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A Rack-Mounting DC-300 KC Oscilloscope With Expandable Sweep

FIG. 1 shows the new *-hp-* Model 130BR high-sensitivity oscilloscope which has been designed to make available in a rack-mountable instrument the same excellence in measuring ability that has been available in the *-hp-* cabinet-style Model 130A oscilloscope introduced a year ago.* The new rack-style instrument, in fact, has even more conveniences and measuring flexibility than its cabinet-style companion.

Since the introduction of the -hp- Model 130A d-c — 300 kc oscilloscope last year, many readers have had an opportunity to become acquainted with that instrument firsthand. As a result, it gained notable popularity and shortly became the standard of the field.

Now, a rack-mounting version of the instrument has been designed. Although basically similar to its cabinet-style companion, the new instrument has even more features and will be interesting both to readers who may not use rack style instruments as well as to those who do.

Like its companion, the new Model 130BR has been designed as a voltage-time-phase shift measuring instrument of wide range, high sensitivity, and overall quality as evidenced by the following major characteristics:

- It operates from d-c to above 300 kc.
- It has a wide voltage-measuring range of from 1 millivolt/cm to approximately 1500 volts peak-to-peak full scale.
- It has a wide time-measuring range of from 0.2 microsecond/cm to approximately 15 *seconds*/cm.
- For phase measurements the vertical and horizontal amplifiers have been made identical, enabling phase measurements to be made up to 100 kc or more, depending on accuracy requirements.
- A x5 sweep expansion feature is provided for all sweep speeds to enable easy examination of points of special interest in a display.
- The sweep arrangement includes the *-hp-* originated *Preset* feature which automatically operates the sweep on viewable waveforms.
- In addition to front panel terminals, terminals for the vertical and horizontal amplifier inputs are provided at the rear of the chassis for console operation.
- The instrument displays balanced inputs of up to approximately 1.5 volts p-p in both channels.

*Duane Dunwoodie and Dick Reynolds, *A New DC-300 KC High-Sensitivity Oscilloscope with Triggered Sweep*, Hewlett-Packard Journal, Vol. 7, No. 7, March, 1956.

Fig. 1. New -hp- Model 130BR DC-300 KC Oscilloscope is designed with high sensitivity, high stability, wide range of sweep speeds, x5 expandable sweep, and identical amplifiers so as to simplify measurements of voltage, time and phase shift. Console operation is facilitated by additional input terminals at rear of chassis.

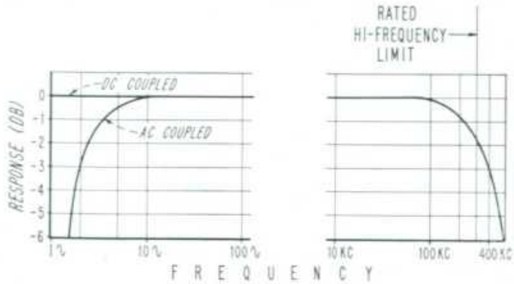

Fig. 2. Typical bandwidth characteristic of -hp- Model 130BR Oscilloscope. Curve applies to both vertical and horizontal amplifier and is essentially independent of sensitivity settings.

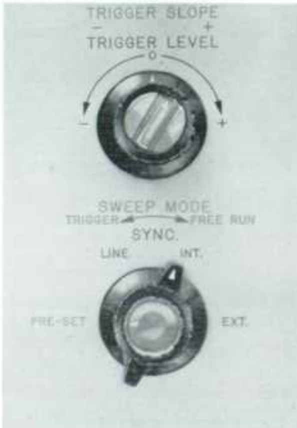

Fig. 3. *Trigger controls provide for automatic triggering (Preset) from internal or external signals and (upper controls) for selection of trigger point from —30 to +30 volts at either slope.*

- Bandwidths of the vertical and horizontal amplifiers are constant regardless of sensitivity to insure accurate measurements at all rated frequencies.
- A mono-accelerator tube is used to obtain good overall spot focus and is operated at 3,000 vdc to obtain high light output.
- The level and slope at which the sweep triggers on the sync signal can be selected by simple panel controls.
- Many mechanical and functional conveniences are incorporated including the -*hp*- developed crt alignment lever and quick-change bezel assembly.

