



*Manufacturers of*

**CATHODE - RAY OSCILLOSCOPES  
AND VIDEO TEST INSTRUMENTS**

MARCH 1952

## **O**UR CONTINUING CREED

*is that of serving Tektronix customers with products and policies that are unexcelled in the electronics industry and limited only by the current state of the art.*



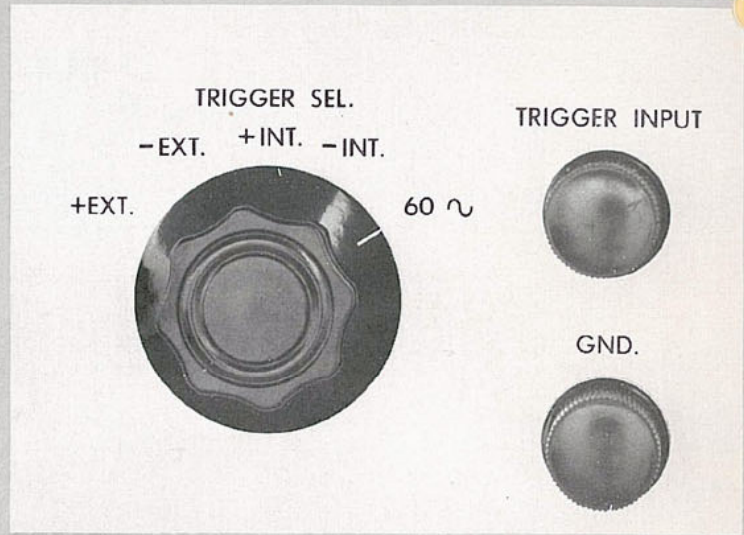
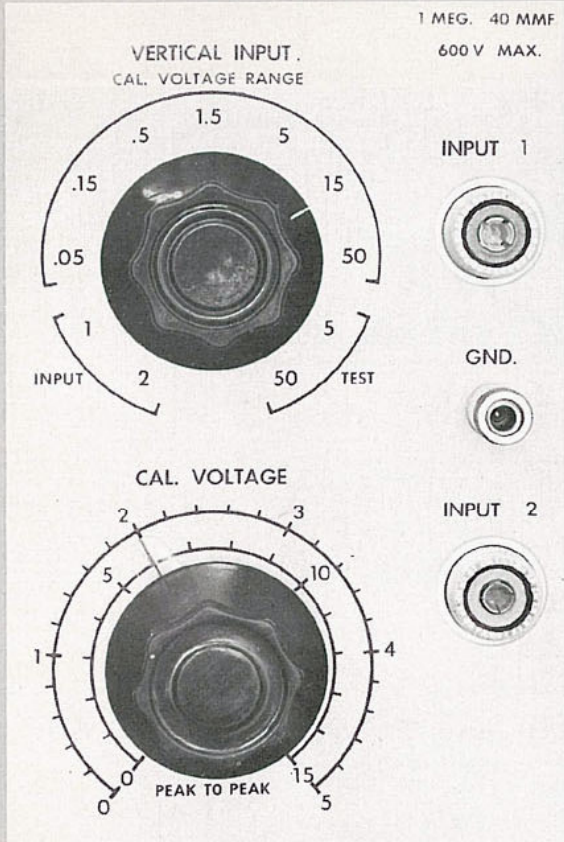
TEKTRONIX INC.

## TEKTRONIX, INC.

*was organized and incorporated in January 1946 for the purpose of developing and manufacturing cathode ray oscilloscopes. The owners all had extensive wartime electronic experience, in either military or civilian capacities. All hold active supervisory or engineering positions in the organization.*

*In reviewing this backlog of experience, a large portion of which pertained to oscilloscopes, it was felt that a valuable contribution could be made in this field. This decision has been strengthened by the passage of time, and by the exceptional response of science and industry to the efforts that have been put forth.*

*The primary interest of Tektronix is the further development and improvement of the oscilloscope, not only as a "quality observation" device but, increasingly, as an accurate tool capable of precise quantitative measurements of time and amplitude. All present efforts are toward accomplishment of this goal, and all other Tektronix instruments have been developed for the purpose of supplementing and augmenting the operation of the oscilloscope.*



**VOLTAGE CALIBRATOR OF TYPE 514D OSCILLOSCOPE**

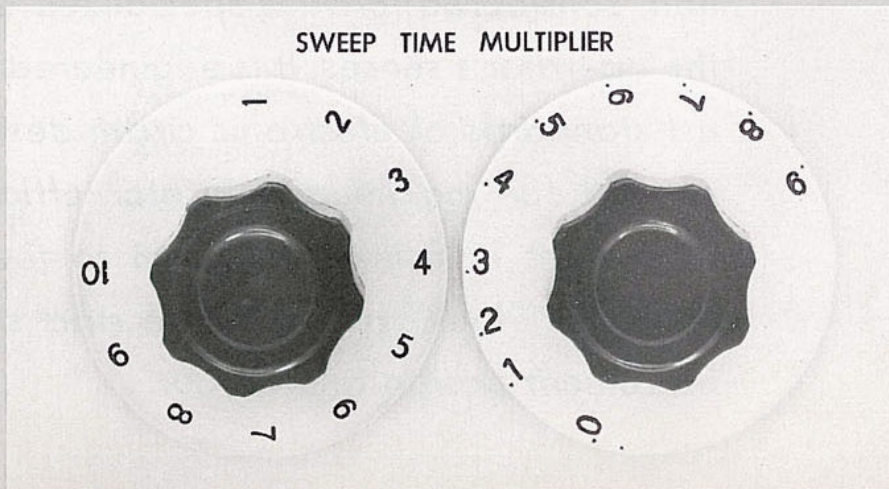
**AMPLITUDE CALIBRATION**—Every Tektronix Oscilloscope contains a built-in voltage calibrator which provides an amplitude measuring facility. According to the type of instrument, the calibrating waveform consists of a 60 cycle square wave, a 1 kc multivibrator controlled square wave, or a 25 kc multivibrator controlled pulse.

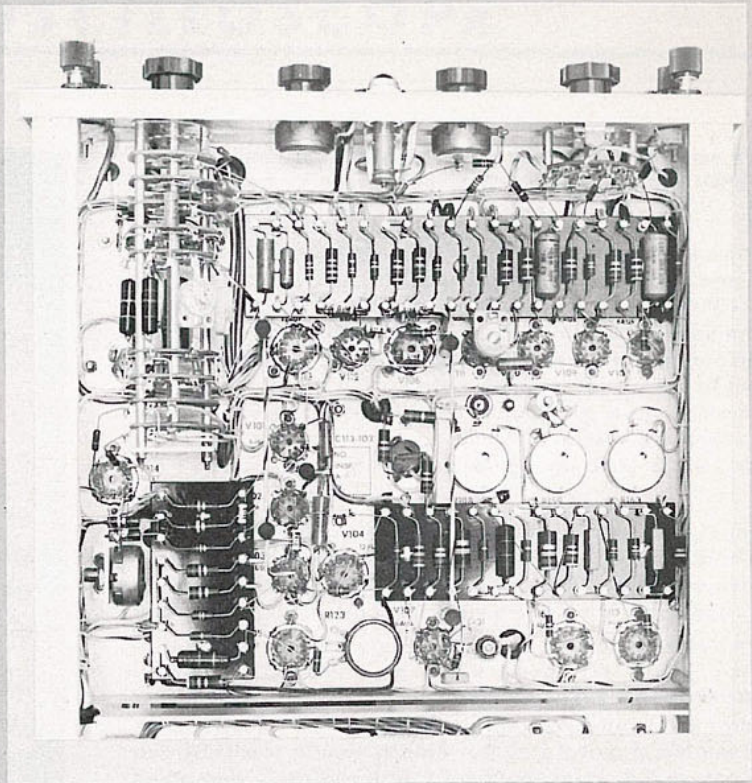
**TRIGGER SELECTOR OF TYPE 511AD OSCILLOSCOPE**

**TRIGGER SELECTION**—A multi-position switch, mounted on the front panel of Tektronix Oscilloscopes, permits the instrument to be triggered from an observed signal or an external source of negative or positive polarity, or from the 60 cycle line voltage.

**SWEEP DIALS OF TYPE 513D OSCILLOSCOPE**

**DIRECT READING SWEEP DIALS**—Any "time of occurrence" data, required when measuring an observed waveform, is very simply obtained with Tektronix Oscilloscopes. The sweep indicator dials are calibrated directly in "time/unit distance," and one has only to refer to the illuminated graticule markings to measure the time intervals desired.





**SWEEP STABILITY CONTROL OF TYPE 514D OSCILLOSCOPE**

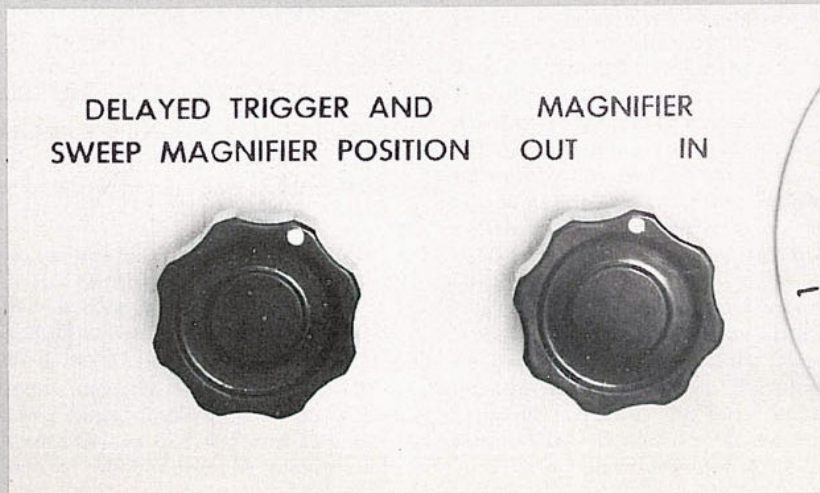
**SWEEP OPERATION** — A simple adjustment of a single control is sufficient to observe a phenomenon which occurs only once, takes place at irregular intervals or recurs with unerring precision. The setting of the sweep stability control determines whether the sweep generator is triggered into operation or is "free-running."

**SWEEP CHASSIS OF TYPE 512 OSCILLOSCOPE**

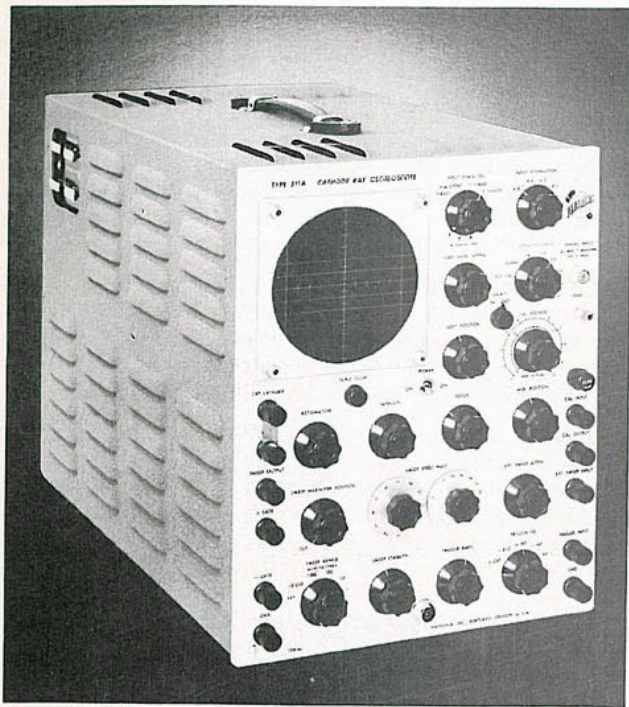
**MAINTENANCE** — Ease of maintenance is a prime consideration in the design and construction of a Tektronix Oscilloscope. Components are mounted on boards, leads are fully color-coded, all component parts and connections are exposed as much as possible and every effort is made to make the interior of the instruments accessible to the technician.

**SWEEP MAGNIFIER CONTROLS OF TYPE 512 OSCILLOSCOPE**

**SWEEP MAGNIFICATION** — To aid in determining the characteristics of a circuit, detailed scrutiny of certain portions of a waveform is sometimes necessary. Tektronix Oscilloscopes simplify this type of observation with a Sweep Magnifier Control, which enables any 20% of the sweep to be examined at a magnification of 5 times.



# CATHODE-RAY OSCILLOSCOPE



## TYPE 511A TYPE 511AD

### GENERAL DESCRIPTION

The Tektronix **Type 511A** Cathode Ray Oscilloscope is a moderately priced portable instrument utilizing a 5" tube.

Its continuously variable triggered sweep circuit synchronizes readily with frequencies as high as 10 megacycles, thus extending oscillographic methods into the broadcast and medium frequency communication bands. The combination of a wide range of triggered sweeps and the excellent transient response of the vertical deflection system, makes possible the observation of a wide variety of pulses and other non-sinusoidal waveshapes.

Both time and amplitude calibrations are provided, permitting quantitative measurements.

### VERTICAL DEFLECTION SYSTEM

The **Type 511A** is equipped with a very flexible vertical deflection system capable of amplifying or attenuating, as necessary, a wide range of waveshapes. Some of the more important features are:

**Input Channel Selector**—Since the best amplifiers have their limitations, it is desirable to use the minimum number of stages which will give the necessary gain. To make it convenient to do this a switching system is employed which connects the SIGNAL INPUT binding post to the deflection plates in four ways; directly, via a coupling condenser, or via a one or two stage amplifier. This gives the **Type 511A** three basic sensitivities: .25, 2.5 and 25 V per cm. The input impedance of all channels is maintained

equal within 1%, making possible the use of the same RC compensated attenuator for any position of the INPUT CHANNEL SELECTOR.

**Input Attenuator**—An RC compensated attenuator with ratios of 1, 2, 4, and 8 provides sensitivities between those which are made available by the INPUT CHANNEL SELECTOR. Since the attenuator is usable on all positions of the INPUT CHANNEL SELECTOR, sensitivities ranging from .25 to 200 V per cm are available. The design of the attenuator is such that its input impedance is the same as that of the oscilloscope alone. Thus, the input impedance of the **Type 511A** is always the same regardless of the control settings.

**Wideband Amplifier**—The vertical amplifiers in the **Type 511A** are designed to provide optimum transient response consistent with reasonable gain and image size. Both high and low frequency compensation is employed.

The high frequency compensation of each oscilloscope is adjusted by observing a one megacycle square wave having a rise time of .02 microseconds. When the compensation is adjusted to provide the optimum rate of rise without overshoot a very smooth response curve is obtained, being only 3 db down at 10 megacycles with one stage, and 3 db down at 8 megacycles with two stages. (Fig. 1.)

The low frequency compensation of each stage is adjusted to produce the flattest top on a 60 cycle square wave. When properly adjusted, the tops are flat within  $\pm 3\%$ . (Fig. 2.)

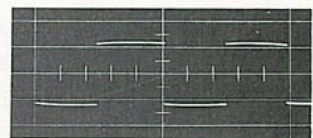
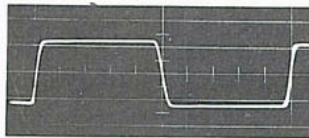


Fig. 1. 1 megacycle square wave. Fig. 2. 60 cycle square wave.  
Response of 2 Stage Vertical Amplifier.

A cathode follower precedes the output stage to permit the use of a low impedance gain control, thus providing continuously variable attenuation between the steps of the input attenuator.

**Signal Delay Network**—If it is desired to observe the front of a pulse which is being used to trigger the sweep, a delay must be inserted in the signal channel. This may be accomplished by the use of the 24 section Tektronix **Type 1-AD-25** delay network. This delays the signals .25 microsecond without appreciably affecting the pulse shape. All necessary mounting holes are drilled in the **Type 511A** chassis so that incorporation of the network may be accomplished by the owner at any time. When the delay network is not needed, it may be removed by means of a panel switch. If the delay network is installed at the factory, the oscilloscope is designated **Type 511-AD**.

**Probe**—Since the input impedance of the **Type 511A** is the same for any position of the controls it is possible to decrease the loading on the circuit under observation by the use of an RC probe. The probe furnished with the instrument increases the input impedance from 1 megohm shunted by 40 mmf to 10 megohms shunted by 14 mmf, introducing an attenuation of ten.

# CATHODE-RAY OSCILLOSCOPE

## HORIZONTAL DEFLECTION SYSTEM

One of the most important features of the **Type 511A** is its very versatile sweep system. The sweep generator used employs a commercial adaptation of widely used radar circuits. A brief description of its more important points follows:

**Triggered Sweep**—A continuously variable, linear, triggered sweep, covering the range of .01 sec/cm to .1 microsec/cm, is available for the first time in a moderately priced oscilloscope. With this type sweep, the beam is cut off in its normal rest position at the left side of the screen until it is turned on and released by an external trigger signal or by the waveshape under observation. It then moves across the screen at a speed determined by the setting of the **SWEEP RANGE** and **SWEEP SPEED MULTIPLIER** controls. At the end of the sweep, the beam is cut off and rapidly returned to the left side of the screen to await another trigger. This type circuit enables the operator to vary the sweep speed without upsetting the synchronism as is inevitable with a conventional sawtooth or recurrent sweep.

The use of a wide band trigger amplifier permits the sweep to be readily synchronized with sine waves of frequencies as high as 10 megacycles or pulses as short as .05 microsecond. Fig. 3 illustrates the excellent linearity of even the fastest sweep and the ability to observe high frequency signals. When triggered by a sharp pulse, the sweep is started and the cathode ray tube is unblanked in less than .1 microsecond.

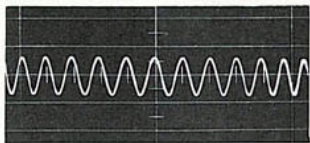


Fig. 3. 10 megacycle sine wave.

**Recurrent Sweep**—If it is desirable to have a sweep without the necessity of providing a trigger, a conventional sawtooth sweep may be obtained merely by readjusting the **SWEEP STABILITY** control.

**Single Trace Sweep**—The triggered sweep in the **Type 511A** inherently provides for single sweep operation. Single sweeps can be triggered either by pulses or by grounding the **TRIGGER INPUT** binding post with a mechanical switch.

**Trigger Selector**—The **TRIGGER SELECTOR** switch enables the sweep to be started by either positive or negative triggers from an external source, from the signal via the vertical amplifier, or from the 60 cycle line voltage.

**Calibrated Sweep Speeds**—The time in microseconds for the sweep to cross the ruled portion of the graticule can be determined with an error of less than 3% of full scale reading by multiplying the **SWEEP RANGE** setting by the readings on the **SWEEP SPEED MULTIPLIER** dials.

**Sweep Speed Magnifier**—A control on the panel allows any selected 20% of the sweep to be amplified five times and thus expanded to cover the entire trace. (Figs. 4, 5.) This is especially useful in examining widely spaced waveshapes such as television sync. pulses.

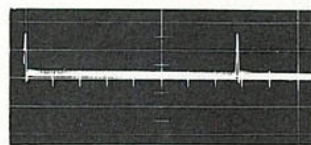


Fig. 4. Sweep magnifier off.  
20 Microsecond Pulse.

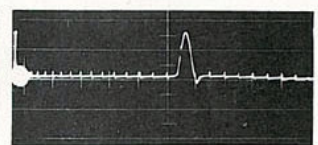
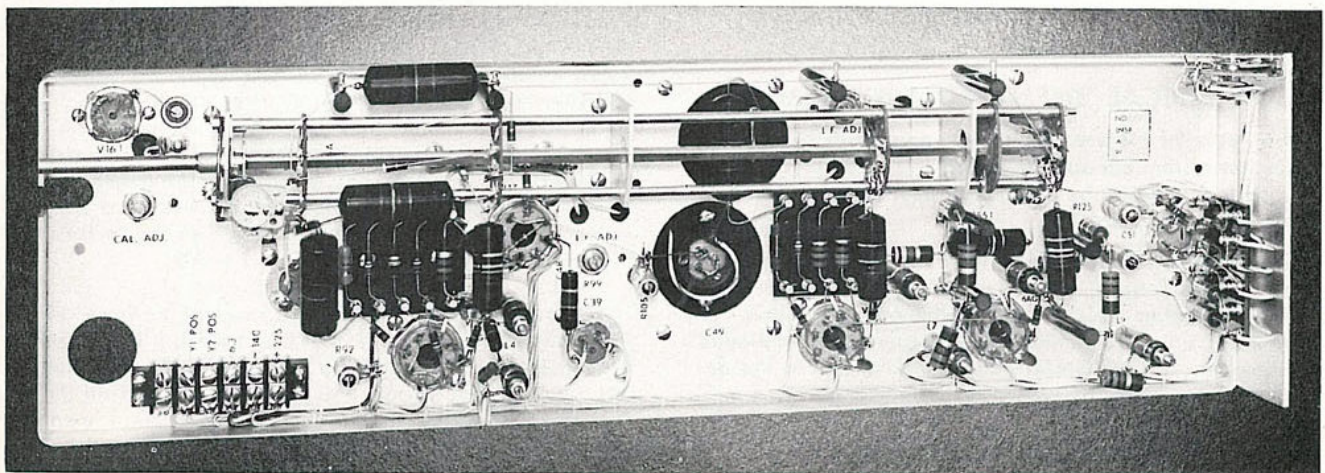


Fig. 5. Sweep magnifier on.  
20 Microsecond Pulse.

**External Sweep**—The **EXTERNAL SWEEP INPUT** binding post is connected to the horizontal deflection plates via the **EXTERNAL SWEEP ATTENUATOR** and a one stage push-pull amplifier. The entire system is DC coupled, permitting the use of very slow sweeps.

