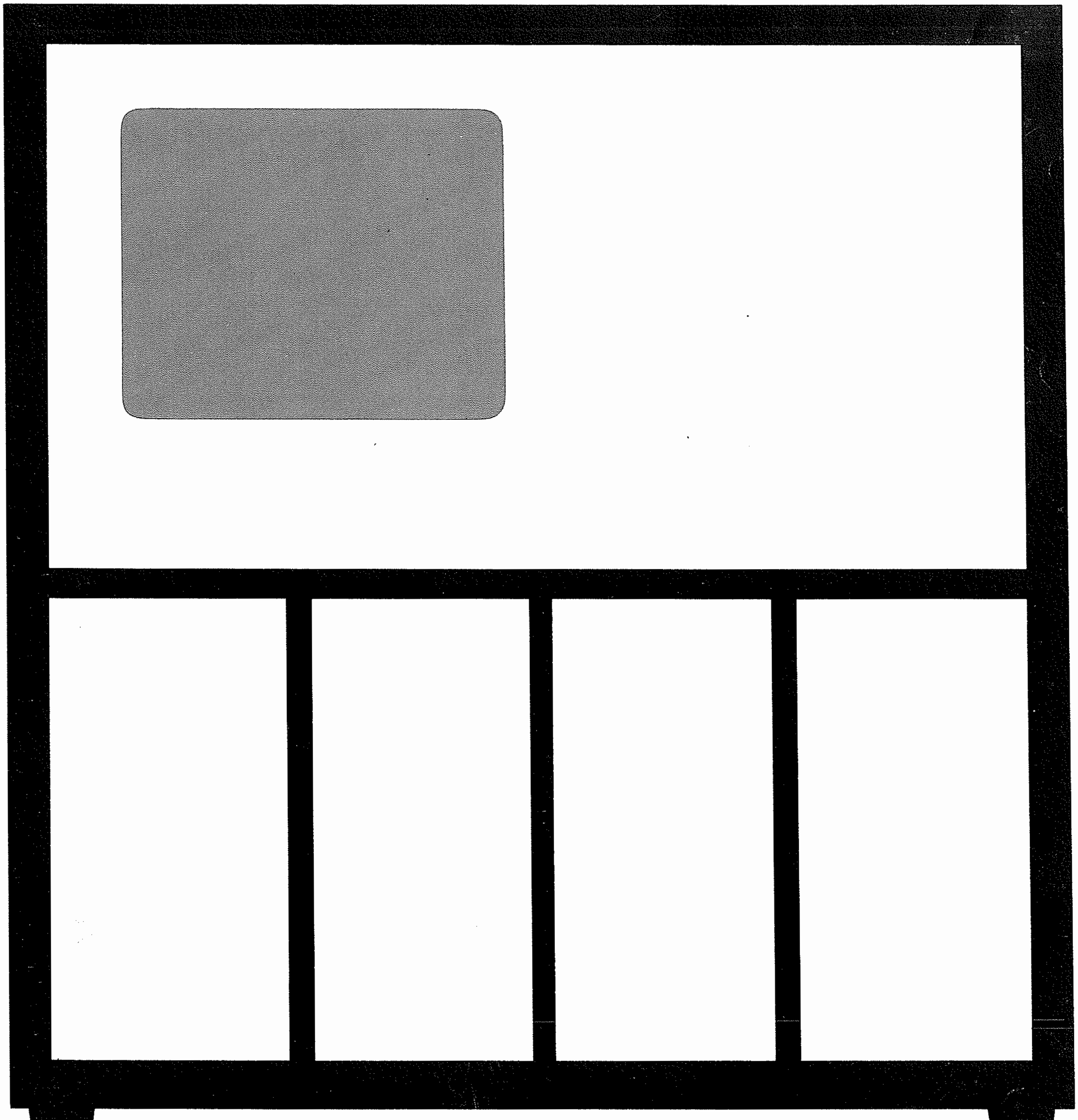
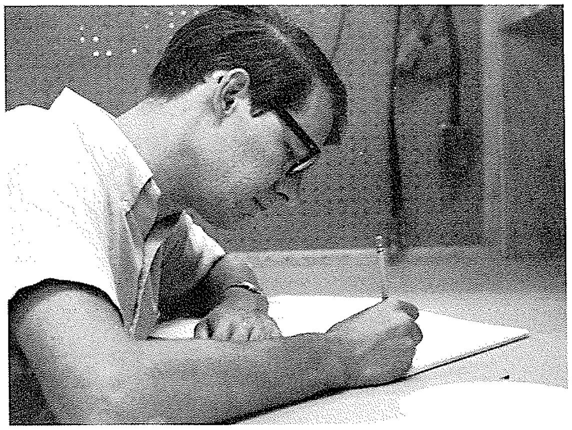
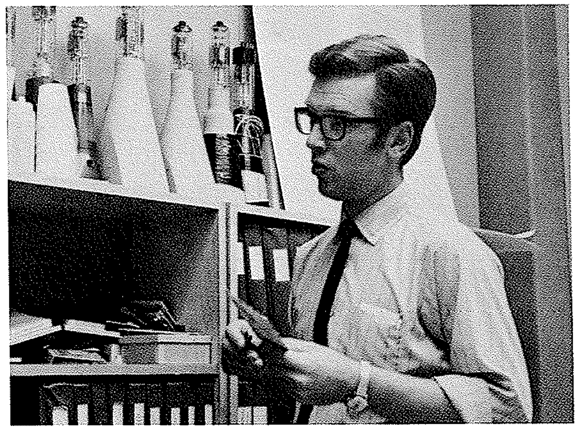
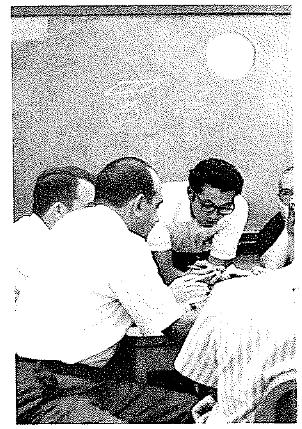
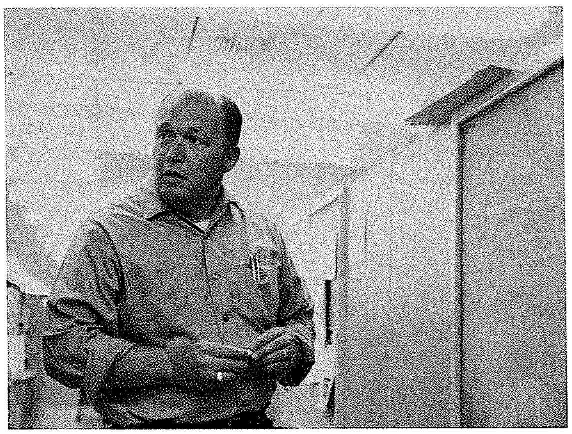
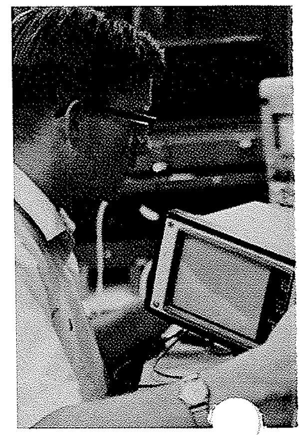
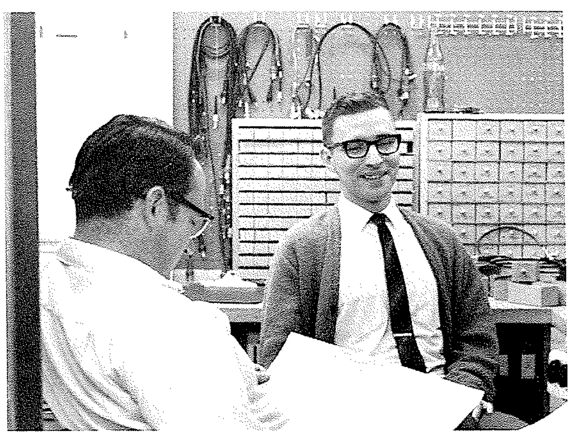
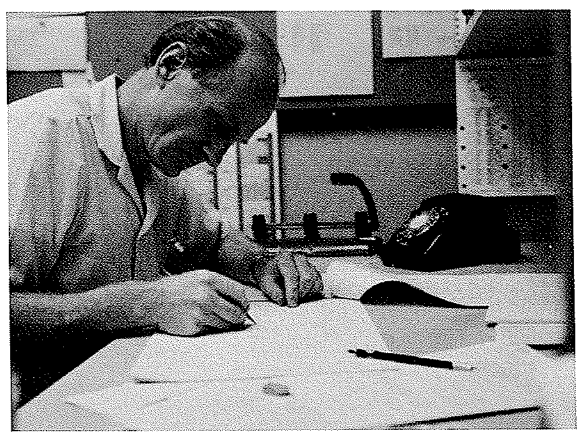
TEKSCOPE

OCTOBER 1969

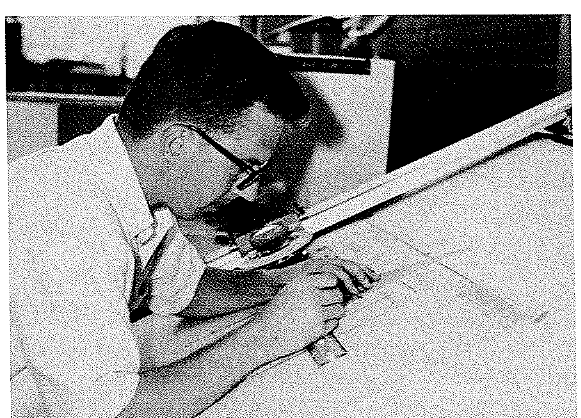
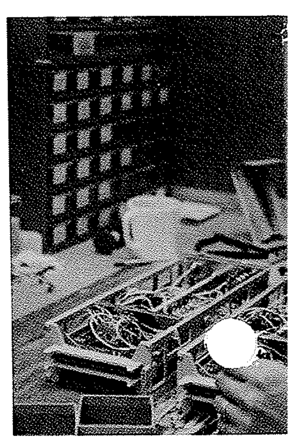


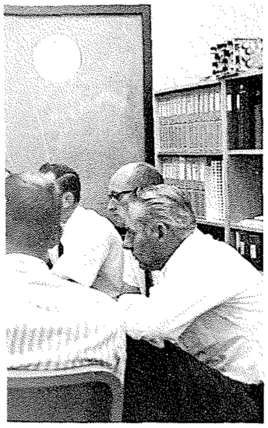





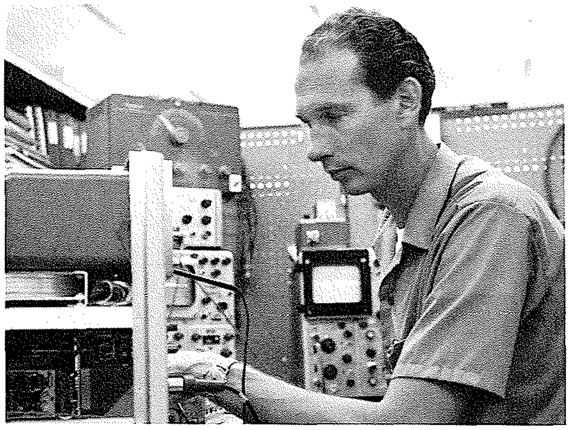
NEW GEN

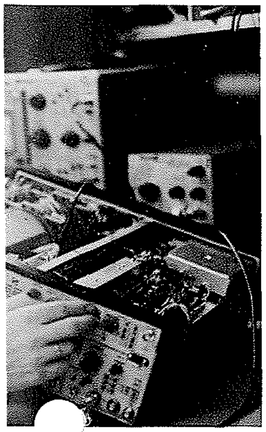

October TEKSCOPE focuses on some of the more unique aspects of our new generation of oscilloscopes. The cover symbolizes the bold new concepts embodied in these instruments . . . . Pictured within these pages are a few of the individuals involved with the myriad of problems associated with developing a totally new product line. . . . . Future articles in TEKSCOPE will deal with some of the more specific measurement capabilities of these sophisticated designs . . . .

