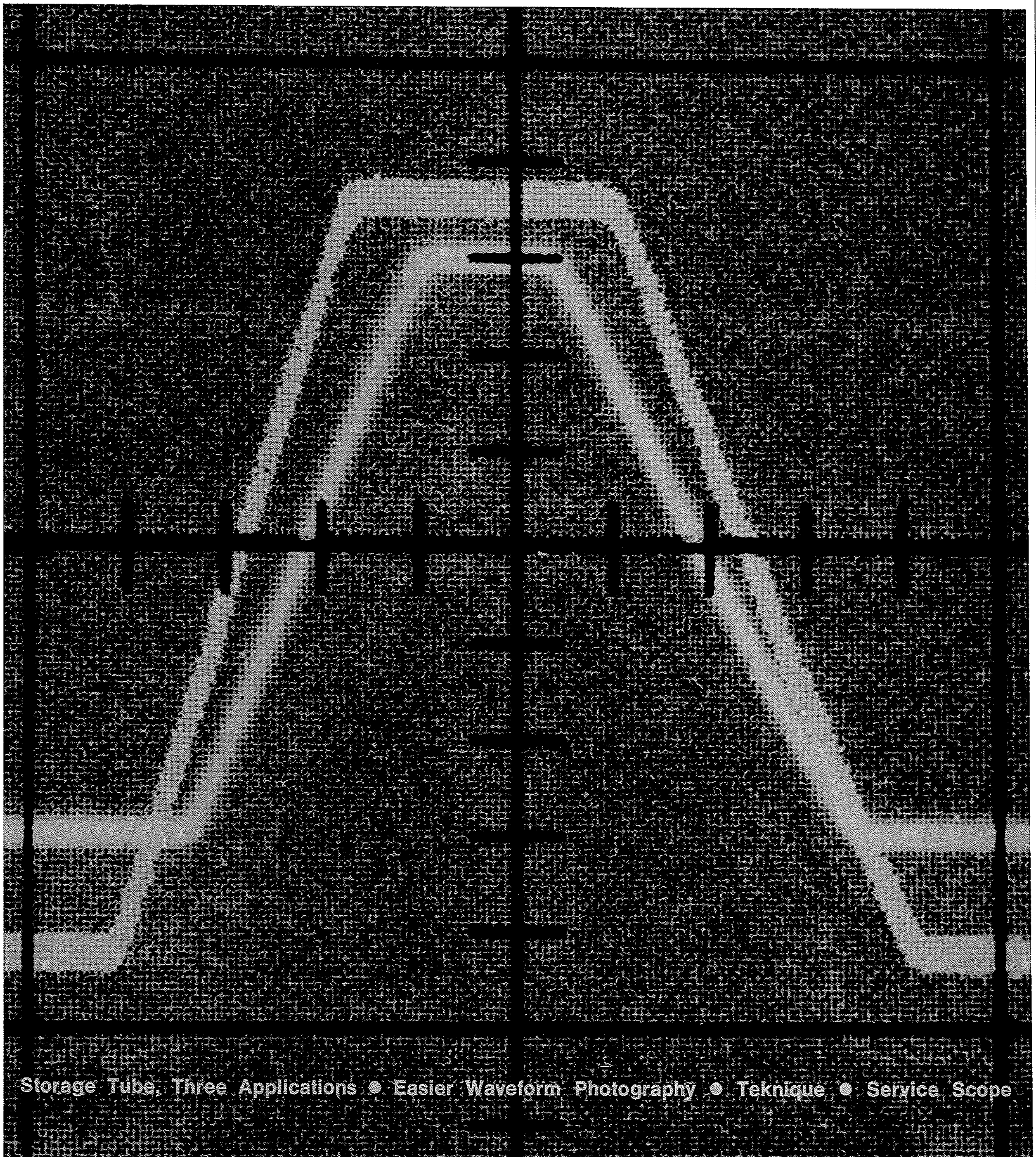
TEKSCOPE

OCTOBER 1970



Tektronix storage tubes have three major applications . . . . . . just one is the oscilloscope

The development of the Tektronix bistable-storage tube was a significant breakthrough in Cathode-Ray Tube design. This reliable and versatile CRT functioned with ease both as a conventional tube and as a tube with long term recording capacity. It was immediately apparent that this storage tube was of value in oscilloscopes, but the tube turned out to be the basis for other products.

COVER—Did you ever run your finger through a raindrop on a window screen? The resemblance of the squares pattern of the target and stored trace on a 7514 Storage Oscilloscope to lines of filled in squares on an old fashioned screen is striking. But, no window screen was ever put together with the precise care used in aligning the 5 mil target squares to an exact right angle relationship with each other. The result: A precision tube, yet rugged and able to function without special care. (The smaller, inner waveform is a write-thru plot simultaneously displayed with the stored information.)

Today, eleven Tektronix products use this remarkable device. Seven are non-oscilloscope products. The capacity to both store and display makes this CRT useful for information display in computer terminals, machine control units, and automatic-measurement systems. In addition, bistable-storage tubes make excellent scan conversion devices and there are two distinctly different Tektronix scan-conversion products based on this storage-tube function.

THE PRINCIPLES OF BISTABLE STORAGE

The Tektronix direct-view bistable storage tube (DVBST) functions by secondary emission. When the normal writing gun bombards the CRT phosphor screen with a beam of high-speed, focused electrons, the beam dislodges great numbers of secondary electrons. The phosphor surface where the beam has written loses electrons and charges positive. A conductive, transparent faceplate under the phosphor completes the circuit and allows storage of charge to take place.

In addition to the normal CRT writing gun, flood guns are used to cover the complete phosphor screen

At left are seven Tektronix Bistable Storage Tubes, the basis for a variety of Scan Conversion, Information Display, and Oscilloscope Products.

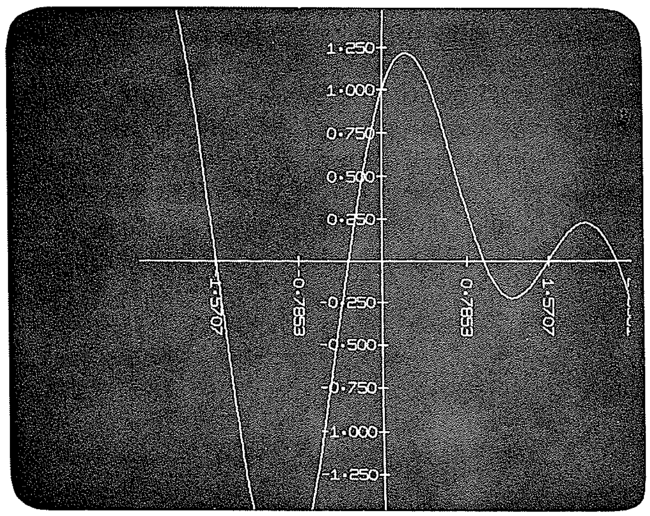
uniformly with low-velocity electrons. The electrons strike the unwritten area with too little energy to jar loose many secondaries. As a result, the unwritten areas merely collect electrons until they are driven negative and can attract no more current.

The positive target areas, where the beam has written, attract flood electrons at such a velocity that each entering electron dislodges sufficient secondaries to hold the phosphor target positive. Thus, the written area neither gains nor loses electrons but remains positively charged and continues to attract flood gun current. As a result of this equilibrium, the written trace remains stored for long periods. The same flood gun current that holds the stored trace also holds that stored trace bright, since energy of the flood gun electrons striking the stored target is sufficient to cause significant fluorescence. The unstored area in contrast remains relatively dark.

BISTABLE STORAGE TUBES IN INFORMATION DISPLAY

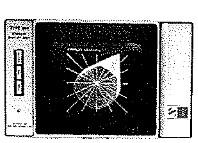
Cathode-ray oscilloscope waveform recording was the first application for the Tektronix direct-view bistable-storage tube. Very early it was recognized that the tube was, in effect, a high-capacity memory, capable of recording many equivalent bits of data. With display and memory both in the same device, information retention and display is greatly simplified. For display of computer-generated graphics and alphanumerics, the bistable-storage tube eliminates or minimizes the need for refreshed memory systems. A computer, for example, can write once and then go on to other work and the CRT display will remain, flicker-free, for continued use. The Tektronix T4005 Graphic Computer Terminal is a low-cost, but sophisticated terminal that exploits this storage tube ability. The T4005, through interface and accessory systems, not only stores and displays, but allows interactive communication at baud rates limited only, in most cases, by external data lines.