## OTHER FEATURES

**Deflection Polarity Switch**—To increase the undistorted deflection when observing pulses of a particular polarity, provision is made to move the operating point of the push-pull output amplifier from its normal position to one which allows almost the entire output swing to be



# CATHODE-RAY OSCILLOSCOPE

utilized in either one direction or the other.

A three-position lever-type switch mounted at the rear of the Type 511-A and 511-AD permits the operating bias on grid No. 1 of V19 to be varied. With the switch set at the center (normal) position, the bias applied to V19 is equal to the bias of V18, resulting in balanced operation and equal upward and downward undistorted deflection of the trace.

If it is desired to observe pulses, the switch should be set in either the upward or downward position, corresponding to the deflection of the image on the cathode ray tube. In the upward position, the bias of V19 is increased, resulting in decreased output of V19 and increased output of V18, thus permitting greater undistorted upward deflection. These conditions are reversed when the deflection polarity switch is in the downward position.

**Regulated Power Supply**—All DC voltages including the accelerating potential for the CRT are obtained from an electronically regulated supply. Sweep speed, vertical deflection sensitivity and image brightness are unchanged by line voltage variations from 105 to 125 volts. The image stability thus obtained saves many hours of engineering time when quantitative measurements are being made.

**Voltage Calibration**—A 60 cycle square wave calibrating voltage is provided to measure by comparison the amplitude of the waveshapes under observation. This is continuously variable, by means of a calibrated potentiometer, from 100 millivolts to 100 volts peak to peak, in six ranges.

**Illuminated Graticule**—An illuminated graticule aids in the measurement of amplitude and duration of waveshapes being observed. By edge lighting the graticule, fine red lines are visible, which do not obscure the tube trace. A color filter is provided to increase the contrast of the trace when viewed in brightly lighted rooms.

**Deflection Plate Connections**—Although a signal can be supplied directly to the deflection plates from the front panel, a side panel is provided which allows the use of short leads to provide a low capacity direct connection to all plates.

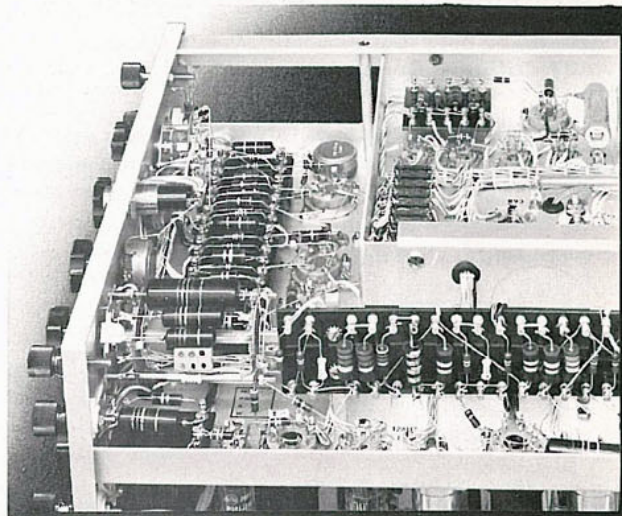
**Output Waveshapes**—The sweep sawtooth, and positive and negative square wave gate pulses, having the same duration as the sweep, are available on the front panel.

**CRT Cathode Connection (Z Axis)**—A binding post is provided on the panel for the purpose of receiving blanking pulses or brightness time markers, etc.

## CONSTRUCTION

The **Type 511A** is constructed of the highest quality materials throughout. The three chassis, metal framework, case and front panel are all made of light, strong, electrically welded, aluminum alloys. The various chassis are supported in a frame making possible a compact instrument with all components readily accessible.

Satin finished aluminum with photo etched lettering is used for the front panel. A light gray baked wrinkle finish is used on the cabinet.



## CHARACTERISTICS

**Signals Observable**—Sine waves, 10 cycles to 10 mc. Pulses, .1 microsecond to 1/50 sec.

**Sweep Circuit**—Hard tube type, either triggered or recurrent as desired.

**Sweep Speeds**—Continuously variable, .1 sec to 1 microsecond for a sweep length of 10 cm.

**Trigger Requirements**—.5 to 50 V (peak) sine wave, or pulses as short as .05 microsecond.

**Sweep Lag**—.1 microsecond, max.

**Sweep Magnification**—5 times indicated sweep speed.

**External Sweep Input**—DC coupled via 100 K pot. and sweep amplifier. Maximum deflection sensitivity, 1.6 V per cm. DC or peak to peak AC.

**Input Attenuator Ratios**—2, 4 and 8. An additional 10 times available by use of PROBE.

**Vertical Deflection Sensitivity**—(peak to peak).

Without amplifier, 25 V per cm.

With 1 stage, 2.5 V per cm.

With 2 stages, .25 V per cm.

**Input Impedance**—1 meg. shunted by 40 mmf PROBE, 10 meg. shunted by 14 mmf.

**Vertical Amplifier Bandwidth**—(3 db down from 1 mc response)

1 stage, 5 cps to 10 mc.

2 stages, 5 cps to 8 mc.

**Vertical Amplifier Transient Response**—

Rise time (10% to 90%):

1 stage, .04 microsecond;

2 stages, .05 microsecond.

**Calibrating Voltage**—Line frequency square wave ranges, .3 V, 1 V, 3 V, 10 V, 30 V and 100 V peak to peak. Accuracy 3% of full scale.



# CATHODE-RAY OSCILLOSCOPE

**Waveforms Available**—Sweep sawtooth, positive and negative gates.

**CRT Cathode Connection** — Via .1 mfd capacitor RC=.012 sec.

**Cathode Ray Tube**—A Type 5CPA tube is used with accelerating potential of 3 kv. The P-1 screen is normally supplied, with P-7 or P-11 screens optional at no additional cost.

**Power Requirements**—105-125/210-250 volts, 50-60 cycles, 240 watts.

**Weight**—55 pounds complete with accessories.

**Dimensions**—15 1/2" high, 12 1/2" wide, 21 1/2" deep.

## Vacuum Tube Complement

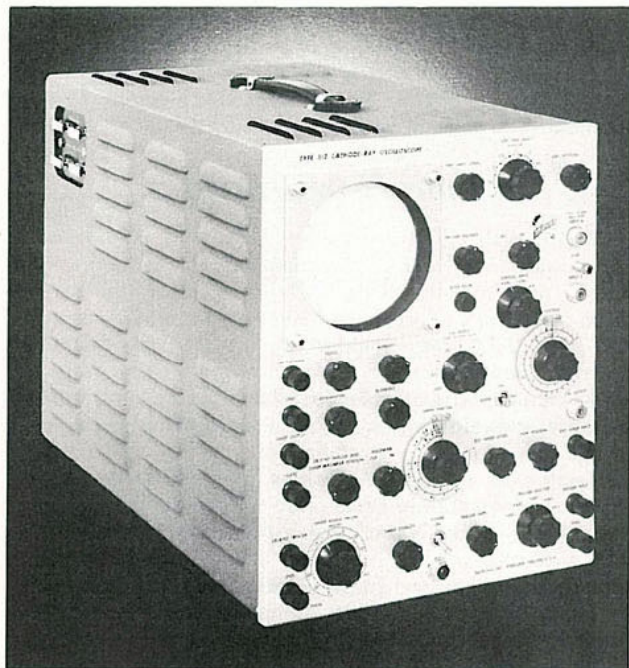
Trigger Phase Splitter . . . . .	6AC7
Trigger Amplifier . . . . .	6AG7
Trigger Coupling Diode . . . . .	6AL5
Multivibrator . . . . .	6AC7
Multivibrator . . . . .	6AG7
Unblanking Amplifier and Cathode Follower . . . . .	12AT7
Gate Output Phase Splitter . . . . .	6C4
Sweep Generator . . . . .	6AG7

Sweep Output Cathode Follower . . . . .	6C4
Sweep Magnifier . . . . .	6J6
Magnified Sweep DC Restorer . . . . .	6AL5
Sweep DC Restorer . . . . .	6AL5
Sweep Amplifier . . . . .	2-6AU6
Sweep Voltage Regulator . . . . .	6C4
Video Amplifier, 1st Stage . . . . .	6AG7
Cal. Clipper and Cathode Follower . . . . .	12AT7
Video Amplifier, 2nd Stage . . . . .	2-6AG7
Video Amplifier, Gain Control Cathode Follower . . . . .	6AG7
Low Voltage Rectifier . . . . .	2-5V4G
Low Voltage Regulator . . . . .	6AS7G
Low Voltage Regulator Amplifier . . . . .	6AU6
Voltage Reference . . . . .	5651
Sweep Supply Rectifier . . . . .	6X4
Sweep Supply Regulator . . . . .	6AQ5
Sweep Supply Regulator Amplifier . . . . .	6AU6
High Voltage Supply Oscillator . . . . .	6AQ5
High Voltage Supply Rectifier . . . . .	2-1Y2
Bias Rectifier . . . . .	6X4
Bias Regulator . . . . .	OD3
Cathode Ray Tube . . . . .	5CP—A

**Price, Type 511A \$795.00** f.o.b. Portland, Oregon.

**Price, Type 511AD \$845.00** f.o.b. Portland, Oregon.

# CATHODE-RAY OSCILLOSCOPE



## TYPE 512

### GENERAL DESCRIPTION

The TEKTRONIX Type 512 is a portable precision laboratory instrument incorporating direct coupled amplifiers throughout. Its sensitivity of 5 mv/cm DC and sweeps as slow as .3 sec/cm solve many problems confronting workers in the fields where comparatively slow phenomena must be observed. The vertical band width of 1 mc at maximum sensitivity (2 mc at lesser sensitivity) and sweeps as fast as 3 microsec./cm make it an excellent general purpose oscilloscope as well.

### VERTICAL DEFLECTION SYSTEM

**Direct Coupled Amplifier** — A high-gain direct-coupled wide-band vertical amplifier provides for observation of an extremely wide range of wave forms. The amplifier is divided into two sections, a pre-amplifier and an output amplifier, each having two push-pull stages. Both sections are used only in the three most sensitive positions of the vertical deflection sensitivity control, i.e. 5 to 150 mv/cm. In the first five positions, with only the output amplifier in use, a bandwidth of 2 mc is available. Because of the requirements of low drift, hum, grid current, etc., the bandwidth of the pre-amplifier is limited to 1 mc by the available tubes. As in all Tektronix instruments, primary emphasis is placed on obtaining excellent transient response rather than flat sine wave response. Each oscilloscope is adjusted for optimum transient response, with sine wave measurements made as an additional check. Since it is frequently desirable to observe only the AC components, a switch on the front panel permits optional insertion of coupling capacitors. To insure stability when operating as a DC amplifier, the heaters of the 1st,

2nd, cathode follower and 3rd stages are supplied by direct current from an electronically regulated power supply.

**Balanced Differential Input** — Extreme versatility of input is provided by a differential amplifier which permits optional single ended or push-pull input. In the push-pull connection the differential feature minimizes effects of the in-phase components. At full gain of the amplifier, one volt of in-phase signal will produce less deflection than 5 mv applied between the inputs. The differential input also provides a ready means of mixing two signals without interaction or frequency discrimination.

The Type 512 Oscilloscope permits full cycle observation of frequencies as low as 1/3 cps or of pulses as long as 3 sec. It can be synchronized with frequencies of at least 1 mc or higher, and pulses of as short as 1  $\mu$ sec will trigger the sweep.

**Sensitivity Control** — Two controls are provided to enable the Type 512 to display a wide range of signal amplitudes. The vertical deflection sensitivity control inserts RC compensated attenuators and simultaneously removes or inserts the pre-amplifier as necessary to provide eight degrees of sensitivity in steps of approximately three times. The second control is a low impedance potentiometer in a cathode follower circuit giving continuous attenuation to fill in the steps. All attenuators are in balanced pairs on both sides of the push-pull amplifier.

**Direct Connection to Deflection Plates** — Since it is often desirable to make a low capacity, direct connection to the deflection plates, terminals are accessible externally through a side panel in the case. The terminals are of the banana jack type, being inter-connected with jumper plugs.

**Probes** — The Type 512 is supplied complete with 2 probes on 42-inch cables. The probes have an attenuation of ten and an input impedance of 10 megohms with a capacity of approximately 14 mmf.

### HORIZONTAL DEFLECTION SYSTEM

**Sweep Generator** — The Type 512 employs a screen-coupled phantastron as the basic sweep generator. An adaptation of a circuit developed in England during World War II, it is similar to the well known "bootstrap" circuit used in the United States in radar applications. One of the important differences is that the output is taken from the plate, rather than from the cathode circuit, doing away with the necessity for a floating power supply between the grid and cathode.

The circuit is capable of excellent inherent linearity, which makes it ideal for precision sweep generation. It is additionally useful because the positive screen pulse is available for operating the blanking circuits.

**Sweep Amplifier** — The sweep amplifier, which is direct-coupled, provides the 350 v swing necessary to deflect the electron beam from one side of the CRT screen to the other. A constant average potential at the deflection plates is maintained — by the balanced output of the stages — to prevent defocusing the spot as it moves across the screen. The gain of the amplifier can be ad-

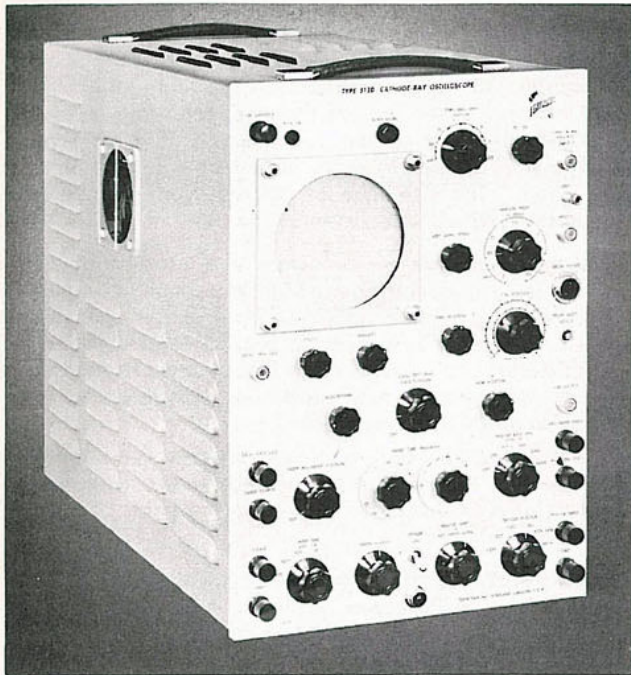
# CATHODE-RAY OSCILLOSCOPE

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Magnifier Sweep Generator . . . . .	6AU6	Vertical Main Amplifier Outputs . . . . .	2	6AG7
Magnifier Sweep and Delayed Trigger Cathode Followers . . . . .	12AU7	Vertical Amplifier Voltage Regulators . . . . .	2	12AU7
Magnifier Sweep Voltage Regulator and Clamp Diode . . . . .	12AU7	Marker Input Amplifier . . . . .		6AU6
+ Gate Amplifier and Blanking Gate Inverter	12AU7	Low Voltage Rectifiers . . . . .	4	6W4GT
Blanking Oscillator . . . . .	6AU6	High Voltage Rectifiers . . . . .	2	1V2
Calibrator Multivibrator . . . . .	12AU7	High Voltage Supply Oscillator . . . . .		6AQ5
Calibrator Diode and Output Cathode Follower . . . . .	12AU7	Voltage Reference . . . . .		5651
Blanking Bias Rectifier . . . . .	6AL5	Voltage Regulator Amplifiers . . . . .	2	6AU6
Vertical Pre-Amp. Inputs . . . . .	2	6AK6		6AS7G
Vertical Pre-Amp. Outputs . . . . .	2	12AU6		Sweep Power Supply Rectifier . . . . .
Vertical Gain Control Cathode Followers . . . . .	2	12AU6		6X4
Vertical Main Amplifier Inputs . . . . .	2	12AU6		Sweep Power Supply Regulator . . . . .
				12AU7
				Cathode Ray Tube . . . . .
				5CPA

**Price \$950.00** f.o.b. Portland, Oregon

# CATHODE-RAY OSCILLOSCOPE



## TYPE 513-D

### GENERAL DESCRIPTION

The TEKTRONIX **Type 513-D** is a portable, self-contained, precision instrument specifically designed for the study of short duration pulses. It features a 5XP type cathode ray tube with an accelerating potential of 12KV, making it particularly useful where a high writing rate is required, or when it is desired to photograph single high speed sweeps.

The direct coupled vertical amplifier, with its rise time of  $.025\mu\text{sec}$ , extends its usefulness beyond the limits of any previous cathode ray oscilloscope in general laboratory work.

Frequencies of 10 mc can be synchronized and clearly observed on this instrument. A pulse as short as  $.05\mu\text{sec}$  will serve to trigger the sweep generator, but pulses of .1 sec duration or full cycles of as low as 10 cps can be observed in their entirety.

### VERTICAL DEFLECTION SYSTEM

**Direct Coupled Amplifier** — A distributed type vertical amplifier is used which provides a sensitivity of .3 v/cm in the direct coupled position, or a maximum sensitivity of .03 v/cm when capacitively coupled. The vertical amplifier is adjusted for optimum transient response.

**Sensitivity Control** — Two controls are provided to enable the **Type 513-D** to display a wide range of signal amplitudes. The vertical deflection sensitivity control inserts RC compensated attenuators and also inserts the pre-amplifier stages in the two highest gain positions. It is variable in steps of approximately 3 to 1. The vertical

amplifier attenuator is a low impedance potentiometer providing a continuously variable attenuation of 3 to 1 to fill in the steps of the vertical deflection sensitivity control. The overall sensitivity of the vertical amplifier is continuously variable from .03 volts/centimeter to 100 volts/centimeter, peak to peak.

**A. C. - D. C. Switch** — When the direct coupled feature of the amplifier is not needed, or when it is desirable to observe only the A.C. components of the signal, this switch may be thrown to the A.C. position, inserting a coupling capacitor.

**Input Selector** — The **513-D** is equipped with two signal input connections, either of which may be used, still retaining the full bandwidth. Selection is made by the vertical input selector switch. This feature offers a convenient method of making rapid comparison between two signals.

**Constant Input Impedance** — The input impedance of 1 megohm and  $35\mu\text{mf}$  is maintained at all sensitivity settings, permitting use of R-C input probes.

**Probe** — The **Type 513-D** is supplied complete with a high impedance probe on a 42" cable. The probe is R-C compensated and has an attenuation of 10X with an input impedance of 10 megohms and a capacity of approximately 12 mmf.

**Auxiliary Power** — A power supply socket is provided for a cathode follower probe or an auxiliary amplifier stage connected close to the circuit under observation. 6.3 volts A.C. at .5 amp and 20 to 150 volts regulated D.C. at 20 ma. is available. 6.3 volts A.C. is also available from a front panel pin jack.

**Signal Delay Network** — A .25 microsecond delay network provides a means of observing the front of a pulse which is being used to trigger the sweep, by delaying the appearance of the signal until the cathode ray tube is unblanked and the sweep operating linearly.

**Amplitude Calibrator** — Amplitude calibration is accomplished by means of a comparison 1 kc square wave whose amplitude is continuously variable in 7 ranges from .05 volts full scale to 50 volts full scale. Accuracy of square wave amplitude exceeds  $\pm 2\%$  of full scale. The calibrator voltage is also brought out to a binding post so that it may be used for checking the adjustment of the probe or the R-C attenuators incorporated in the vertical amplifier, or used in conjunction with other equipment.

**Direct Connection to CRT Deflection Plates** — It is often desirable to make a low capacity-low inductance connection to the deflection plates to permit observation of extremely high speed transients which would be distorted by the amplifier. A hinged door in the side of the case permits convenient direct connection to the deflection plates.

### HORIZONTAL DEFLECTION SYSTEM

The sweep system employed in the **Type 513-D** is in most respects similar to that of the widely used TEKTRONIX

# CATHODE-RAY OSCILLOSCOPE

Type 511-A Oscilloscope.

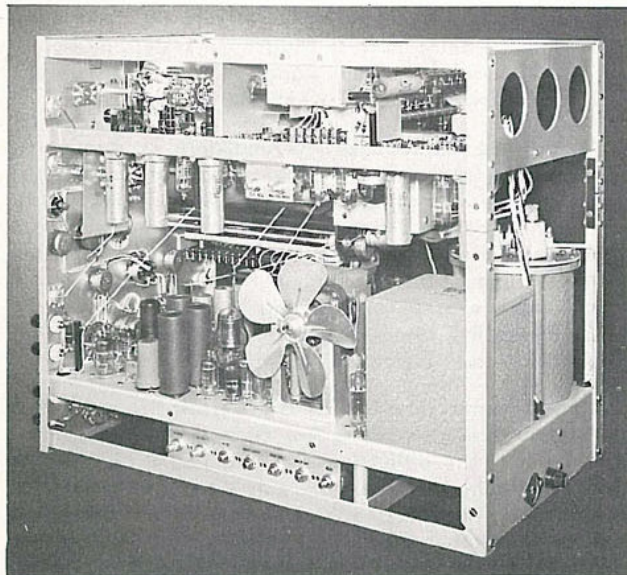
**Triggered Sweep** — A continuously variable, linear, triggered sweep is available covering the range of .01 sec/cm to .1 microsec/cm. A two dial sweep time multiplier is used which makes possible much more accurate readings than were possible with previous instruments. The sweep time is accurate to within 5% of the dial readings, permitting the **Type 513-D** to be used for many frequency and time measurements. The sweep may be readily synchronized with sine waves of frequencies as high as 10 mc. or with pulses as short as .05 microsecond. When triggered by a sharp pulse, the sweep is started, and the cathode ray tube is unblanked, in less than .1 microsecond.

