A New 50 MC Oscilloscope
Based on an Advanced CRT Design

Fig. 1 below shows a major new oscilloscope which has electrical and mechanical innovations that promise to make it a standard for high-frequency oscilloscope applications. The oscilloscope's electrical advances are fundamental in that they are made possible by a new cathode-ray tube which has been designed in the -hp- crt laboratory. The result is an oscilloscope that operates from dc to 50 megacycles and does so with a substantial decrease in circuit complexity. The oscilloscope is one that has a 50%-increased vertical deflection of 6 cm, has constancy of focus to the degree that no panel astigmatism control is necessary, and has the versatility that results from using plug-ins for both the vertical and horizontal systems.

CRT CONSTRUCTION

The new cathode-ray tube achieves its enlarged 6 cm vertical scan and high sensitivity together with other desirable features by means of a novel type of post-acceleration of the electron beam. As shown in Fig. 2, there is located between the deflection plates and the phosphor screen a thin spherical metal-gauze shield, a mesh, having extremely small apertures. The mesh is placed with its convex side toward the phosphor screen and serves to terminate the lines of force from the post-accelerator field in a controllable way. The resulting field configuration permits the electron beam to be accelerated by a large factor without the reduction in sensitivity or demagnification of deflection that limits the per-

Fig. 1. -hp- Model 175A Oscilloscope uses new high-sensitivity -hp- cathode-ray tube to obtain dc-50 megacycle performance with simplified circuitry. New crt is also free of deflection defocusing so no astigmatism control is needed.

Fig. 2. Diagram indicating how spherical shield or mesh in new crt terminates post-acceleration lines of force so as to magnify beam deflection angle.
from the shield along radii originating at C. If C lies between the center of deflection D and the shield, then the angle of deflection of the beam will be increased by the action of the radial accelerating field. In the region of the screen where the lines of force terminate, the lines are no longer radial, but the field is there weak and the beam velocity high so that the resulting demagnification is negligible. The overall result of the foregoing design approach is that the deflection sensitivity of the production CRT is two to three times as high as that of otherwise-similar tubes.

In addition to achieving an increased amount of vertical scan, the new CRT also has a markedly-reduced deflection defocusing and distortion. This occurs because of the reduced maximum angle of deflection at the deflection plates and because of the spherical symmetry of the post-accelerator field. As a consequence, no panel astigmatism control is required or provided in the new oscilloscope. In the new CRT the mesh also repels toward the cathode secondary electrons produced in overscan and thus reduces the background light at the screen as compared with tubes having open post-acceleration.

VERTICAL AMPLIFIER CONSIDERATIONS

The high deflection sensitivity attained by the new cathode-ray tube leads to the advantageous result that the main vertical amplifier of the oscilloscope can achieve wide bandwidth and fast rise time without resort to complex circuitry. For example, the response of the main vertical system extends from dc to well beyond 60 megacycles with a rise time of less than 6 nanoseconds, as shown in Fig. 5. At the same time, though, the amplifier consists of but 3 amplifying stages separated by 3 impedance-reducing stages. Also, the delay element in the amplifier is merely a fixed delay cable. This simple system contrasts with the complicated distributed amplifiers and multi-adjustment delay networks that have previously been employed.

Simplicity of the vertical amplifier has been further enhanced by using only one tube type. This is the 6DJ8 triode, a frame-grid tube that has a respected performance record with regard to ruggedness and dependability. Also, in the amplifier as a whole, the number of calibration adjustments is confined merely to one gain control and 3 pulse-response adjustments (Fig. 4).

In addition to driving the CRT deflection plates, the vertical amplifier provides two additional outputs. One of these is coupled from the deflection plates by a cathode follower and drives the Display Scanner, a horizontal plug-in used to
make X-Y recordings of the oscilloscope display. The second output is used for internal syncing of the oscilloscope. In this latter case a signal is coupled from the vertical amplifier ahead of the delay line and amplified by the sync stage before triggering the sweep.