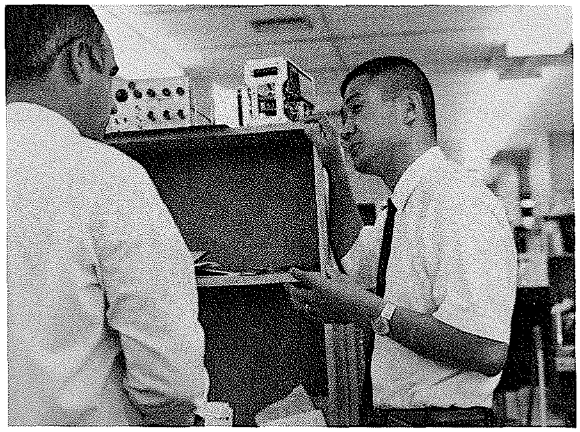



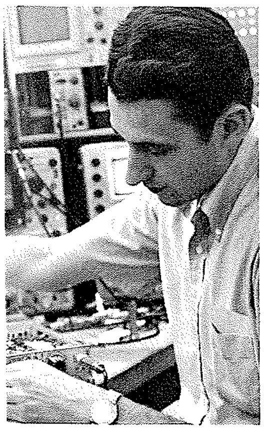


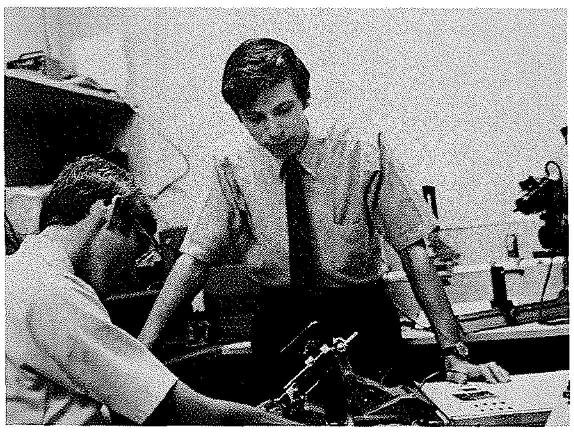


Over 15 years ago Tektronix introduced the plug-in concept with the introduction of the Type 535 Oscilloscope. The instrument accepted any one of four plug-ins and for the first time allowed the user to quickly adapt a single oscilloscope to observe many varied signal sources. Oscilloscope plug-in preamplifiers provided high-gain, wide bandwidth, differential, and dual-trace performance, and provided great versatility at a reasonable price. Since that time the spectrum has widened to include 14 other oscilloscopes with 30 additional plug-ins, and all are compatible. Storage, sampling, time-domain reflectometry, spectrum analysis, and a number of other advancements have all been incorporated to expand the versatility of the concept.





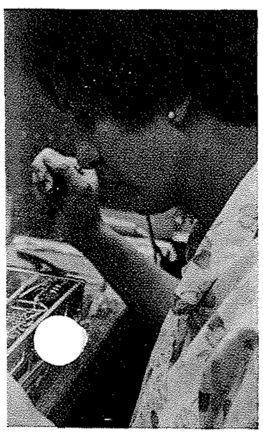


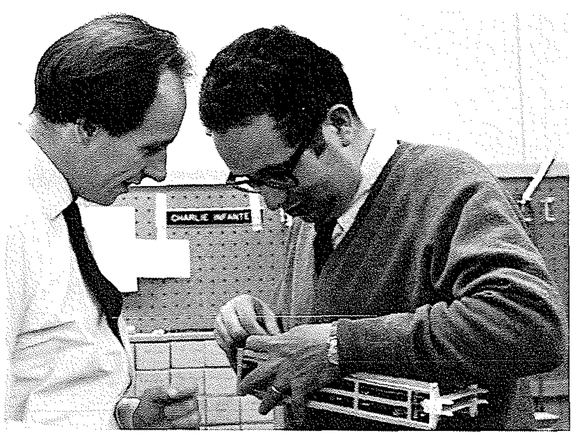


The NEW GENERATION is a term used by those who have participated in the development of a new concept in oscilloscope design. To the men and women of Tektronix, who have labored with their many varied skills to convert these thoughts into reality, it will always be the NEW GEN.

The NEW GEN has taken the best efforts of a large segment of the Tektronix development population. The beginnings were over five years ago when a small task force first began studies of a product line designed for the future with optimum versatility. Over 20 years of oscilloscope experience and accumulated skills have interacted with these studies to result in the new 7000-Series and 5000-Series Oscilloscopes. New components have been built as well as new facilities to produce them. Over two years of intensive engineering development precedes the introduction of these instruments. The results are the *finest* oscilloscopes available based on today's most advanced technology.

This issue of TEKSCOPE can only tell the beginning of the New Generation evolution. The future, we believe, will be even more exciting.





INTRODUCING THE NEW GENERATION

The 7504 and 7704 with their array of 13 plug-ins are the vanguard of a new oscilloscope line designed with an unprecedented degree of flexibility in anticipation of future requirements. Each instrument accepts up to four plug-ins and can display its output in a wide variety of ways. Blank plug-in panels are available to cover the unused panels if four plug-ins are not required initially.

The new plug-in oscilloscopes are designed to be the most expandable line of oscilloscopes ever developed. Thought has been given to probable technical developments in both components and instruments, and every effort has been taken to ensure the future compatibility of these designs.

The 13 plug-ins provide an overall measurement capability exceeding that of any other plug-in oscilloscope. 5-mV performance at 150 MHz with a full 8-cm scan, 5-mV four-trace performance at 105 MHz, are just two of the features currently available only in the 7000 Series.

The two plug-in oscilloscopes are identical in front panel appearance. The major differences are in the vertical amplifier, the low voltage power supply, and the cathode ray tubes. The 7504 with appropriate plug-ins provides up to 90 MHz bandwidth performance, while the 7704 has 150 MHz capability.

Possibly the most dramatic feature of the new instruments is the readout capability. Auto scale-factor readout is a standard feature of both oscilloscopes and automatically provides a display of vertical and horizontal sensitivity. By providing the correct scale factors on the face of the CRT, the operator is relieved from simple but bothersome mental calculations. Plug-in knob settings are read out on the CRT screen by means of a unique character generator which time-shares the CRT beam with the normal oscilloscope display.

Magnifier settings and probe attenuation are automatically taken into consideration. Therefore, the operator always reads the value at the probe tip at the correct sweep speed. Should plug-in polarity be inverted, an indication (↓) is given. If any knob becomes uncalibrated, a greater than symbol (>) will precede the quantity. A photograph will include both the analog display and alphanumeric data, eliminating the possibility of incorrect labeling.

A new trigger circuit is featured in the new oscilloscopes that greatly simplifies trigger operation. The peak-to-peak auto trigger circuit detects the peak-to-peak excursions of the displayed waveform, stores the value in the peak-to-peak memories, and matches the range of the level control to the range of the displayed signal. With the trigger in the peak-to-peak auto position, the operator can go through the maximum excursions on either slope and never reach an untriggerable position on the control knob.

Switching in the 7000 Series is accomplished in the mainframe of the oscilloscope. Five vertical mode push buttons and four horizontal mode push buttons determine which plug-in outputs will be displayed. Twenty possible combinations of vertical and horizontal operating modes are provided for maximum versatility. This design choice allows comparison between any two vertical channels to enable comparison of signals with significantly different characteristics. For example, sampling (50 Ω) and conventional (1 MΩ); wide bandwidth and high sensitivity; differential comparator and current probe; dual trace and dual trace for four-trace operation are all easily accommodated in the appropriate plug-ins. In addition, as higher performance or special performance plug-ins are developed, they may be used with a more conventional unit.

The center two compartments are designed so they may be devoted to sampling capability, spectrum analysis, or

X-Y display. This allows a signal to be observed in a conventional manner while simultaneously monitoring a sampling display, frequency display, or X-Y display of the identical phenomenon.

Switching is also provided between the two horizontal plug-ins to provide sweep-switching capability. In addition to ALT, a CHOP mode is provided which is convenient when observing two displays of greatly different repetition rates. This mode also provides dual-beam capability up to approximately 20-μs/div sweep speed.

Placing the plug-in interface before the oscilloscope amplifier provides a number of important advantages. For maximum versatility, we have chosen a plug-in output of 25 mV/div at 0 volts in a 50-Ω environment. This convenient interface will allow us to take the maximum benefit of new developments in components and in signal conditioning. In addition, as future oscilloscopes evolve, changes in display sensitivities are easily accommodated with the buffering vertical amplifier.