**Trigger Selector** — The sweep may be triggered by an external signal of either positive or negative polarity. It may also be triggered by either the positive or negative portion of the signal under observation, or it may be synchronized with the power line frequency.

**Trigger Rate Generator** — A built-in, free running, blocking oscillator is used as a trigger rate generator. The frequency is variable in 5 steps from 200 to 5000 cycles per sec. A positive pulse of approximately 60 volts amplitude is available on a front panel binding post so that the trigger rate generator may be used to synchronize external equipment.

**Recurrent Sweep** — A conventional free running, sawtooth sweep may be obtained merely by readjusting the sweep stability control. This sweep may be readily synchronized with the waveform under observation.

**Sweep Magnifier** — A control on the panel allows any selected 20% of the sweep to be amplified five times and thus expanded to cover the entire trace.



**External Sweep** — An external sweep may be applied to the horizontal deflection plates via an attenuator and a two stage direct coupled amplifier. The maximum sensitivity is 1.6 volts (peak to peak) per cm. of deflection.

## OTHER FEATURES

**Delayed Gate** — A delayed positive gate of approximately 30 volts amplitude is available at a front panel binding post. The start of the gate may be positioned at any point on the sweep up to .3 microsecond from the start of the sweep by means of a control on the front panel. The rise time of this delayed gate is approximately .75 microseconds.

**Delayed Trigger** — In cases where a trigger of short rise time is desired, a trigger of 50 volts amplitude, across 100 ohms, is available on a separate output connector. The rise time is .1 microsecond and its total duration is approximately .25 microsecond. This delayed trigger may be positioned to any point on the sweep, from within .4 microseconds of its start.

The delayed gate and the delayed trigger may be used simultaneously if it is desired. This feature greatly extends the usefulness of the **Type 513-D** in the fields of radar, medical research, etc.

**Edge Lighted Graticule** — As in all other TEKTRONIX Cathode Ray Oscilloscopes, a plastic, edge-lighted graticule is provided. The illumination on this graticule may be adjusted by a front panel control. Centimeter lines are scribed in both the horizontal and vertical directions to facilitate accurate measurement of amplitude and duration of the waveshapes being observed. A color filter is provided to increase the contrast when viewing in a brightly lighted room.

**Output Waveforms** — Binding posts are provided on the front panel, making available, in addition to the delayed gate and trigger, the sweep sawtooth and a positive gate starting simultaneously with the sweep and of the same duration. These waveforms are taken from the outputs of cathode followers, so that the termination will not affect the operation of the instrument.

**Regulated Power Supply** — All D.C. voltages are electronically regulated. Also, the **Type 513-D** features a regulated 12 kv. accelerating voltage supply. This prevents a change in acceleration potential as the intensity is changed. It makes possible the high accuracy of the calibration on the **Type 513-D** as there is very little change of image size with a change of brightness. The **Type 513-D** is not affected by line voltage variations over the range of 105 to 125 volts.

**Intensity Modulation (Z Axis)** — A binding post is provided on the panel for the purpose of receiving external blanking pulses, time markers, etc.

## CHARACTERISTICS

**Sweep Circuit** — Hard tube type, either triggered or recurrent as desired.

**Sweep Time** — Continuously variable, .01 sec. to .1 microsecond per centimeter of deflection. Calibration accuracy 5% or better.

**Trigger Requirements** — .5 to 50 volt (peak) sine wave, pulses as short as .05 microsecond, or signal under observation producing .5 cm. deflection or more.

**Sweep Lag** — .1 microsecond, maximum.

**Sweep Magnification** — Any 20% of sweep, mag-

# CATHODE-RAY OSCILLOSCOPE

nified 5 times.

**External Sweep Input** — Coupled via 100K potentiometer and 2 stage direct coupled sweep amplifier. Maximum deflection sensitivity, 1.6 volts per cm. D.C. or peak to peak A.C.

**Vertical Amplifier** — 4 stage. 3rd and 4th stage direct coupled push-pull. Distributed output (4th) stage.

**A. C. Vertical Deflection Sensitivity** — Continuously variable from .03 volts/cm. to 100 volts/cm., peak to peak.

**D. C. Vertical Deflection Sensitivity** — Continuously variable from .3 volt/cm. to 100 volts/cm., peak to peak.

**Probe** — R-C frequency compensated. The sensitivity is reduced by a factor of 10 when the probe is used.

**Input Impedance** — 1 meg. shunted by 35 mmf. With probe, 10 meg. shunted by 12 mmf.

**Vertical Amplifier Transient Response** — Rise time (10%-90%) .025 microsecond.

**Vertical Amplifier Response** — D.C. to 18 mc. sensitivity of .3 volts/cm. or lower. 2 cycles to 17 mc. sensitivity .03 volts/cm. or lower.

**Signal Delay Network** — Provides .25 microsecond signal delay. Permits observation of wavefront that triggers sweep.

**Calibrating Voltage** — 1 kc square wave. Seven ranges .05 volt to 50 volts full scale. Accuracy  $\pm 2\%$  of full scale.

**Output Waveforms** — Sweep sawtooth, delayed trigger, delayed gate, gate, 1 kc calibrator square wave, trigger from internal rate generator.

**Internal Trigger Rate Generator** — 5 ranges from 200 to 5000 cycles per sec.

**Cathode Ray Tube** — A metallized type 5XP cathode-ray tube with P2 phosphor is furnished with the **Type 513** unless a P1 or P11 phosphor is specified as the optional choice.

**Construction** — Completely self-contained, cabinet and chassis made of electrically welded aluminum alloy. Photo etched front panel.

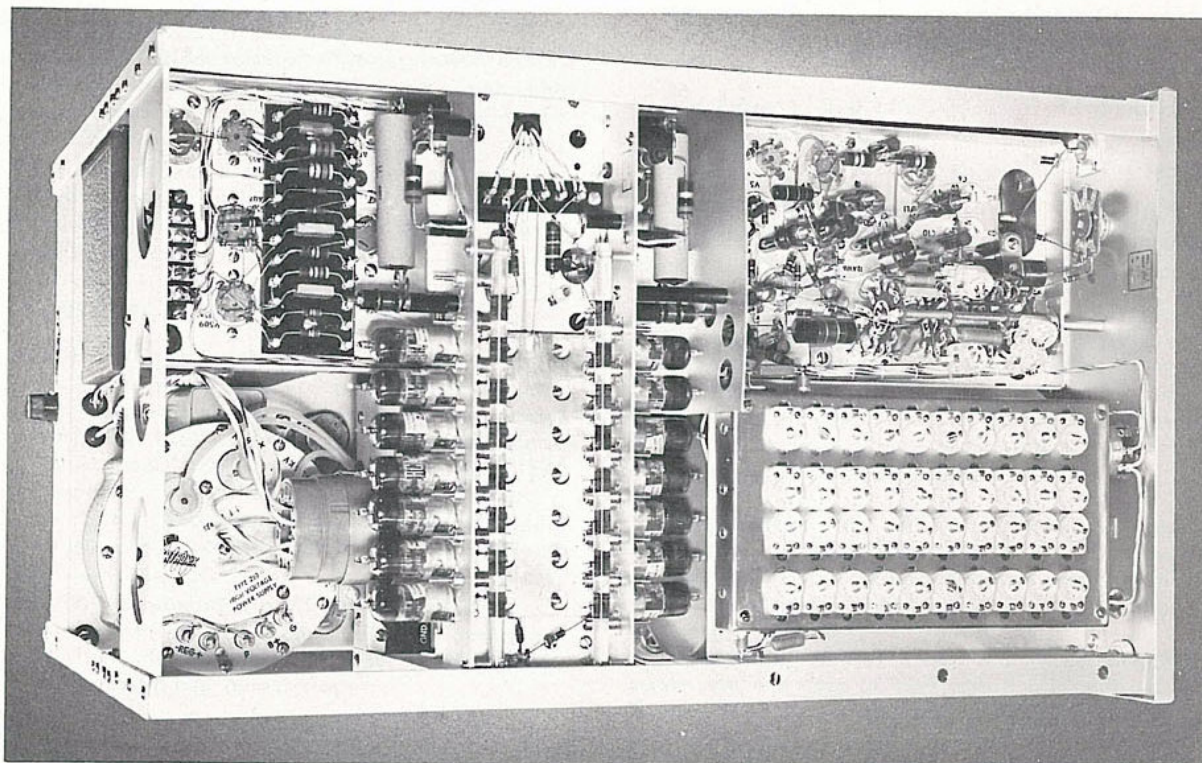
**Dimensions** — 18 1/2" high, 12 1/2" wide, 21 1/2" deep.

**Weight** — 79 pounds, complete with accessories.

**Power Requirements** — 105-125 or 210-250 volts, 50-60 cycles A.C., 475 watts.

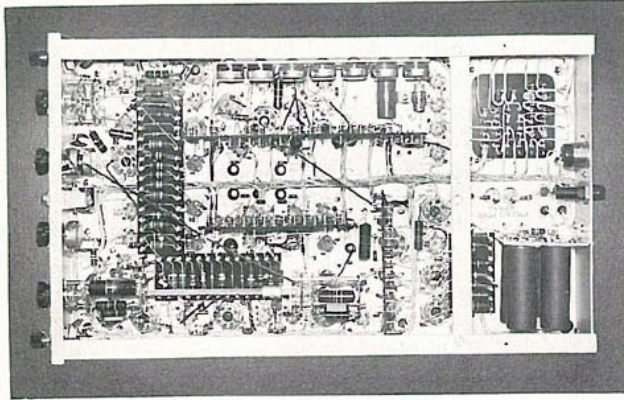
## VACUUM TUBE COMPLEMENT

Input Pre-Amplifier .....	12AW6
2nd Stage Pre-Amplifier .....	12AW6
Pre-Amplifier Cathode Follower .....	12AT7
Gain Control Cathode Follower .....	12AT7
Probe Power Cathode Follower .....	6J6
Internal Trigger Amplifier .....	12AW6
Delay Line Impedance Matching Cathode Follower .....	12AT7
Driver Cathode Follower .....	12AT7



TEKTRONIX, INC.

# CATHODE-RAY OSCILLOSCOPE



Driver .....	4	6AH6
Driver Voltage Cathode Follower .....		6AS5
Cal. Multivibrator .....		12AU7
Cal. Limiter and Output Cathode Follower ..		12AU7
Output Distributed Amplifier .....	14	6CB6
Trigger Inverter .....		6AH6
Trigger Amplifier D.C. Restorer ..	1/2	6AL5
Coupling Diode .....	1/2	6AL5
Trigger Amplifier .....		6AG7
Sweep Multivibrator .....		6AH6
Sweep Multivibrator .....		6AG7
Sweep Generator Clamp Tube .....		6AG7
Sweep Charging Potential Cathode Follower .....		6C4
Sweep D.C. Restorer .....		6AL5
Sweep Amplifier, Phase Inverter .....		12AU7
Sweep Amplifier .....	2	6AQ5
Sweep D.C. Level Control .....	2	6CB6
+Gate Output Cathode Follower .....	1/2	12AU7
Astigmatism Potential Cathode Follower ..	1/2	12AU7
Unblanking Amplifier, Inverter .....		12AT7
Unblanking Cathode Follower .....		6C4

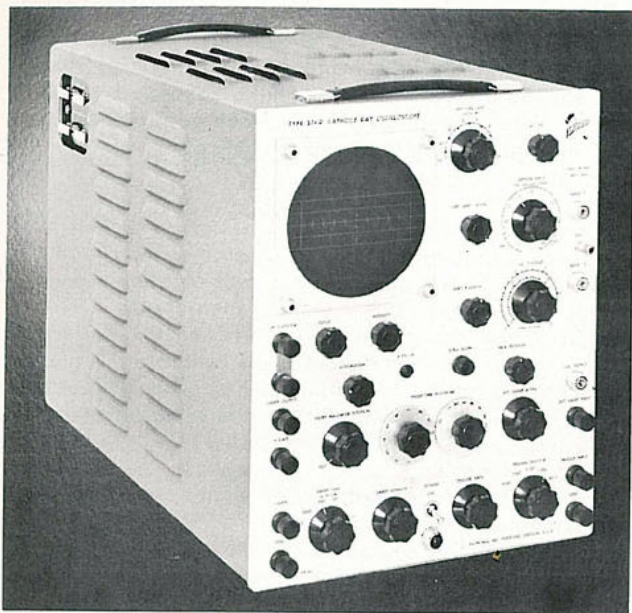
Sweep Length Multivibrator .....		12AT7
Sweep Output Cathode Follower .....		6C4
Sweep Magnifier D.C. Restorer .....		6AL5
Sweep Magnifier .....		6J6
Cathode Ray Tube .....		5XP
+800V Rectifier, Doubler .....	2	6X4
+800V Series Regulator .....		6AS5
+800V Regulator Amplifier .....		6AU6
+275V Series Regulator .....		6AU5
+275V Regulator Amplifier .....		6AU6
+275V Series Regulator .....		6AS7
+225V Regulator Amplifier .....		6AU6
+225V Regulator Comparator .....		12AX7
+225V Voltage Reference .....		5651
-150V Rectifier .....	2	6X4
-150V Reference .....		OD3
High Voltage Oscillator Regulator .....		6AU5
High Voltage Oscillator .....		6AU5
High Voltage Regulator Comparator .....		12AU7
+10KV Rectifier, Doubler .....	2	1X2
-2000V Rectifier .....		1X2
Delayed Gate Multivibrator .....		12AT7
Delayed Gate Cathode Follower .....	1/2	12AT7
Blocking Oscillator Trigger Tube .....	1/2	12AT7
Delayed Trigger Blocking Oscillator .....		12AT7
Delayed Trigger Output Cathode Follower ..		12AT7
Trigger Rate Gen. Blocking Oscillator .....		6J6
Trigger Rate Gen. Cathode Follower .....		12AT7

Price — \$1,650.00 f.o.b. Portland, Oregon.

## TYPE 513 CATHODE RAY OSCILLOSCOPE

The **Type 513** Cathode Ray Oscilloscope is identical to the Type 513-D, except that the .25 microsecond Signal Delay Network is omitted. Price **\$1,600.00** f.o.b. Portland, Oregon.

# CATHODE-RAY OSCILLOSCOPE



## TYPE 514-D

### GENERAL DESCRIPTION

The TEKTRONIX Type 514-D Cathode Ray Oscilloscope is a self-contained general purpose precision instrument, designed specifically to incorporate the advantages of direct coupling, excellent transient response and high gain into a medium priced oscilloscope. The successful realization of these qualities in an instrument has been combined with economy and portability by the use of distributed amplifier techniques.

Accurate measurements of timing and amplitude are possible, with carefully calibrated controls reflecting the use of precision and matched components in fully compensated circuits.

### VERTICAL DEFLECTION SYSTEM

**10 mc Direct Coupled Amplifier** — The best overall criterion of amplifier response is the quality of the reproduction of a square wave. Therefore, the vertical amplifier of the TEKTRONIX Type 514-D Oscilloscope is adjusted for optimum transient response, as are all TEKTRONIX amplifiers. A sensitivity of .3v/cm is available in both direct and capacitively coupled positions. Additional sensitivity of .3v/cm to .03v/cm is provided with capacitive coupling only.

The desirable combination of 10 mc bandwidth, direct coupling, high sensitivity and 4 cm undistorted deflection is achieved efficiently by the use of a 3 section distributed amplifier in the push-pull output stage.

**Dual Inputs** — Provision is made for observing either one of two signal sources separately by the turn of a switch. This permits the change in wave shape between the input and output of a circuit to be conveniently seen,

comparisons of amplitude and time relationships to be made, or observation of other phenomena involving the relative forms of two different signals.

**Direct or Capacitive Coupling** — In the observation of ripple voltage, noise level, etc., it is sometimes unnecessary to display the DC component. Indeed, the sensitivity necessary to amplify the AC component sufficiently to be observed often will cause the DC component to exceed the range of the vertical position control. An AC-DC switch inserts coupling capacitors for the convenient analysis of this type of waveform.

**Deflection Sensitivity Controls** — The problem of attaining a large variation of amplifier gain, to permit displaying a wide range of signal amplitudes without distortion, is multiplied by the necessity of retaining stable amplifier characteristics over the full range of sensitivity. This requirement is solved in the Type 514-D by using a high gain amplifier and inserting precision, frequency compensated attenuator networks. These vary the over-all gain in steps of approximately 10 db, permitting a range in vertical deflection sensitivity of .03 v/cm to 100 v/cm.

To obtain continuous variation between the 10 db steps, a potentiometer is employed in a cathode follower circuit. No appreciable change in amplifier stability or frequency response is encountered in adjusting the gain over this range.

**Direct Input to CRT** — For those occasions when a direct, low capacity connection to the deflection plates is desired, an access panel on the side of the instrument affords convenient plug-in facilities for this purpose.

### SWEEP CIRCUITS

The Type 514-D offers complete flexibility of operation within the limits of its design. A highly adaptable sweep system provides a fitting counterpart to the vertical amplifier previously described. The sweep generator, operating over a wide range of sweep rates, can be triggered from a versatile trigger selector system, offering convenient adaptation to the test conditions.

Offering a range of sweep rates from .1  $\mu$ sec/cm to .01 sec/cm, the sweep generator can be synchronized with frequencies as high as 10 mc, or triggered by pulses as short as .05  $\mu$ sec. The CRT becomes unblanked, and the sweep is operating linearly, within .1  $\mu$ sec after a sharp trigger impulse is received.

**Trigger Facilities** — The ability to synchronize with positive or negative pulses — from the signal being observed or from an external source — offers great flexibility of operation. Synchronization with the power line frequency is optional.

A wide-band phase splitter and trigger amplifier preserves the rise time of high speed transients, permitting the unusually short starting and unblanking time.

**Sweep Generator** — The sweep generator circuit of the Type 514-D is similar to that of the Type 511-AD. The versatility of operation which characterizes the Type



# CATHODE-RAY OSCILLOSCOPE

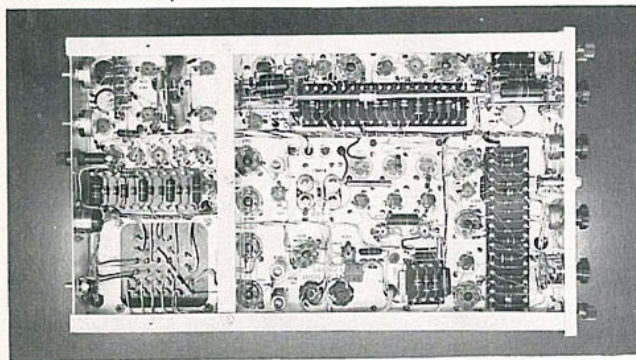
511-AD is shared by this instrument.

The sweep generating circuitry is such that a slight adjustment of the sweep stability control is sufficient to obtain either recurrent or triggered sweeps. Pulses occurring 5  $\mu$ sec apart will trigger individual sweeps, and the operating stability of the circuits is such that long periods can separate enabling pulses. In the free running condition, a sweep repetition rate of unusual stability is obtained.

**Sweep Amplifier** — The sweep amplifier is a direct coupled, wide band amplifier engineered to reproduce the sawtooth waveform faithfully and amplify it to the necessary voltage to deflect the electron beam across the cathode ray tube screen. An internal adjustment is provided should it become necessary to compensate for the changes caused by replacement of the sweep amplifier or cathode ray tubes.

For those occasions when it is necessary to use an external source as a sweep generator, the introduction of desired waveforms is simplified by a front panel connection. This input, which is connected to the amplifier by means of the sweep time selector switch, is provided with a separate variable attenuator, permitting a maximum sensitivity of 1.5 v/cm.

**Sweep Magnifier** — Closer inspection of certain portions of a waveform is sometimes necessary to properly analyze the operation of a circuit. Due to the time of occurrence of the portions in question, readjustment of the sweep controls to facilitate observation at a higher basic sweep rate may be difficult or impossible. The sweep magnifier permits the scrutiny of any 20% of the sweep at a 5X magnification without changing the settings of the main sweep controls.



## MEASUREMENT FEATURES

The accuracy of indication of the **Type 514-D** is insured by the consistent operation of the carefully designed amplifier, sweep and calibrator circuits.

**Amplitude Calibration** — To facilitate the amplitude measurement of any desired portion of a waveform, a 1 kc square wave generator is provided. Seven ranges from .05 volt to 50 volts are available on the input selector switch, permitting convenient selection of the proper range to be used in the comparison of the signal and the square wave. A carefully calibrated potentiometer allows amplitude measurements which are accurate to within 2% of full scale readings.

**Sweep Timing** — The five range sweep time selector offers a choice of sweeps ranging from .1  $\mu$ sec/cm to .01 sec/cm. The sweep time multiplier, consisting of a 10-section precision fixed resistance and a calibrated variable resistor, permits readings of sweep time accurate to within 5%, thus eliminating the need for timing markers in most measurement applications.

**Illuminated Graticule** — Accuracy of timing and amplitude measurements is enhanced by scribed graticule markings, which are illuminated in a color complementary to that of the filter. Direct voltage measurements of any portion of the signal can be made when the deflection sensitivity is pre-set with the aid of the calibrator. A glance at the settings of the sweep time controls likewise suffices for accurate measurements of duration, repetition rates, etc.

**Intensity Modulation** — Provision is made for brightening or blanking pulses to be introduced on the cathode of the CRT, via an RC coupling network. In cases where the observed waveform is extremely complex, and measurements must be made more accurately than is possible with the oscilloscope calibration alone, intensity modulation offers an easy method of introducing timing pulses.