Tektronix bistable-storage tube products are used in numerous systems produced by other manufacturers. The 601 and 611 storage display monitors are available for use in various computer peripheral devices and other systems requiring the advantages of both storage and display. The 5-inch 601 and 11-inch 611 are complete storage monitors easily installed and ready to store and display X, Y, and Z information.

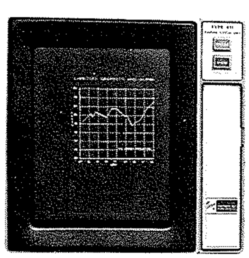


This is a display plotted on the T4005 Graphic Display Unit after repositioning and expansion by the 4201 Graphic Display Controller. When working with the IBM 1130, the Graphic Display Unit and Controller eliminates the delays caused by slow plotters.

Information Display Products Made Possible by the Tektronix Storage CRT

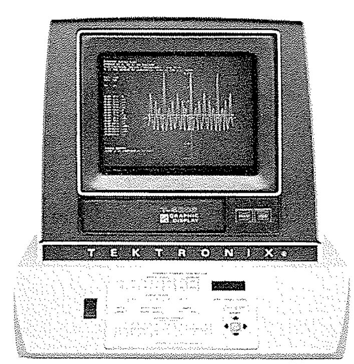


601 - STORAGE DISPLAY UNIT



611 - 11-INCH DISPLAY UNIT

T4002 - GRAPHIC COMPUTER TERMINAL



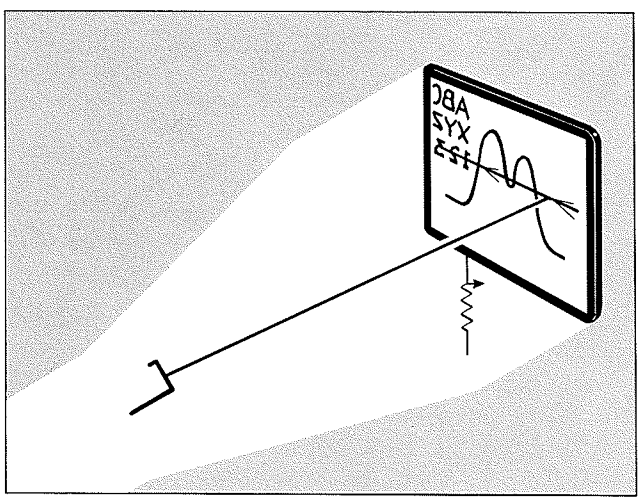
T4005/4201 - GRAPHIC DISPLAY AND GRAPHIC DISPLAY CONTROLLER

SCAN CONVERSION WITH THE BISTABLE STORAGE TUBE

Scan conversion is a process of scan reading CRT information at a different rate or in a different sequence than that in which the information was originally written. Scan converters using the bistable-storage tube write and store in an identical manner to the other storage tubes. To retrieve the information both the stored and non-stored areas of the tube are raster scanned by the beam, operating in a reading mode. The reading beam current divides into two paths after reaching the target. The ratio of the beam current in each path at any instant is determined by the charge of the target area being scanned. The difference in charge between stored and non-stored areas is reflected by a difference in current. This current develops a voltage across a sampling resistor.

At this time, scan conversion of stored displays is used in two distinctly different Tektronix products: the 4501 Scan Converter and the 4601 Hard Copy Unit. The 4501 Scan Converter uses a Tektronix storage tube which serves as a graphic memory of single events stored on the CRT or of dynamic displays of changing information. Stored information is scan converted into a format used by standard TV systems.

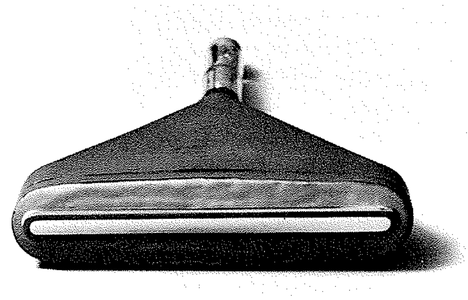
The composite TV signal is developed by processing the voltage developed by the read beam in a video amplifier, and adding sync and blanking pulses. The resulting TV signal can be to EIA or CCIR standards and may be used directly or to modulate an internally generated RF carrier. The composite TV signal can be used directly with conventional TV monitors. The modulated RF, usually Channel 3, works well with low-cost, commercial quality television sets.



The basis of scan conversion using Tektronix Storage Tubes is the ease of changing the writing beam to a reading beam. The sensing resistor detects read current differences as a scan is made of stored and unstored target areas.

The 4501 Scan Converter exists to process cathode-ray tube displays to a form that can be viewed remote from the original source or in multiple monitor displays. Generally, any information that can be displayed on a CRT can be scan converted. In most cases, it is simply a matter of providing a sample of the information that would normally drive the X, Y, and Z axes of a CRT.

The 4601 Hard Copy Unit produces permanent copies of CRT displays by scan conversion. The copy format is of standard 8½ x 11 inch size. This copy in turn can be reproduced in standard office copying machines. The 4601 can work with any direct-view bistable storage tube*. The necessary scanning voltages and control logic are generated by the 4601.



This fiber optic cathode-ray tube is the writing implement that translates scanned storage tube displays to full-sized hard copy in the 4601 Hard Copy Unit.

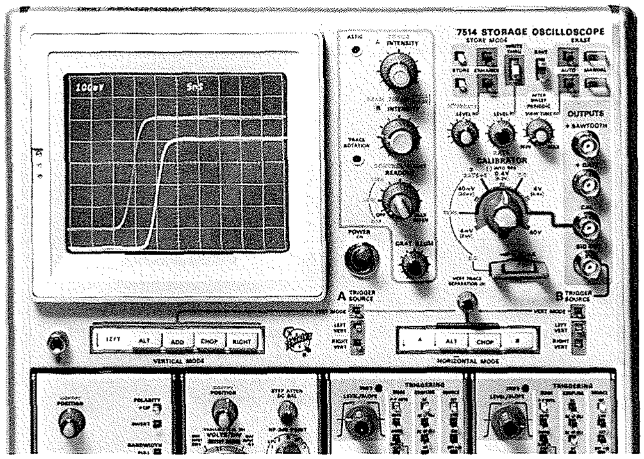
Scanning signals generated in the 4601 are used to read out stored information. The scanning signals and the voltage derived from the storage tube reading beam drive a fiber optic CRT in the 4601. Photo-sensitive paper is drawn across the faceplate of this fiber-optic tube and then is processed. A finished, permanent copy of the storage-tube display is produced. The complete sequence requires 18 seconds for the first copy, 11 seconds for each additional copy.

STORAGE OSCILLOSCOPES

The most obvious storage-tube application is to record non-repetitive events. Users soon found that the storage tube also eliminated flicker from low repetition-rate displays and in slowly plotted traces. In addition, waveforms could be stored for reference and comparison. Photography was simplified; once information was stored, the same exposure could be repeated for recording any stored plot. No matter what is recorded, the light output of the bistable tube is constant from each point of stored information, simplifying exposure. The tube could also be used for a split-screen display of both stored and non-stored traces. Four Tektronix oscilloscopes use storage tubes including the new 7514.

**Some earlier storage tube products require minor modification.*

The 7514 Storage Oscilloscope is the latest addition to the versatile 7000 Series. This instrument includes all the significant features of 7000 Series: CRT readout of scale factor and other inputs, multiple plug-in capacity, high writing-speed CRT, and 17 available plug-ins.



*The latest addition to the growing 7000 Series, the 7514 shown above, introduces **Write-Thru**. The Write-Thru feature displays real time, dynamic and stored information simultaneously—without interaction.*

450 centimeters per microsecond is the non-stored writing speed of the 7514. The stored writing speed is 1 centimeter per microsecond. In addition to the features of split screen, auto erasure, fast display integration, and long storage time, this oscilloscope introduces *write thru* and *auto focus*. In the write-thru mode a conventional, non-stored trace can be displayed simultaneously, and on the same screen area with stored displays. Bright write thru traces are displayed with no effects on previously stored information through the use of special Z-axis control circuitry. Auto focus maintains a well-defined trace or spot through a wide range of intensity settings. All that is necessary for a crisp trace is initial adjustment.

The 7514's non-stored performance is quite similar to that of the 7504. Both instruments feature four plug-in compartments. Time-shared displays in each channel adapt two vertical and two horizontal systems to a wide variety of amplifier and sweep and/or amplifier and amplifier applications. The bandpass with amplifier plug-ins is 90 MHz. In addition the 7514, like all 7000 Series instruments, provides 25-picosecond risetime and real-time sampling.