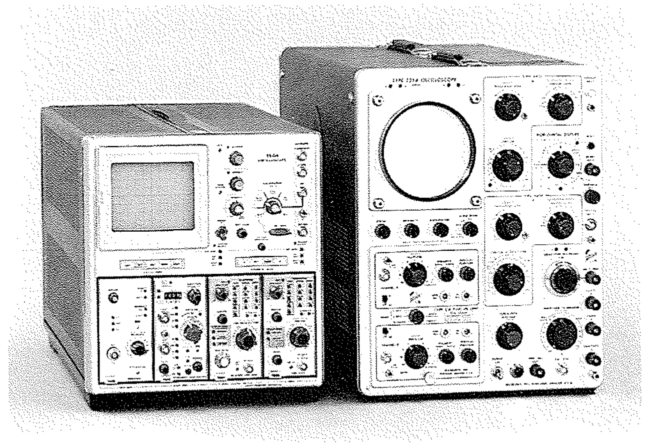
Although this design choice increases the initial price of the oscilloscope, it decreases the price of each plug-in. With the vertical amplifier in the oscilloscope, it is not necessary to build an output amplifier for each plug-in and this saving may be passed along to the customer.

The 150-MHz 7704 utilizes a "high efficiency" power supply which eliminates the bulky iron-core transformer and heat sink and eliminates any necessity for a fan. This new supply dissipates approximately 60 watts com-

7-SERIES PLUG-IN PERFORMANCE

AMPLIFIER	BANDWIDTH 7704	7504	MIN DEFL FACTOR	PERFORMANCE FEATURED
7A11	150 MHz	90 MHz	5 mV/div	Low-capacitance FET Probe Amplifier
7A12	105 MHz	75 MHz	5 mV/div	Dual-channel Amplifier
7A13	100 MHz	75 MHz	1 mV/div	Differential DC Offset, High-Freq. CMRR Amplifier
7A14	50 MHz 105 MHz	45 MHz 75 MHz	1 mA/div	AC Current Probe Amplifier (2 current probes)
7A16	150 MHz	90 MHz	5 mV/div	Wide-bandwidth Conventional Input Amplifier
7A22	1 MHz		10 μV/div	DC-Coupled, High Gain Differential Amplifier
*7S11	350 MHz - 14 GHz depending on Sampling Head		2 mV/div	Sampling Amplifier *Sampling head required
**7M11	2 GHz (175 ps)		X2 atten	**Passive Dual Delay Line Unit

TIME BASE	FUNCTION	MAX SWEEP RATE	TRIGGERING FREQ. RANGE
7B50	Delayed Sweep & Ext. Amp	5 ns/div	DC - 100 MHz
7B51	Delaying Sweep		
7B70	Delayed Sweep & Ext. Amp.	2 ns/div	DC - 200 MHz
7B71	Delaying Sweep		
7T11	Random, Sequential & Real-Time Sampling	10 ps/div	DC - 12.4 GHz



7000 Series and Type 535A. Four plug-in capability and auto scale-factor readout are distinguishing characteristics of the new instrument line.

pared to 140 watts that a conventional supply would dissipate. Use of this new supply removes approximately 12 pounds from the weight of the instrument, providing a 200-W power supply in a 10-lb package.

The instruments make extensive use of color coding to simplify front panel logic for the operator, and improve user interface. In addition, proper front panel component selection has assisted in attaining this goal.

The new R5030 is a dual-beam differential oscilloscope providing 1-MHz, 10-μV performance in a 6½-inch CRT. The instrument makes use of a fiber-optic readout display adjacent to the CRT area. A separate current mode is provided to accept a current probe (1-mA sensitivity) with no external termination being required.

The instrument is designed for simple operation and uses color coding extensively. Depressing a push button changes the display from a dual beam Y-T to a single beam X-Y display for additional versatility.

Unique to this instrument is a LOCATE function associated with the time-base magnifier. When depressed, the time base is returned to an X1 magnification position and the area which will be magnified is intensified. The magnifier, which is direct reading on the auto scale-factor readout offers five positions of magnification on the time-base switch. The locate feature allows the operator to easily pick out where on the trace he has chosen his magnified sweep.

For further information on all of these new Tektronix instruments, consult your local field engineer. Complete information is given in the August 1969 New Products Catalog Supplement.

READOUT

Since an oscilloscope display is basically a graph, it is logical that the axes be labeled with the scales used, to simplify interpretation of both displays and photographic records. The calibration of this system is accomplished with a coding system that extends to the probe tip and is carried through the plug-in interface. Thus, the oscilloscope takes on the characteristic of a true quantitative instrument.

The 7000 Series introduces a dramatic new system of readout inexpensive enough for oscilloscope use. As oscilloscope displays may present several traces at different sensitivities and sweep speeds, a versatile system is required. A fully integrated electronic character generating system has been developed which timeshares the cathode ray tube with all regular functions. The result is a system which collates within the CRT area all the important parameters of the measurement.

The symbols are 3-mm high and 2-mm wide with spacing 0.3 mm between words. Eight words are possible, four in the upper CRT area and four in the lower CRT area. The intensity of the readout display is adjustable by a front panel control and may be switched off if desired.

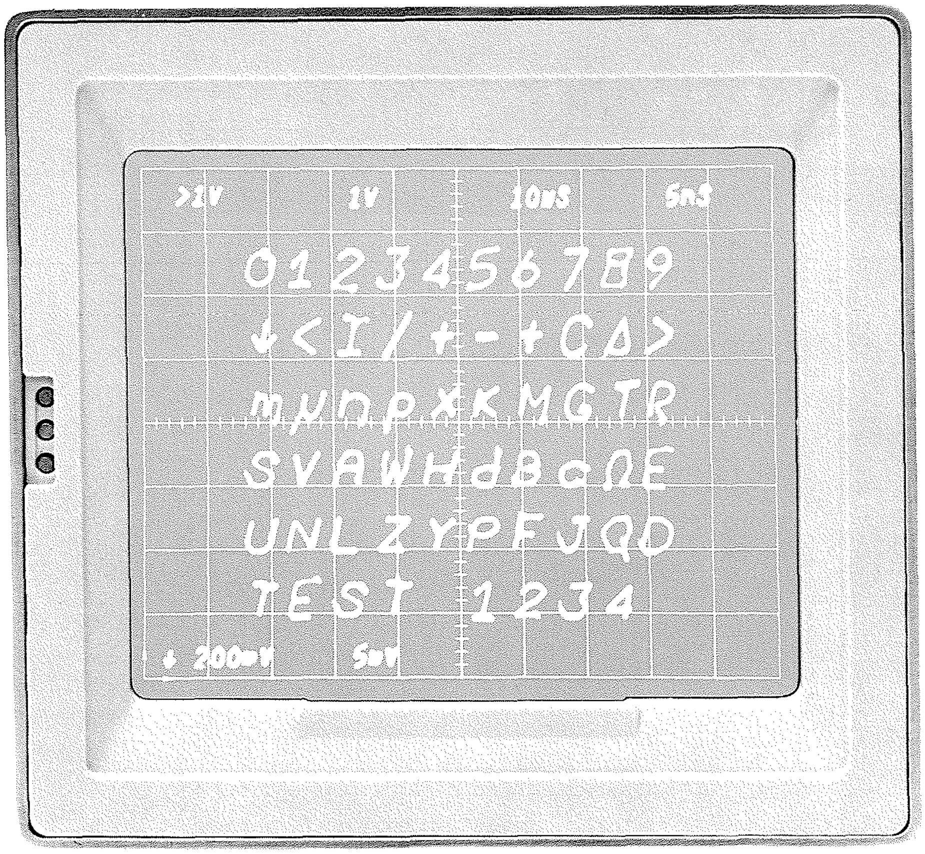
The character is written in 9.8 μs. The display rate is 71.5 Hz, independent of the amount of data. The fractional time taken out of the display is proportional to the number of symbols displayed (0.1% per symbol) and has little effect on the intensity of the normal display.

The system uses 14 Tektronix bipolar integrated circuits (the equivalent of some 6000 active devices) and is contained on a 4½ x 5-inch circuit board. The heart of the system is the novel character-generator proper. Utilizing two new circuit principles, ten symbols are packaged in each 65-mil square die, fabricated by the standard planar process. A total of five dice provide a basic 50-character font, but changes in the style of the character (italicization, aspect ratio, size, etc.) are readily made externally. To generate a new set of symbols, it is only necessary to change one mask in the process—the pre-ohmic mask. Since this step is near the end of the process, wafers can be processed in common up to this point.

Each circuit is a complete system, requiring only a power supply and a scanning voltage to produce characters on the CRT. The characters are selected directly by applying a current to one of ten selection pins. The outputs appear from "free" collectors and thus any number of packages may be connected in parallel. The outputs correspond to the scanned X- and Y-values of the complete symbol, and require no further processing. Addressing is performed by currents on column-select lines and row-select lines. The column-select current is in the range 0 to 1 mA, and the character size is directly proportional to it; thus, it is simple matter to generate a display having mixed symbol sizes.

Each symbol is composed of seven strokes, but unlike prevalent seven-stroke generators, the break-points of the strokes may be placed at any one of several hundred locations. In addition, the strokes may have virtually any length and angle, permitting high-quality symbols to be generated by a small number of co-ordinate pairs. Each of the eight break-points consists of an X-co-ordinate and a Y-co-ordinate (no Z-axis information is required to generate the symbol), and these are defined by the number of emitters connected through the pre-ohmic holes in the oxide. A total of 1440 emitters are used in the co-ordinate section of the circuit. This use of multiple emitter-areas as precise current-splitting elements is the first of the features that enabled Tektronix to achieve the high packaging density.

The second feature is found in the method devised for scanning symbols. A simple sequential pulsing of the eight co-ordinates would produce only an eight-dot display. A smooth scanning from one point to the next is required to trace out the character fully. This is achieved by using a resistive ladder network connected to the bases of the co-ordinate-forming transistors.



Multiple exposure. This photograph illustrates a typical auto scale-factor readout at top and bottom. Note the uncalibrated scale of Channel 1 and the polarity inversion of Channel 2. The 50-character font provided is also shown enlarged for clarity, in the center of the photo.

A triangular input waveform smoothly sequences through the co-ordinate pairs, and by proper network biasing produces an X- and Y-current waveform corresponding to the symbol. Scanning rates can be anywhere from DC to a megahertz.

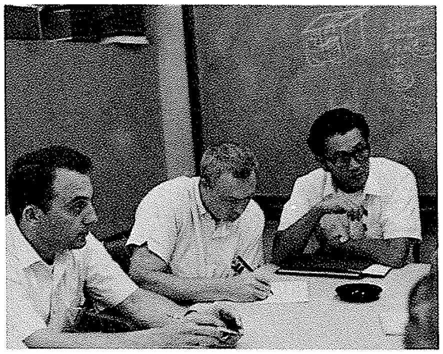
Much of the flexibility of the system stems from the data coding techniques used. Instead of using the usual binary codes, a time-multiplexed multi-level analog current code was adopted, in which the data is divided up into eleven 100-μA levels at 250-μs intervals. Since the symbols are stored in a matrix of ten rows (some correspond to the stored instructions, and some are spares) by ten columns, two lines are needed to convey the data out of the plug-in. Data is encoded in the plug-in by switch-closures and resistors. Decoding is accomplished on the readout board by integrated A-D convertors (one IC for row and one for column data) which then address the matrix.