## OUTPUT WAVESHAPES

In the measurement and observation of complex phenomena, it is frequently necessary that much auxiliary equipment, in addition to the oscilloscope, be operated in a strict time relationship to the phenomena. To eliminate the necessity of special external shaping and amplifying circuits, the **Type 514-D** offers a variety of output waveforms to control the operation of this accessory equipment.

**Sweep Output** — To use as a sweep on an external CRT, or to facilitate time delay operations, a sweep sawtooth of 20 volts amplitude is available at the front panel. Cathode follower output provides a relatively low impedance and prevents loading of the sweep generator circuit.

**Positive Gate** — Frequently, it is desirable that auxiliary equipment operate only for the period of the sweep. A square positive pulse of the same duration of the sweep, and of 40 volts amplitude, provides a convenient means of triggering and gating associated equipment.

**Negative Gate** — A similar pulse, of opposite polarity and -40 volts amplitude, appears simultaneously at another front panel binding post, offering like aid in operating auxiliary devices.

**Calibrator Output** — The 1 kc square wave calibrator output, available at the front panel, permits convenient checking and adjustment of the **Type 514-D**'s compensating capacitors, and provides an accurately adjustable signal source for calibrating other equipment.

## ADDITIONAL FEATURES

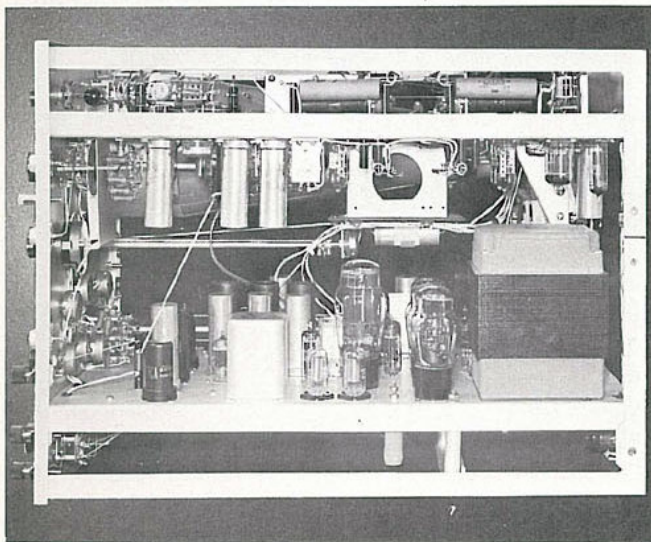
**Probe** — Some observations require great care to prevent undue interference with the signal source. The

# CATHODE-RAY OSCILLOSCOPE

shielded, frequency compensated probe supplied with the **Type 514-D** oscilloscope presents an input impedance of 10 megohms and 12  $\mu\mu\text{f}$ , minimizing pickup of stray fields and providing reduced loading on the circuit under observation.

**Regulated Power Supplies** — To insure consistency in operation, all DC power supplies in the **Type 514-D** have been regulated against variations in load, and line voltage changes over the range of 105-125v. Changes in load, such as increasing the intensity of the trace, do not appreciably vary the deflection sensitivity of the instrument, thus maintaining accuracy of timing and amplitude calibration.

**Construction** — High quality, electrically welded aluminum alloy is used in the construction of the frame, chassis and case, providing a light, clean mechanical design that reflects the careful thought which enters into the development of all TEKTRONIX instruments. All chassis are mounted so that the wiring layouts and components are readily accessible, permitting easy maintenance and repair. The cabled wiring, terminal boards, mounting brackets and other details mirror the effort which is put forth to make the appearance of TEKTRONIX instruments consistent with their operation.



## TYPE 514-D CHARACTERISTICS

**Sweep Circuit** — Hard tube type, triggered or re-current operation as desired.

**Sweeps** — Continuously variable, .01 sec/cm to .1  $\mu\text{sec/cm}$ . Calibration accuracy 5%.

**Trigger Requirements** — .5 to 50v (peak). Pulses as short as .05  $\mu\text{sec}$ . Signal under observation producing .5 cm deflection or more.

**Sweep Lag** — .1  $\mu\text{sec}$ , maximum.

**Sweep Magnification** — Any desired 20% of sweep, magnified 5 times.

**External Sweep Input** — Coupled via 100k poten-

tiometer and 2 stage direct coupled sweep amplifier. Maximum deflection sensitivity, 1.5 v/cm D.C. or A.C. peak to peak.

**Vertical Amplifier** — 4 stage. 3rd and 4th stage direct coupled push-pull. Distributed output (4th) stage.

**A. C. Vertical Deflection Sensitivity** — Continuously variable from .03 v/cm to 100 v/cm, peak to peak.

**D. C. Vertical Deflection Sensitivity** — Continuously variable from .3 v/cm to 100 v/cm, peak to peak.

**Input Impedance** — 1 meg. shunted by 30  $\mu\mu\text{f}$ . With probe, 10 meg. shunted by 14  $\mu\mu\text{f}$ .

**Vertical Amplifier Response** — D.C. to 10 mc, sensitivity or .3 v/cm or lower; 2 cps to 10 mc, sensitivity of .03 v/cm or less.

**Vertical Amplifier Transient Response** — Rise time (10% -90%) .04  $\mu\text{sec}$ .

**Signal Delay Network** — Provides .25  $\mu\text{sec}$  signal delay. Permits observation of the waveform which triggers sweep.

**Calibrating Voltage** — 1 kc square wave. Seven ranges .05 to 50 v full scale. Accuracy  $\pm 2\%$  of full scale.

**Output Waveforms** — Sweep sawtooth, positive gate, negative gate, 1 kc square wave calibration signal.

**Cathode Ray Tube** — A 5CP1A cathode-ray tube is furnished with the Type 514-D unless a P7 or P11 phosphor is specified as the optional choice. An accelerating potential of a 3 KV is used (+1.5 and -1.5 kv).

**Construction** — Completely self-contained, cabinet and chassis made of electrically welded aluminum. Photo etched front panel.

**Dimensions** — 15 1/2" high, 12 1/2" wide, 21 1/2" deep.

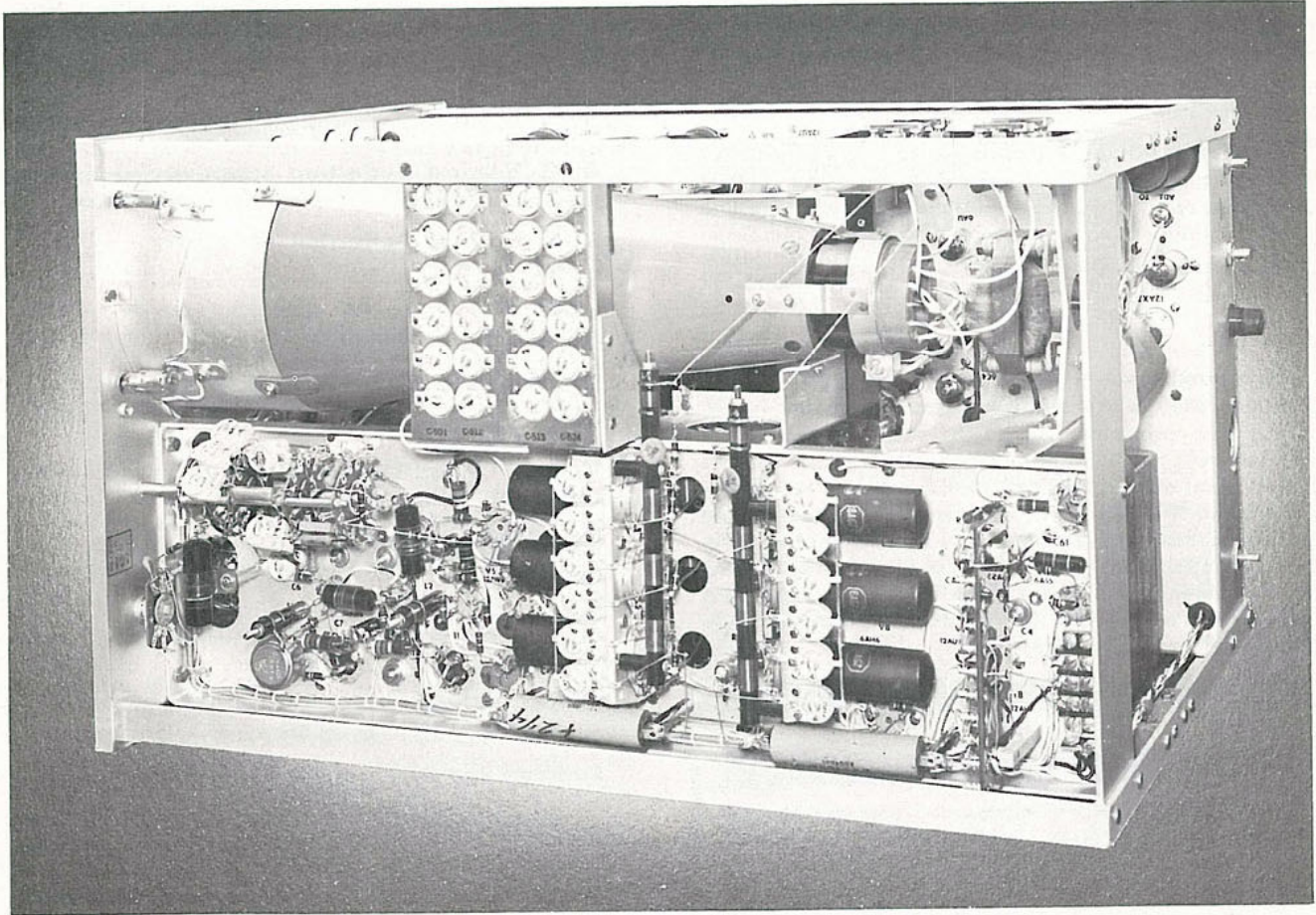
**Weight** — 61 pounds complete with accessories.

**Power Requirements** — 105-125 or 210-250 volts, 50-60 cycles A.C. 375 watts.

### Vacuum Tube Complement —

Trigger Phase Splitter.....	6AC7
Trigger Amplifier .....	6AG7
Trigger Coupling Diode.....	6AL5
Multivibrator .....	6AC7
Multivibrator .....	6AG7
Unblanking Cathode Follower.....	1/2 12AU7
Unblanking Limiter .....	1/2 12AU7
Gate Output Phase Splitter.....	1/2 12AU7
Second Anode Cathode Follower.....	1/2 12AU7
Magnified Sweep DC Restorer.....	1/2 12AU7
Sweep Output Cathode Follower.....	1/2 12AU7
Sweep Generator .....	6AG7
Sweep Charging Potential Cathode Follower.....	6C4
Sweep Magnifier .....	6J6
Sweep DC Restorer.....	6AL5
Sweep Amplifier .....	2 6AU6

# CATHODE-RAY OSCILLOSCOPE



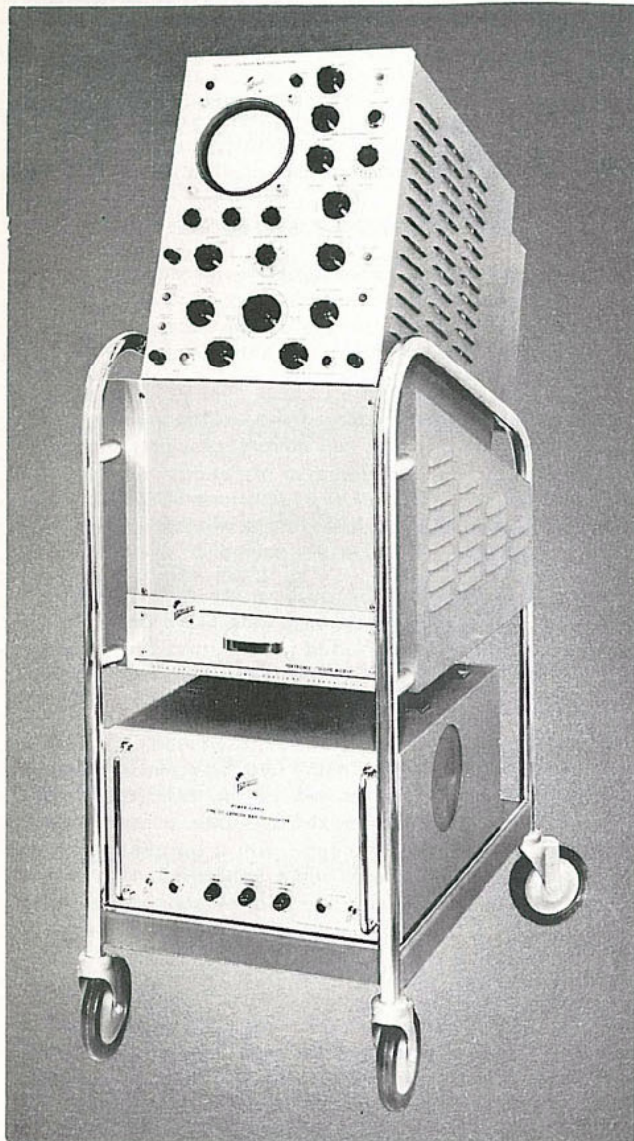
Output Level Tubes . . . . .	2	6CB6	2nd Preamp Stage . . . . .	12AW6
+450V Rectifier . . . . .		6X4	Trigger Amplifier . . . . .	12AW6
+450V Series Regulator . . . . .		6AQ5	Cathode Follower . . . . .	2 12AT7
+450V Regulator Amplifier . . . . .		6AU6	C. F. Voltage Regulator . . . . .	6AS5
+225V Rectifier . . . . .	3	5V4	Output Driver . . . . .	4 6AH6
+225V Voltage Reference . . . . .		5651	Push-Pull Output . . . . .	6 6AG7
+225V Regulator Comparator . . . . .		12AX7	Cal. Multivibrator . . . . .	12AU7
+225V Regulator Amplifier . . . . .		6AU6	Cal. Limiter and Output Cathode Follower . .	12AU7
+225V Series Regulator . . . . .		6AS7		
-150V Rectifier . . . . .		6X4		
-150V Regulator . . . . .		OD3		
High Voltage Regulator Amplifier . . . . .		6AS5		
High Voltage Regulator Comparator . . . . .		12AU7		
High Voltage Oscillator . . . . .		6AQ5		
High Voltage Rectifier . . . . .	2	1V2		
1st Preamp Stage . . . . .		12AW6		

Price — \$950.00 f.o.b. Portland, Oregon.

## TYPE 514 CATHODE RAY OSCILLOSCOPE

The **Type 514** Cathode Ray Oscilloscope is identical to the **Type 514-D**, except that the .25  $\mu$ sec Signal Delay Network is omitted. **Price — \$900.00** f.o.b. Portland, Oregon.

# CATHODE-RAY OSCILLOSCOPE



## TYPE 517

### GENERAL DESCRIPTION

The TEKTRONIX Type 517 is a wide-band high-voltage cathode-ray oscilloscope designed primarily for the observation and photographic recording of very fast-rising waveforms having low duty cycle.

The use of 24 KV accelerating potential on a metallized cathode-ray tube permits photographic recording of single sweeps at the maximum writing-rate permitted by the vertical amplifier and sweep circuits. Distributed type vertical amplifiers provide a rise-time of 7 milli-microseconds with a maximum sensitivity of .1 V/cm. Both amplitude and time calibrations are provided. Sufficient time delay is incorporated in the vertical amplifier to

permit viewing the leading edge of the waveform which triggers the sweep.

The Type 517 consists of two units, indicator and power supply, mounted on a Scope-Mobile, thus making a very convenient mobile unit. If desired, the units may be lifted off the Scope-Mobile for bench use.

### VERTICAL DEFLECTION SYSTEM

**Distributed Amplifier** — In order to provide sufficient vertical deflection voltage with a rise-time as short as 7 milli-microseconds for a cathode-ray tube using 24 KV accelerating potential, a distributed amplifier is employed. This amplifier consists of 5 distributed stages plus a phase inverter and a trigger tube. The first two stages use six 6AK5 tubes each, next a stage of seven 6CB6 tubes and a phase inverter of three 6CB6 tubes. The signal now goes to a push-pull driver stage having six 6CB6 tubes on a side; and finally to the output stage with twelve 6CB6 tubes on each side.

**Input** — The input to the vertical amplifier is directly to a 170 ohm grid line, through a UHF type coaxial connector mounted on the front panel.

**Probe** — In order to provide higher input impedances, a cathode follower input probe, preceded by a capacitive attenuator, is used. By substituting various capacitive attenuators, a wide range of sensitivities and input capacitances can be obtained.

**Auxiliary Power** — A power supply socket is provided for a cathode follower probe or an auxiliary amplifier stage connected close to the circuit under observation. 6.3 V AC at 1 amp and 120 V regulated DC at 10 ma. is available.

**Sensitivity** — A front panel vertical amplifier attenuator control is provided which decreases the sensitivity of the vertical amplifier from .1 V/cm to .2 V/cm — a range of 2 to 1. Operation of this attenuator does not appreciably affect the characteristics of the vertical amplifier.

**Signal Delay** — Approximately 60 milli-microseconds of delay cable is incorporated in the signal channel. This delay, along with the inherent delay in the vertical amplifier, permits the sweep to start before the signal reaches the vertical deflection plates.

**Amplitude Calibrator** — A pulse-type amplitude calibrator is incorporated which provides continuously variable output voltages in six ranges, from .15 V full scale to 50 V full scale, with an accuracy better than 4% of full scale.

**Direct Connection to CRT Deflection Plates** — It is often desirable to make a low-capacity, low-inductance connection to the deflection plates to permit observation of extremely high speed transients which would be distorted by the amplifier. An aperture in the side of the case permits convenient direct connection to the deflection plates.

### HORIZONTAL DEFLECTION SYSTEM

Since many of the fast-rising pulses to be observed are

# CATHODE-RAY OSCILLOSCOPE

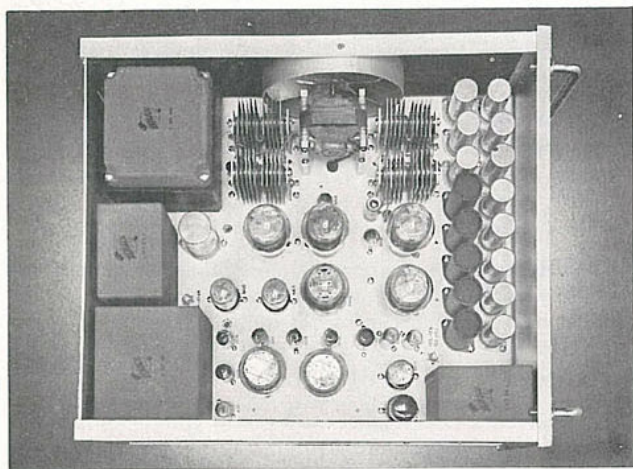
either non-repetitive or non-uniformly spaced, it is essential to have a sweep which can be triggered by the observed pulse itself. The sweep circuit of the **Type 517** can be so triggered.

**Triggered Sweep** — A linear, triggered sweep is available with eleven fixed, accurately timed sweeps ranging from  $.01 \mu\text{sec}/\text{cm}$  to  $20 \mu\text{sec}/\text{cm}$  at 24 KV accelerating potential and twice these rates for 12 KV. The basic sweep waveform is generated by a pentode clamp with a cathode follower boot-strap to maintain the charging current constant throughout the sweep. The waveform is inverted and fed to the opposite deflection plate for balanced deflection.

**Trigger Selector** — A front panel switch permits the choice of a trigger from an external source of either polarity, an observed signal of either polarity, or an internal trigger-rate generator.

**Trigger Amplifier** — To enable the **Type 517** to trigger from fast-rising signals of small amplitude, a wide-band, distributed type trigger amplifier is incorporated. Signals of .3 V amplitude, with a rise-time of 1 milli-micro-second, will easily trigger the sweep. When using the observed signal as trigger, any signal giving a deflection of 2 mm is adequate.

**Trigger-Rate Generator** — A continuously variable trigger-rate generator operating from 15 to 15,000 cps is incorporated. This consists of a calibrated phantatron oscillator controlling a blocking oscillator. Two cathode-follower outputs are provided so that a time delay may be inserted in one output if desired.



**POWER SUPPLY**

Since the **Type 517** is a quantitative instrument, it is necessary that sweep rates and deflection sensitivities remain constant in spite of line voltage variations. To accomplish this, all critical voltages are electronically controlled. The DC supplies utilize series-regulator tubes controlled by high-gain amplifiers. All heaters in the indicator unit are regulated in RMS terms by a saturable-reactor regulator.

The accelerating potentials for the CRT are derived from an oil-filled oscillator-type supply with the CRT gun voltage regulated to compensate for both load and line changes. A panel switch on the indicator unit changes the accel-

erating voltage from approximately 24 KV to approximately 12 KV by changing the point of sampling in the regulator circuit.

Total power consumption for the **Type 517** is approximately 1250 watts at 105-125 or 210-250 V, 60 cycle, single-phase AC.

## OTHER FEATURES

**Calibrated Horizontal Shift** — In addition to the usual full scale horizontal positioning control, a vernier control calibrated in millimeters provides accurate measurements over a range of 1. cm for use in measuring rise-time, etc.

**Metallized Cathode Ray Tube** — The use of a metallized CRT screen provides two advantages: first, increased brightness; and second, removal of residual charge from previous sweeps. This is very important in single sweep operation, since any residual charge will cause the image to be displaced from its correct position.

**Forced Cooling** — Because of the high power consumption of the fast sweep and wide-band amplifier circuits, cooling fans are included in both units. The indicator unit has an efficient air filter to remove dust and foreign matter from the cooling air.

