March, 1979 □ $2.25

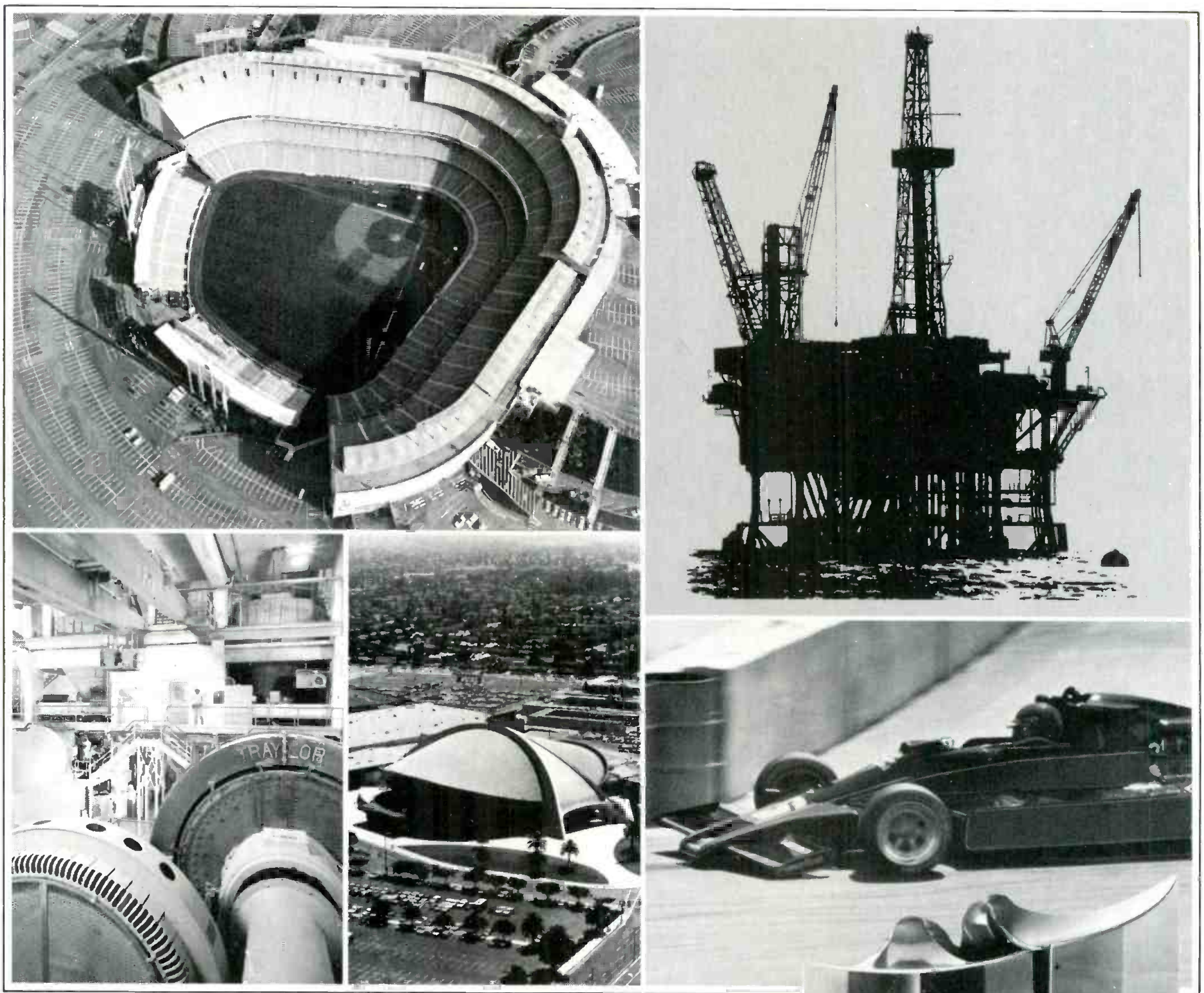
Electronic Servicing®

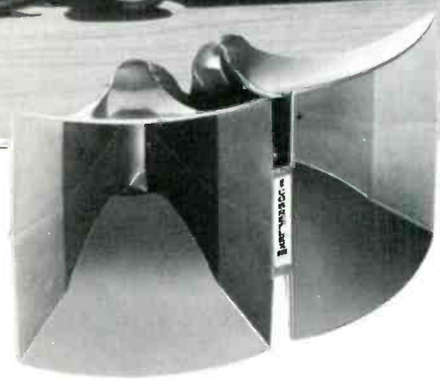
Scope Tips and Features

Wideband and Medical Scopes

Special Scope Issue

University Sound is being heard everywhere.