RECORDING FAST DISPLAYS ON X-Y RECORDERS

Recorders make permanent oscillograms but are much too slow for many applications. Response-limited recorders can be adapted to record repetitive fast events with the aid of a sampling oscilloscope. It is a simple matter to use your sampling oscilloscope with your X-Y plotter since sampling instruments have outputs specifically designed for that task.

The purpose of sampling is the conversion of very fast analog information for processing and display in relatively slow systems. The same technique that matches a 25-picosecond risetime to a one-megahertz scope amplifier easily matches a 25-picosecond, or a 25-microsecond risetime, to a one-kilohertz or slower recorder.

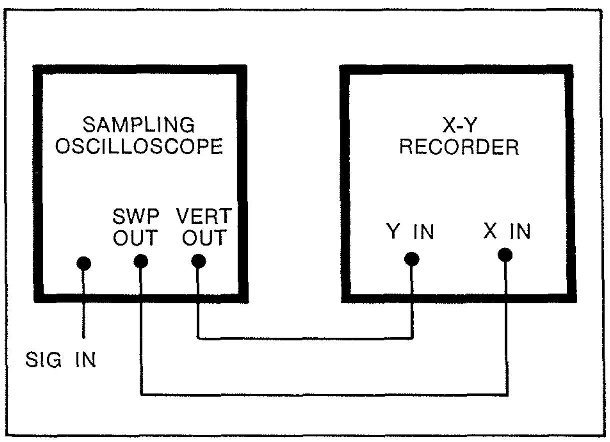
The sampling oscilloscope normally works in equivalent time. The timing of each sample in sequential systems is determined by three factors.

ONE, a ramp representing equivalent time.

TWO, a DC voltage representing T_o in equivalent time.

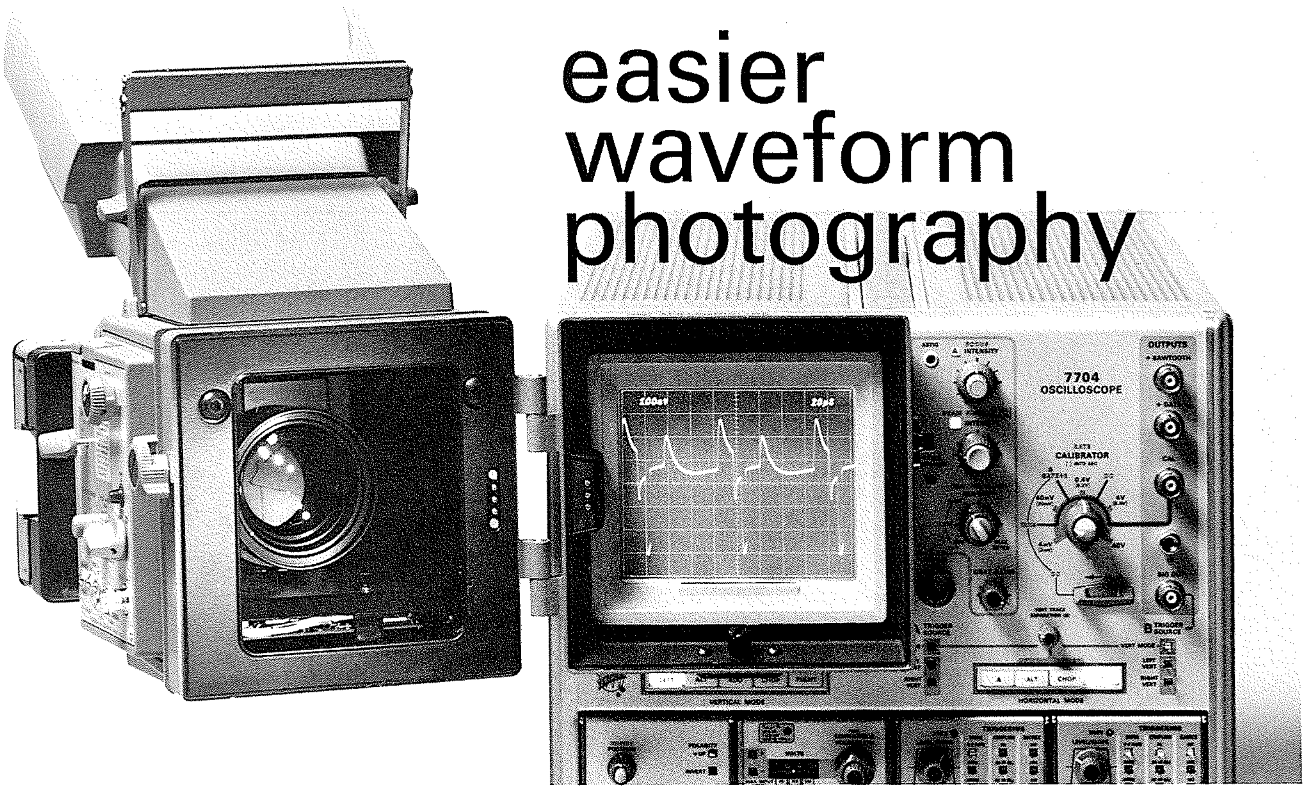
THREE, a voltage, either internally or externally generated, which plots the display in the X axis.

When using an X-Y plotter, the plotting voltage must be a slowly changing voltage. This contrasts with a CRT plot where the rate of sweep is usually fast to eliminate flicker. Substituting a slow, external X-axis signal or using the convenient manual plot control built into the sampling time base in place of the usual CRT X-axis deflection signal allows the output(s) of the sampling scope to be accurately plotted on paper. It is really quite easy.



The setup above uses the manual scan function built into samplers. If your recorder features a time base output, it can be used in place of manual scan.

easier waveform photography



Oscilloscope photography is an art involving many variables. It has probably been your experience that the first try often produces less than acceptable results. It is possible to get acceptable results on the first try if you are armed with a little extra knowledge of waveform photography. This article will discuss oscilloscope photography with the objective of clearing some of the mysteries and providing simple, workable techniques for better waveform pictures.

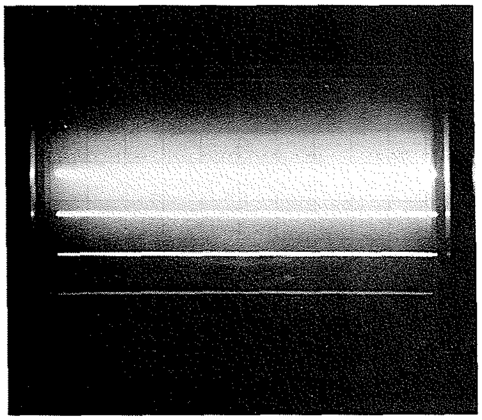
To take good waveform pictures, it is necessary to consider the difference between eye and camera. The camera obviously does not sense light as the eye does. It is also important to know the differences between ordinary scene photography and scope trace recording. You should also know that the oscilloscope is built to be used visually and therefore is usually optimized for that purpose. Now, let us look at the process of taking a waveform picture.

EXPOSURE SETTING

Exposure setting is the attempt to get just the right amount of light on the film to record the image within the photographic limits of the film. Usually exposure is determined by visual techniques although there are vast differences between the eye and the camera. The eye, for example, can sense light over a range of intensity of greater than one million to one. Film can only handle ranges of about one hundred to one. The eye's extensive range is partly because it responds to light logarithmically; film responds linearly. With the limited dynamic range of film, overexposure or underexposure is very easy. How then can acceptable trace recordings be made?

It is fortunate that the information displayed on the oscilloscope is usually graphic. It consists of lines, therefore, it does not matter if portions are overexposed. Within limits, overexposure can create a solid trace; crisp, clear, and pleasing to look at. It is the dim or indistinct portions of a waveform photograph that could be considered to be within the "normal" exposure range of the film used. It is apparent then that exposure and overexposure are terms which are more relevant to ordinary photography than to scope photography. Trace recording is ideally line photography, that is, complete exposure for the trace and graticule, no exposure for the rest. It seems that all we have to do is "overexpose" and be done with it. Unfortunately, it is not quite that simple.