**Output Waveforms** — Coaxial connectors are provided on the front panel, making available two trigger-rate generator impedances, as well as the calibrator output voltage. A binding post makes available a positive gate waveform of 25 volts amplitude with a duration approximately equal to the sweep being generated, with a rise-time of  $.03 \mu\text{sec}$  from a cathode follower source impedance of 200 ohms.

**Edge Lighted Graticule** — As in all other TEKTRONIX Cathode Ray Oscilloscopes, a specially-designed, edge-lighted, plastic graticule is provided. The illumination on this graticule may be adjusted by a front panel control. Centimeter lines are scribed in both the horizontal and vertical directions to facilitate accurate measurement of amplitude and duration of the waveshapes being observed.

## CHARACTERISTICS

**Vertical Amplifier** — 5 stages of distributed amplification; 4th and 5th stages are push-pull.

**Vertical Amplifier Transient Response** — Rise time (10% to 90%) is  $7 \text{ m}\mu\text{sec}$  ( $.007 \mu\text{sec}$ ). Response is free of ringing and overshoot. See Fig. 1.

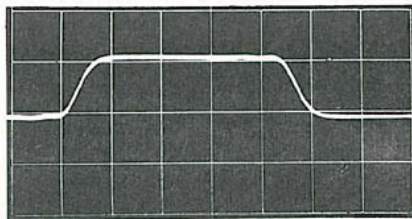


Fig. 1. The accompanying photograph shows the pulse response of the **Type 517** Vertical Amplifier. The sweep rate is  $10 \mu\text{sec}/\text{cm}$ . Note rise-time and freedom from ringing and overshoot.

# CATHODE-RAY OSCILLOSCOPE

**Vertical Amplifier Sensitivity** — The maximum vertical amplifier sensitivity with a 5XP cathode-ray tube\* operated at 24 KV accelerating potential is .1 V/cm without a probe. With a cathode follower probe, the maximum sensitivity is .2 V/cm.

**Vertical Amplifier Attenuator** — A continuous control with a range of attenuation from 1X to 2X is provided in the vertical amplifier. Fixed plug-on attenuators are provided for use in conjunction with the cathode follower probe. An external step attenuator with a characteristic impedance of 170 ohms and a range of 1. to 64 db. in 1. db steps is provided.

**Vertical Amplifier Input Impedance** — Input impedance direct is 170 ohms resistive. Impedance looking into probe is 12. megohm and  $5\mu\mu\text{fd}$ . Higher impedance values can be had depending upon capacitive attenuator used ahead of probe.

**Signal Delay** — Delay line of RG63U coaxial cable contributes 60  $m\mu\text{sec}$  delay. This, plus the inherent delay of the distributed vertical amplifier stages, makes an approximate total signal delay of 120  $m\mu\text{sec}$ . This signal delay permits the sweep to be triggered and under way before the signal is applied to the vertical deflection plates.

**Vertical Amplitude Calibrator** — Pulse generator of 25 kc available on the front panel, with six ranges from .15 V to 50 V peak full scale. Accuracy is 4% of full scale.

**Vertical Amplifier Position Control** — With 24 KV accelerating potential, the vertical positioning control moves the trace  $\pm 2.0$  cm from the center line.

**Sweep Circuit** — Triggered, hard-tube bootstrap type sweep circuit with inverter to produce balanced deflection.

**Sweeps** — Eleven fixed ranges of 10, 20, 50, 100, 200, 500  $m\mu\text{sec/cm}$  and 1, 2, 5, 10, 20  $\mu\text{sec/cm}$ , with a maximum displacement error of 2% for 8 cm sweep length.

**Sweep Starting Time** — Approximately 70  $m\mu\text{sec}$  for the average instrument. A total signal delay of approximately 120  $m\mu\text{sec}$  permits the sweep to be triggered and underway before the signal is applied to the vertical deflection plates.

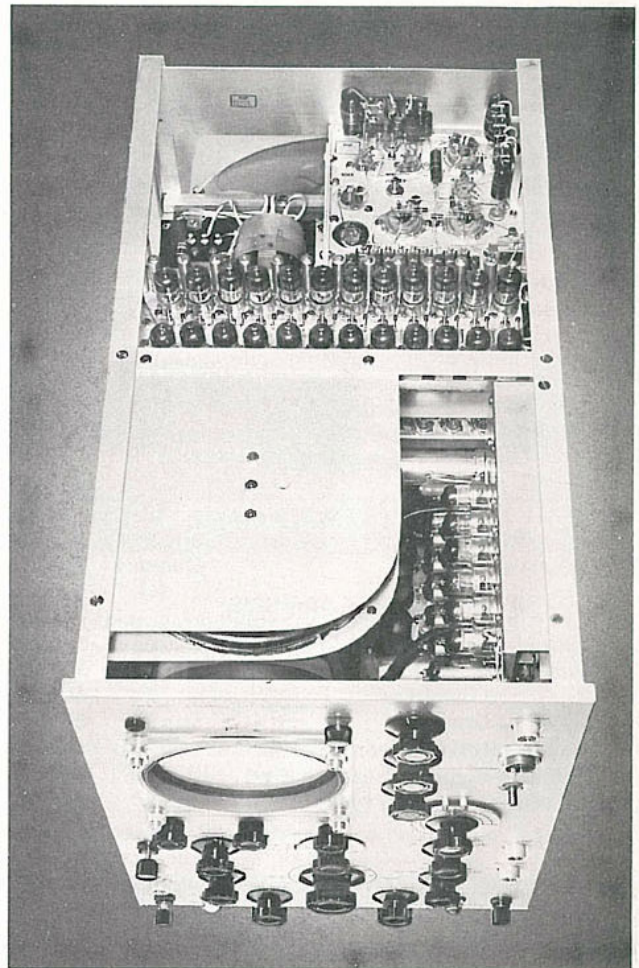
**Horizontal Position Control** — With 24 KV accelerating potential, the horizontal position control moves the trace approximately 5 cm.

**Horizontal Position Vernier** — In addition to the normal horizontal positioning control, a vernier control calibrated in millimeters provides accurate measurements over a range of 1 cm for use in measuring rise-time, etc.

**Duty Cycle** — The approximate limitations on sweep repetition rates for sweep ranges are:

Sweep Time	Maximum Repetition Rate
20 $\mu\text{sec/cm}$ .....	1.5 kc
10 $\mu\text{sec/cm}$ .....	3. kc
5 $\mu\text{sec/cm}$ .....	6. kc
2 $\mu\text{sec/cm}$ .....	12. kc
1 $\mu\text{sec/cm}$ .....	20. kc

\*With a nominal tube vertical deflection sensitivity of 30 V/cm.



Sweep Time	Maximum Repetition Rate
500 $m\mu\text{sec/cm}$ .....	50. kc
200 $m\mu\text{sec/cm}$ .....	50. kc
100 $m\mu\text{sec/cm}$ .....	50. kc
50 $m\mu\text{sec/cm}$ .....	50. kc
20 $m\mu\text{sec/cm}$ .....	60. kc
10 $m\mu\text{sec/cm}$ .....	80. kc

## Trigger Requirements —

External trigger: .3 - 15 V peak amplitude.

Internal trigger (from signal): 2 mm deflection.

For optimum triggering, the rise time of the trigger source should be as short as possible.

## Trigger Rate Generator —

Polarity .....

Length .....

Rise time .....

Output level: 20 V with 50 ohms internal impedance;  
60 V with 200 ohms internal impedance.

Repetition rate: 15-15,000 cps variable in three ranges with an accuracy of 5% of full scale.

**Cathode Ray Tube** — A metallized type 5XP cathode-ray tube with P11 phosphor is furnished with the **Type 517** unless a P1 or P2 phosphor is specified as the optional choice.

# CATHODE-RAY OSCILLOSCOPE

**Construction** — Contained in two separate units of convenient size, normally mounted on a TEKTRONIX Type R-500 Scope-Mobile. Cabinets and chassis are made of electrically-welded aluminum alloy. Photo-etched front panels are employed.

**Power Requirements** — 1250 watts, 105-125 or 210-250 V, 60 cycle, single-phase AC. Three primary-circuit fuses are provided for protection against sustained over-load conditions.

**Dimensions** —

Indicator unit: 12 1/2" wide, 18 1/2" high, 25 1/2" deep.  
Power unit: 16" wide, 10" high, 18" deep.

**Weight** —

Indicator unit: 76 lbs.  
Power unit: 72 lbs.  
R-500 Scope-Mobile: 42 lbs.

## TUBE COMPLEMENT

Circuit Use	Quantity	Type
<b>Vertical Amplifier</b>		
1st Distributed amplifier	6	6AK5*
2nd Distributed amplifier	6	6AK5*
3rd Distributed amplifier	7	6CB6*
Phase inverter stage	3	6CB6*
Push-pull distributed driver amplifier	12	6CB6*
Push-pull distributed output amplifier	24	6CB6*
Internal trigger coupling tube	1	6CB6*

\* Selected

**Circuit Use**

Quantity Type

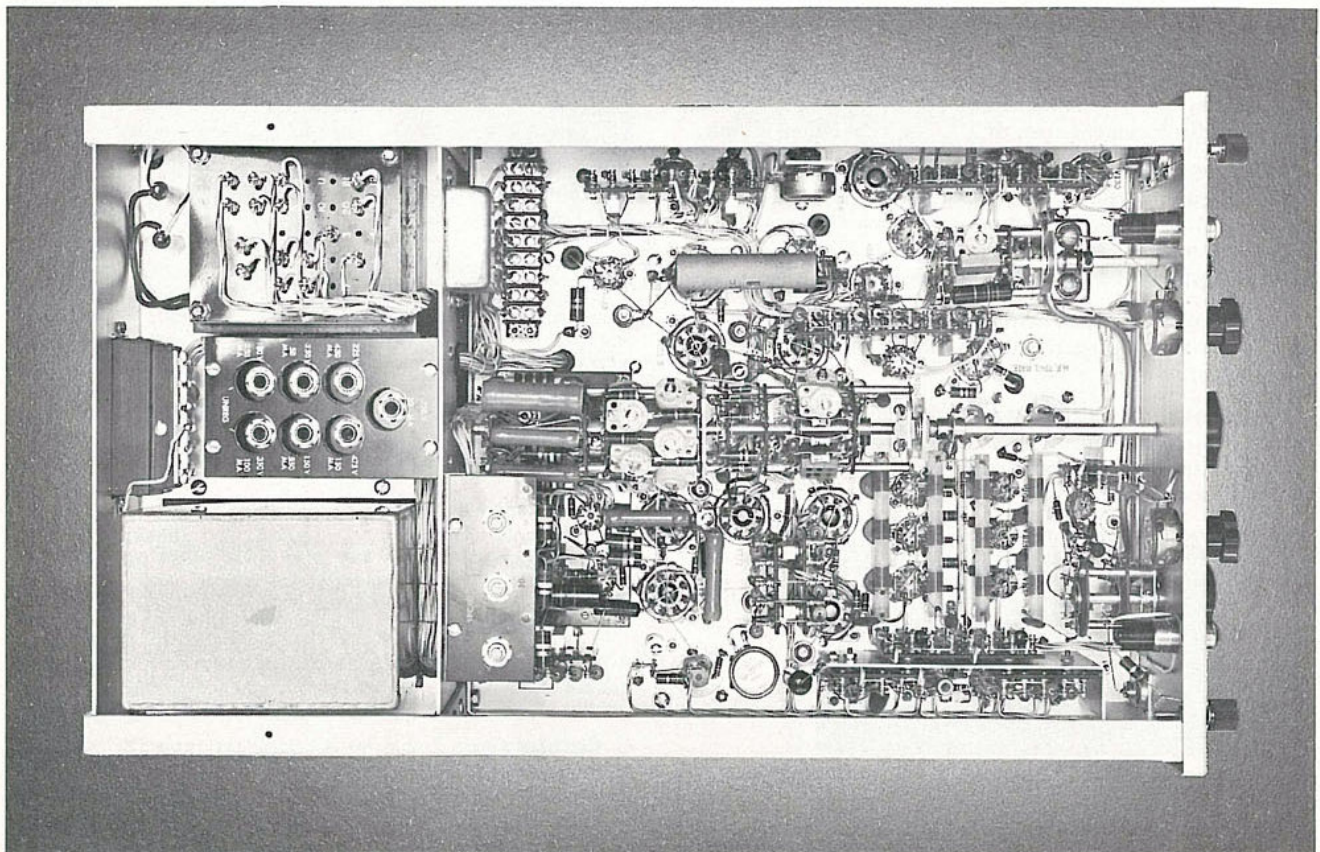
### Sweep Generator Circuit

Trigger phase-splitter	1	6J6*
1st Distributed trigger amplifier	3	6AK5*
2nd Distributed trigger amplifier	3	6AK5*
Trigger limiter tube		6AG7
Trigger switch tube		6AG7
Trigger coupling diode		6J6
Multivibrator	2	6AG7
Paralleled sweep clamp tubes	2	6AG7
Positive sweep out, cathode follower		6J6*
Paralleled bootstrap cathode followers	2	6J6*
Decoupling-diode, bootstrap circuit		6X4
Sweep inverter		6AG7
Bias, screen, CF voltage-regulator for sweep inverter tube		12AU7
Sweep output DC restorer		6AL5
Paralleled unblanking amplifier tubes	2	6AG7
Screen CF voltage-regulator for unblanking amplifier tubes		6AS5
Unblanking voltage CF output tube		6J6
Plus gate output cathode follower		6J6
CRT grid bias stabilizers	4	NE2*

### Calibrator Circuit

Multivibrator		12AU7
Clipper		6J6
Cathode follower calibrate voltage adj.		6J6
Calibrator range output, cathode follower		6J6*

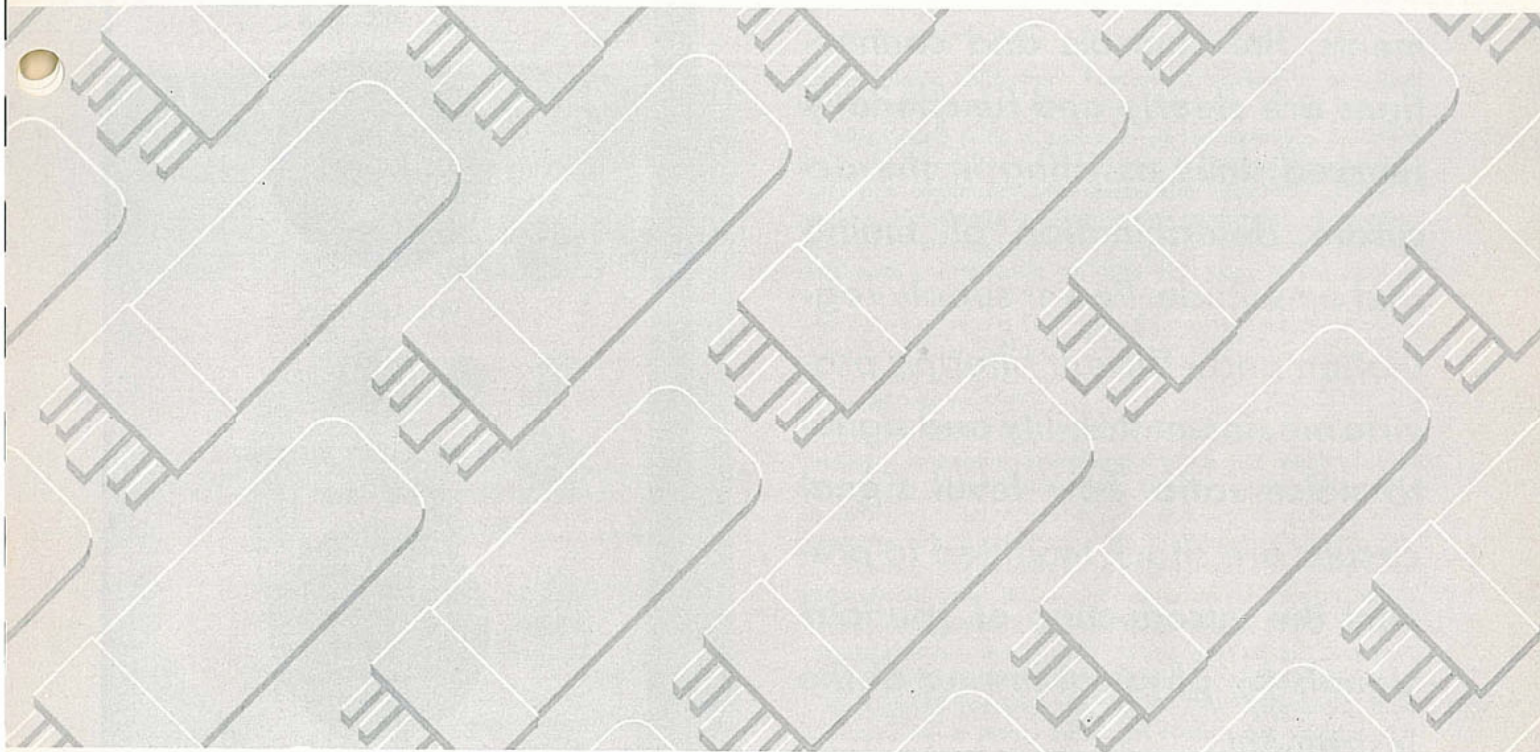
\* Selected



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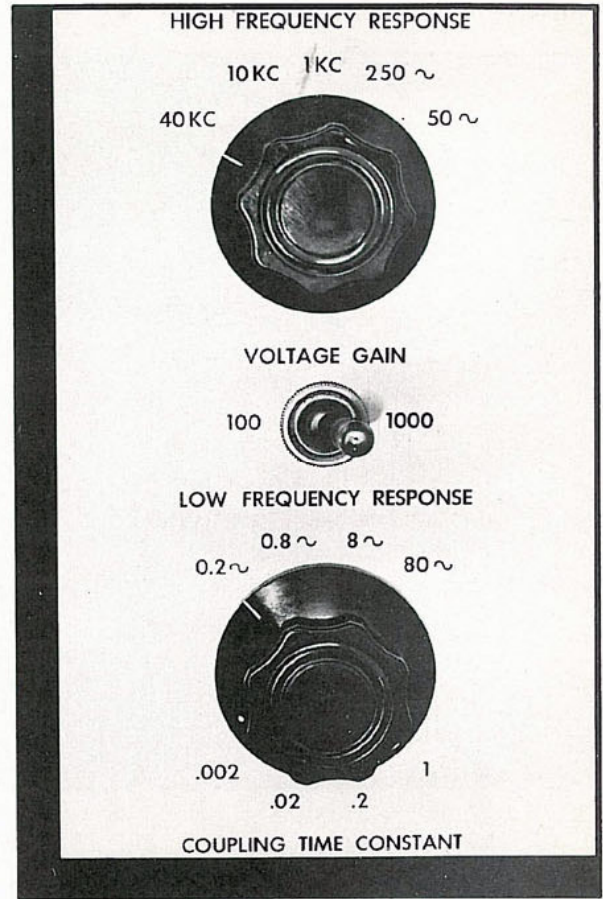




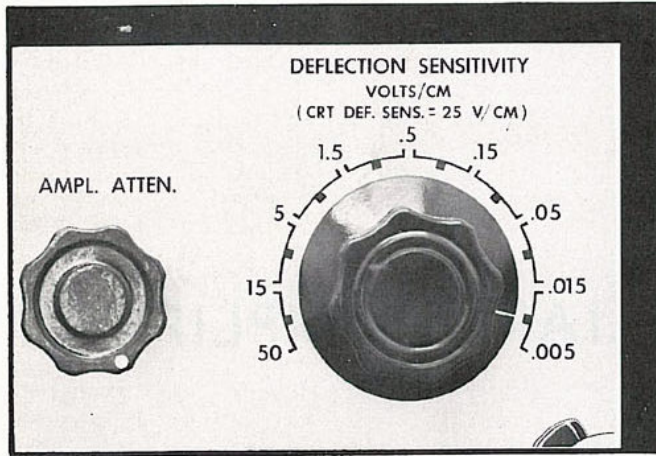
## AUXILIARY AMPLIFIERS

*are designed to expand the area of application of Tektronix oscilloscopes in certain specialized directions. Frequently it is desirable to increase the sensitivity of the oscilloscope amplifier into the mv/cm or  $\mu$ v/cm region. Other measurements may require that the horizontal deflection circuits have the same order of bandwidth or sensitivity as the vertical circuits.*

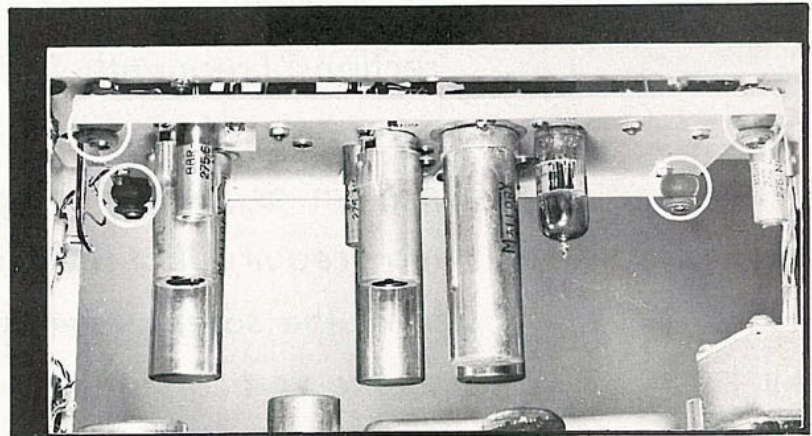
As with other Tektronix instruments, the controls and connections are clearly and functionally marked, thus assisting in the accurate determination of timing and amplitude. Power supply regulation and efficient filtering provide maximum stability and signal to noise ratio. Low level signal circuits are shock mounted to prevent the introduction of spurious signals by physical jarring of the instrument.