Why? Because University Sound manufactures a full line of horns, drivers and speakers to meet almost any requirement. Unique equipment to handle tough situations. Maybe that's why demanding installations like the Long Beach, California Grand Prix, coal mines in West Virginia, grain elevators and off-shore oil rigs rely on University Sound products.

At University Sound we've been building tough, reliable commercial sound products for over forty years. Products like industrial paging horns, background music speakers, and heavy duty compression drivers. And we're constantly researching and developing new products like our tough, new horn, the Cobreflex III.

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March, 1979
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Electronic Servicing

Departments

About the cover Video and horizontal-sweep waveforms are shown on a wideband scope screen. *Photograph by Carl Babcoke; design by Linda Franzblau.*

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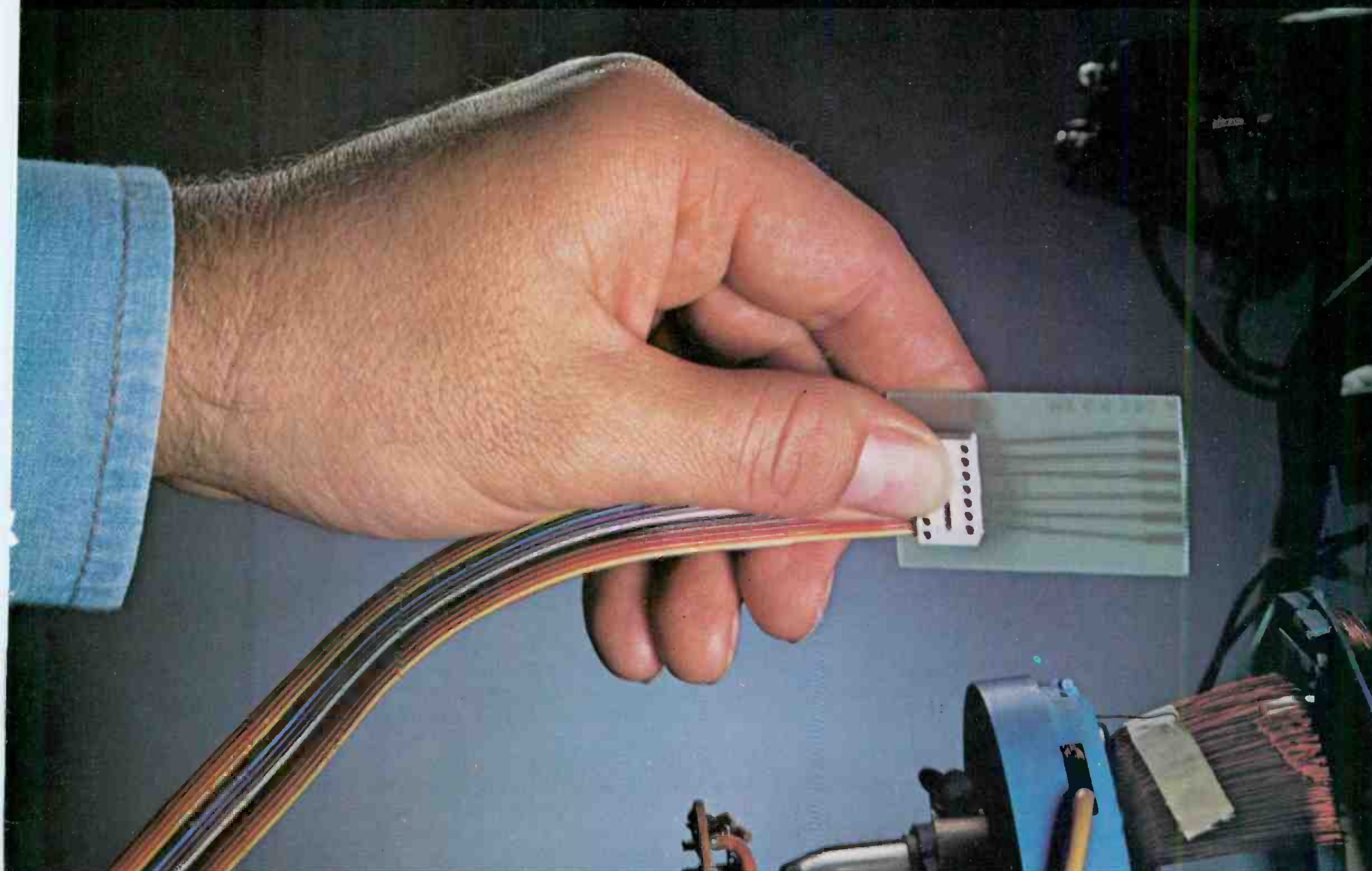
SYLVANIA WILL TELL YOU WHAT'S WRONG WITH RCA AND ZENITH.