Overexposure would be fine if the only source of light was from the trace and graticule. This is not the case since the fluorescence caused by the beam illuminates the area surrounding the spot. Overexposure settings,



Film cannot respond to large variations of light level. Each of the four traces shown is a single sweep, photographed with all camera and scope settings the same except vertical position and sweep time per centimeter. The lower trace sweep rate is 1 µs/div. Since each trace upward is progressively 10X slower than the preceding trace, therefore, the light available to the camera is 1000X greater for the top trace than the lowest trace. The top trace is grossly overexposed, clearly showing that film cannot handle light variations greater than 100:1 without exposure change.

if carelessly used, can result in an unattractive picture of the trace plus the reflected light of the spot. Even though this reflected light level is low and not objectionable visually, it can appear very messy on film. Another undesirable effect, as exposure is increased, is a broadening of the recorded trace. This occurs as more and more of the spot's width is recorded. The CRT beam has a Gaussian distribution of electrons through its cross section. The resulting spot has the same light distribution in cross section. As the exposure is increased, more of the skirts of the spot, plus the nearby reflected light, exposes the film and the recorded trace becomes broader. These side effects of overexposure create a practical dynamic range of beam movement that can be recorded for any one exposure setting. The best exposure setting chosen, therefore, involves an attempt to bracket the brightest and dimmest portions of the display without unattractive side effects.

It is practical to use the eye to judge exposure, even though the eye and the camera are different. Whenever the eye sees the trace as a continuous line, (no flicker or distinct spot movement), the scope user can make a good exposure estimate. If you have had problems in estimating exposure, you might try this: Adjust your scope display for "normal brightness". (That is what appears proper to you for visual use.) Set your camera for f/11 at 1/10 second and shoot. You should have an acceptable picture. At least you will be quite close. The use of f/11, a relatively small f stop, will give good depth of field. Everything will be in focus on any scope. The relatively long exposure of 1/10 second minimizes the effects of recording a fractional sweep. Now, let's look at a different photographic problem.

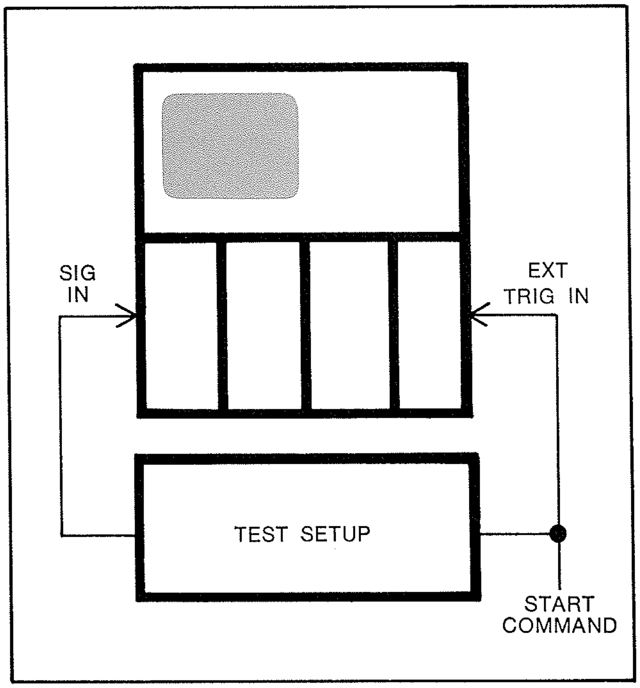
Low duty cycle, fast-sweep displays require a higher intensity control setting to bring up the brightness. If the intensity appears "normal", exposure of the display can be judged as described in the last paragraph. At some point a low duty cycle will require a very high intensity setting and a blurry, defocused trace may result. The scope's intensity control can change the light output over a very wide range. But it is the practice to have more beam current available than can be completely controlled by focus and astigmatism at the highest intensity settings.

When defocusing occurs because of high beam current, back off a bit on intensity and use a longer exposure. Control of exposure by f stop change is limited in comparison to the wide range of trace light available over the full possible ranges of sweep rate and duty-cycle combinations. Because of f stop range limitations (typically 2^7), time exposures greater than 1/10 are more useful with dim, low duty cycle displays. As an alternate to longer time exposures, you may want to try exposing to a controlled number of sweeps. Your scope's single sweep mode can be used. Press the RESET button for the number of sweeps desired for proper exposure. The shutter, meanwhile, is kept open in the Time position. This technique requires a little trial and error effort, but it can produce excellent results.

The non-repetitive event, particularly the fast transient, often strains the maximum performance of the scope/camera system and frustrates the user. Events in the microsecond or slower time domain are within the performance limits of the typical scope and camera. The problems in recording these events usually involve "posing" the waveform for trial and error runs to set correct exposure. Sometimes a lot of trial and error is involved to get just the right deflection factor and time base. Even more troublesome is the proper location of T_o by correct triggering. What you are attempting to do by triggering is to nail down a specific, brief time interval out of infinity. It can be difficult.

TRAPPING THE ELUSIVE TRANSIENT

When setting out to trap a single transient, most users find that it is better not to use internal triggering because noise or other undesirable signals will often false-trigger. When possible, externally trigger your instrument from the same switch or circuit that initiated the transient. Another technique is to start a sweep and then use a time-related output of the scope* to initiate the transient event. Now, let us get to the problem of recording the fast, single transient.



Single Shot photography can be more trouble free if the scope is externally triggered with the same predictable and noise free command that initiates the events necessary to produce the transient. Avoid internal triggering from the transient signal source as it is often noisy and the transient itself may have a waveform unsuitable for triggering.

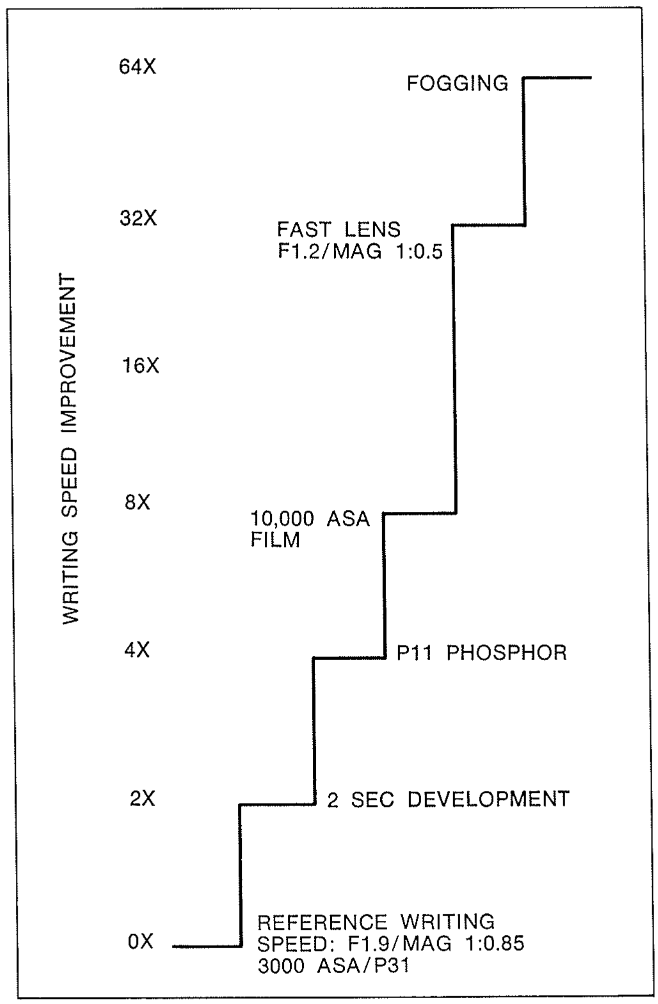
The typical scope camera has an f/1.9 lens with a magnification of 0.85. With the readily available 3000 ASA speed film, many fast transients are well within this camera's ability to record. When operating on the fringe of a camera's single transient usability, whenever maximum CRT intensity does not produce a usable trace, there are several steps that can help. Reduce the display amplitude. This reduction will decrease the rate of beam movement and often makes the necessary difference between good and unacceptable. Developing the film for 2 seconds instead of ten can also increase writing speed at the expense of contrast. This generally produces a poor looking picture. When both techniques do not work, it is time to consider a faster camera, CRT, film, or all three.