The internal delay line is an *hp*-development and has a simple and compact design. It consists of two helically-wound center conductors enclosed in one ground shield. Its electrical length is 0.2 microsecond and its characteristic impedance is 330 ohms. The losses inherent in a delay line are compensated by fixed components in the vertical amplifier so that variable compensation is not necessary. Balanced construction has permitted the line to be encased in a small container with only input and output connections necessary.

**VERTICAL/HORIZONTAL PLUG-INS**

The Model 175A oscilloscope has been planned to achieve a high order of sophistication and flexibility, and in accordance with this philosophy the instrument has been designed so that both the horizontal and vertical axes employ plug-ins. A variety of such plug-ins has been designed. Thus, the range of applications to which the oscilloscope can be fitted is impressive. Additional plug-ins are currently under design. Further, the dual-plug-in plan stands as a safeguard of the oscilloscope's adaptability to possible new and unforeseen oscilloscope uses.

For the vertical axis three plug-ins have been designed. The dual-channel Model 1750A plug-in is a fast-rise unit with a 40-megacycle bandwidth when in the 175A main frame. Its basic sensitivity is 50 millivolts per centimeter ac or dc coupled, which is adjustable to 20 volts per centimeter with its range switch. The second plug-in, the Model 1753A, is a single-channel version of the dual-channel unit. Finally, for low signal levels, a higher-sensitivity unit is available. Its bandwidth is 18 megacycles with a sensitivity of 5 millivolts per centimeter when in the main frame.

At present there are four horizontal plug-ins available. The Sweep Delay Generator, Model 1781A, accurately measures time relationships on complex signals and pulse trains. It also provides for single sweep operation of the oscilloscope. The Model 1783A Time Mark Generator provides time markers to facilitate measuring rise times and other time intervals of interest. Thirdly, the Model 1780A Auxiliary plug-in is the basic horizontal plug-in and includes the single-sweep feature.

The fourth horizontal plug-in is the Model 1782A Display Scanner. This unit translates a repetitive display appearing on the crt into a low-frequency signal that will operate an X-Y recorder. Additional information on the horizontal and vertical plug-ins is given elsewhere in this issue.

**TRIGGER CIRCUITY**

The sweep employs a new triggering circuit based on a tunnel diode to achieve jitter-free syncing well beyond the frequency limit of the oscilloscope. The tunnel diode circuit generates very fast triggers to assure stable syncing and automatically counts down on high-frequency signals ahead of the sweep circuit to provide reliable high-frequency syncing.

The basic circuit arrangement of the trigger circuit is shown in Fig. 8.
A signal from the vertical signal channel, the power line, or from an external trigger source is converted to a current signal by a 6D18 triode. This signal drives a tunnel diode which in turn drives a transistor amplifier. The level on the input signal at which the tunnel diode will be triggered is determined by the Trigger Level control. At the higher frequencies the range of the control varies the countdown frequency slightly to facilitate syncing. The pulse transformer load of the transistor amplifier differentiates the amplified tunnel diode pulse and couples it to the sweep generator. The tunnel diode load, R-L, has been adjusted such that the pulse rep rate of the tunnel diode is never higher than 2.5 mc, assuring very stable triggering of the sweep.

The accuracy of the sweep is typically within 2%. Sweep times are adjustable in 24 steps from 5 seconds per centimeter to 100 nanoseconds/cm.

(Continued on page 6)
HORIZONTAL PLUG-INS

The horizontal plug-ins have been planned to give a high degree of flexibility to the sweep system in the oscilloscope. The basic sweep circuits are located in the main frame, and in general the plug-ins add special capabilities such as delayed sweeping to these basic circuits.

As with the vertical plug-ins, the oscilloscope does not have to be turned off to install or remove the horizontal plug-ins.

MODEL 1780A
AUXILIARY PLUG-IN

The Auxiliary Plug-in is shown in place in the Model 175A Oscilloscope in Fig. 6. This plug-in is a basic, low-cost unit that supplements the normal oscilloscope sweep circuits by providing a single-sweep capability to the main sweep system of the oscilloscope.