Apart from the increased data-handling capacity (some 10^{160} combinations are possible for the readout system), a more subtle advantage results from the use of an analog current code: data can be modified systematically by the addition or subtraction of levels. For example, one of the instructions controls the number of zeros that follow the first digit of a scaling factor.

Each higher level adds a zero, until two zeros are displayed. The next level causes zeros to be dropped and the prefix (n, μ, m, etc.) to be shifted a factor of 1,000. Consequently, responding to the addition of attenuator probes is a simple matter.

Each word may have up to 10 symbols, although typically there are between 2-5 symbols per word. The symbols are normally written without redundant spaces, but spaces may be called for in the code, if desired. In addition to the scale factor, provision is made for indicating inverted polarity (↓) and not calibrated (> symbol) preceding labeling.

A special "identify" feature is included to determine which scale factor goes with which trace. Depressing the IDENTIFY button replaces the appropriate scale factor with IDENTIFY and deflects the identified trace up a few millimeters. This feature is available on all the new plug-ins and is also present on the new probes introduced.



COMPONENTS

The new generation of instruments would not have been possible without the extensive component development program embarked upon by Tektronix component engineers. Early in the program it was recognized that commercially available components would be much too restrictive; so simultaneous development programs were initiated in integrated circuits, rotary and push-button switches, relays, and thick film attenuators. At the same time, efforts were launched in developing the "mother-board" etched circuit board concept along with the required interface connectors.

The results of these efforts are the prime factors in the ability to introduce the R5030 and the 7000-Series. For example, auto scale-factor readout would not have been possible without custom integrated circuit design, since the price and size would have been prohibitive. Much of the versatile switching that characterizes the 7000-Series is also accomplished with custom IC's.

Tektronix Integrated Circuits are widely used in new generation oscilloscope circuitry. Seventeen different integrated circuits are included in the new instrument designs and allow performance that would otherwise be unattainable. The ability to custom-design IC's permits instrument features that would otherwise be prohibitively expensive. The ability to use the best logic for a given job, instead of relying on logic designed for other applications, results in a more versatile, logical instrument at a more economical price.

Tektronix switch engineers developed the small reliable rotary cam switch to replace bulky multiganged rotary switches. Two basic sizes have been developed. One incorporates a 0.83-inch drum diameter and is available in up to 28 positions. The other is 0.454 inch in diameter and is available in up to 12 positions. In the case of the R5030, two 12-position cams and a 28-position cam are linked together with a clutch to provide a direct reading magnifier and direct reading external horizontal amplifier on the same knob as the TIME/DIV control. This novel configuration simplifies the front panel logic and conserves front panel space.

Rotary cam switches provide the following advantages:

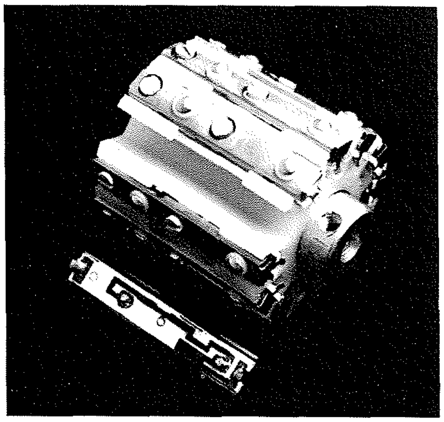
1. Lower and more controllable torque. A cam switch may be turned without a knob. Thus a smaller diameter knob may be used allowing more efficient use of front panel space.
2. Higher reliability and longer contact life.
3. More accurate control of tolerances since cam manufacturing uses numerically controlled equipment.
4. Wiring to the switch is more direct. "On board" wiring may be used since no separate wiring harness is required.

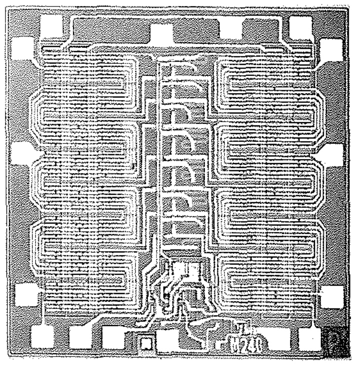
New miniature push buttons indicate the status of various functions and replace many of the larger switches used in previous designs. The basic family of push-button switches is provided in rows of 2 through 10 positions. Most configurations require only one lamp to light any button in a row.

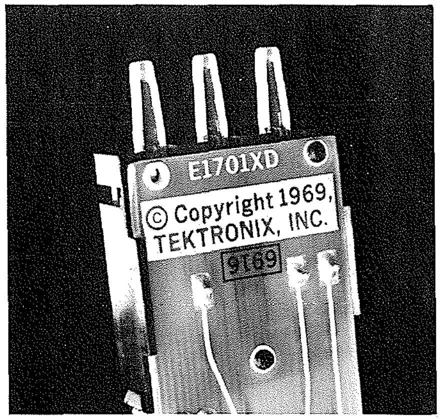
Depressing a push button causes the rear beveled edge of the button to obtain light from the lamp at the end of the rows. The light is then transmitted to the front of the transparent button. The push-button switches are mounted on an etched circuit card that contains the appropriate circuitry. The lamps used are rated at 50,000 hours at full power with even longer life at partial power.

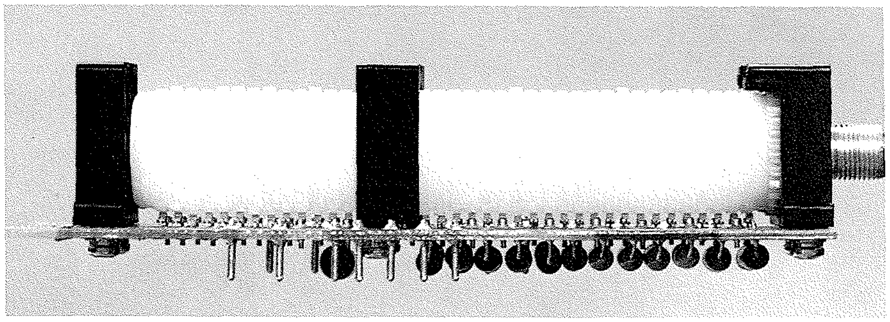
These small switches require less inward travel than other commercially available switches. Since the holes in the casting are quite small, the switch design also creates less of an EMI problem than the older larger switches.

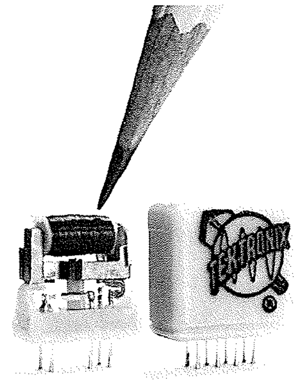
The new Tektronix instruments make extensive use of relays and relay switching. As there were no inexpensive miniature relays on the market, Tektronix engineers developed a 200-mW double-pole, double-throw











Some of the Tektronix components used in new generation instruments. Clockwise from upper left: thick-film drum attenuator, character-generator IC with 1440 emitters, miniature lighted push-button switch, miniature relays, and rotary cam switch.

sensitive relay. From this basic design, there are currently 16 variations including a single-pole, single-throw version, a magnetic latch version, and a bifilar wound center tap latch version.

Tektronix relays are generally designed to plug into a socket that is flow soldered to the etched circuit board, assuring quick and easy servicing. These low-capacitance miniature sensitive relays have less leakage than semiconductor switches and are much more tolerant of transient voltage considerations.

A new potentiometer design contributes to operator convenience and saves front panel space. The design uses a 3:1 reduction drive to improve the resolution of the triggering control. By combining this potentiometer with a relay, the slope is automatically changed as the level control passes 0° and 180°. The development of this feature provides a new ease in oscilloscope triggering and contributes to the human engineering of the new instruments.

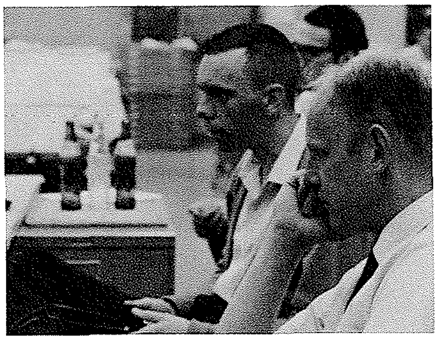
A "push-push" switch design was developed to switch variable controls in and out of the circuit. The small switch, which conveniently solders to a circuit board, is used wherever a variable function might uncalibrate an oscilloscope.

Thick film technology permitted the drum attenuator design for the 7A16 Amplifier and allows this unit to provide 5 mV sensitivity with 150 MHz bandwidth in the 7704.

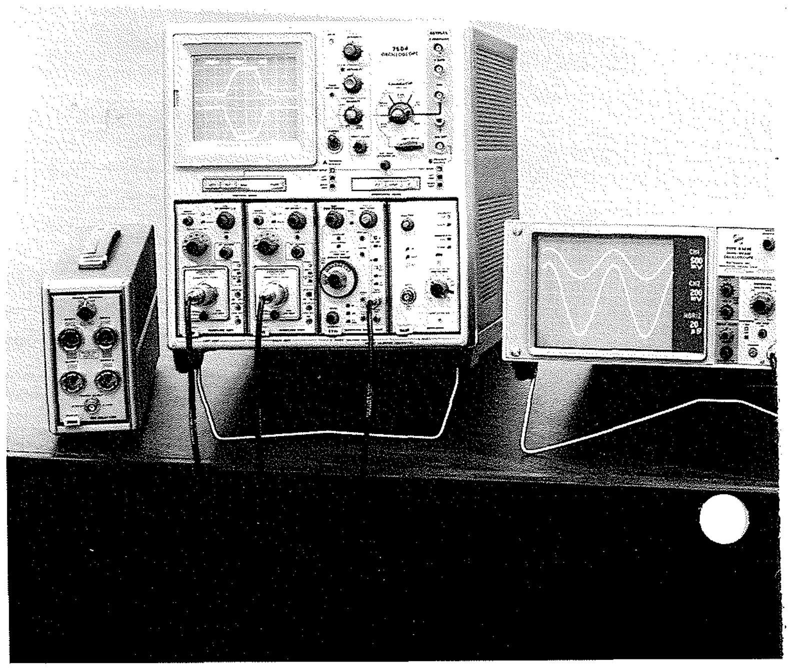
The drum attenuator design consists of a ceramic chip for each attenuator position. The chip consists of two resistors whose value is determined by the amount of thallium oxide and glass fired onto the chip. Although stray capacitance is still a factor, it is constant and controllable, and once compensated it remains the same. The attenuator design incorporates subminiature butterfly trimmers formed of small round ceramic discs with a deposited silver film to allow compensation and standardization.