*See June 1970 Tekscope—Page 8

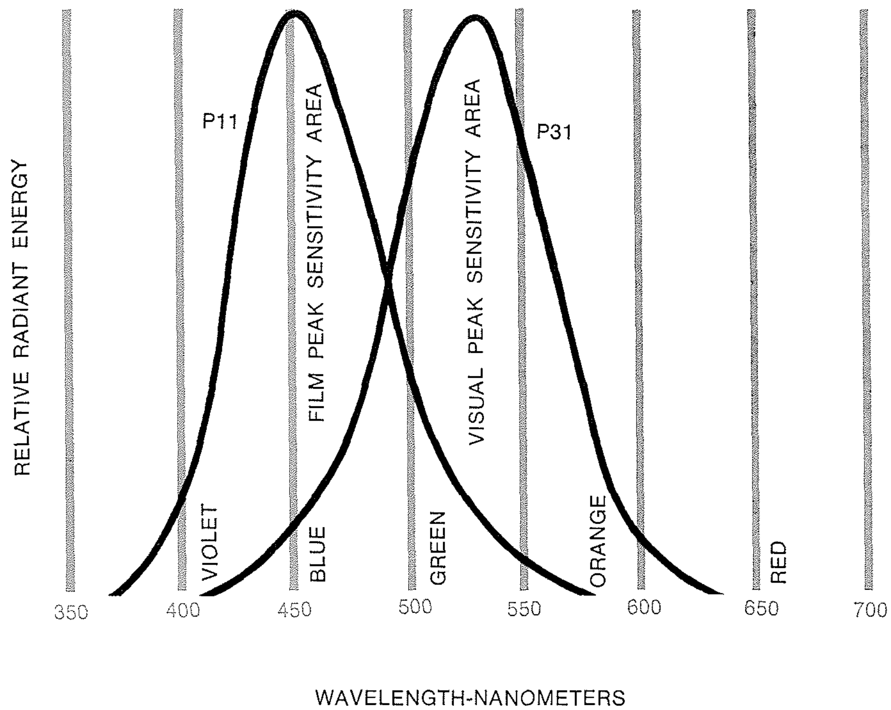
STEPS TO MORE WRITING SPEED

The oscilloscope that you are using, in all probability, has a CRT with P31 phosphor. This phosphor is a highly efficient source of light peaked at about 530 nanometers, an optimum wavelength for visual observation. For this reason, phosphor comparison charts often use P31 as a 100% reference for relative luminance.

Luminance values are light values measured through a C.I.E. Standard Eye Filter and are appropriate for visual work. Luminance charts, however, do not adequately represent the response of film. Although P31 is good for most waveform photograph applications, it is not optimum for speed. In addition, P31's persistence, or after-glow after excitation is removed, will often require a short wait to avoid recording previous traces or even the results of ambient light excitation. Colored light filters can reduce the persistence effects but filters also attenuate total light output.



How much can you improve writing speed with practical techniques? The range of improvement is ***approximated*** *above. Approximated because the many variables in CRT, film, and camera performance make writing speed prediction difficult.*



The color (wavelength) of the peak light emitted is the key to phosphor selection. Normally, P31 is selected for its excellent visibility to the eye. P11 is best only when writing speed and persistence must be optimum for oscilloscope photography.

P11 can double writing speed over P31. P11 phosphor light output peaks at 450 nanometers, very close to optimum for CRT photographic writing speed. P11 has a relative luminance of 25% compared to P31 and is far from optimum visually. In addition to its photographic writing speed, P11 has the photographic advantages of very short persistence characteristics. Most Tektronix oscilloscopes offer P11 phosphor as a no-charge option at time of purchase. Careful consideration should be given to the less-than-optimum visual-use characteristics of this P11 phosphor before making a decision to purchase.

Where an extra 2 to 2.5 faster writing speed is desired, Polaroid* Type 410 film can be used. This film is rated at 10,000 ASA. ASA ratings are not fully appropriate to scope use, but they do indicate roughly the speed in trace recording. This film is not stocked everywhere but is available through normal suppliers of Polaroid film. 410 is a roll film, not compatible with flat pack backs.

General purpose cameras are not slow cameras in the sense that they cannot capture high speed, single traces. But, at some rate of beam movement, a faster camera may be required. Faster scope cameras have a larger lens of more than an f stop better and usually a smaller magnification. Light gathering capacity is increased by the lens, by greater than two, and then concentrated on a smaller film area by the smaller magnification. An overall gain of at least four in writing speed results.

There is a less convenient step that can increase writing speed. A slight overall exposure in addition to the regular exposure can increase writing speed by a factor of two. This sensitizing process is called fogging and can be done prior to, coincidental with, or after trace exposure. Fogging techniques are not necessary when using optimum photographic techniques with the 454 and 7000 Series Oscilloscopes.

We have not covered focusing, mounting, and other factors in camera usage since this information is available in your camera manual. The subject of lens and CRT distortions and their effects has been bypassed. There are other second order writing speed improvement techniques that are doubtful in value from the point of view of results or costs. The techniques described in this article have been proven to be useful.

**Polaroid is a registered trademark of the Polaroid Corp.*

THREE IMPROVED CAMERAS

C50—General Purpose—Particularly Well Suited for the 7000 Series

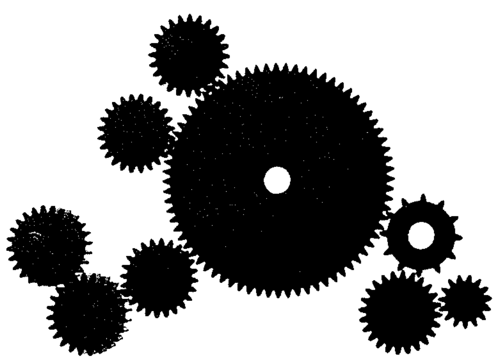
C51—Fast Scope Photography—Particularly Well Suited for the 7000 Series

C70—General Purpose—6½-Inch CRT Applications

Two important steps in waveform photography, setting focus and exposure, are greatly simplified in the newest Tektronix oscilloscope cameras. With simple adjustments, pictures will be right on the first try. Other new camera features enable the operator to control single sweep operations at the camera or at remote locations. With one step, at one location, the user can initiate the complete sequence necessary to record transient events.

FOCUS AND EXPOSURE

Setting focus on many scope cameras requires accessory focusing plates and low ambient light levels. The new cameras provide a built-in pair of focusing light bars to simplify the process. It is no long necessary to seek focusing accessories, which are often misplaced, or to turn down the lights. The bars are an aid to focusing, projected onto the CRT screen. Aligning the bars, by a simple adjustment, completes the focusing process.

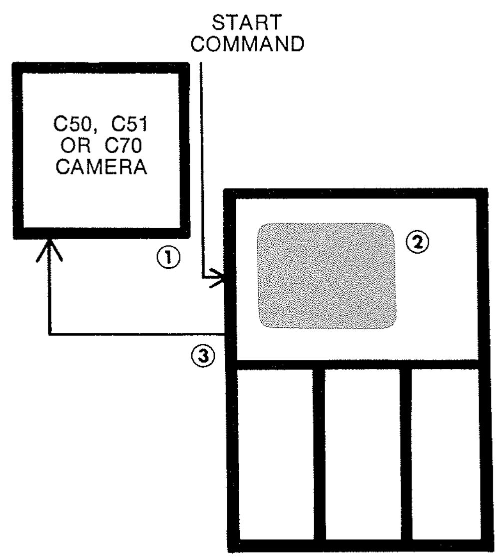


Film speed, phosphor, exposure time, and lens opening are interrelated by the computation gears of the trace brightness photometer. This feature is standard in the C50, C51, and C70 Oscilloscope Cameras.

Exposure setting is equally as easy with the aid of a new, built-in spot photometer. The operator merely matches the photometer spot intensity to the trace intensity. All factors affecting exposure such as film speed, shutter time, and CRT phosphor are related to lens aperture and trace brightness through a mechanical computer. In setting exposure the operator uses one knob to match photometer spot and trace intensity. The adjustment is quick. After setting, variation of lens aperture or exposure time will not disturb correct exposure. The computer automatically maintains correct exposure relationship through all subsequent adjustments.

SINGLE TRANSIENT PHOTOGRAPHY

Single transient photography requires careful preparation of the scope and camera to capture all information. After the initial set up, a check list is often necessary to insure that every vital step is made. In some complex experiments and tests, dozens of scope/camera systems are required to completely record the vital parameters of the transient event. This can make the process even more subject to error by multiplying the required steps. The new cameras remove at least two steps from the task of recording the single transient.



1. The start command triggers the oscilloscope and initiates the transient event.

2. The trace is photographed.

3. Approximately 5 seconds after sweep, the shutter closes.

One step, at the camera or remote location, initiates the complete sequence necessary to capture single events photographically.