BANDWIDTH CONTROLS OF TYPE 122 PRE-AMPLIFIER

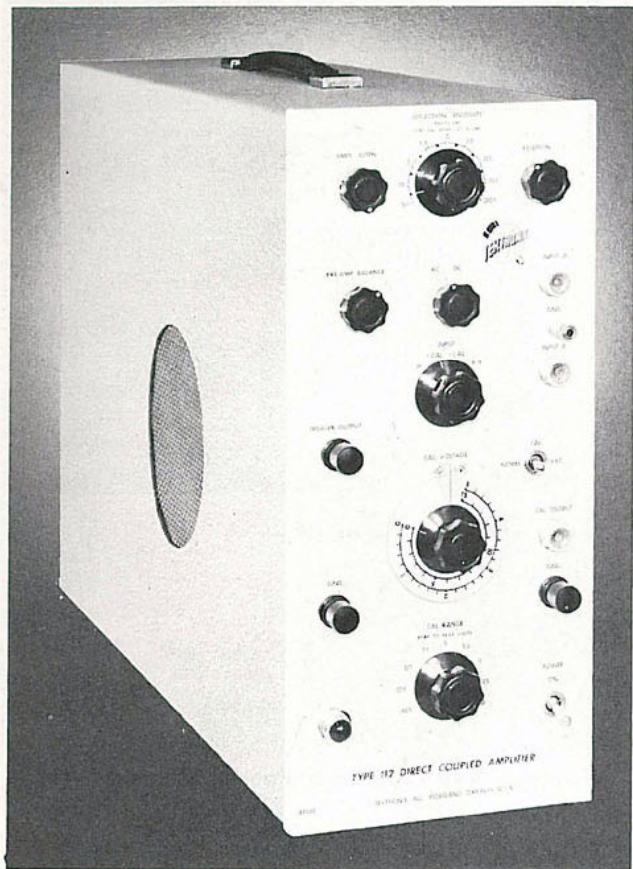


SENSITIVITY CONTROLS OF TYPE 112 AMPLIFIER



SHOCK MOUNTING OF TYPE 121 PRE-AMPLIFIER

# DIRECT COUPLED AMPLIFIER



## TYPE 112

**Differential Input—Push-Pull Throughout  
Band Pass DC — 2 mc  
Gain .5 to 5000, Continuously Variable  
Shock Mounted Pre-amplifier**

The TEKTRONIX Type 112 Direct-Coupled Amplifier is an auxiliary instrument primarily intended for use with the TEKTRONIX Type 511-A, 511-AD, 512 or other cathode-ray oscilloscopes. It consists of the vertical amplifier of the Type 512 Oscilloscope complete with self-contained, fully-regulated power supply and 1 kc square

wave voltage calibrator. Forced air cooling is provided by a fan mounted on the power chassis.

When used with a cathode-ray oscilloscope in which the cathode-ray tube has a basic deflection factor of 25 volts per centimeter, the deflection sensitivity (peak to peak) is 5 millivolts to 50 volts per centimeter. Expressed in terms of voltage gain, the range is .5 minimum to 5000 maximum, continuously variable by means of the step attenuator and variable potentiometer. The pass band, when working into a 5CP type CRT and using short leads, is DC to 2 mc when voltage gain requirements are 166 or less, DC to 1 mc when voltage gain requirements fall within the range of 166 to 5000.

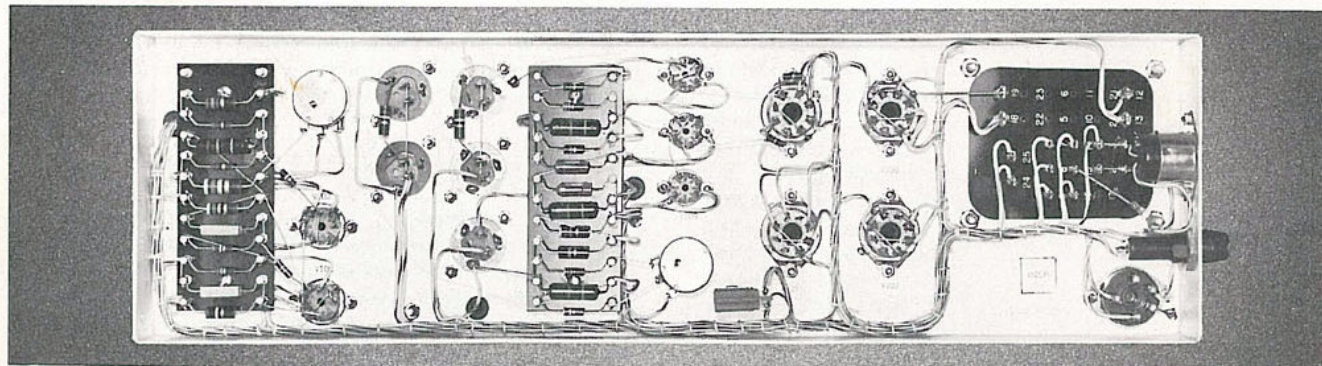
The TEKTRONIX Type 112 input impedance is approximately 1 megohm paralleled by 45  $\mu\text{f}$  each side to ground for direct connection, and is approximately 10 megohms paralleled by 14  $\mu\text{f}$  each side to ground when using the two RC probes which are supplied as standard accessories. The probes have an attenuation of ten. Either single-ended or a differential input may be employed.

When using the differential input, effects of the in-phase components are minimized. At full gain of the amplifier, one volt of in-phase signal will produce less deflection than 5 mv applied between the inputs. The differential input also provides a ready means of mixing two signals without interaction or frequency discrimination.

The amplitude response curves are approximately 3 db down at the high frequency points mentioned above. The rate of fall of amplitude response, however, is quite gradual, with useful amplification existing considerably above the quoted points.

Designed to work into a high impedance load (CRT plates), each output tube plate is connected to output terminals via 100 k current limiting resistors and by-pass capacitors. For other applications, short circuiting the limiting components will provide an output impedance of 8000 ohms plate to plate. A maximum output voltage of approximately 150 volts (peak to peak) is available when working into a high impedance load.

Output connections are from a right hand side access panel by means of banana jacks and plugs. Mounted at the rear of the amplifier, a coaxial connector permits the injection of time markers at a point just ahead of the output stage without interaction with other signals present. Also, at the rear of the cabinet are two controls which determine the voltage point with respect to ground at which the output circuits (CRT deflection plates when so used) function. The output level is adjustable between 0 and +150



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# DIRECT COUPLED AMPLIFIER

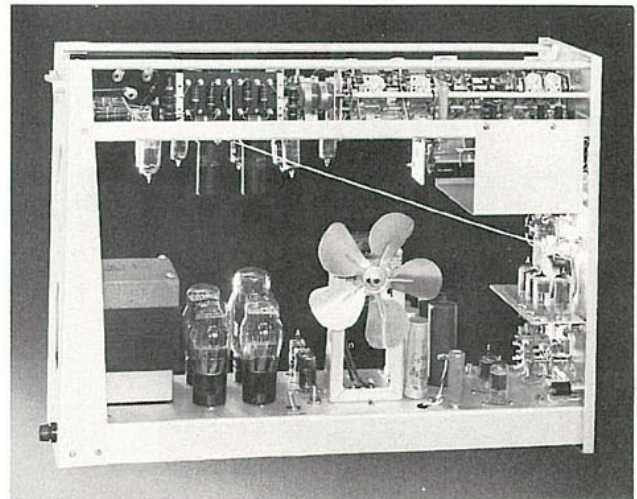
v. A rapid change between the adjusted output level and  $\pm 150$  v. is provided by a toggle switch.

## SPECIFICATIONS

**Voltage Gain** . . . . . .5 to 5000, continuously variable  
**Band Pass** . . . . . DC—2 mc, gain 166 or less  
 DC—1 mc, gain 166-5000  
**Input Impedance** . . . . . 1 meg paralleled by 45  $\mu\text{mf}$  direct  
 10 meg paralleled by 14  $\mu\text{mf}$  with probes  
**Maximum Signal Input Voltage** . . . . . 600 v (peak)  
**Voltage Calibrator** . . . . . 1 kc square wave  
 Nine ranges, .5 mv to 50 v full scale  
 Accuracy  $\pm 3\%$  of full scale  
**Output Voltage** . . . . . 150 v high imp.; 75 v 8000 ohms  
**Power Requirement** . . . . . 105-125/210-250 v,  
 50-60 cycles, 200 watts  
**Dimensions** . . . . . 15 1/2" high, 6 1/2" wide, 21 1/2" deep  
**Weight** . . . . . 32 pounds, complete with accessories

### Vacuum Tube Complement—

1st Stage . . . . .	2	6AK6
2nd Stage . . . . .	2	12AU6
Cathode Follower . . . . .	2	12AU6
3rd Stage . . . . .	2	12AU6
4th Stage . . . . .	2	6AG7
Voltage Regulators . . . . .	2	12AU7
Marker Input Ampl . . . . .		6AU6
Constant Current Control . . . . .	2	6BH6
Calibrator Multivibrator . . . . .		12AU7

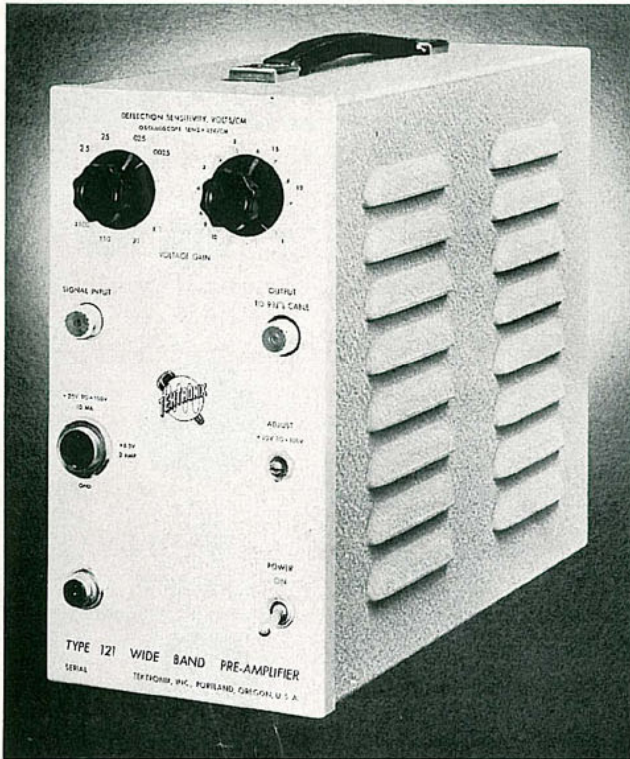


### Vacuum Tube Complement—

Calibrator Diode and Output Cathode Follower . . . . .		12AU7
Low Voltage Rectifiers . . . . .	3	5V4G
Voltage Reference . . . . .		5651
Voltage Regulator Amplifier . . . . .	2	6AU6
Voltage Regulator Series Tube . . . . .		6AS7G

**Price \$495.00 f.o.b. Portland, Oregon**

# WIDE BAND PRE-AMPLIFIER



## TYPE 121

**Optimum Transient Response**

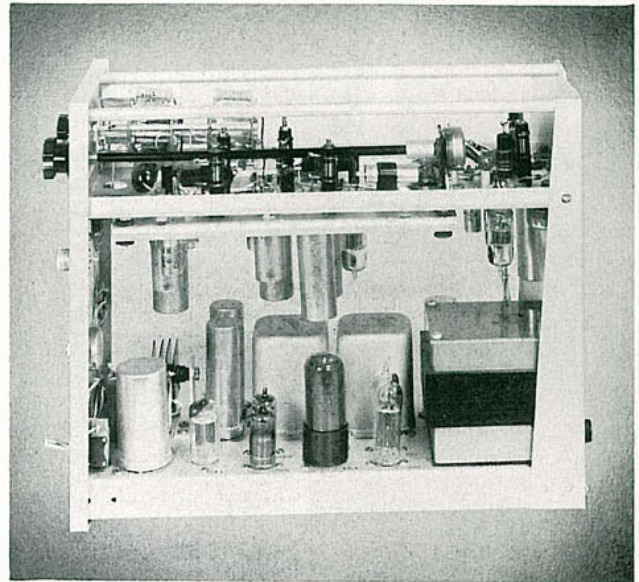
**Unusual Adaptability**

The TEKTRONIX Type 121 Wide Band Pre-amplifier is a self-contained three-stage amplifier designed primarily to increase the sensitivity of the Type 511, 511-A, and 511-AD oscilloscopes. A maximum voltage gain of 100 is available, increasing the sensitivity of the oscilloscope to 2.5 mv per cm. A combination of step and continuous attenuators on the TEKTRONIX Type 121 provides a complete range of sensitivity from 2.5 mv/cm to 25 v/cm without the use of the attenuators on the oscilloscope. Connection between the TEKTRONIX Type 121 and oscilloscope is via a matched 93-ohm co-axial cable so that the separation of the instruments may be 100 feet or more. As in all TEKTRONIX instruments, primary emphasis has been placed on transient response. A bandwidth in excess of 12 mc preserves the excellent rise time of the oscilloscope.

Careful design results in a high input impedance of 1 meg shunted by 20 mmf, maintained for all positions of the attenuators. When desired, conventional RC probes may be used to increase this impedance at the expense of a reduction of gain. DC plate and heater supplies are available on a front panel power supply socket so that when both high input impedance and high gain are necessary, a cathode follower probe or a special pre-amplifier

stage mounted directly on the signal source may conveniently be used.

The self-contained power supply in the TEKTRONIX Type 121 provides electronically regulated DC for the plates of the tubes and to minimize the hum level, rectified, filtered DC is supplied to the heaters of the first three tubes as well as the front panel power supply socket. The first, second, and C.F. gain control stages are shock mounted.



## SPECIFICATIONS

Voltage Gain	100
Input Impedance, Direct	1 meg paralld by 25 mmf
Max. Peak Output	±1 v in 93-ohm cable
Band Pass	5 cps — 12 mc
Front Panel Power Supply Socket	6.3 v DC 20 - 120 v DC

**Power Requirements** — 105-125/210-250 volts, 50-60 cycles, 80 watts.

**Dimensions** . . . . . 5" wide, 10" high, 14" deep  
Self-contained — Total Weight 18 ½ lbs.

### Vacuum Tube Complement

First Stage	6CB6
Second Stage	6CB6
C.F. Gain Control	6J6
Third Stage	6AH6
C.F. Output	6J6
C.F. Voltage Regulator	6J6
Voltage Regulator Comparator	12AX7
Plate Rectifiers	2 6X4
Series Voltage Regulator	25L6
Regulator Amplifier	6AU6
Voltage Reference	5651

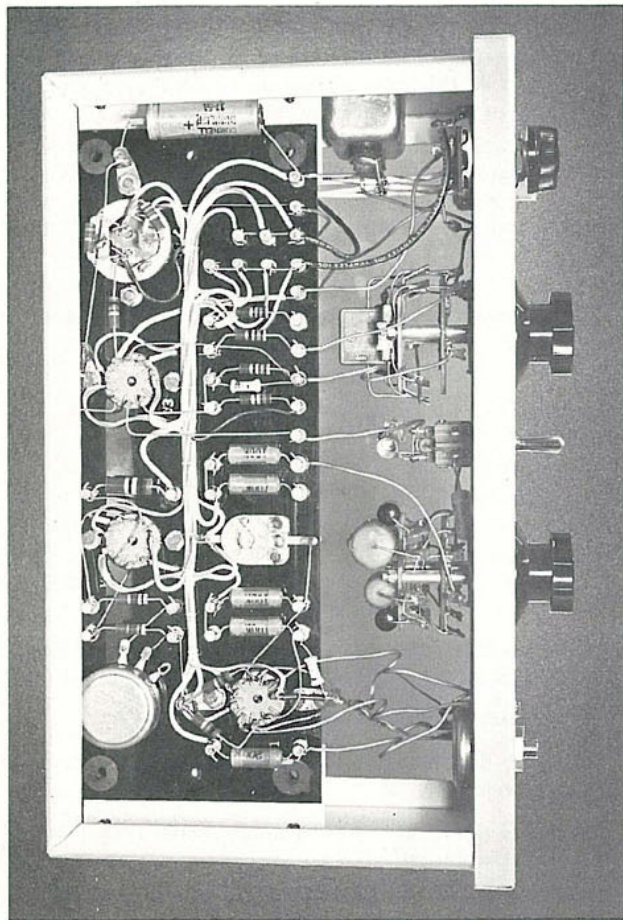
**Price \$265.00 f.o.b. Portland, Oregon**

**TEKTRONIX, INC.**

# LOW LEVEL PRE-AMPLIFIER

end of the panel.

**Panel Size** — 19" standard relay rack width, 5 1/4" height.



**Power Input** — Battery cable socket is on right end, to rear.

**Accessories Furnished** — Type W122 battery cable with battery plugs, Type CON3P input plug, Type P93 output cable.

**Price** — \$90.00 f.o.b. Portland, Oregon.

## FRAME MOUNTED TYPE 122

**Mounting Method** — The Type 122 is designed for mounting in a special adapter frame, Type FA160; or it may be fastened to an existing support.

**Panel Size** — 4 1/8" wide, 12 1/4" high.

**Power Input** — Battery cable socket is on top, to rear.

**Accessories Furnished** — Type W122 battery cable with battery plugs, Type CON3P input plug, Type P93 output cable.

**Price** — \$90.00 f.o.b. Portland, Oregon.

## ADAPTER FRAME

**Type FA160** — Adapter frame mounts in a relay rack and is designed to hold four units made up of any combination of Type 122, Type 161, or Type 162. (A Type 160 power supply requires the panel space of two units.)

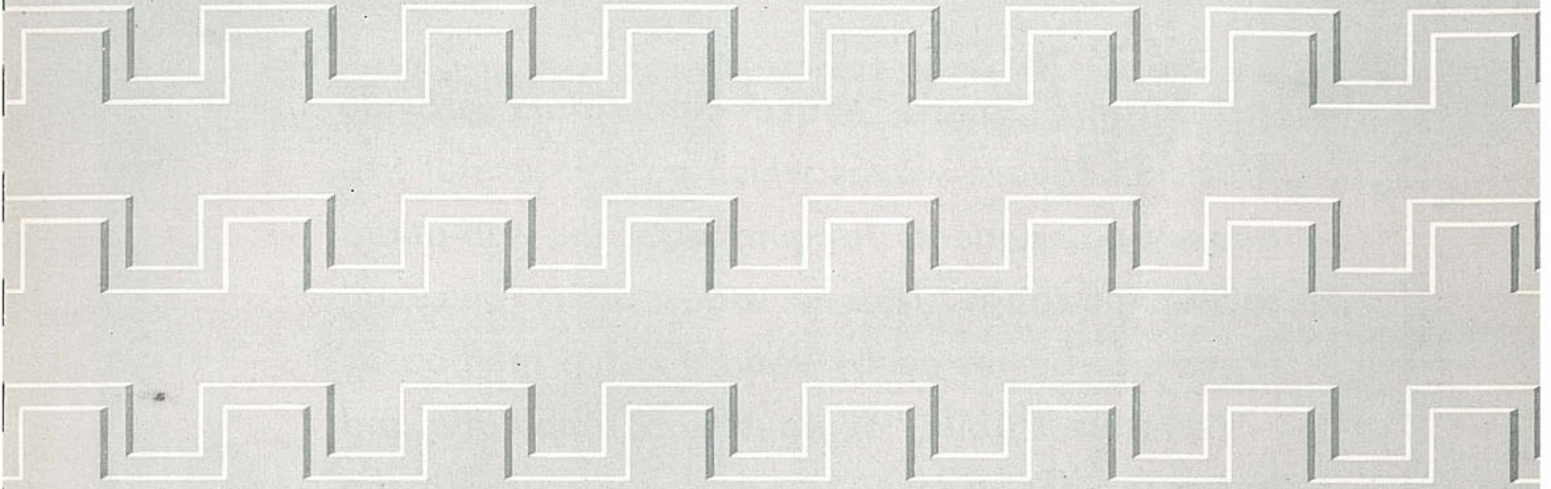
**Outside Dimensions** — 19" standard relay rack width, 12 1/4" high.