MODEL 1781A
SWEEP DELAY GENERATOR

The Sweep Delay Generator gives a variety of sweep delay features to the oscilloscope and also provides for single-sweep operation. Through use of the plug-in, time relationships on complex signals or pulse trains can be conveniently and accurately measured.

The basic operation of the 1781A involves generating a linear ramp which, in conjunction with a pick-off circuit, generates a trigger that can be used either to arm or to actually start the main sweep after a selected time interval.

The selector on the panel of the unit provides for four different types of operation. With the sweep selector in the Main Sweep position, the oscilloscope operates in the normal manner using the main sweep controls. In Delaying Sweep operation, trigger and sweep control are transferred to the Sweep Delay Generator, which then drives the trace across the crt in accordance with the setting of the delay control. When the ramp becomes equal to the value selected by the delay length pick-off control, the main sweep is triggered (or armed) and appears as an intensified segment of the trace.

The Main Sweep Delayed position differs from the previous position in that the delaying sweep is not fed to the horizontal crt plates, which instead are driven by the main sweep. Thus, the brightened section, which appeared in the Delaying Sweep position, is expanded to occupy the full 10 cm of the crt face.

MODEL 1782A
DISPLAY SCANNER

Although it is a horizontal plug-in, the operation of the Display Scanner is not limited to the horizontal system but ties to the vertical system as well. The function of the Display Scanner is to sample a repetitive trace displayed by the oscilloscope and translate it into low-frequency signals suited to driving an X-Y recorder. By this means permanent records can be made of the oscilloscope display.

MODEL 1783A
MARKER GENERATOR

To facilitate measurement of rise time and other important time intervals, the Marker Generator provides accurately calibrated intensity markers on the oscilloscope trace. Markers are available at 10, 1, and 0.1 microsecond intervals, accurate within ±0.5%, and synchronized to the signal being displayed.

In a second mode of operation, markers are available in a continuous train at a front panel jack for external use.

Typical 1-microsecond time markers provided by Model 1783A Marker Generator for internal or external use. Markers of 10 and 0.1 microseconds are also provided.

Use of 1-microsecond time markers as intensity-modulated markers to assist in time measurements.
Oscilloscope is provided with brackets that quickly convert the standard instrument into a rack-mountable unit.

Fig. 10. Oscilloscope is provided with brackets that quickly convert the standard instrument into a rack-mountable unit.

(Continued from page 4)

seconds per centimeter. A x10 calibrated magnifier expands all sweep times and increases the fastest sweep to 10 nanoseconds per centimeter. The sweep times are continuously adjustable between steps by use of the vernier which also slows the slowest sweep time to 15 seconds per centimeter.

The horizontal amplifier has an external calibrated sensitivity of 0.1 volt/cm and 1 volt/cm, ac or dc coupled. A vernier adjusts the horizontal sensitivity to 10 volts/cm.

A fast gate-rise time assures viewing of the initial portion of the trace with uniform trace intensity.

CRT OPERATION

In the oscilloscope the new high-sensitivity crt is operated with an accelerating potential of 12 kilovols. This high value, combined with the aluminized phosphor in the tube, results in a bright trace and a high writing rate. The standard phosphor for the instrument is the type P31, which has a spectral output favorable to the eye. Other phosphors, namely the P2, 7, or 11, are optional.

The crt is constructed in the -hp-internal-graticule style in which the graticule is located inside the tube on the back of the front glass and thus in the same plane as the phosphor. This construction avoids parallax error and permits two or more observers to view the crt display with equal accuracy. A faceplate is bonded to the front of the crt and is constructed to reduce "mirroring" and glare to unnoticeable proportions. The non-glare faceplate is not structurally integral with the tube envelope and constitutes the safety plate for the crt.

As described previously, the tube is operated with no panel astigmatism control. An internal astigmatism control is provided to accommodate tube interchanges.

TRANSISTORIZED POWER SUPPLIES

The low-voltage power supply has been transistorized for high efficiency and long-term maintenance-free operation. Turn-on voltages are kept within safe values so that a time-delay relay is not required. In addition, the power supply is insensitive to loading, enabling it to handle wide variations in plug-in power requirements. This gives the oscilloscope the feature that plugs can be changed without turning off the instrument.