Now when an RCA or Zenith TV module breaks down you don't have to be nervous. Because Sylvania makes Chek-A-Board® module extension kits that let you pinpoint the problem without pulling the chassis. Once you know what's wrong, there's a Sylvania ECG® semiconductor to make it right.

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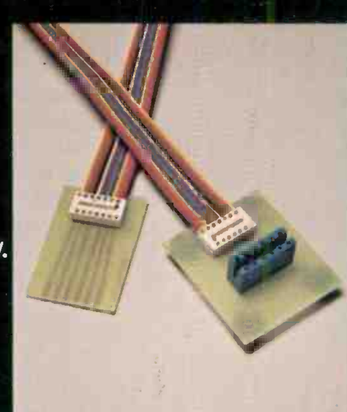

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electronicscanner

news of the industry

The Frigidaire division of General Motors has been sold to White Consolidated Industries, subject to a possible veto by the Justice Department. White intends to manufacture and market the Frigidaire line, after a transistion period that is designed to prevent scarcities of merchandise to the dealers.

Magic Chef recently purchased the Admiral refrigeration business from Rockwell International. Negotiations now are underway with Norge for the sale of the Norge laundry business to Magic Chef. If both sales are completed, Magic Chef will market a complete line of major appliances.

RCA has announced a 1.2% increase in the wholesale prices of color TV receivers, which might raise each retail sale by about $10. This is the second increase within three months. More remote-controlled models were announced, including some 13-inch sets.

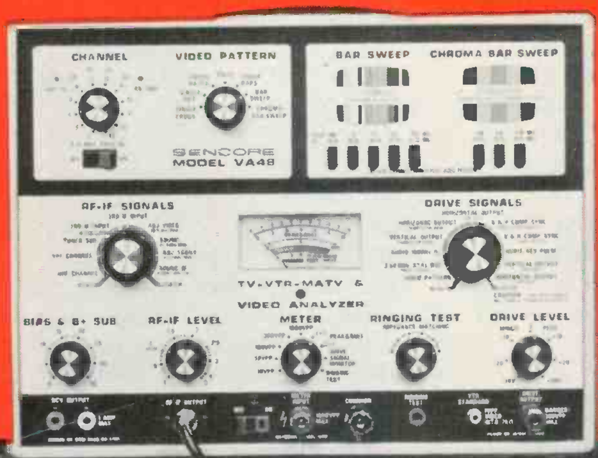
Total power needs for the 96 residents of a Papago Indian village near Tucson, AZ are supplied by solar panels. The 3.5 kW system uses 24 silicon 4'x8' solar panels to maintain the charge in 52 lead-acid storage batteries. The 120 Vdc operates a large water pump, one community washing machine, fluorescent lights and 15 refrigerators. It is said to be the only United States community to rely solely on solar power. Funding came from the Department of Energy, and the equipment was specified by NASA engineers.