The C50, C51, and C70 are ideal for remote operation of single or multiple camera systems. They feature electrically operated shutters. The operator, through a new single-sweep mode, can arm the scope's single sweep system at the camera, or at a remote control site. Then, after the transient event triggers the sweep, the electrically-operated shutters will be automatically closed. Just one step does it all. The new oscilloscope cameras greatly simplify the art of waveform photography, saving time, film, and frustration.

TEKNIQUE: *Amplitude measurements to better than 1%*

The first step towards making more accurate amplitude measurements is to increase resolving power. The second step is to make the measurement by comparison to an accurate voltage reference.

Certain plug-in amplifiers are built specifically to improve resolution and to provide a precision reference voltage. These units are called differential comparator amplifiers; occasionally they are described as slide-back amplifiers. These plug-ins work equally as well in either the vertical or the horizontal compartment of an oscilloscope.

In the August issue, *Teknique* discussed resolution and comparison as related to improved time base accuracy. Analogous concepts are used in differential comparison. That is magnification, employing considerable off-screen deflection, comparison to an accurate reference. The technique nulls or balances a point on the magnified waveform to the same position on the CRT screen that was occupied before comparison by the other extreme of the voltage being measured. The "readout" task is transferred from the calibrated graticule, which has limitations in resolution, to a device which is, in effect, a calibrated position control. This position control provides hundreds (sometimes thousands) of resolvable measurement increments.

Accuracy is further improved by comparison since the reference values used are more accurate than that necessary in attenuators. Attenuator tolerances are typically specified as 3% (2% in the 7000 Series). These attenuator specifications, of course, are "worst case" statements. Comparison voltage specified accuracies are always significantly better. In some units accuracies approach 0.1%.

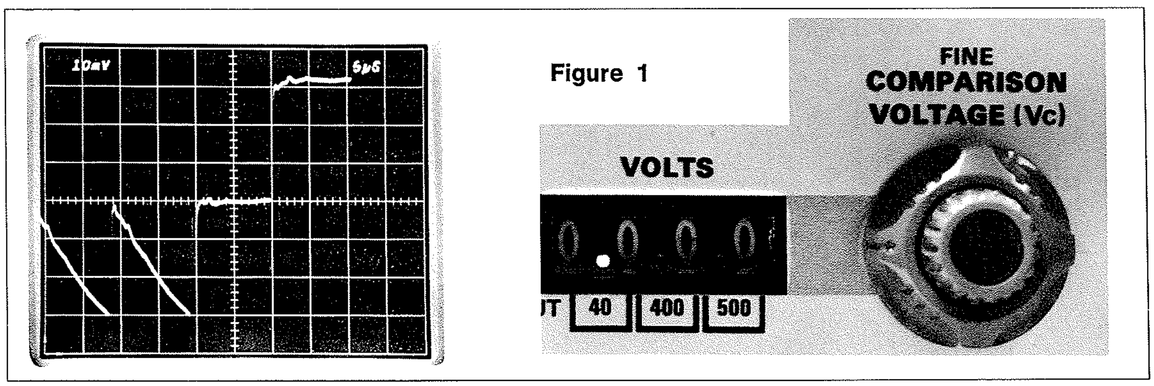


Figure 1

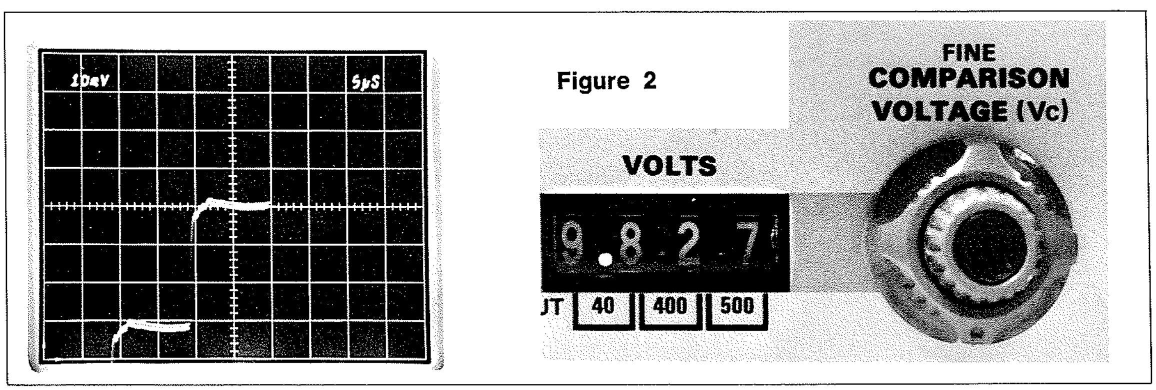


Figure 2

Figure 1 shows the bottom of a stairstep waveform of approximately 10-volts amplitude positioned to a Y-axis graticule line. The comparison voltage reads 000.0 volts. Figure 2 shows the top of the same waveform positioned to the former location of the bottom. The comparison voltage reads 9.827 volts, a precise reading of the peak-to-peak amplitude. The difference between intermediate points on the waveform can be derived just as easily.

The photographs were made displaying the equivalent time base deflection voltage of a 1S1 Sampling System. The oscilloscope is a 7503 with 7A13 Differential Comparator Amplifier. The 7A13, 1A5, W, and 3A7 are four plug-ins that feature the differential comparison measurement technique.

SERVICE SCOPE

SERVICING THE C12, C13, C19 and C27 CAMERAS

By Charles Phillips
Product Service Technician, Factory Service Center

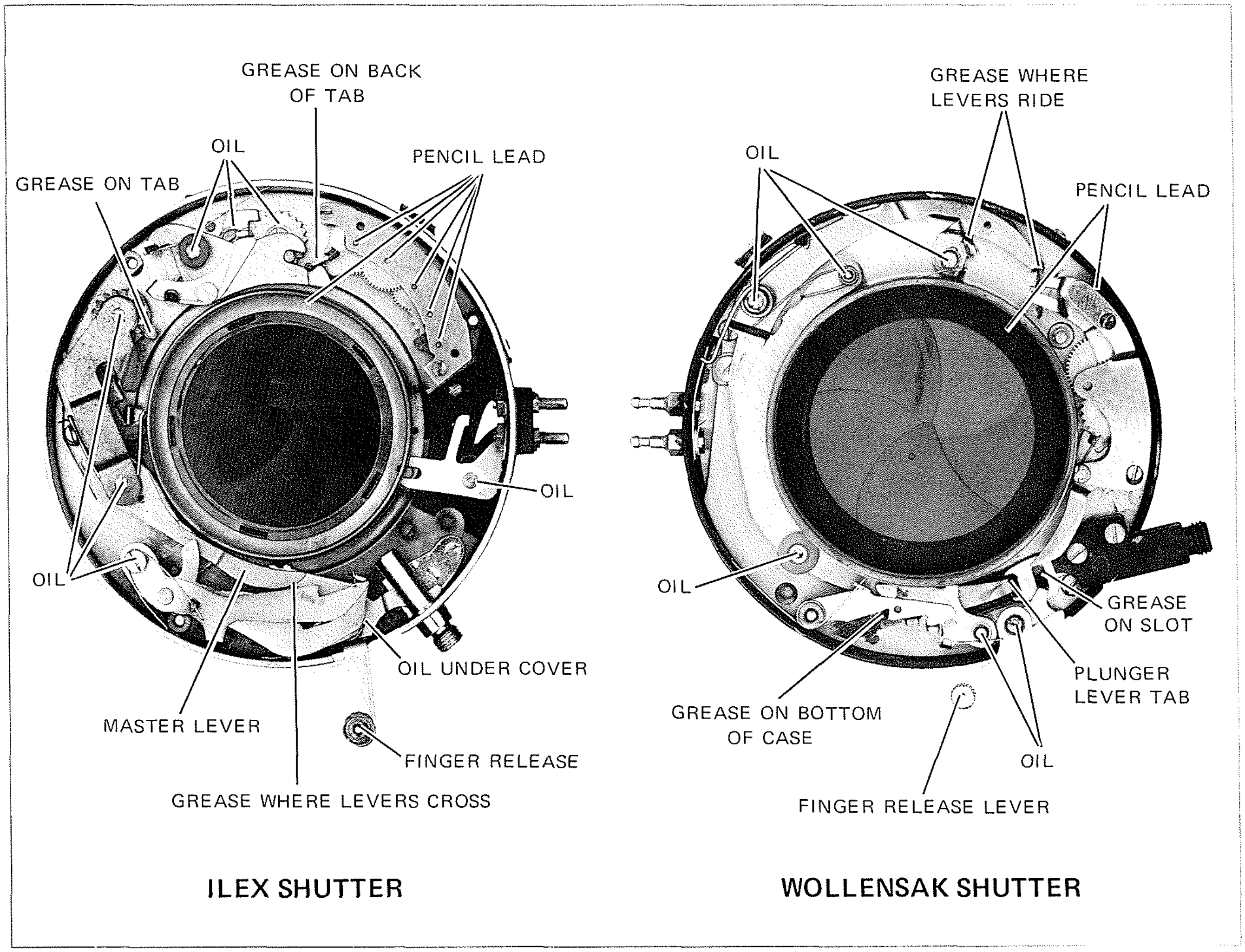
Until recently oscilloscope cameras have been assemblies of commercially available lenses, shutters, and film backs. The rest; frames, mounting hardware, and so forth; have been built by scope camera manufacturers to suit the special photographic and mounting needs of scope trace recording. Failures and malfunctions in cameras of this type are usually confined to sticking shutters and light leaks. There is some rare breakage due to accidents. Mechanical parts broken by such accidents are readily replaced. Each camera manual shows a detailed exploded view of the necessary replacement parts. These parts, except for components of the lens/shutter assembly are readily obtained through the same channels you use to get other Tektronix parts. Be sure to use the full nine digit part number and the camera type and serial number when ordering.