**Inside Dimensions** — 16 1/2" long, 10 3/8" high.

**Price** — \$15.00 f.o.b. Portland, Oregon.

## SPECIALS

**Battery Cables** — Extra long, similar to Type W122 can be ordered as a special item.



## SQUARE WAVE GENERATORS

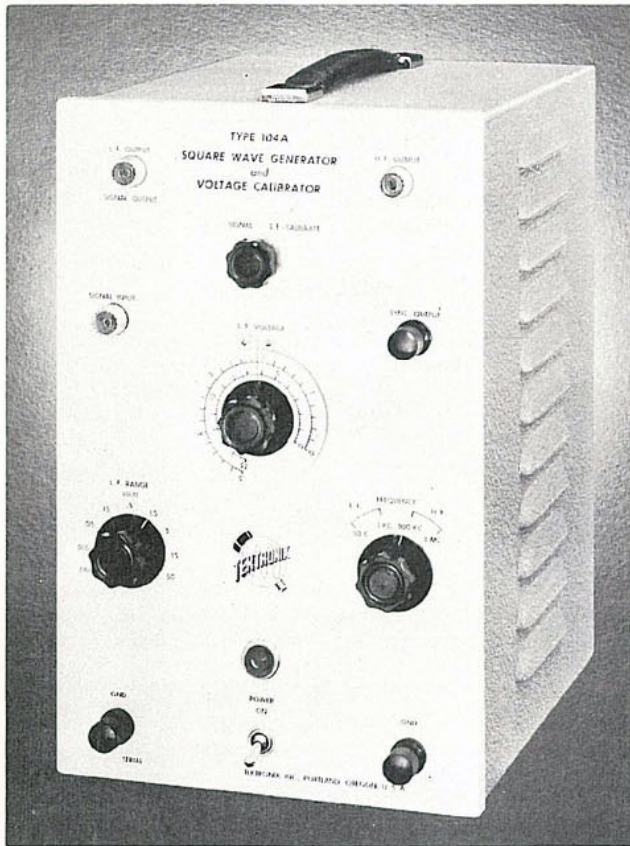
*Square wave testing techniques are recognized as providing one of the most efficient means of determining electronic circuit response. Precise adjustment of frequency compensated attenuator, amplifier and filter circuits is reduced to a simple procedure.*

*Tektronix Square Wave Generators provide precision square waves which contain useful frequency components ranging from the sub-audio to the vhf range. Thus, a wide variety of circuit types can be tested by square wave methods.*

*To insure stability of waveform, amplitude and indicated frequency, regulation circuits in the power supply compensate for adverse conditions of load, or for power line changes over the range of 105v to 125v.*



# SQUARE WAVE GENERATOR & VOLTAGE CALIBRATOR



## TYPE 104A

### GENERAL DESCRIPTION

The TEKTRONIX **Type 104-A Square Wave Generator** is an inexpensive generator of precision square waves in the frequency range most commonly used for amplifier response testing. The instrument is similar to its predecessor, the **Type 104**, except that it now includes an accurate voltage calibrator utilizing the two lower frequencies. Improved physical arrangement provides increased usefulness on the test bench. The **Type 104-A** is ordinarily furnished to supply square waves of 50 cps, 1 kc, 100 kc and 1 mc, giving good coverage of the audio and video ranges. By proper choice of these frequencies, the **Type 104-A** permits convenient adjustment of a wide range of amplifier types and accurate observation of their frequency and transient response.

### FEATURES

**Short Rise Time**—As a result of careful design, the two high frequency square waves have a rise time of not more than .02 microsecond without overshoot.

**High Frequency Output Available at Low Impedance**—The output of the two high frequencies is available through a matched cable terminated by a continuously variable attenuator and provides a signal of at least 5 volts.

**Low Frequency Output Available as Calibrating Voltage**—Since the rise time is of less consequence at the

two lower frequencies, a second multivibrator-limiter circuit provides these signals at a higher impedance, making it possible to obtain the low frequency output via a precision attenuator in 9 ranges of 5 mv to 50 v peak-to-peak. A calibrated wire wound potentiometer permits continuously variable amplitude adjustment for each range, accurate to within 3% of the full scale reading.

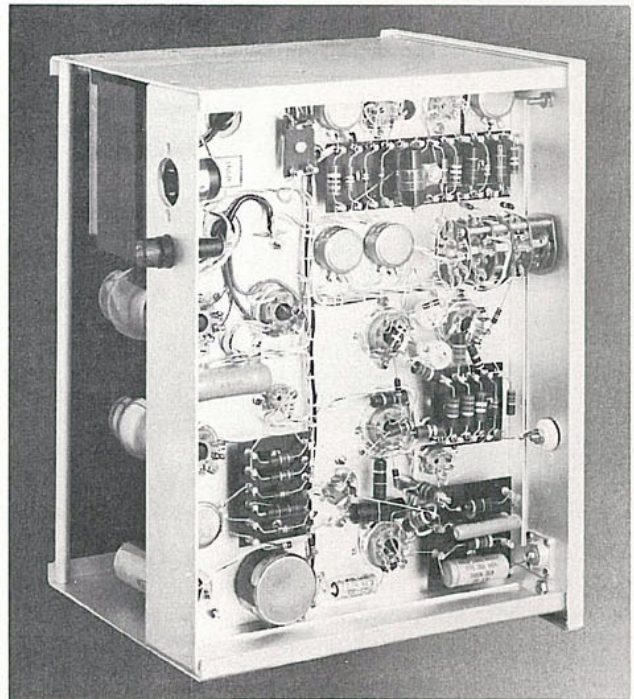
**Synchronizing Signal**—In order to synchronize the oscilloscope being used, a separate binding post supplies a synchronizing signal of at least 3 volts at all settings of attenuator or calibrator controls.

### APPLICATIONS

The 50 cycle square wave provides a quick test for the low frequency characteristics of amplifiers. The 1 kc square wave is a convenient signal for quickly and accurately adjusting capacity compensated attenuators. The 100 kc and 1 mc square waves permit convenient adjustment of high frequency compensating networks for video amplifiers.

Provision is made on the two low frequencies for inserting the instrument between a signal source and the oscilloscope. By the turn of a switch, either the signal or the calibrating voltage can be observed, permitting accurate measurement of amplitude of any portion of the signal waveform.

The small size and low cost of the **Type 104-A** extend the square wave testing technique into many fields of production testing.



### CHARACTERISTICS

**Frequencies**—Four fixed: 50 cps, 1 kc, 100 kc, 1 mc.

**Impedance**—Varies from 0 to 93 ohms for the high frequency output, depending on the attenuator setting. Varies from 0 to 10,000 ohms for the low frequency out-

TEKTRONIX, INC.

# SQUARE WAVE GENERATOR & VOLTAGE CALIBRATOR

put, depending upon the calibrator control settings.

**Rise Time**—0.2  $\mu$ sec for the high frequency outputs, and 3  $\mu$ sec for the low frequency outputs.

**Amplitude**—Continuously variable from 0 to 5 volts for the high frequency outputs. Continuously variable from 0 to 50 volts, in 9 calibrated ranges, for the low frequency outputs.

**Construction**—Chassis and cabinet are made of welded aluminum alloy. Front panel is photo etched, satin finished aluminum. Cabinet has baked gray wrinkle finish.

**Dimensions**—13 1/2" high; 9" wide; 10 1/2" deep.

**Weight**—22 pounds, complete with accessories.

**Power Requirements**—105-125/210-250 volts, 50-60 cycles, approximately 115 watts.

## Vacuum Tube Complement—

High Frequency Multivibrators . . . . .	2	6AG7
High Frequency Limiter . . . . .		6AG7
High Frequency Output Amplifier . . . . .		6AG7
Low Frequency Multivibrator . . . . .		12AU7
Low Frequency Limiter Diode and Cathode Follower . . . . .		12AU7
Trigger Output Cathode Follower . . . . .		6J6
Power Supply Rectifier . . . . .		5Y4G
Series Regulator . . . . .		6AU5
Regulator Amplifier . . . . .		6AU6
Voltage Reference . . . . .		OC3/VR105

**Price** with listed frequencies **\$195.00** f.o.b. Portland, Oregon. With selected frequencies, **\$20.00** additional.

# SQUARE WAVE GENERATOR



## TYPE 105

**Continuously Variable, 25 CPS - 1 MC**  
**Rise Time, .02 Microseconds**  
**Direct Reading Frequency Meter**

### APPLICATIONS

Square wave testing techniques come into wider use as the need for good transient response in wide band amplifiers becomes increasingly important. In order to test the high frequency response it is necessary to have a signal which has a rise and fall at least equal to and preferably faster than the risetime of the amplifier being tested. In addition to a sharp rise and fall, the test signal should be free of over-shoots and other spurious responses. For examination of the low frequency response a square wave signal having flat horizontal portions is needed.

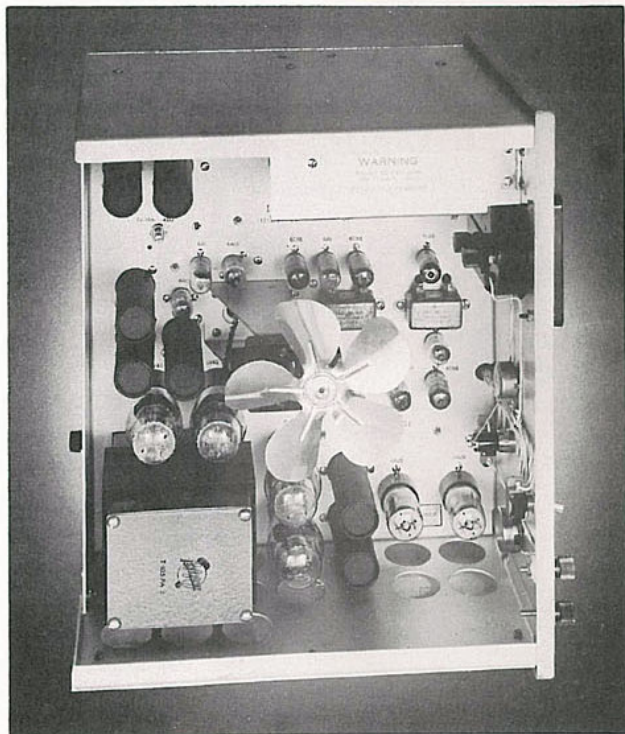
The TEKTRONIX Type 105 Square Wave Generator provides a suitable signal for both of these tests. Its frequency range extending continuously from 25 cycles to 1 mc., combined with its risetime of .02 microseconds, makes it possible to quickly and accurately test amplifiers, filters, etc., having pass bands from a few cycles to 20 mc.

For an excellent discussion on the connection between

bandwidth and frequency response, composition of rise-time and other details associated with square wave testing, see Vol. 18, Radiation Laboratory Series, "Vacuum Tube Amplifiers" (McGraw-Hill).

### GENERAL DESCRIPTION

The TEKTRONIX Type 105 Square Wave Generator consists of a multivibrator frequency generator, having nine ranges in two steps per decade. The signal from the multivibrator is fed through two shaper stages to the output stage which consists of three 6AG7 tubes in parallel. The maximum square wave current available at the output terminals is approximately 160 ma. (peak to peak). This gives approximately 12 V. in 75-ohm cable or 15 V. in 93-ohm cable, the 93-ohm cable being supplied as a standard part. If higher output voltages are needed, correspondingly larger loads may be used with a deterioration of the rise-time approximately proportional to the increased load. Maximum available output voltage is 100 V. A panel control permits setting the output amplitude from near zero to the previously mentioned maximums.



Because of the difficulties of maintaining frequency calibration on multivibrators using small plate loads, a direct reading frequency meter is incorporated. The ranges of the frequency meter are changed simultaneously with those of the multivibrator, thus providing two scales per decade.

Provision is made to furnish a synchronizing signal to an oscilloscope. The amplitude of this signal is independent of the output control setting. A sync. input binding post is also provided so that the square wave frequency may be synchronized with any desired standard.

All DC power supplies are electronically regulated so that uniform operation is obtained at line voltages of 105-125 V./210-250 V.

**TEKTRONIX, INC.**

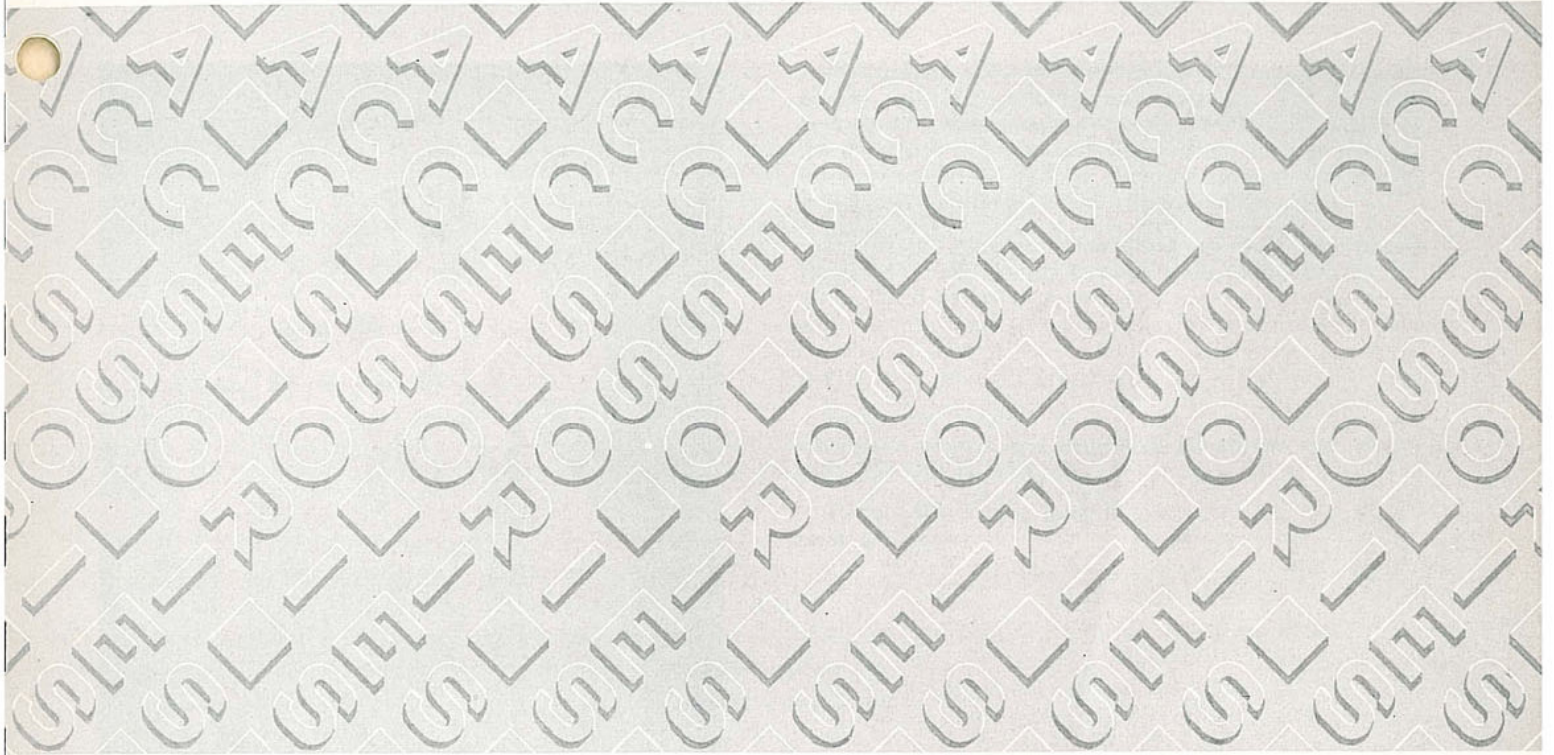
# SQUARE WAVE GENERATOR

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**Frequency Range** . . . . . 25 cycles to 1 mc  
**Rise Time** . . . . . .02 microseconds for output load of  
 100 ohms or less  
**Output Amplitude** . . . . . 0-100 V. peak to peak across  
 internal 600-ohm load  
 0-160 ma. available for external load  
**Accuracy of Frequency Indication**  $\pm 3\%$  of full scale  
**Sync. Output** . . . . . 5 Volts  
**Sync. Input** . . . . . 3 Volts  
**Power Requirements** . . . . . 105-125, 210-250 V., 50-60  
 cycles, 250 watts  
**Dimensions** . . . . . 10½" wide, 16" high, 14½" deep  
**Weight** . . . . . 35½ pounds complete with accessories  
**Vacuum Tube Complement**  
 Multivibrator . . . . . 2 6CB6  
 Shaper amplifier . . . . . 6AG7

Driver amplifier . . . . . 2 6AG7  
 Output amplifier . . . . . 3 6AG7  
 Sync input amplifier . . . . . 6CB6  
 Sync coupling diode . . . . . 6AL5  
 Meter amplifier . . . . . 6CB6  
 Limiter and catcher diode . . . . . 6AL5  
 Cathode follower voltage regulator . . . . . 6J6  
 Meter diode . . . . . 6AL5  
 Sync output cathode follower . . . . . 6J6  
 Fixed power supply rectifiers . . . . . 2 5V4G  
 Series regulator tubes . . . . . 2 6AU5  
 Regulator amplifier . . . . . 6AU6  
 Voltage reference tube . . . . . 5651  
 Variable power supply rectifiers . . . . . 2 5V4G  
 Series regulator tubes . . . . . 2 6AU5  
 Regulator amplifier . . . . . 6AU6

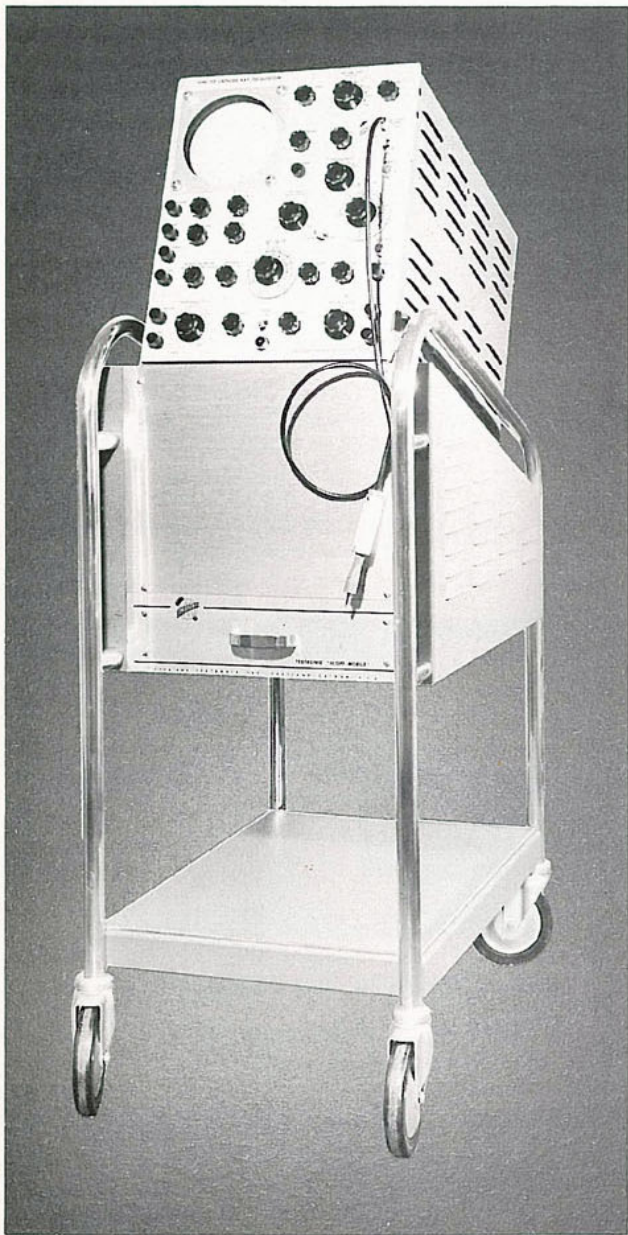
**Price \$395.00 f.o.b. Portland, Oregon**



## ACCESSORIES

*These accessories are designed to expand the applicability of Tektronix Oscilloscopes in order that a greater benefit might accrue to the user.*

# SCOPE - MOBILE



## TYPE 500

The TEKTRONIX **Type 500 Scope-Mobile** has been especially designed to accommodate the Tektronix Cathode Ray Oscilloscopes. It provides a sturdy yet mobile and therefore highly useful support for the Oscilloscope. Convenient and easy observation of the CRT face is achieved by a 20° tilt back.

A blank panel, 11"x15", fronting a mounting space of approximately 1 1/2 cubic feet allows for auxiliary built-in equipment as an aid in meeting specialized requirements. This space is fully ventilated by means of louvres. A power input connector and three convenience outlets appear at the back.

A drawer is provided for the handy storage of cords, probes, instruction books, small tools, etc. For quietness and ease of operation the drawer, 15"x15"x3" in size, is felt lined and operates in roller bearing support runners. An open shelf, 17"x24" in size and topped with battleship linoleum, is located at the bottom of the unit.

The unique and functional design of the Scope-Mobile assures ease of mobility through multi-handhold rails, 5" rubber tired castoring wheels and low weight. The entire unit is constructed of aluminum alloy materials, finished in bright buffed aluminum and baked grey crackle to match other Tektronix products.

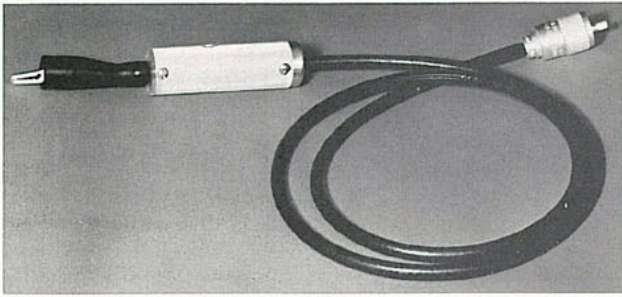
Total "dry" weight of the Scope-Mobile is approximately 42 pounds and clearance dimensions are 18 1/2" wide, 39" high and 30" deep.

**Type 500 Scope-Mobile** price \$97.50, f.o.b. Portland, Oregon.



TEKTRONIX, INC.