AUTOMATIC SWEEP

The sweep system used in the instrument can be introduced by saying that its basic quality and flexibility are unmatched outside the finest high-frequency oscilloscope class. Even there, the system used becomes surpassed mainly by the fact that higher speeds are used commensurate with the high-frequency character of such instruments.

Except for the important sweep expansion feature, the system used in the instrument is identical to that used in the Model 130A and includes the -*hp*- developed automatic sweep *(Preset)* feature. This feature is such that the sweep occurs automatically when a signal is applied to the vertical system. Nearly any type of viewable waveform will trigger the sweep, since it is only necessary that the signal have sufficient amplitude to give ½ cm of deflection. On the most sensitive 1 millivolt/cm range of the instrument, it is thus only necessary that the signal be ½ millivolt in amplitude to give automatic sweeping. Automatic operation is obtained by setting the *Sweep Mode* control (Fig. 3) to the *Preset* position.

Besides operating from the signal applied to the vertical system, the automatic feature can also be operated from external sync signals of ½ volt p-p minimum amplitude or from the power line frequency. The *Sync* selector switch enables the operator to select the source of the signal that triggers the sweep.

The user also has the option of using a free-running sweep if desired. The *Sweep Mode* control, when turned clockwise, causes the sweep to free-run, a feature that is often convenient when establishing set-ups such as when arbitrary baselines are desired.

TRIGGER POINT SELECTION

The sweep system is also made unique in this class of instrument by the fact that it will trigger from a selectable point on the signal used as the trigger. The *Trigger Level* control (Fig. 3) enables any level of a viewed signal or from —30 to +30 volts on an external signal to be selected, while the *Trigger Slope* control enables either positive or negative slopes to be selected.

SWEEP RANGE

A further distinction of the sweep system lies in the range of sweep speeds provided and the unusually straightforward manner in which they can be selected. Sweep times are selected by a single switch (Fig. 4) which provides 21 calibrated speeds ranging from 1 microsecond/cm to 5 seconds/cm. Any desired speed can thus be selected with a single direct-reading control so that no mental computation of the settings of two or more controls with accompanying possibility of error is required.

Sweep speeds that lie between the fixed steps can be selected with the *Vernier* control which is concentric with the sweep time selector. The

Fig. 4. *To simplify sweep selection, sweep time selector is a single, direct-reading control. Concentric vernier enables continuous variation between steps.*

vernier has a nominal 3:1 range which, besides selecting intermediate sweep speeds, can be used to extend the slowest sweep from 5 seconds/cm to approximately 15 seconds/cm or 150 seconds for the total 10 cm sweep. The system thus conveniently accommodates very low frequency phenomena.

SWEEP EXPANSION

One of the important new features of the instrument is that it is provided with an expandable sweep. An expansion of 5 times is provided and is obtainable with any of the sweep speeds of the instrument, including the fastest 1 microsecond/cm sweep. The feature can thus also be used to extend the 1 microsecond/cm sweep to 0.2 microsecond/cm, should a sweep of that speed be desirable. Sweep expansion is selected by setting the *Horiz. Sensitivity* control (Fig. 6) to the *x5* position.

Circuitwise, sweep expansion is obtained by reducing the feedback in the sweep amplifier to obtain a 5 times increase in gain. A reduction in accuracy thus occurs, but this is slight, the derating being from its regular 5% value to a 10% value.