Each attenuator position has its own attenuator without switching in stacked resistors. As a result, inductance, feedthrough, and crosstalk are held to a minimum. In addition, the process lends itself well to tight tolerances since the resistors may be easily trimmed to 0.1%. The result makes possible a very clean, fast plug-in amplifier with a 1 MΩ and 15 pF input impedance.

Thick-film techniques are also used for the high resistance dividers in the high voltage supplies of the 7504, 7704, and R5030.



HUMAN ENGINEERING



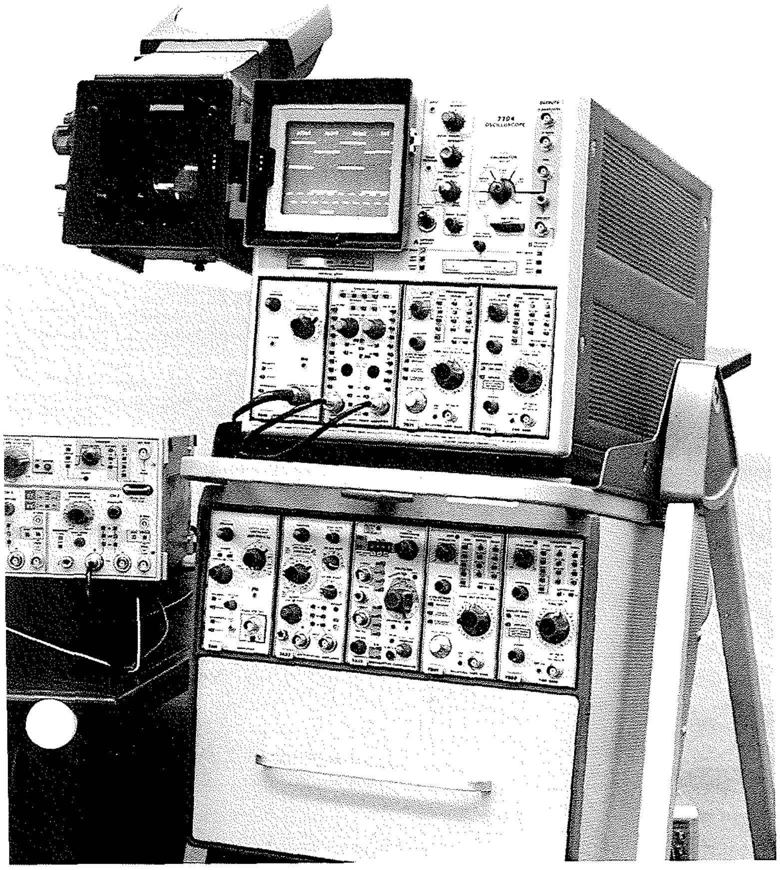
The new generation design concept of Tektronix instruments has provided the ability for the front panel to keep pace with circuit miniaturization developments. Portable oscilloscopes such as the Type 453 were designed in appreciably smaller packages by using solid-state techniques. Front panel controls, however, made no significant size reduction since essentially the same components were being used. Once the choice of plug-in size for the 7000-Series was determined ($2\frac{5}{8}$" W x 5" H x $14\frac{1}{4}$" L), it became evident that commercially available rotary switches would no longer do the job. The same problem was present with lever switches and the push buttons available.

As a result of a joint effort between component development engineers, circuit engineers, mechanical engineers, and industrial design engineers, suitable Tektronix components were developed. Once these new components were available, it was then possible to design an instrument front panel considerably different than before. The result is the radically new and logical front panel layouts of the 7000-Series and the R5030.

The miniature lighted push buttons were designed to eliminate function selector switches and rotary switches wherever possible. Rows of miniature lighted push buttons quickly indicate the status of all controls where a choice must be made.

The push-button spacing has been given considerable attention. Since the finger is oval, not round, vertical and horizontal requirements are different. The curvature of the finger and how far you have to push determines the minimum spacing of the buttons. This spacing has been closely calculated and as a result, there is more finger space than is present in commercially available push buttons used in the Type 184. These self-cancelling push buttons are one of the greatest contributors to the simplified front panel logic of these new instruments.

A logical and consistent use of front-panel color coding identifies specific functions and simplifies front-panel logic. The following colors have been assigned to assist the user in oscilloscope operation:



The NEW GENERATION of Tektronix instruments and accessories.

Black (and gray) is neutral and is used for all general nomenclature and controls. It is also used for grouping similar kinds of things (e.g. signal outputs on the mainframe of the 7000-Series). Varying shades of gray are used to denote various logical sub-groups.

White indicates status and normal operating conditions (e.g. push-button lights and whether A or B intensity control affects the display).

Blue is assigned to the display mode function. For example, the display mode of the plug-ins and the mainframe switching is coded in blue. The user knows that he must make a decision in each area where he sees blue.

Green is assigned to triggering functions. A subtle difference is that in the sampling instruments a green outline is used instead of the normal solid color block. This indicates the triggering does not go through the mainframe, and thus the operator need not bother with mainframe controls.

Yellow is used for notes of caution or unusual operating functions. As an example, yellow is used to indicate the restricted sensitivity (1 — 50 mV) available in the electrometric mode ($R \simeq \infty$) of the 7A13 Differential Comparator Amplifier.

Orange is used for exclusive functions on a given instrument (e.g. current inputs on the R5030).

Red is exclusively assigned to controls that will uncalibrate the instrument and indicates that an inaccurate measurement is possible. Thus, when a variable control is in use, the red color band of the knob (as well as the readout on the display) warns the user that the instrument is in an uncalibrated position. Depressing the knob removes the red from the front panel, recesses the knob flush with the outer control, and returns the instrument to a calibrated display. If an uncalibrated display is desired, a slight push on the knob releases the red variable knob and the user regains variable control of the function.

This new component simplifies front panel logic and guards against unintentional non-calibrated displays. Its use allows seldom used controls to essentially disappear when not in use.

Color-coding has been extended to include concentric knob color and lettering style. If concentric knobs are used for similar functions (e.g., offset—fine, coarse), the knobs are identical in color. If concentric knobs are used for dissimilar functions (e.g., focus and intensity), the knobs are dissimilar in color.

The same logic is used for labeling. Outline lettering is used to relate to the light gray inner knobs and normal black lettering is used to relate to the dark gray outer knob. In the case of similar functions, the inner control is in smaller lettering than the outer knob nomenclature.

We, at Tektronix, feel that a major breakthrough has been achieved in simplifying front panel understanding. Although this first Tektronix offering of our new products provides more flexibility than ever before, we think the improvement in human engineering will make them even simpler to operate. One thing is certain. A great deal of thought, discussion, and effort has gone into the final design choices. If acceptance is as we expect, future designs will all be compatible in their logic. As new designs evolve, less and less effort will be necessary for the user to easily understand and use the capabilities of his Tektronix instruments.

CONSTRUCTION

All three new instruments make use of front and rear panel castings connected by aluminum extrusions. The oscilloscope plug-in compartment is designed with no dividers for maximum future flexibility. The modular power supplies are located behind the plug-in compartment on cables for easy access. The R5030 power supply is located at the right rear of the instrument and is accessible via a swingout heat sink.

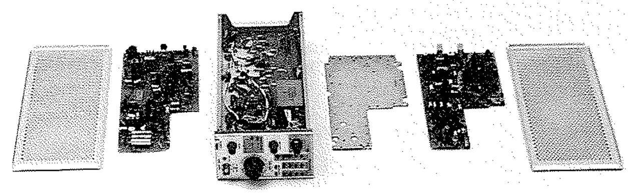
Plug-in construction consists of a front casting, aluminum extrusions top and bottom, a plastic rear panel, and a circuit board. The central "motherboard" contains the circuitry and forms the connector of the plug-in. This connector then plugs into the female connector at the rear of the plug-in compartments and provides the interface to the oscilloscope amplifiers. The circuit board connectors have been specifically designed for low insertion and withdrawal forces to provide a reliable connection with long life characteristics.

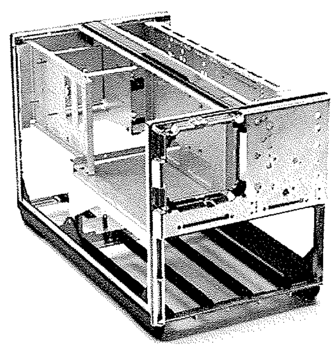
Extensive use is made of new 0.025 square gold-plated pins. Female clips on the end of wires clip directly to the gold pins. Where possible, plastic clips containing multiple connectors group wires together for easier servicing. The use of long pins permits stacking of boards when component density is high. This technique provides good accessibility and ease of maintenance and contributes to a neat overall instrument appearance. The format also provides for easier automatic pretesting and faster instrument assembly.

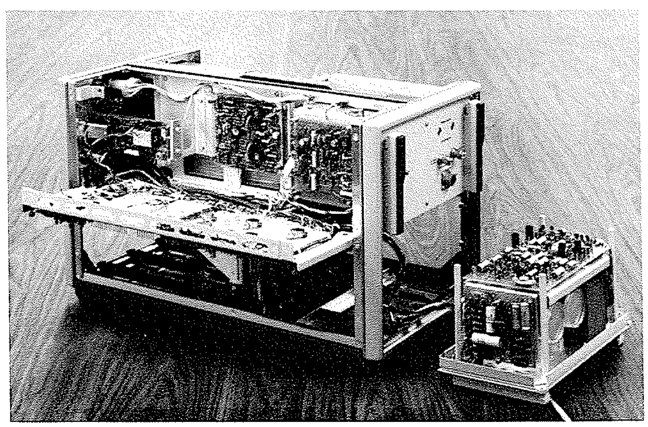
Gold-plated glass epoxy circuit boards are used to ensure maximum reliability. Features such as plated-through holes, built-in test points, and transistor and IC sockets all combine to enhance maintainability.

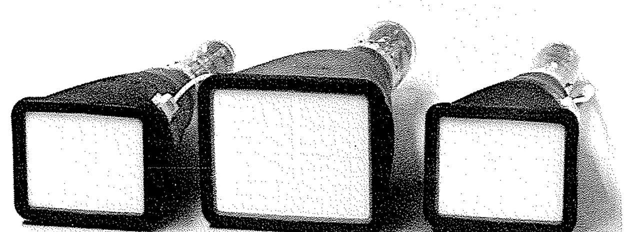
Eletromagnetic Interference requirements have been taken into consideration and are a standard feature in the plug-ins. The 7000-Series oscilloscopes are designed to be convertible to meet EMI specification by a special set of side panels. This feature guards against obsolescence in the event of stricter EMI regulations.

