



Carl J. Clement



B. P. Hand



Peter D. Lacy



Horace E. Overacker



Norman B. Schrock



W. Bruce Wholey

In line with expanded laboratory activity -hp-'s Research and Development Department has been arranged into four new product divisions as well as an advanced development section, a standards laboratory, and an industrial design section, all under the direction of Dr. Bernard M. Oliver, Vice-President for Research and Development.

NEW PRODUCT DIVISIONS

Engineering Manager of the Electronic Counter Division is Alan S. Bagley. Mr. Bagley obtained a B.S. at the California Institute of Technology and an M.S. at Stanford University. He then came to -hp- where he has been project leader for the development of most of the -hp- counters including the industry's first 10-megacycle counter and the new high-speed digital recorder.

Engineering Manager of the Oscilloscope Division is Norman B. Schrock. Mr. Schrock obtained an A.B. and M.A. from Stanford University. He has since been at -hp- where he has been project leader for the development of a number of major -hp- instruments such as the -hp- FM broadcast monitors, the -hp- 140-megacycle bandwidth distributed amplifiers, and more recently the -hp- oscilloscopes.

Engineering Manager of the Microwave and Signal Generator Division is W. Bruce Wholey. Mr. Wholey obtained a B.S. at the University of Alberta and an M.A. at Stanford University. At -hp- he has been project leader on such instruments as the well-known parallel-plane slotted line as well as a number of other -hp- microwave and associated equipments. He is also the author of the section on receiver measuring equipment in the book "Very High Frequency

Techniques" by the Radio Research Laboratory Staff.

Engineering Manager of the Audio and Video Equipment Division is John M. Cage. Mr. Cage was formerly head of the electronics section at Purdue University and Professor of Electrical Engineering at the University of Colorado. He has also been General Manager of the Industrial Electronics Division for one of the country's major electronic firms and is the author of the book "Theory and Application of Industrial Electronics." At -hp- he has been project leader for several important new instruments to be described in future issues.

STAFF OPERATIONS

Serving in advanced development capacities are E. F. Barnett, Brunton Bauer, Dr. Peter D. Lacy, and Dr. Horace E. Overacker.

Mr. Barnett received a B.S. at Stanford University. He has since been at -hp- where he has been responsible for the design of such instruments as the -hp- multi-hole waveguide directional couplers and the precision waveguide phase-shifter.

Mr. Bauer received a B.S. from M. I. T. and has a wide background in the electronic design field. At -hp- he has supervised the design of much of the -hp- line of audio oscillators and related equipment such as distortion analyzers, audio signal generators, etc.

Dr. Lacy obtained his B.S. at the University of Florida and an M.S. and Ph.D. at Stanford University. At -hp- he has been responsible for the design of such instruments as the X-band test set, the wide-band traveling-wave amplifiers, and the recently announced microwave sweeping oscillators, as well as a series of radar simulators.

Dr. Overacker has had extensive experience in electronics design. He received his A.B., E.E., and Ph.D. from Stanford University and has been in development work in several prominent electronic laboratories. At -hp- he has been engaged in signal generator development and, more recently, has been responsible for semi-conductor development.

The Standards Laboratory, which establishes and develops standards in all regions of the radio spectrum, is supervised by B. P. Hand. Mr. Hand received a B.S. at Santa Clara University and an M.S. at Stanford University. At -hp- he has been responsible for the design of microwave power and attenuation equipment such as the precision rotary attenuator.

The Industrial Design Section is supervised by Carl J. Clement. Mr. Clement is a graduate of the University of Washington. At -hp- he has developed many of the appearance and mechanical features of -hp- instruments in recent years.

Dr. Oliver received his A.B. from Stanford University and an M.S. and Ph.D. from the California Institute of Technology, where he was selected as Institute of International Education honor exchange student and attended the Technische Hochschule in Darmstadt, Germany, under that program. He is the author or co-author of a number of advanced papers and has directed -hp- R & D activities since 1952. He is also a Lecturer in E. E. at Stanford University and has been active in professional affairs, serving as Vice-Chairman of the 1957 WESCON and Chairman of the A.I.E.E.-I.R.E.-N.B.S. Conference on Electronic Standards and Measurements to be held in August in Boulder.