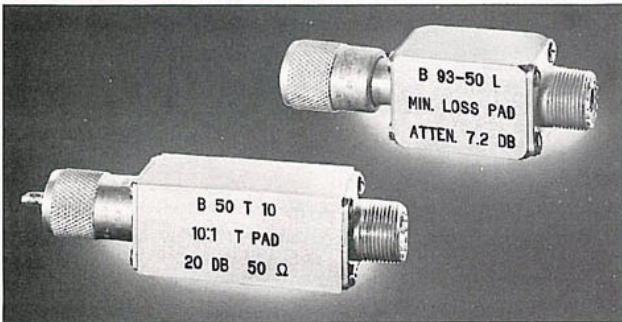
# ACCESSORIES



## PROBES

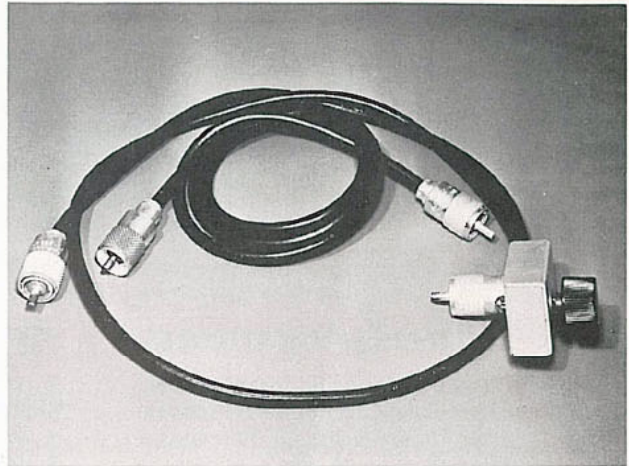
The TEKTRONIX Type P-510 Attenuator Probe has an input impedance of 10 megohms paralleled by approximately 14 micro-microfarads and provides an attenuation of ten times when used with TEKTRONIX Oscilloscopes and Amplifiers. Measurements in relatively high impedance circuits can be made with minimum disturbance to the circuit when the Type P-510 is used.

Type P510 Attenuator Probe . . . . . \$9.25



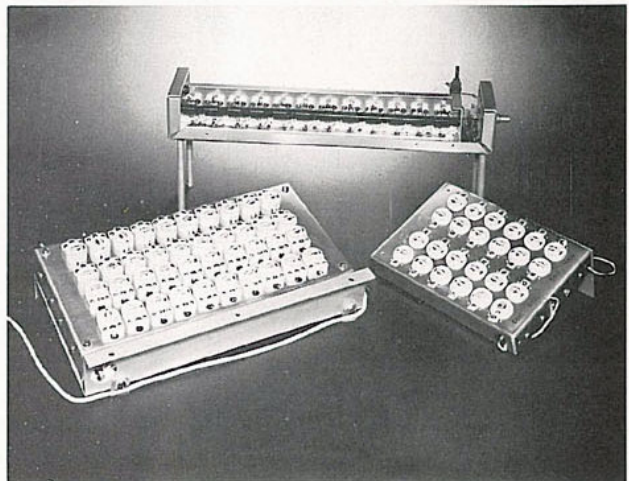
## TERMINATION ACCESSORIES

- B50R Resistor, terminating, 50 ohms . . . . . \$ 8.50
- B93R Resistor, terminating, 93 ohms . . . . . \$ 8.50
- B50DB2 Attenuator, 50 ohms impedance, 3 and 6 db attenuation . . . . . \$17.00
- B50L5 Pad, "L" configuration, 50 ohms impedance, 5:1 voltage ratio . . . . . \$ 8.50
- B50L10 Pad, "L" configuration, 50 ohms impedance, 10:1 voltage ratio . . . . . \$ 8.50
- B93L5 Pad, "L" configuration, 93 ohms impedance, 5:1 voltage ratio . . . . . \$ 8.50
- B93L10 Pad, "L" configuration, 93 ohms impedance, 10:1 voltage ratio . . . . . \$ 8.50
- B50T10 Pad, "T" configuration, symmetrical, 50 ohms, 10:1 voltage ratio . . . . . \$11.50
- B93T10 Pad, "T" configuration, symmetrical, 93 ohms, 10:1 voltage ratio . . . . . \$11.50
- B93-50L Pad, "L" configuration, minimum loss, input 93 ohms, output 50 ohms . . . . . \$11.50
- B52-170L Pad, "L" configuration, minimum loss, input 52 ohms, output 170 ohms . . . . . \$11.50
- B52-170T10 Pad, "T" configuration, 170 ohms to 52 ohms . . . . . \$11.50
- B170V Attenuator, step, 1-64 db in 1. db steps, 170 ohms impedance . . . . . \$45.00



## COAXIAL CABLES

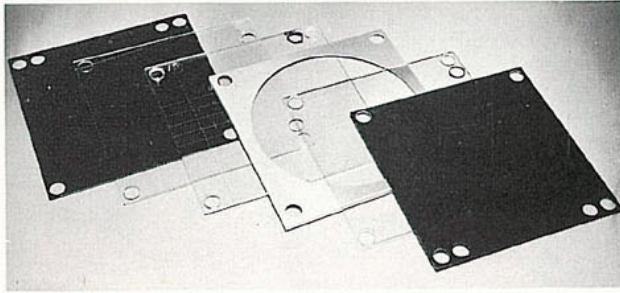
- P50 Cable, coaxial, 50 ohms impedance, 42" long . . . . . \$ 4.00
- P93 Cable, coaxial, 93 ohms impedance, 42" long . . . . . \$ 4.00
- P93A Cable, coaxial, output, 93 ohms impedance, terminated one end with variable attenuator, 42" long . . . . . \$13.50
- P93B Cable, coaxial, output, 93 ohms impedance, terminated one end with 1/2 watt, 93 ohm resistor, 42" long . . . . . \$ 5.00
- P170 Cable, coaxial, 170 ohms impedance, 42" long . . . . . \$ 9.50



## DELAY NETWORKS

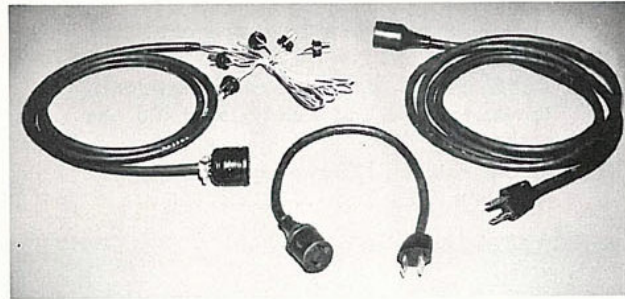
- 1-D-25 Delay network, .25 μsec delay, for Type 511 . . . . . \$50.00
- 1-AD-25 Delay network, .25 μsec delay, for Type 511A . . . . . \$50.00
- 3-D-25 Delay network, .25 μsec delay, for Type 513 . . . . . \$65.00
- 4-D-25 Delay network, .25 μsec delay, for Type 514 . . . . . \$50.00

# ACCESSORIES



## FILTERS — GRATICULES

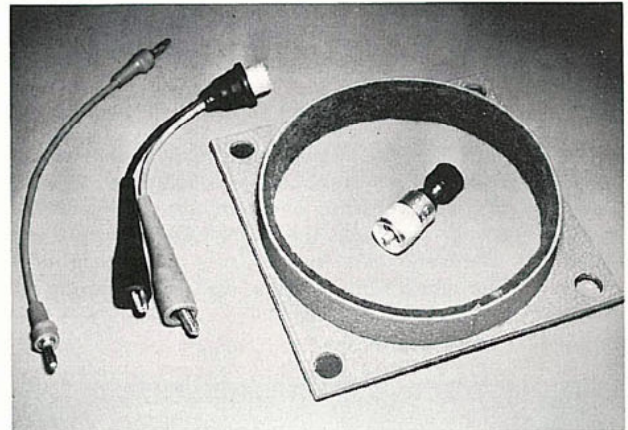
F13	Filter, amber, lucite, for 5" scopes . . . . .	\$ .90
F14	Filter, yellow, lucite, for 5" scopes . . . . .	\$ .90
F15	Filter, green, lucite, for 5" scopes . . . . .	\$ .90
F16	Filter, blue, lucite, for 5" scopes . . . . .	\$ .90
GR511A	Graticule, for Type 511A . . . . .	\$1.50
GR512	Graticule, for Type 512 . . . . .	\$1.50
GR513	Graticule, for Type 513 . . . . .	\$1.50
GR514	Graticule, for Type 514 . . . . .	\$1.50
GR517	Graticule, for Type 517 . . . . .	\$9.50
GC510	Graticule Cover . . . . .	\$ .50
GC513	Graticule Cover . . . . .	\$ .50



## POWER CABLES

W122	Cable, battery, for Type 122 . . . . .	\$7.50
W160	Cord, Power, interconnecting X160 power supply with X160 series units . . . . .	\$3.90

W517	Cable, interconnecting, Type 517 inter-unit . . . . .	\$9.50
COP18-8	Cord, power, two #18 wires, 8 ft. long . . . . .	\$1.50
COP16-8	Cord, power, two #16 wires, 8 ft. long, for Type 517 . . . . .	\$2.40
COP18-1	Cord, power, two #18 wires, 1 foot long, for Scope-mobile . . . . .	\$ .85



## MISCELLANEOUS

BE510	Bezel, 5" . . . . .	\$ 4.50
A100	Adapter, clip lead . . . . .	\$ 2.50
A150	Adapter, binding post . . . . .	\$ 1.88
CON3P	Plug, input, for Type 122 . . . . .	\$ .66
W112R	Lead, red, interconnecting, for Type 112 . . . . .	\$ 1.00
W112B	Lead, black, interconnecting, for Type 112 . . . . .	\$ 1.00
FA160	Frame, mounting, for Type 122 and Type 160 series units . . . . .	\$15.00



# GENERAL INFORMATION

## Terms and Shipment

Our terms are 1% ten days, net thirty days on domestic orders; net thirty days on export orders. Shipping delay may be prevented by establishing credit at time of placing order. When desirable, C.O.D. shipments can be arranged.

For information relative to discounts on quantity purchases, please contact your nearest Tektronix representative, distributor, or branch office.

Although all quotations are for shipment f.o.b. Portland, Oregon, upon request transportation costs can be prepaid and the amount added to the invoice.

Normally, shipments are made by Railway Express or Motor Freight. If shipment by air is desired, please specify Air EXPRESS or Air FREIGHT. Experience has eliminated rail freight as a satisfactory method of surface transportation for electronic instruments.

## Export Orders

All orders and inquiries from countries other than the United States should be addressed directly to: Tektronix, Inc., Export Department, P.O. Box 831, Portland 7, Oregon. Cable address: TEKTRONIX.

## Delivery

Acceptance of purchase orders is indicated by our acknowledgment, and estimated delivery time is given from date of acknowledged acceptance. Every effort is made to meet the estimated delivery date, but it must be remembered that a manufacturer's ability to meet delivery schedules is contingent upon factors which tend to be uncertain during a time of national emergency.

## Field Maintenance

Tektronix Field Maintenance is operated on a non-profit basis, as a service to our customers. Work is expedited whether or not the instrument is in warranty.

Requests for repairs or replacement parts should include type number and serial number and should be directed to our representative or branch office in your area. In an emergency, please wire or phone Field Maintenance, Tektronix, Inc., Portland, Oregon, in addition to notifying the local representative. This procedure will assure you the fastest possible service.

If an instrument must be returned to the factory for repairs, notify Field Maintenance directly or through the local representative, **indicating type number and serial number**, and you will be notified at once as to procedure to be followed. PLEASE DO NOT RETURN AN INSTRUMENT BEFORE RECEIVING DIRECTIONS.

It is standard practice for Tektronix to incorporate improvements into production instruments as they are developed in our laboratories. Owners of existing instruments are notified of modifications, and modification kits are made available, when practicable, to those who wish to modernize their own instruments.

For customers who have large quantities of Tektronix instruments and wish to equip their maintenance departments with factory-tested components, integrated kits of parts are available. Kits are designed to cover expected needs of a group of ten instruments of the same type.

## Warranty

All Tektronix instruments are fully guaranteed against defective materials and workmanship for one year. Should replacement parts be required, whether at no charge under warranty or at established net prices, they will be shipped from the factory, via air transportation on request, prepaid to any point within continental North America.

All Tektronix transformers manufactured within our plant are guaranteed against failure due to faulty workmanship or materials for the life of the instrument.

## APPROXIMATE SHIPPING WEIGHTS

INSTRUMENT TYPE	NET WEIGHT IN POUNDS	DOMESTIC PACKED IN POUNDS	EXPORT PACKED IN POUNDS	EQUIVALENT DIMENSIONAL WEIGHTS IN	
				POUNDS	KILOGRAMS
511A .....	53½	70½	92½	135	61.2
511AD .....	55	72	94	135	61.2
512 .....	56	73	95	135	61.2
513 .....	77	95	124	178	80.7
513D .....	79	97	126	178	80.7
514 .....	60	77	99	135	61.2
514D. ....	61	78	100	135	61.2
517 Indicator Unit.....	76	103	127	178	80.7
Power Supply.....	72	86	105	105	47.7
Scopemobile .....	42	56	<del>67</del> 60	<del>115</del> 147	<del>52.2</del> 66.7
104A. ....	22	30	50	90	40.8
105 .....	35½	47	66	90	40.8
112 .....	32	49	76	135	61.2
121 .....	18½	24	48	90	40.8
122 .....	5½	9	19	35	15.9
500 .....	42	56	67	115	52.2

# CURRENTLY AVAILABLE EXTRAS

	First	Second	Successive
<b>TYPE 104A SQUARE WAVE GENERATOR</b>			
Tropicalization* .....	{ New ..... \$20	\$12	\$ 8
	{ Returned ..... \$20	\$15	\$10
With selected frequencies			
2 in range 50 cps to 10 kc			
2 in range 50 kc to 1 mc..... Add .....	\$20		
 <b>Type 105 SQUARE WAVE GENERATOR</b>			
Tropicalization* .....	{ New ..... \$20	\$12	\$ 8
	{ Returned ..... \$20	\$15	\$10
 <b>Type 112 DIRECT COUPLED AMPLIFIER</b>			
Tropicalization* .....	{ New ..... \$25	\$15	\$10
	{ Returned ..... \$25	\$20	\$15
 <b>Type 121 WIDE BAND PRE-AMPLIFIER</b>			
Tropicalization* .....	{ New ..... \$20	\$12	\$ 8
	{ Returned ..... \$20	\$15	\$10
 <b>Type 122 LOW LEVEL PRE-AMPLIFIER</b>			
Tropicalization* .....	{ New ..... \$10	\$ 7	\$ 5
	{ Returned ..... \$12	\$ 9	\$ 7
Cabinet mounting .....	Full Price .....	\$85	
Rack mounting .....	Full Price .....	\$90	
Frame mounting .....	Full Price .....	\$90	
FA160 Frame for above.....		\$15	
 <b>Type 511A, 511AD CATHODE-RAY OSCILLOSCOPE</b>			
Tropicalization* .....	{ New ..... \$25	\$15	\$10
	{ Returned ..... \$25	\$20	\$15
Rack mounted .....	Add .....	\$25	
Marker generator, 1 microsecond.....	Add .....	\$40	
(1 $\mu$ sec time markers available on spare position of Signal-Calibrate switch)			
CRT Phosphors available:			
P1 NORMALLY FURNISHED			
P7 Optional .....		No extra charge	
P11 Optional .....		No extra charge	

\*Tropicalization: TEKTRONIX instruments are tropicalized after assembly by spraying with a fungicidal varnish, Brooklyn Varnish Company #74S, which conforms with specifications of JAN-T-152. While we attempt to do the best possible job, our method of application and extent of coverage does **not** necessarily conform with JAN-T-152.

# CURRENTLY AVAILABLE EXTRAS

## Type 512 CATHODE-RAY OSCILLOSCOPE

	First	Second	Successive
Tropicalization* . . . . .	{ New . . . . . \$25 Returned . . . . . \$25	\$15 \$20	\$10 \$15
Right-hand cathode-ray tube . . . . .	Add . . . . . \$100		
10 $\mu$ sec/cm to 1 sec/cm sweep time . . . . .	Add . . . . . \$25		
30 $\mu$ sec/cm to 3 sec/cm sweep time . . . . .	Add . . . . . \$25		
Rack mounted . . . . .	Add . . . . . \$25		
CRT Phosphors available:			
P1 Optional . . . . .		No extra charge	
P7 NORMALLY FURNISHED			
P11 Optional . . . . .		No extra charge	

## Type 513, 513D CATHODE-RAY OSCILLOSCOPE

Tropicalization* . . . . .	{ New . . . . . \$50 Returned . . . . . \$50	\$30 \$40	\$20 \$30
CRT Phosphors available:			
P1 Metallized Optional . . . . .		No extra charge	
P2 Metallized NORMALLY FURNISHED			
P11 Metallized Optional . . . . .		No extra charge	

## Type 514, 514D CATHODE-RAY OSCILLOSCOPE

Tropicalization* . . . . .	{ New . . . . . \$25 Returned . . . . . \$25	\$15 \$20	\$10 \$15
Rack mounted . . . . .	Add . . . . . \$25		
CRT Phosphors available:			
P1 NORMALLY FURNISHED			
P7 Optional . . . . .		No extra charge	
P11 Optional . . . . .		No extra charge	

## Type 517 CATHODE-RAY OSCILLOSCOPE

Tropicalization* . . . . .	{ New . . . . . \$75 Returned . . . . . \$75	\$40 \$50	\$30 \$45
CRT Phosphors available:			
P1 Metallized Optional . . . . .		No extra charge	
P2 Metallized Optional . . . . .		No extra charge	
P11 Metallized NORMALLY FURNISHED			

\*Tropicalization: TEKTRONIX instruments are tropicalized after assembly by spraying with a fungicidal varnish, Brooklyn Varnish Company #74S, which conforms with specifications of JAN-T-152. While we attempt to do the best possible job, our method of application and extent of coverage does **not** necessarily conform with JAN-T-152.

# TEKTRONIX, INC.

Manufacturers of Cathode-Ray and Video Test Instruments

## HOME OFFICE

SUNSET HIGHWAY AND BARNES ROAD • P. O. BOX 831 • PORTLAND 7, OREGON, U. S. A.  
**PHONE: ATwater 6357**      **CABLES: TEKTRONIX**

## EASTERN DIVISION OFFICE

TEKTRONIX, INC. .... 49 PONDFIELD ROAD ..... BRONXVILLE 8, NEW YORK  
*J. J. Cassidy*      BRonxville 2-3266      *Jack Day*

## BRANCH OFFICE

TEKTRONIX, INC. .... 8118 HARFORD ROAD ..... BALTIMORE 14, MARYLAND  
*G. F. Bauder*      Boulevard 2600

## TEKTRONIX ENGINEERING REPRESENTATIVES

<b>FLORIDA</b> Arthur Lynch & Associates P. O. Box 466 Fort Myers 5-6762	<b>FORT MYERS</b> <i>Arthur H. Lynch</i>	<b>ARIZONA</b> Neely Enterprises 32 West Jefferson St. Phone: 4-7311	<b>PHOENIX</b> <i>Bill Saxon</i>	<b>MISSOURI</b> Everett Associates 411 West 74th Terrace DElmar 7996	<b>KANSAS CITY, 5</b> <i>Eugene Shapiro</i>
<b>ILLINOIS</b> Everett Associates 6744 N. California Ave. AMBassador 2-3702	<b>CHICAGO, 45</b> <i>Jim Everett</i> <i>Geo. Knackstedt</i> <i>Dave Pivan</i>	<b>CALIFORNIA</b> Neely Enterprises 7422 Melrose Avenue WHitney 1147	<b>HOLLYWOOD, 46</b> <i>N. B. Neely</i> <i>R. L. Morgan</i> <i>John O'Halloran</i>	<b>NEW MEXICO</b> Neely Enterprises 107 So. Washington St. Phone: 5-8731	<b>ALBUQUERQUE</b> <i>L. E. French</i> <i>Hoyt Westcott</i>
<b>MICHIGAN</b> The Satullo Company 7635 E. Jefferson Lorain 8-1508	<b>DETROIT, 14</b> <i>Anthony R. Satullo</i>	<b>CALIFORNIA</b> Neely Enterprises 309 Oschner Bldg. GIlbert 3-7461	<b>SACRAMENTO</b> <i>Rudy Paucher</i>	<b>OKLAHOMA</b> M. F. Klicpera Company P. O. Box 1012	<b>TULSA</b> <i>A. R. Loomis</i>
<b>NORTH CAROLINA</b> Bivins & Caldwell Security Bank Bldg. Phone: 3672	<b>HIGH POINT</b> <i>John Bivins</i> <i>Dave Caldwell</i> <i>C. M. Smith, Jr.</i>	<b>CALIFORNIA</b> Neely Enterprises 2830 Geary Blvd. WAlnut 1-3960	<b>SAN FRANCISCO, 3</b> <i>Jack Ingersoll</i> <i>Don Kestell</i>	<b>OREGON</b> Hawthorne Electronics 700 S. E. Hawthorne Blvd. VERmont 5585	<b>PORTLAND, 14</b> <i>Glenn McDowell</i> <i>Jack Stevenson</i>
<b>OHIO</b> The Satullo Company 1125 Fidelity Bldg. Prospect 1552	<b>CLEVELAND</b> <i>Howard Heasley</i>	<b>CALIFORNIA</b> Neely Enterprises 2830 Geary Blvd. WAlnut 1-3960	<b>SAN FRANCISCO, 3</b> <i>Jack Ingersoll</i> <i>Don Kestell</i>	<b>TEXAS</b> M. F. Klicpera Company P. O. Box 3113 JACKson 2-8459	<b>HOUSTON, 1</b> <i>Mil Klicpera</i>

## TEKTRONIX OVERSEAS DISTRIBUTORS

<b>NORWAY</b> Eugen Nilsson Moltergaten 8 Phone: 331428	<b>OSLO</b> <i>Jens A. Stavnes</i>	<b>SWEDEN</b> Erik Ferner Postfack Phone: 198949	<b>STOCKHOLM, 32</b> <i>Erik Ferner</i>	<b>SOUTH AFRICA</b> Protea Holdings, Ltd. 7 Newton St., Wemmer Phone: 33-2211	<b>JOHANNESBURG</b> <i>Eric Mance</i>
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Other OVERSEAS areas please write or cable directly to:

EXPORT DEPARTMENT  
P. O. Box 831  
Portland 7, Oregon  
Cable: TEKTRONIX      *W. K. Dallas*

CAT. 5203