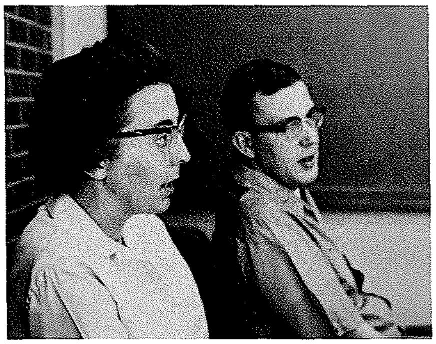
Top to bottom: construction of a typical stacked plug-in unit; basic structure of casting, extrusions, and chassis; 7704 with modular high-efficiency power supply extended for servicing; the three new CRT's developed for the New Generation instruments.











CATHODE RAY TUBES

The heart of any oscilloscope is the cathode ray tube. The ceramic post-deflection accelerator CRT's developed for the Tektronix 7000-Series Oscilloscopes offer significant improvements over CRT's currently available. The 8 x 10 cm viewing area provides a large bright display with high writing speed. Both the 7504 and 7704 can easily record an 8-cm single-shot photo of their risetime, using standard Tektronix P31 phosphor, without employing film fogging techniques.

The new Tektronix CRT's use a frame-grid construction. Frame-grid CRT's employ scan expansion and provide a very good compromise of deflection sensitivity and writing speed. Because frame-grid conductors run only in the vertical direction, electron-beam transmission is nearly 50% greater than most mesh construction tubes. The result is a high writing-speed tube with very good linearity and sensitivity (e.g., the 7704 CRT vertical sensitivity is $\simeq$ 3.3 v/cm) over a full 8 x 10 division scan.

Good horizontal sensitivity is achieved by placing the frame grid as far forward as possible into the post accelerator field. This causes the field lines to curve around the front of it sufficiently that the effect on the electron beam is similar to a curved horizontal plane. Thus many of the advantages of a mesh are obtained with few disadvantages.

Tektronix CRT's are designed to provide single-shot writing speeds sufficient to record a transient at the risetime limit of the instrument. Writing speed is specified with no film fogging using P31 phosphor, the optimum phosphor for general purpose viewing and long-life characteristics.

The 7504 CRT is operated at 18 kV and provides a specified minimum writing speed of 2500 cm/μs (with C-51 camera) using Tektronix standard P31 phosphor with no film fogging.

The 7704 CRT is operated at 24 kV and provides a specified minimum writing speed of 3300 cm/μs (with C-51 camera) using Tektronix standard P31 phosphor with no film fogging. This photographic writing speed is more than twice that of the Type 454 with P31 phosphor (identical camera systems).

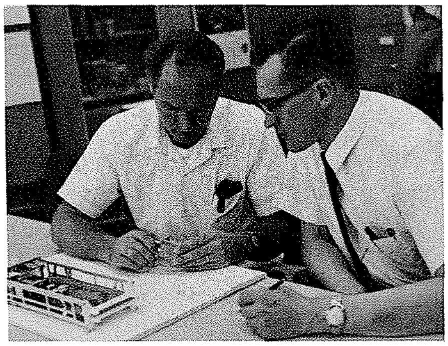
The 7704 incorporates a special face plate design to ensure that X-ray radiation is attenuated well below the TV standard recommended by the National Council on Radiation Protection and Measurement (100% duty cycle raster with full intensity). In addition, circuitry has been included to limit the maximum possible high voltage to keep the specification well within this figure.

The R5030 CRT is a dual beam 6½-inch ceramic mono-accelerator CRT. This unique tube provides a full 8 x 10 div (div = 1.27 cm) coverage for both electron guns with deflection defocusing better than 1.5 to 1 on any axis. The large divisions provide 50% greater viewing area than conventional 8 x 10 cm designs. The tube provides a bright high-resolution display which minimizes operator fatigue.

A novel dynamic geometry circuit maintains excellent geometry in this tube over the wide extended deflection angles. An additional deflection element is placed between the two sets of vertical deflection plates and corrects the beam at the deflection extremes (i.e. upper edge of lower gun display and lower edge of upper gun display). The correction voltage minimizes geometry problems providing an excellent overall geometry.

The new Tektronix tubes employ a new female type neck connector for the deflection elements that is essentially flush with the glass. As a result, tubes may be removed without worrying about the pins catching and bending, or breaking off. A new male connector on the deflection leads simplifies CRT replacement.

The ceramic construction provides greater strength, lighter weight, and improved internal graticule edge lighting. This construction technique also allows tighter tolerances and decreases development time, due to our well-developed ceramics technology.



ACCESSORIES

The probes and accessories developed for the new generation of Tektronix instruments embody the same philosophy as the instruments themselves. Thus, new probes have been designed to automatically provide the correct scale factors and ensure that the auto scale-factor readout represents the sensitivity at the probe tip.

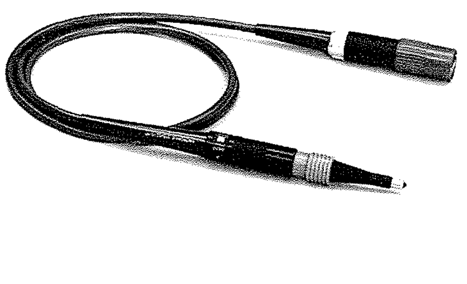
For example, an FET probe was designed as an integral part of the 7A11 FET Probe/Amplifier. By incorporating two stacked attenuators and a temperature compensated FET amplifier in the probe itself (<0.8 in^3) it is possible to relay switch the attenuators from the front panel. A miniature relay had to be developed to fit into the nose of the probe to switch the two 20X high speed, high impedance attenuators.

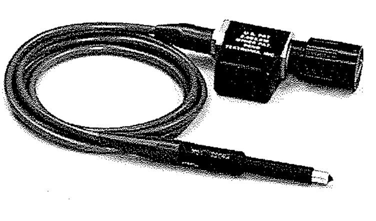
The result is an FET probe that is small in size with no bulky amplifier to mount to the oscilloscope and which cannot be made to clip or limit the signal on the CRT by an incorrect combination of input attenuator and plug-in sensitivity. Thus, the operator is freed from concern with manual plug-on attenuators and dynamic signal range over the complete range of 5 mV/div to 20 V/div. If the signal can be positioned or offset to fall within the viewing area, the amplifier is operating linearly. The sensitivity at the probe tip may be read directly from the front panel or from the auto-scale readout.

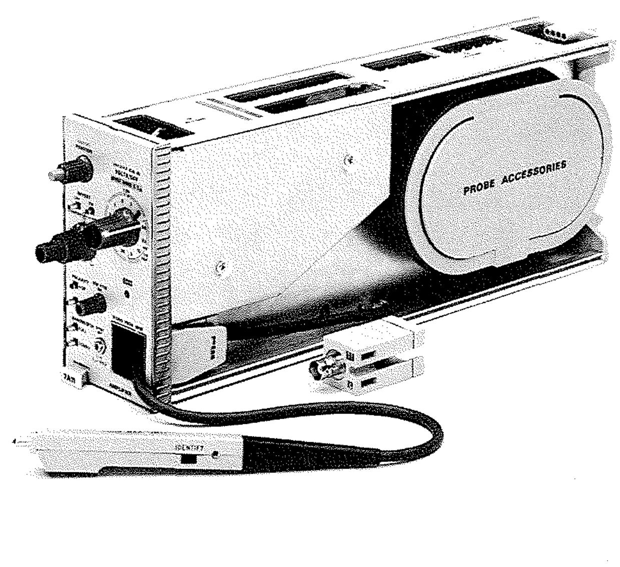
A second mode of operation is provided via a BNC connector on the front panel. When the full capability of the system is not required, the probe is stored internally and is accessible via a front panel BNC connector. Storage space for probe accessories is also provided within the plug-in.

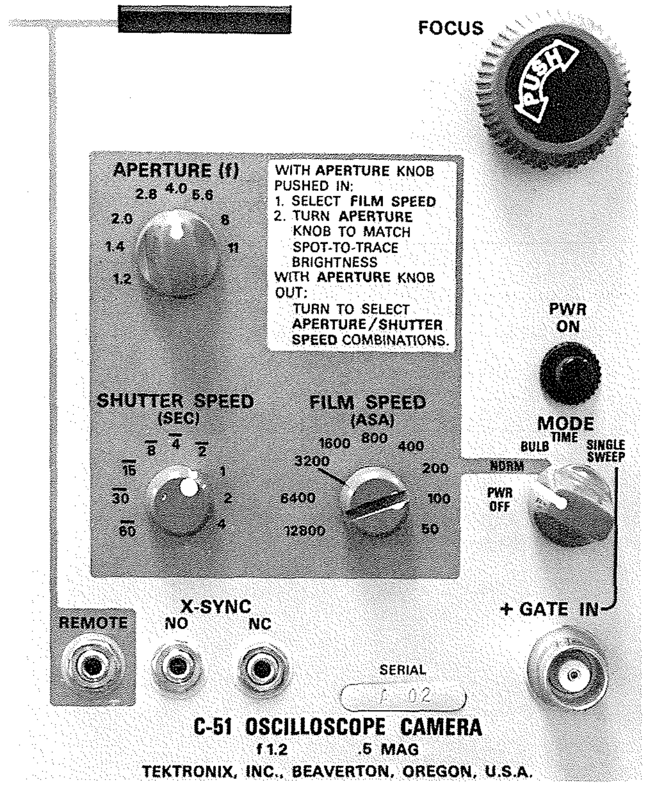
The 7A11 FET/Probe Amplifier provides 150 MHz bandwidth (2.4 ns risetime) in the 7704 and 90 MHz bandwidth (3.9 ns risetime) in the 7504. The capaci-

The 7A11 Probe/Amplifier and the P6052 and P6053 probes offer new versatility in probe usage. Each probe is coded to ensure the correct readout, regardless of attenuation used, and contains a push-button trace-identify feature.









The C50/51 camera offers a new ease in waveform photography. When used with auto scale-factor readout the user is assured of recording the essential information of his oscilloscope display.

tance is a function of the attenuators and is 5.8 pF from 5 mV to 50 mV/div; 3.4 pF from 0.1 V to 1 V/div; and 2.0 pF from 2 V to 20 V/div. When the front-panel BNC connector is used, approximately 1 pF is added to the input capacitance.