HIGH-SENSITIVITY TWIN AMPLIFIERS

Commensurate with its level of performance in other respects, the oscilloscope is provided with vertical and horizontal amplifiers that have a high order of quality. Bandwidth is constant and wide (d-c to above 300 kc), sensitivity is high (1

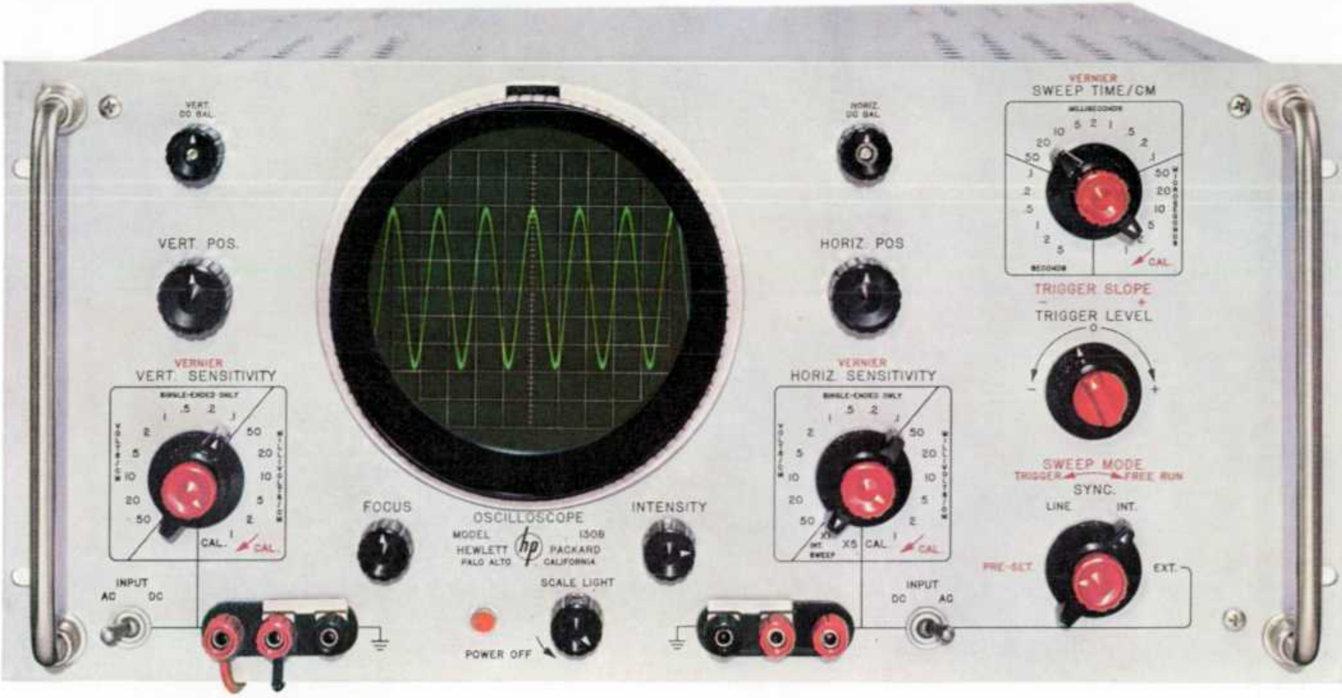

Fig. 5. *Model 130BR panel has been designed with controls arranged in three simple columns: vertical controls at left, horizontal at middle right, and sweep at far right. Large, heavy-duty guard handles facilitate rack installation as well as general portability.*

millivolt/cm maximum), and stability is extremely high. In other words, the amplifiers represent a generally first-rank design in which all performance aspects have been carefully treated to give the user maximum measuring convenience and flexibility.

A further feature worthy of special mention is the fact that the vertical and horizontal amplifiers are identical. This fact enables the instrument to be useful in measuring relative phases in external circuits, since the identical amplifiers give the oscilloscope an extremely low order of differential phase shift. Phase shift at 50 kc, for example, is all but undetectable and is still small at several times that frequency. Because this low differential phase shift is provided in vertical and horizontal systems that have high sensitivities, external relative phase can be measured in regions where high attenuation may be occurring in one of the signals. In feedback systems, for example, where it is necessary to check loop phase characteristics in low loop transmission regions beyond normally useful ranges, the high sensitivity of the amplifiers is of considerable value.