If you have a light leak you may find the source difficult to locate. In general, they are due to improper installation of camera hardware. It pays to carefully examine the camera back for loose or missing screws. If you have a "light leak" that occurs only with extra long exposures, you may be recording the light emitted by the CRT heater. This is not a common occurrence today. Aluminized tubes have virtually eliminated the effect. There isn't much you can do about this light source except shorten your exposure. Long exposures, on older scopes, are sometimes subject to light leakage in through the scope sides and out through the CRT.

Shutter sticking is an occasional problem. Servicing shutters requires some mechanical skills; not quite as much as clock repair, but the task is not to be undertaken casually. You may prefer to have your Tektronix Field Engineer arrange repair through a Service Center. It is practical, however, for you to cure this problem using normally available equipment.

The following servicing techniques apply to both the Elgeet/Ilex 3X and the Ilex 3X Shutter as well as the Wollensak Alphax and Pi-Alphax Shutters.* If you are not familiar with shutter mechanisms, I recommend that you tackle an Ilex before a Wollensak. The springs in a Wollensak are apt to pop out as you work the shutter without the cover. The Ilex springs are held in place by screws and won't pop out. Therefore, it's best to get a feel for the action with an Ilex.

**Ilex is a registered trademark of Ilex Optical Company, Inc. Alphax and Pi-Alphax are registered trademarks of Wollensak.*



Proper attention to the above points, during servicing, will assure smooth and reliable shutter function.

First, determine that the shutter is malfunctioning by the feel of the actuator (a spongy or rasping action is a common symptom). Then unscrew the lenses from front and rear of the shutter housing.—Be sure to remember or mark which is which; you could have an identification problem at reassembly. If the lenses are stubborn, use a towel to get a better grip. In a few cases, mostly with Wollensak lens assemblies, Glyptol cement was used to seal the assembly. Acetone will soften it. In extreme cases, a gripping device such as used to open stubborn jars may be necessary.

After the lenses are removed, set the shutter speed at 1. Put a mark on the shutter cover at the finger release lever. Then put a mark on and remove the second cover. (Ilex and Elgeet only). The marks aid in alignment at reassembly. Note the position of levers and springs. *Don't operate the Wollensak shutter with the cover off.* The springs can jump off their posts.

Next, fill a small bowl with enough Freon to cover the shutter. Caution—use tube puller or similar gripping device to dip shutter into Freon. Freon will remove oil and foreign matter from the shutter *and the hand;* it is best not to touch.

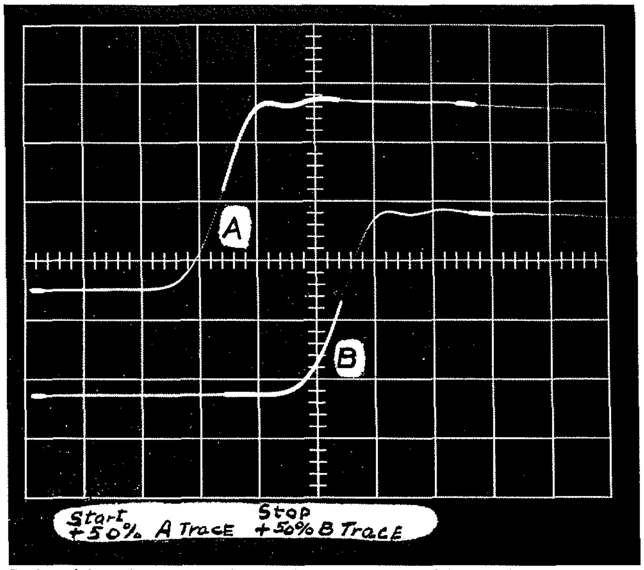
A Freon bath will remove encrusted material from the vital moving parts in a shutter assembly.

Let the shutter dry, you can use low pressure air if available. The shutter should now work freely. If not, here are some suggestions:

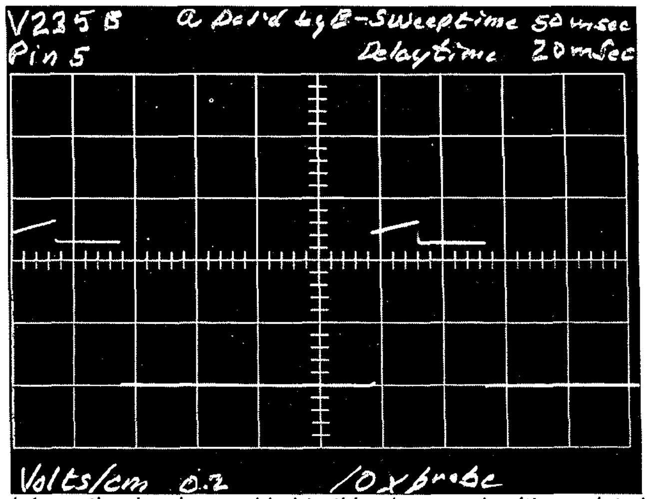
Wollensak	Problem #1	— Plunger lever jumps out of slot.
	Solution	— Bend tab inward slightly and reinstall in slot.
	Problem #2	— Bent master lever or plunger lever.
	Solution	— Carefully experiment, small bends may be necessary to make it work.
Ilex & Elgeet	Problem #1	— Finger release lever rides over or under master lever.
	Solution	— Raise or lower end of master lever to ride in slot on finger release lever. A small bend upward on the end of the master lever will prevent these two levers from jamming.

Next, some lubrication. On Ilex shutters, loosen screws (see photo) one at a time and add a small drop of oil on top of post. Retighten screw. On the Wollensak, just add a drop of oil. Blot excess oil; a cotton tip swab is excellent. There are four oils that we feel are satisfactory; WD40, No Noise, Clock Oil, or the oil commonly used on meter movements. Rub a dry lubricant or a "lead" pencil (graphite), on the points shown on the photograph. Install cover on Wollensak and operate shutter a few times. Blow off any excess dry lubricant. Grease at points indicated with switch detent lube. Check springs and levers again for proper function. Assemble shutter assembly. Check all ranges of speed control.

Now clean the lens with lens paper or tissue. Blow off any lint. Reassemble all lenses and the shutter. You should now have a reliable shutter, good for years of service.



Polaroid prints can be written upon with ordinary pen or pencil—see Technique 1 for details.



Information has been added to this photograph with a pointed implement—see Technique 2 below for details.

ADDING INFORMATION TO POLAROID PRINTS

Over the years customers have had the need to record data on Polaroid waveform photos. Some imaginative techniques have been reported to us and we are passing them along.

Technique 1—Use a draftsman's thin metal erasing shield and an eraser (an electric eraser is ideal if you're lucky enough to have one handy) to label or pinpoint information on Polaroid Land prints. The shield and eraser will enable you to erase through the print to the underlying white paper. You can erase away a portion of the print to form an arrow or a space to write in a number or a brief description.

This technique is most effective when used after the surface has dried a few minutes after development. Don't apply the coater until after completing the erasure and recording your data.