All 7-series amplifier plug-ins are equipped with special signal input connectors. These consist of a BNC connector with a concentric outer ring that is connected to the readout circuitry. The amount of resistance between the outer ring and ground determines the attenuation factor to be used by the auto scale-factor readout. For example, a 10X probe has a 13 kΩ resistance connected between the outer ring and ground. In addition, when the ring is shorted to ground the circuitry acts as a trace identifier and shifts the trace on the screen.

Two new coded passive probes are currently provided. The P6052 is a DC-30 MHz dual-attenuation probe designed for low-frequency applications. A sliding collar on the probe barrel selects 1X or 10X attenuation and a push button provides a trace-identify feature. The P6053 is a miniature 10X probe designed for the Tektronix 7-Series amplifier plug-in units. The probe has a risetime of 1.2 ns (290 MHz bandwidth) and also provides a push button for trace identification.

Two compact semi-automatic cameras have been developed for use with all Tektronix 7000-Series Oscilloscopes. The C-50 (f/1.9, 1:0.7) and C-51 (f/1.2, 1:0.5) differ only in the lens system. Both cameras provide rangefinder focusing to assure correct focus for every exposure.

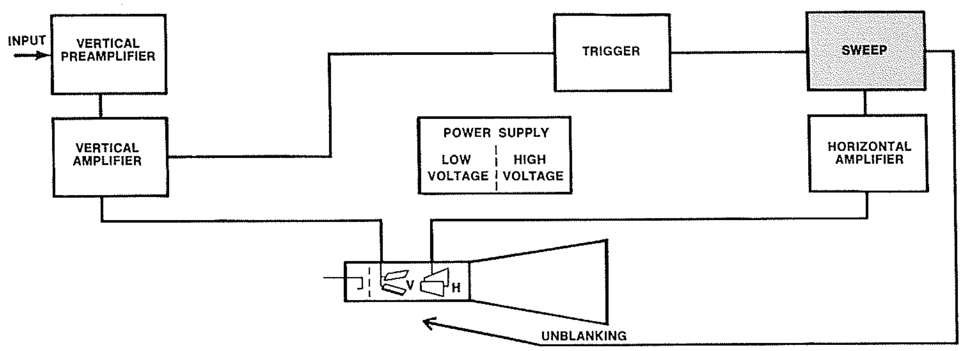
By depressing a spring-loaded focus control, two light bars are projected on the CRT screen. The operator turns the focus control until the bars merge, and when the control knob is released, the camera is locked in focus.

Both cameras use electrically controlled shutters and provide a trace brightness photometer to determine the correct exposure. The operator sets the ASA index, depresses the f knob until the photometer brightness matches the trace intensity and releases the f knob. The camera will now automatically track to keep the same exposure if either the f knob or shutter speed is changed. A shutter open lamp is lighted when the shutter is open at shutter speeds of 1/8 second or slower, and in the TIME and BULB modes. Power for the camera is obtained through the oscilloscope bezel so that no external power cord is required.

The SINGLE-SHOT mode offers the operator additional features. When the SHUTTER push button is depressed, the shutter opens and the camera provides a reset pulse to arm the oscilloscope sweep. If the +GATE is connected to the camera, the shutter control circuit will close 5 seconds after the sweep has occurred. The light then extinguishes to alert the operator that the shutter is closed.

A new Scopemobile® Cart is specifically designed to accommodate 7000-Series Oscilloscopes. The Type 204-2 features 9 tiltlock positions, holds 5 plug-ins and provides a large drawer for storage. A locking mechanism on the Scopemobile goes through the oscilloscope mainframe securely fastening the instrument to the tray.

SERVICE SCOPE



TROUBLESHOOTING THE SWEEP CIRCUITS

By Charles Phillips
Product Service Technician, Factory Service Center

This fifth article in a series discusses troubleshooting techniques in the sweep circuits of Tektronix instruments. For copies of the preceding four TEKSCOPE articles, please contact your local field engineer.

Tektronix sweep circuits are designed to develop a linear sawtooth voltage over a wide range of sweep times. Linear sawtooth voltages ensure that the waveform passes through a given number of volts during each unit of time. The sawtooth rate of rise (or fall) is set by the normally calibrated TIME/DIV control. This sawtooth voltage is then processed in the horizontal amplifier and applied to the plates of the CRT, resulting in the horizontal deflection of the electron beam.

As a result, the cathode-ray beam is swept horizontally to the right through a given number of graticule divisions during each unit of time—the sweep rate being controlled by the TIME/DIV control. In this manner, a baseline is produced that is proportional to discrete amounts of time (determined by the TIME/DIV control). By measuring the distance between two different horizontal points on the CRT display a time difference reading may be easily made.

Delaying sweep oscilloscopes are quite common and provide two separate complete sweep systems. The first, or delaying sweep, provides a delayed sweep trigger just prior to the moment when the signal of interest occurs. Generally, a 10-turn multiplier dial used with the TIME/DIV control provides a continuously variable sweep trigger and initiates the delayed sweep at the desired time. Delaying sweep oscilloscopes provide both increased measurement resolution and accuracy.

Modern time-base generators generally consist of five main circuits: a sweep gating multivibrator, a Miller runup (or rundown circuits (sawtooth generator and disconnect diode), holdoff circuitry, sweep lockout circuitry, and automatic sweep generator circuitry. In addition, the sweep circuit provides the unblanking signal to the CRT and often a sawtooth and/or gate output on the instrument panel.

Sweep generators make use of operational amplifier techniques to obtain their required linearity. As a result, if circuit problems appear, they are sometimes difficult to troubleshoot because of the feedback loops involved. Usually the feedback loop must be broken in order to localize the circuit problem.

When troubleshooting an oscilloscope sweep circuit, examine the simple possibilities before proceeding with extensive troubleshooting. The following list provides a logical sequence to follow while troubleshooting sweep circuitry.

1. Observe CRT display characteristics.
2. Check control settings.
3. Isolate trouble to block.

4. Thorough visual check.
5. Check voltages and waveform.
6. Check individual components.

When troubleshooting sweep circuits, free run the sweep to be certain that the trigger circuitry is not inhibiting sweep operation. Gate and sawtooth output connectors provide a quick check of circuit operation and may provide a clue to the problem. If no outputs are observed, check to be certain that trigger inputs are gating the sweep gate circuits.

Holdoff and feedback operation may be checked by monitoring the cathode of the holdoff circuit. Check to see if the cathode of the holdoff cathode follower follows the action of the sweep length control. A similar check is to vary the stability control while monitoring the lockout multivibrator cathode. These two blocks comprise most of the feedback path and if their cathode follower action is inoperative, the problem is quickly localized.

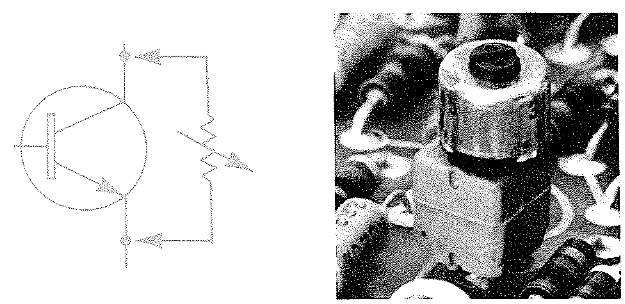
TECHNIQUES

A Tektronix Type 575 or Type 576 is very useful to check tunnel diodes in the circuit (in most cases). If there is any doubt of device performance, one end may be lifted. Connect test leads directly across the TD. Set the vertical sensitivity on the 576 to cover the sensitivity of the diode under test and the horizontal to .1 V/div. (Typical TD's have a horizontal switching voltage of $\simeq$½ volt.) The waveform is not exactly like an out-of-circuit check, but in most cases, it indicates whether the TD is working properly. This procedure prevents mechanical strain or excessive heat from being applied to the TD. The photos below show an in-circuit and out-of-circuit check being made on the same TD. Interaction caused between the test leads and the circuit will sometimes produce a cluttered trace, but switching can nearly always be detected.

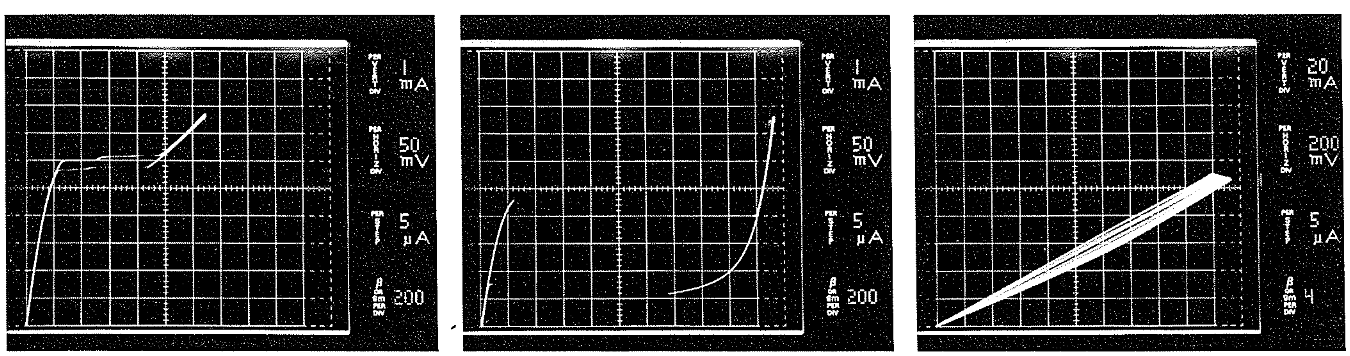
Noisy resistors can also be checked dynamically (with power off on instrument under test) on a Tektronix Type 576. Connect test leads from the sockets on the 576 to the resistor under test. Use the emitter test lead for the low point of the resistor under test and the collector lead for the high point. With the collector sweep in "+" polarity, dial in the proper amount of voltage. (If you don't know how much voltage to use—turn the instrument on and check the voltage drop across the resistor with a meter first.) Next, set the horizontal and vertical switches on the 576 to display the waveform on screen. Noisy resistors will show as an intermittent or broken line. The photo below shows a defective resistor that appeared normal with an ohmic check.

Often it is necessary to start the sweep gating multivibrator manually. If the sweep does not run, ground the collector of the sweep gating multivibrator (e.g. Q504 in a Type 453) and monitor the collector of the sawtooth sweep rundown circuit. This should cause the sweep to rundown and let you troubleshoot in a normal manner.

Breaking the feedback loop is often helpful in large operational amplifiers. One technique that can be used is to pull the transistor from the reset emitter follower and ground the emitter terminal (e.g. Q543 in a Type 453). A sweep should occur each time the point is grounded. Or remove the reset multivibrator (e.g. Q585 in a Type 453) and apply an external positive DC voltage at the collector terminal to "brute force" the sweep to run. (The Type 576 is again convenient for this application.) Often a 10-kΩ minipot connected as shown will work nicely and will plug right into the transistor socket. This is a convenient method since the internal voltage from the collector supply may be used as the voltage source.