More detailed information on the differential phase characteristic of the amplifiers is given in the discussion of the Model 130-A. Although the Model 130-BR amplifiers are not entirely identical electrically to those in the Model 130A, they do equal if not surpass those in the Model 130A.

STABILITY

One of the most popular features of the Model 130A is the fact that, despite its high sensitivity, the stability of the trace is virtually independent of line voltage changes. In this respect, too, the new Model 130BR is the full equal of the Model 130A.

AMPLIFIER CONTROLS

In the new instrument there are some additional amplifier operating features that give the instrument even greater convenience than its cabinet-style companion. For one thing, an additional calibrated sensitivity step has been added (50 volts/cm step). This enables a-c voltages as high as approximately 1500 volts p-p full scale (10 cm) to be measured by using the nominal 3:1 sensitivity vernier with the basic sensitivity switch. D-c levels up to 600 volts can be applied and measured.

Fig. 6. *Vertical and horizontal sensitivity controls are simple, direct-reading type which are identical except for x1 and x5 sweep positions at ccw end of horizontal control.*

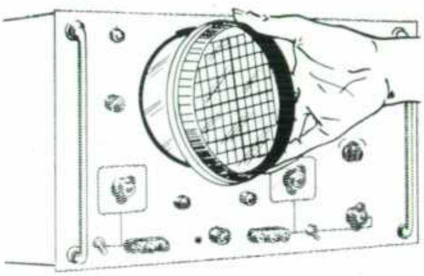

Fig. 7. *-hp- quick-change bezel is also designed to serve as camera mount.*

The maximum balanced input has also been increased from 20 millivolts/cm to 50 millivolts/cm. This means that balanced inputs as high as 500 millivolts p-p can be displayed by the instrument without use of the sensitivity vernier. Use of the vernier will permit balanced voltages up to approximately 1.5 volts p-p to be displayed. Suppression of common mode signals on balanced inputs is at least 40 db with the limitation that the common signal should not exceed 1.5 volts.

The d-c coarse balance control, which in the cabinet instrument is accessible through the side of the cabinet, has been located concentrically with the fine balance control on the front panel. It is thus unnecessary to remove the instrument from the rack if adjustment of this control becomes desirable.

The sensitivity controls themselves are of the single direct-reading type which virtually prevents a mis-setting or mis-reading of sensitivity through error in calculating the calibrations of multiple controls.

TERMINALS AT REAR

Console operation of the instrument is facilitated by terminals at the rear of the instrument for the vertical and horizontal inputs. These are in parallel with the front panel inputs and consist of the commercial equivalent of an AN type 3102A receptacle for each input. This receptacle is a common AN type which provides for a 3-wire input to accommodate the two balanced terminals of the amplifier in addition to a ground lead.

AMPLITUDE CALIBRATOR

The amplitude calibrator in the new instrument differs from that in the companion instrument in that it produces a nominal 300 cps square wave instead of a 1,000 cps wave and in that it uses a tubeless circuit. The circuit is a relaxation oscillator using two neon lamps which have a superior operating life. The circuit arrangement is such that the characteristics of the lamps themselves have little influence on the square wave because the lamps act merely as on-off switches in a high-impedance circuit.

MECHANICAL CONVENIENCES

The rack style instrument also reflects the mechanical conveniences that were introduced and received wide acceptance on the Model 130A. These include the crt alignment lever and the quick-change -*hp*- type bezel-filter-graticule assembly.

Fig. 8. *Crt alignment lever simplifies angular tube positioning.*

GENERAL

In other respects the rack-style instrument at least equals the Model 130A and reference can be made to the discussion of that design for additional information.