Technique 2—Polaroid prints are soft enough to be scratched for some time after development. This softness enables a metal point to scribe data on the print. The point should be sized somewhere between a common pin and a sharpened pencil. If the print is too hard, soften it with reapplication of the coater.

Technique 3—Apply SNOPAKE® correction fluid, manufactured by Litho-Art Products, Inc., to a select section of the print. This fast drying stuff will form a surface for writing. Ask your secretary; she probably has some stashed away. If not, your local office supply source has it.

Technique 4—Less convenient, but effective. Take a pencil type soldering iron and write. The results should be clear and distinct.

MARKING PHOTOS FOR ORIENTATION

You can avoid confusing moments for others if you will mark on your waveform photos which end is which. Some cameras reverse the waveform, some don't; some flip it upside down, some don't. Most of you indicate this information in a note attached to the photo, but woe to a person who gets the photo minus the note!

SPRAY MATTE FINISH ACCEPTS PEN OR PENCIL

The glossy surface of Polaroid opaque prints can be dulled to a matte finish by application of Marshall's Pre-Color Spray or Marshall's Pro-tek-to Spray.

The dulled surface can easily be written on with ordinary lead pencil, ball-point pen, etc., Dulling the surface also makes the prints suitable for use in opaque slide projectors (magic lantern).

The spray treatment is not a substitute for application of the regular coating chemical provided with each roll of Polaroid film for fixing and protecting the print; use Marshall Spray after the regular protective coating has been applied and allowed to dry.

Marshall's Pre-Color Spray is available through artist supply stores. Marshall's Pro-tek-to Spray is available through photo dealers.

WRITING ON GRATICULES

For writing on graticules for photographic purposes, we suggest a yellow grease pencil. Flora-Fluorescent made by the Swan Pencil Co. is one type that may be useful.

INSTRUMENTS FOR SALE

316, $450. CA Plug-In, $120. Roy B. Lang, 1003 Reseda Drive, Houston, Texas 77058. (713) 488-0149.

547, 1A2, $1900. Mr. J. Infusino, 3 Dogwood Lane, Nutley, N.J. (201) 667-4266.

601. Manny Mandell, Tonus, Inc., 45 Kenneth Street, Newton Highlands, Mass. 02161. (617) 969-0810.

RM181. Dr. D. Mellon, University of Virginia, Department of Biology, Charlottesville, Virginia. (703) 924-7119.

453, $1500. Jack Hart, New Jersey Communications, 760 Fairfield Ave., Kenilworth, New Jersey. (609) 245-8000.

532, 53C. Roger Harker, Bently Nevada Corporation, Box 157, Minden, Nevada. (702) 782-2255.

516 with P6017 Probes. Carl Frederiksen, Moline Tool Company, 102 20th Street, Moline, Illinois 61265. (309) 764-2418.

545B, 1A1, $2000. P.O. Box 1300, Winter Park, Florida. (305) 831-6222.

310A. Paul Katz, 5224 Linden, Bellaire, Texas 77401. (713) 524-3761 or (713) 667-5232.

454 Mod 163D, $2500. Palmer Agnew, 314 Front Street, Owego, New York 13827.

551, CA, 53/54C. Guy O'Balinski, Bromion, Inc., Rt. 17, Sloatsburg, New York 10974. (914) 753-2733.

535A, 545A, 531A & CA, L - 503, 515A, LC130. Henry Posner, Pacific Certified Electric Co., 5272 E. Valley Blvd., Los Angeles, California 90032 (213) 225-6191.

R422, $1000. William H. Greenbaum, Unilux, Inc., 48-20 70th Street, Woodside, New York 11377.

520, $1850. Jerry Childs, Datatron, Inc., 1562 Reynolds Avenue, Santa Ana, California. (714) 540-9330.

535A, CA Plug-In, $950. Bob Duke, 13526 Pyramid Drive, Dallas, Texas 75234. (214) 241-2888.

RM15, $600. RM45, $900. Z Plug-Ins $275 each. Stuart Ex, 14827 Cohasset Street, Van Nuys, California 91405, (213) 786-7672 or (213) 873-7672.

519, C-27, 202-1 Mod 52. All $4500. Bill Hall, KMS Technology Center, 7810 Burnet Avenue, Van Nuys, California 91405. (213) 787-7300.

514AD, $350. Dr. Robert Howson, Bell Telephone Laboratories, Room 1E-315, Holmdel, New Jersey 07733. (201) 949-5503.

80 with probes, 53/54B, T Time Base, 535. Joe McCauley, P.O. Box 118, Carmichael, California 95608. (916) 635-1773.

519, $3200. Ed Snyder, Science Accessories Corporation, 65 Station Street, Southport, Connecticut. (203) 255-1526.

122, $45. Mr. A. Wolff, Caltronic Laboratory, P.O. Box 36356, Los Angeles, California 90036.

323, $950. R. H. Ellis, Ellis Automotive Electrics Co., 7 Century St., Hamilton 21, Ontario, Canada.

555, 21A, 22A, M, CA, $2400. Ken Buddin, Optical Scanning Corp., Newtown, Pa. (215) 968-4611.

RM535A, 127 Power Supply, O, Q, E, Z, M Plug-Ins. RM567, 6R1A, 3A2, 3B2. C12 w/Graflok & Polaroid. Peter M. Guida, 525 East 68th Street, New York, N.Y. 10021.

127, 132, 123, H, L, D, G, B, 160A, P, TU-2. Ken Huff, Bryant Computer Products Division Ex-Cell-O Corp., 850 Ladd Road, Walled Lake, Michigan 48088. (313) 624-4571.

531, $400. Dennis Kraft, 7522 Tampa, Reseda, California 91335. (213) 881-1551.

130, $200. Robert H. Becker, Becker Electronics, Inc., 144 Westside Ave., Freeport, New York 11520. (516) FR 8-3005 or (516) FR 8-3092.

531A, 1A2, N, $1250. Michael Muegge, 100 Foerster St., San Francisco, California 94112. (415) 931-8000, Ext. 522 or (415) 585-1625.

INSTRUMENTS WANTED

453. Carl Frederiksen, Moline Tool Company, 102 20th Street, Moline, Illinois 61265. (309) 764-2418.

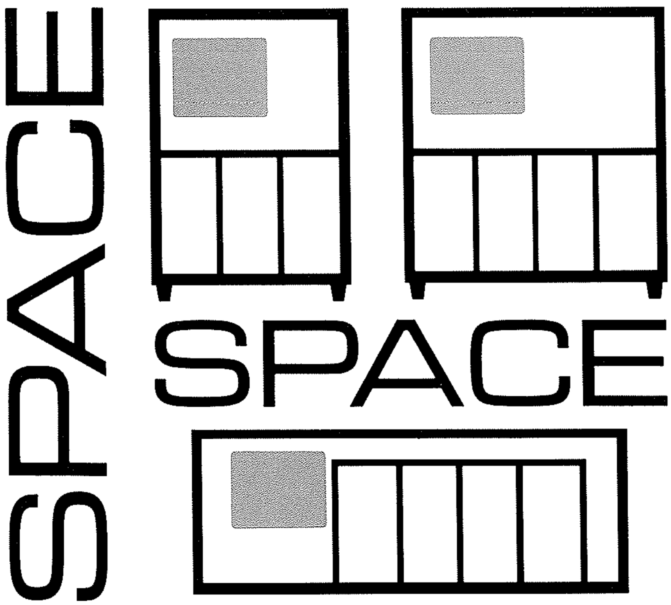
453. F. Jambor, 302 Easy St., Apt. 60, Mt. View, California 94040.

517A Power Supply. Prefer working, will consider repairable unit. J. E. Churchill, P.O. Box 4092, Santa Fe, New Mexico 87501.

TEKSCOPE

Volume 2 Number 5 October 1970

Customer Information from Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005
Editor: Art Andersen Artist: Nancy Sageser For regular receipt of TEKSCOPE contact your local field engineer.



Separate instrumentation requires space, space required by separate digital multimeter, separate counter, separate oscilloscope. Now the 7000 Series combines three, basic instrument functions in one system—saving space, without sacrificing performance. The Integrated Test System, a new and unique concept from Tektronix, has been created. Created by the addition of the plug-in 7D13 Digital Multimeter and the plug-in 7D14 Digital Counter to the 15 Oscilloscope Plug-Ins already available.

MEASURES: VOLTAGE ● CURRENT ● PERIOD FREQUENCY ● RESISTANCE ● TEMPERATURE