Virtually all of the tubes are operated from a regulated dc filament supply which minimizes hum, increases tube life and provides excellent stability.

1% CALIBRATOR

The internal square-wave calibrator is accurate within 1% over a temperature range of ±10°C from the temperature at which it was calibrated, and over the much wider range of from 0°C to 55°C its accuracy is ±3%. The calibrator has a low output impedance and is provided with front panel outputs for use in probe compensation and gain calibration of the vertical and horizontal amplifiers.

ACCESSIBILITY AND SERVICEABILITY

Simplicity of design has been extended to all aspects of the instrument, and two important features, accessibility and serviceability, are apparent at first glance. By utilizing the new -hp-modular cabinet design, a clean, uncluttered mechanical layout has been obtained. Also, all internal adjustments and components are easy to get to, and all circuits are plated-through printed circuit boards with "edge-on" type lead connectors. These connectors, which are recognized for high reliability and ease of servicing in the computer industry, permit extremely easy removal of any printed circuit board in a minimum of time without unsoldering leads.

A minimum number of tube and transistor types are used in the Model 175A to simplify mainte-
nance. The reliable 6D18 frame-grid triode is used extensively throughout the oscilloscope. All tubes are replaceable either from the top or the bottom of the unit. Components have been derated to increase dependability and all circuits have been proven through extensive environmental tests.

**WIDE BANDWIDTH PROBE**

A new 10:1 voltage divider probe has been designed to be compatible with the bandwidth of the Model 1750A 40-mc plug-in. The new probe has the same physical size and shape of the well-known present Model HP-6B oscilloscope probe.

**GENERAL**

The oscilloscope includes the positive and simple -hp- beam finder control on the front panel to facilitate the immediate location of an off-screen trace. Sweep and gate outputs are available on the rear panel as an option. Both output levels are approximately 5 volts peak-to-peak, centered around ground. The external Z-axis modulation input is provided on the rear panel and is standard for all Model 175A's.

The oscilloscope is fan-cooled and has a maximum weight of approximately 70 pounds.

**ACKNOWLEDGMENT**

The design and development of the 175A Oscilloscope and its plug-ins represents the effort of a number of individuals in the -hp- Oscilloscope Research Division. Included were Al F. Augustine, Phillip G. Foster, William L. Grein, Wayne M. Grove, Tom D. McLaughlin, Don L. Palmer, John W. Riggen, Stuart C. Slade, Allen R. Smith, and James D. Williams, and the undersigned. William Kruger's design of the cathode-ray tube was a key contribution to the development of the oscilloscope. A number of valuable ideas and suggestions were contributed by Oscilloscope Research Manager Norman B. Schrock.

--Floyd G. Siegel

---

**SPECIFICATIONS**

**HORIZONTAL PLUG-INS**

**-hp-**

**MODEL 1781A**

Sweep Delay Generator

(In installed in the -hp- Model 175A)

- Delay Time; 1 usec to 10 sec. Delay Time is the product of the DELAYING SWEEP setting in sec/cm, and the DELAY LENGTH setting in cm.
- Delaying Sweep; 2 usec/cm to 1 sec/cm. 18 calibrated ranges in a 1, 2, 5, 10 sequence.
- Delay Length; (the physical location, in cm from the beginning of the trace, to the point at which the main sweep is triggered) 0 to 10 cm.
- Accuracy: ±1% 2 usec to 0.1 second ranges; ±3% 0.2, 0.5, 1 second ranges. ±0.2% linearity, all but 2, 5, and 10 usec ranges. ±0.5% linearity, 2, 5, 10 usec ranges. Jitter: Less than 0.01 usec or ≤0.005% of total delay.
- Delay Functions; (a) Trigger main sweep. (b) Arm main sweep.
  - Triggering; Internal, ac-coupled; power line; external, ac or dc coupled, (2 mm or more vertical deflection. External, 1/2 volt peak-to-peak or more.)
  - Triggering Point; Controls allow selection of level and slope. Trigger level of external signal adjustable -30 to +30 volts.
  - Sweep Selector; (a) Main Sweep. (b) Delaying Sweep. Brightened segment of trace indicates time relationship between delaying sweep display and main sweep display. (c) Main Sweep Delayed. (d) Mixed Sweep.
- Delayed Trigger Output; Approximately 20 volts positive.
- Single Sweep; Manual or external arming.
- Power; Supplied by Model 175A Oscilloscope.
- Weight: Net 4/5 lbs. Shipping 7 lbs.
- Price: $375.00 f.o.b. factory.