DESIGN TEAM

The design group for the Model 130BR included a number of members of the -*hp*- engineering departments. Members of the group were leader Norman B. Schrock, Duane Dunwoodie, Eric Hammerquist, Donald L. Palmer, Dick Reynolds, and Harold C. Rocklitz.

—Duane Dunwoodie and Dick Reynolds

SPECIFICATIONS
-*hp*- MODEL 130BR
DC-300KC
OSCILLOSCOPE

SWEEP

Range: 0.2μsec/cm to approx. 15 sec/cm.

Calibrated: 21 calibrated sweeps in 1-2-5-10 sequence, 1μsec/cm to 5 sec/cm. Accuracy within 5%.

Magnifier: X5 Magnifier may be used on all ranges and expands fastest sweep to 0.2μsec/cm. Accuracy within 10%.

Vernier: Permits continuous adjustment of sweep time and extends slowest sweep time to approximately 15 sec/cm.

Synchronization: Internally from line voltage or from signals causing ½ centimeter or more vertical deflection.
Externally from 0.5 volt peak to peak or more.

Trigger Point: Continuously adjustable from −30 to +30 volts on either positive or negative slope of external synchronizing signal, or from any point of the vertical signal presented on the screen.

Preset Triggering: Switch position on sweep mode control selects optimum setting for automatic triggering.

INPUT AMPLIFIERS

Vertical and horizontal amplifiers have same characteristics

Sensitivity Range: 1 mv/cm to approx. 150 v/cm.

Stability: 1 mv/hr after warm-up.

Input Attenuator: 15 calibrated ranges, in a 1-2-5-10 sequence, 1 mv/cm to 50 v/cm. Vernier permits continuous adjustment between ranges and decreases sensitivity to approx. 150 volts/cm; accuracy ±3%.

Bandwidth: dc to 300 kc independent of attenuator setting.

Input Coupling: Direct or capacitively coupled input; 600 volts d-c or rms max. input.

Input Connectors: 3 conductor terminal on front panel spaced ¾". 3 conductor receptacle on rear panel in parallel with front panel terminals.

Balanced Input: On 1, 2, 5, 10, 20, and 50 mv/cm ranges. Input impedance 2 megohms shunted with approx. 125μμf. Can be reduced to 25μμf by disconnecting rear terminals.

Common Mode Rejection (Balanced input only): Rejection at least 40 db. Common mode signal must not exceed 1.5 volts.

Single Ended Input: On all ranges. Input impedance 1 megohm shunted with approx. 200μμf. Can be reduced to 50μμf by disconnecting rear terminals.

Undistorted Deflection: Three screen diameters.

Internal Calibrator: 300 millivolts peak to peak ±2%, 300 cycle square wave applied to vertical or horizontal amplifiers by CAL position of input attenuators.

GENERAL

Illuminated Graticule: Edge lighted graticule with controlled illumination, 10 cm x 10 cm, marked in centimeter squares with 2 mm subdivisions on major axes.

CRT Bezel: CRT bezel readily removed by a 15° twist. Bezel provides firm mount for standard oscilloscope camera equipment.

CRT Plates: Direct connection to deflecting plates via terminals on rear. Sensitivity approx. 20 volts/cm.

Intensity Modulation: Terminals on rear; 20 v positive signal blanks CRT at normal intensity.

Cathode Ray Tube: 5AQP mono-accelerator flat face type with 3000 volt accelerating potential. Available with P1, P7, or P11 screen.

Dimensions: 19" wide, 8¾" high, 22" deep.

Weight: Net 42 lbs.

Power Supply: 115/230 volts ±10%, 50/1000 cycles, 160 watts.

Filter: Color of filter compatible with screen phosphor.

Accessories Available: AC-83A Viewing Hood; face-fitting molded rubber. Price: $4.50 f.o.b. Palo Alto, California.

Price: $650.00 f.o.b. Palo Alto, California. (Normally supplied with P1 screen. When ordering with P7 screen, specify 130BR-7. When ordering with P11 screen, specify 130BR-11.
Data subject to change without notice.