A minipot connected into a transistor socket as shown is a convenient way to "brute force" the sweep.



Series of waveforms illustrating the use of the Type 576 Curve Tracer as a versatile troubleshooting tool. Left: In-circuit TD check. Center: out-of-circuit TD check. Right: Noisy resistor.

Another technique is useful when timing delaying sweep oscilloscopes. The horizontal display is set for A delayed by B with A sweep free running. Start with the fastest B sweep where A can be run 100 times faster than B. This will make each cm equal to 0.1%. Set the delay time multiplier to 8.95. This will move the 9th marker to center screen for 0% tolerance.

Each cm to the left of center screen now equals —.1% error and each cm to the right equals +.1% error. Start with time marks of the same speed as the B sweep. If the 9th marker shows up on screen, the error can be read directly + or — from how far it is from center screen. Decrease sweep speeds (A and B) by 1 switch setting until each range of the delayed sweep is checked. When two markers show up on screen, it is time to switch the time-mark source to the next lower decade to match the B-sweep TIME/CM setting. If the pulse is off-screen, use the delay time multiplier to position the pulse on screen and read the number of minor divisions that it takes. Each minor division is equal to 0.1%.

TYPICAL SWEEP TROUBLES (TUBE)

1. Sweep shortens at faster sweep speeds.
   Check: The sawtooth output cathode follower may be loading the circuit. Remove the sawtooth cathode follower and note whether the problem disappears. If the trouble is not in this stage, then check the output stage of the horizontal amplifier.

2. Sweep non-linear at the left side of the CRT.

   Check: Faulty holdoff circuit operation may be causing the problem. Check holdoff cathode follower for gassy tube or improper circuit operation.

3. Sweep shortens on right side of the CRT when sweep is triggered.

   Check: An open diode in the positive trigger clipper circuit may inhibit positive clipping of the sweep gate input and cause premature rundown of the sweep.

4. Sweep tends to free run at different sweep speeds when triggered at other speeds.

   Check: Preset stability is misadjusted or lockout multivibrator circuit operation is weak.

5. Sweep will not run by itself, but will start when shock excited (i.e., rotating the TIME/CM switch).

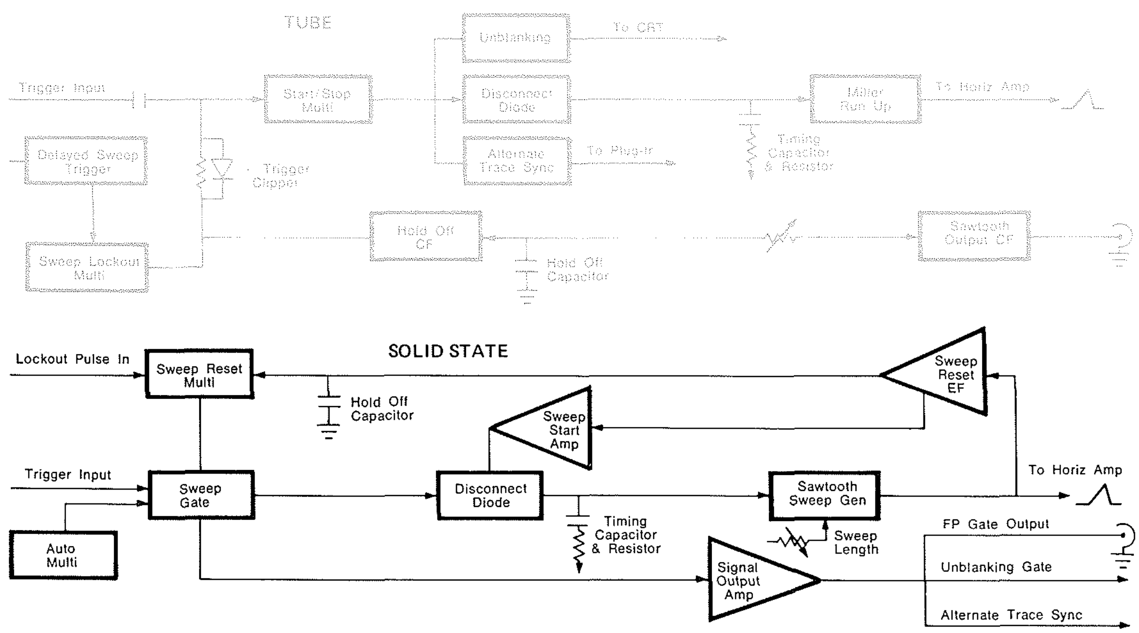
   Check: Start-stop multivibrator circuit failure will show these characteristics. Check the tube and circuitry. Off-tolerance precision (1%) resistors in this circuit will sometimes cause this problem.

6. Sweep non-linear or inaccurate at slow sweep speeds. (In extreme cases, spot may stop part way through the sweep.)

   Check: Disconnect diodes should be tested. Check for proper operation by starting the sweep, and then removing the disconnect diode and see if problem clears itself. The sweep will run for one sweep and stop. Replace diode and repeat procedure if necessary to get a better look. If this procedure clears up the problem, the disconnect diode is faulty (leaky or gassy).

7. Sweep non-linear at some TIME/CM settings; normal operation at others.

   Check: Miller runup circuit may be leaky. Check for gassy Miller tube.



8. Sweep timing off at several of the slower sweep speeds (below 1 ms/div).

   Check: Suspect precision timing resistors. Many older oscilloscopes used brown A-P resistors on the sweep timing switches. These resistors changed value with age and should all be changed.

9. Delayed sweep operation, normal; delaying sweep operation, normal but cannot obtain triggered delayed sweep when using both sweeps.

   Check: Suspect weak or defective delayed sweep trigger amplifier.

10. Sweep timing accuracy long in the .1, .2, and .5 ms/div range.

    Check: Unsolder one end of the small padder capacitor in parallel with the .001 μF timing capacitor located on the A sweep timing switch and monitor timing. If timing is improved, remove the small capacitor.

11. Erratic starting of sweep.

    Check: Noisy resistor in sweep start-stop circuit or poor connection of high voltage anode lead can cause this problem.

12. Erratic sweep operation, sweep start is not erratic.

    Check: Noisy or heater cathode leakage in disconnect diode may cause this problem.

TYPICAL SWEEP TROUBLES (TRANSISTOR)

The operation of transistorized sweep circuitry is generally similar to the tube type circuitry. Some additional specific checks that may be useful are:

1. Sweep inoperative.

   Check: Check the sweep gate transistor and the sweep TD. If these operate properly, then check the fixed divider at the input of the sweep reset multivibrator for proper value.

2. Sweep inoperative.

   Check: If normal troubleshooting doesn't produce a trace (see techniques), check the sweep length circuit. A diode failure or bad switch contact in the sweep length circuit may cause an inoperative sweep.

3. Sweep timing error at different sweep speeds.

   Check: Gallium-arsenide diodes used in the sweep disconnect circuit may be defective. Replace if necessary.

4. Sweep jitter.

   Check: Gallium-arsenide diodes used in the sweep disconnect circuit may be defective. Replace if necessary.

USED INSTRUMENTS FOR SALE

1—Type 526, SN 1544. Price: $1295. Contact: Donald K. McConnell. General Electrodynamics Corp., 4430 Forest Lane, Garland, Texas 75040. Telephone: (214) 276-1161.

1—Type 514D. Excellent condition. Price: $400. Contact: Dr. William Carr, Southern Methodist University, Dallas, Texas 75222. Telephone: (214) 363-5611, extension 2221.

1—Type 524AD/202-1, SN 7750. Two years old. Price: $1000. Contact: Dave Sanders or Charlie Henry, American Microwave & Communications, 203 Stephenson Avenue, Iron Mountain, Michigan 49801. Telephone: (906) 774-2923.

1—Type 422. New. Price: $1,250. Contact: Ellsworth M. Cochran, 7805 Laurel Ave., Cincinnati, Ohio 45243.

1—Type 514D, SN 1348. Excellent condition. Price: $250. Contact: Robert Bartell, RD 2, P.O. Box 31, Kingston, New York 12401. Telephone: (914) 331-9019.

1—Type 545 with D plug-in unit. Price: $1,100. Contact: Dr. J. McConn, Cornell University, Division of Biological Sciences, Savage Hall, Ithaca, New York 14850. Telephone: (607) 275-4809.

1—Type 535A. 1—Type 545A. Several plug-ins for 530/540 Series. 1—Type 515A. 1—Type 575. Contact: Harry Posner, Pacific Certified Electric. Telephone: (213) 225-1584.

1—Type 3A72, SN 4690. Price: $200. 1—Type 53A. Price: $35. Contact: Mr. Myhre, Mission Engineering, Inc., Hiawatha, Iowa 52233. Telephone: (319) 393-2253.

1—Type 310A Contact: Don Pagan, Varian Data Machines, Irvine, California. Telephone: (714) 833-2400.

1—Type 310A, SN 014771. Price: Best offer. Telephone: (415) 326-6200 Extension 2619.

1—Type 551,, SN 3247. Excellent condition. Price: $1350. Contact: Wayne Hunter, Exact Electronics, Hillsboro, Oregon 97123 Telephone: (503) 648-6661.

1—Type 551, SN 002812. 1—Type CA, SN 027013. 2—Type B, SN 011852 and SN 018247. Will sell as a unit for $700. Contact: Jim Rogers, Pacific Assemblers, 4500 Campus Dr., Suite 524, Newport Beach, California 92660. Telephone: (714) 540-0030.

1—Type 454 with cart. Approximately one year old. Perfect condition. Price: $2500. Contact: Robert Crawford, 124 West 86th St., New York, New York 10024. Telephone: (212) 787-6715.

1—Type 321, SN 003443. Has batteries. Price: $400. Contact: Evans Wheeler, 539 South Raymond Ave., Pasadena, California 91101. Telephone (213) 449-5650.

1—Type 533A, SN 4859 with Type B Plug-In, SN 19959. Excellent condition. Used 100 hours. Price: $675. Contact: Henes Manufacturing Co., 4301 East Madison St., Phoenix, Arizona 85034.

Sampling dual-trace and time-base plug-ins for 560 series. 1—Type 3S76, SN 408. 1—Type 3T77, SN 437. 2—Type P6032. All like new condition. Purchase date 4/31/62. Contact: Burr-Brown Research Corp., Tucson, Arizona 85706. Telephone: (602) 294-1431.

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