**-hp-**

**MODEL 1780A**

Auxiliary Plug-In

(In installed in the -hp- Model 175A)

- Sweep Occurrence; NORMAL or SINGLE SWEEP.
- Sweep Arming; Internal or by external pulse.
- External Arming Pulse Required; 1 to 200 usec, approximately +15 to -25 volts peak.
- Input Connector; BNC.
- Weight; Net 1 lb.
- Price: $25.00 f.o.b. factory.

**-hp-**

**MODEL 1782A**

Display Scanner

(In installed in the -hp- Model 175A)

- Vertical Output; Approximately 200 mv/cm. Gain and dc level are independently adjustable.
- Horizontal Output; 0 cm: approximately ±50 volts; 10 cm: approximately ±50 volts.
- Bandwidth; Greater than 20 mc when installed in Model 175A.
- Scanning; Manual, internal (with pen speed either stabilized or linear), or external.
- Scanning Time; Internal; linear; approximately 1/2 minutes. Internal, with pen speed stabilized; approximately 25 seconds when displaying time base only.
- Oscilloscope Sweep Speed; From fastest sweep to 5 usec/cm; signal repetition rate greater than 20 cps.
- Remote Pen Lift; Contact closure provided to facilitate pen lift on X-Y recorder when switching from RECORD to ARM RECORDER.
- Price: $25.00 f.o.b. factory.

-hp-**

**MODEL 1783A**

Time Mark Generator

(In installed in the -hp- Model 175A)

- Intensity Modulation; Range; 10 usec, 1 usec, or 0.1 usec intervals. Accuracy; ±0.5%.
- Presentation; Trace-intensifying marks with duration a function of intensity, but always less than 40% of marker interval. Synchronization: Triggered by sweep gate; synchronized to CRT presentation.
- External Output Markers; Range; 10 usec, 1 usec, or 0.1 usec intervals. Accuracy; ±0.5%.
- Amplitude; 0 to 1 volt peak (positive) into open circuit, adjustable.
- Waveform; Positive polarity clipped sine wave with duration a function of amplitude, but always less than 40% of marker interval.
- Output Impedance; Approximately 75 ohms.

**FUNCTIONS**

- Time Marker; Off—marker de-energized. Output—markers provided at BNC output jack. Display—markers provide synchronized intensity modulation of display (intensity modulation control set to INTERNAL). Intensity Modulation; External provides input for normal intensity modulation. Internal allows intensity modulation of trace. (Time markers set to DISPLAY.)

**GENERAL**

- Power; Supplied by -hp- Model 175A Oscilloscope.
- Weight; Net 3/2 lbs. Shipping 6 lbs.
- Price: $130.00 f.o.b. factory.

**ACCESSORIES AVAILABLE**

- AC-76A Adaptor (BNC to binding post).
- AC-166 Cable (dual banana plug to male BNC, 45 inches long).
- AC-16K Cable (male BNC to male BNC, 48 inches long).
- AC-76A Adaptor (BNC to binding post).

