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.

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.


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.
sweep, since it is only necessary that the signal be \( \frac{1}{2} \) 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 \( \frac{1}{2} \) 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 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...
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 130A. 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.
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.

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**SPECIFICATIONS**

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

**SWEEP**
- Range: 0.2 sec/cm to approx. 15 sec/cm.
- Calibration: 21 calibrated sweeps in 1-2-5-10 sequence, 1/sec/cm to 5/sec/cm. Accuracy within 5%.
- Magnifier: X5 Magnifier may be used on all ranges and expands fastest sweep to 0.2/sec/cm. Accuracy within 10%.
- Vernier: Permits continuous adjustment of sweep time and extends slowest sweep to approximately 15 sec/cm.
- Synchronization: Internally from line voltage or from signals causing 1/2 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 some characteristics:
  - Sensitivity Range: 1 mv/cm to approx. 150 v/cm.
  - Stability: 1 mv/hr after warm-up.
  - Input Attenuators: 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 (500 volts d-c or rms max. input).
- Input Connectors: 3 conductor terminal on front panel spaced 1/8", 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. 125 μf. Can be reduced to 25 μf 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. 200 μf. Can be reduced to 50 μf by disconnecting rear terminals.
- Undistorted Deflection: Three screen diameters.
- Illuminated Graticule: Edge lit cathode ray tube 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 Modification: Terminals on rear: 20 v positive signal blanking CRT at normal intensity.
- Cathode Ray Tube: 5AQ5 mono-accelerator flat face type with 3000 volt accelerating potential. Available with P1, P7, or P11 screen.
- Dimensions: 19" wide, 8½" high, 22" deep.
- Weight: Net 45 lbs.
- Filter: Celor of filter compatible with screen phosphor.
- Price: $50.00 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.

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**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.

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**Duane Dunwoodie and Dick Reynolds**