---

WWW.HPARCHIVE.COM
SWEEP GENERATOR
Sweep Range: 0.1 µsec/cm to 5 sec/cm in 1, 2, 5, 10, 24 steps. Vertically provides continuous adjustment between ranges and extends slowest sweep to at least 12.5 sec/cm.
Sweep Magnification: X10.
Sweep control: 2 cps to 40 mc.
Sweep input: 0 to 5 volts.
Sweep Input: 0 to 5 volts.
Sweep accuracy: ±3% with X10 magnifier.
Triggering: Internal, pc power; external, ac or dc coupled.
Triggering sensitivity: Internal, 2 mm vertical deflection at 1 mc, 2 cm at 50 mc. External, 25 volts peak-to-peak at 1 mc, 5 volts peak-to-peak at 30 mc.
Triggering Point: Controls allow selection of level and slope.
HORIZONTAL AMPLIFIER
Bandwidth: Dc coupled, DC to 500 kc; AC coupled, 2 cps to 500 kc.
Sensitivity: 2 ranges, 0.1 volt/cm and 1 volt/cm. Vernier provides continuous adjustment between the ranges and extends minimum sensitivity to 10 volts/cm.
Input impedance: 1 megohm shunted by approx. 30 pf.
MAIN VERTICAL AMPLIFIER
Rise Time: Less than 7 nsec.
CALIBRATOR
Type: Approx. 1000 cycle square wave, approx. 50 mv/cm.
Voltage: 2 ranges, 1 and 10 peak-to-peak ±1% at 10°C to 35°C ambient; ±3% at 0°C to 55°C ambient.
CATHODE RAY TUBE CONTROLS
Type: Post accelerator, 12 kv accelerating potential.
- hp- MODEL 175A OSCILLOSCOPE
SPECIFICATIONS
SPECIFICATIONS
VERTICAL PLUG-INS
MODE 175A DUAL TRACE AMPLIFIER
(Installed in the -hp- Model 175A)
MODE 175A DUAL TRACE AMPLIFIER
(Installed in the -hp- Model 175A)

- hp- MODEL 175A DUAL TRACE AMPLIFIER
- hp- MODEL 175A DUAL TRACE AMPLIFIER
(Installed in the -hp- Model 175A)
(Installed in the -hp- Model 175A)

- hp- MODEL 175A DUAL TRACE AMPLIFIER
- hp- MODEL 175A DUAL TRACE AMPLIFIER
(Installed in the -hp- Model 175A)
(Installed in the -hp- Model 175A)

- hp- MODEL 175A DUAL TRACE AMPLIFIER
- hp- MODEL 175A DUAL TRACE AMPLIFIER
(Installed in the -hp- Model 175A)
(Installed in the -hp- Model 175A)

- hp- MODEL 175A DUAL TRACE AMPLIFIER
- hp- MODEL 175A DUAL TRACE AMPLIFIER
(Installed in the -hp- Model 175A)
(Installed in the -hp- Model 175A)

- hp- MODEL 175A DUAL TRACE AMPLIFIER
- hp- MODEL 175A DUAL TRACE AMPLIFIER
(Installed in the -hp- Model 175A)
(Installed in the -hp- Model 175A)

- hp- MODEL 175A DUAL TRACE AMPLIFIER
- hp- MODEL 175A DUAL TRACE AMPLIFIER
(Installed in the -hp- Model 175A)
(Installed in the -hp- Model 175A)

- hp- MODEL 175A DUAL TRACE AMPLIFIER
- hp- MODEL 175A DUAL TRACE AMPLIFIER
(Installed in the -hp- Model 175A)
(Installed in the -hp- Model 175A)

- hp- MODEL 175A DUAL TRACE AMPLIFIER
- hp- MODEL 175A DUAL TRACE AMPLIFIER
(Installed in the -hp- Model 175A)
(Installed in the -hp- Model 175A)

- hp- MODEL 175A DUAL TRACE AMPLIFIER
- hp- MODEL 175A DUAL TRACE AMPLIFIER
(Installed in the -hp- Model 175A)
(Installed in the -hp- Model 175A)

- hp- MODEL 175A DUAL TRACE AMPLIFIER
- hp- MODEL 175A DUAL TRACE AMPLIFIER
(Installed in the -hp- Model 175A)
(Installed in the -hp- Model 175A)

- hp- MODEL 175A DUAL TRACE AMPLIFIER
- hp- MODEL 175A DUAL TRACE AMPLIFIER
(Installed in the -hp- Model 175A)
(Installed in the -hp- Model 175A)