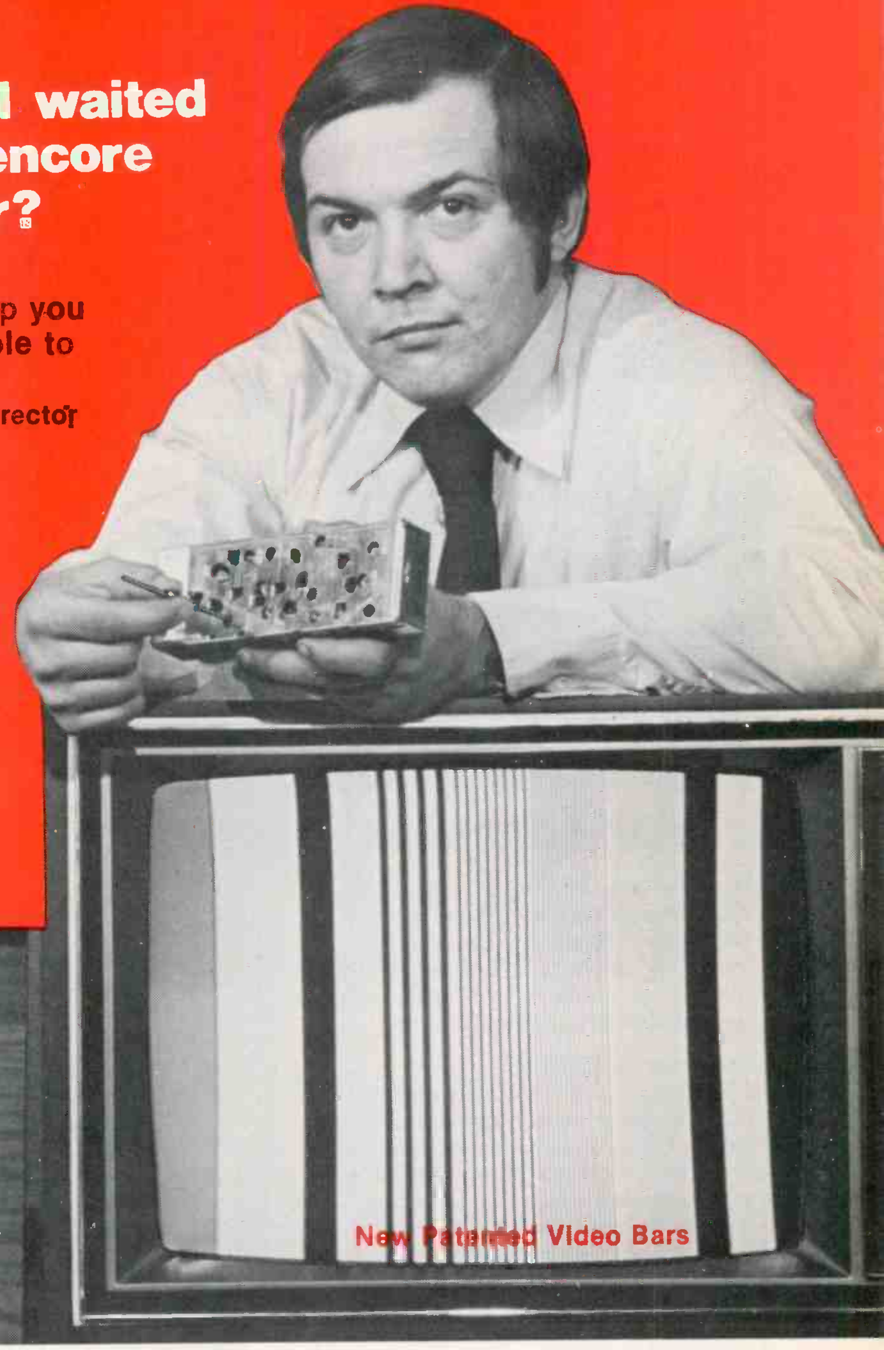
Another approach to harnessing "free" energy is the windmill. A modern version was completed recently by Clarkson College in Potsdam, NY. Built of donated materials, the wind turbine-generator generates 12 to 15 kW of electrical power. Blades of the vertical-axis turbine-generator were made of extruded aluminum 34 feet long and with a chord of 6 inches. When in rotation, these three blades resemble a huge upside-down eggbeater, or perhaps three children's jumping ropes operated vertically. A 3-phase induction motor starts the turbine and brings it up to normal speed, then the drive shifts the speed so the turbine runs faster than the motor, thus overdriving it to become an alternator which supplies power to the regional power grid.

Two new service associations have been formed. The officers of the Electronics Technicians Association, Inc. (ETA) are Jessie B. Leach, chairman; D. C. Larson, vice chairman; Leon F. Howland, secretary; Walter Cooke, treasurer; Ron Crow, director of certification; and Dick Glass, president. ETA has formed a certification program under the International Society of Certified Electronic Technicians, Inc. (ISCET). These two organizations are directly competitive with National Electronic Service Dealers Association (NESDA) and its former committee, the International Society of Certified Electronic Technicians (ISCET). During the recent NESDA convention in San Diego, ISCET was made a full-fledged division of NESDA, with virtually independent status. ISCET now is operated by Forest Belt as acting chairman and Larry Steckler, the acting vice chairman. Charles Porter has resigned as executive vice president of NESDA. Bob Villont (NESDA president) and Forest Belt (ISCET acting chairman) announced jointly the creation of a new job of administrator which has been filled with the appointment of Marti McPherson, who has had extensive administrative experience. All four organizations are very active, and each claims new members and increased support. □

Haven't you wanted and waited long enough for your Sencore VA48 TV-Video Analyzer?®

"I'm dead serious about wanting to help you increase your service by isolating trouble to specific TV stages in minutes."
Rich Brockway, Technical Customer Service Director





Your VA48 is practically jumpin' out of the box in the Sencore stockroom, anxious to help you increase your color TV, black and white TV, VTR, or closed circuit TV service by as much as 50 percent. The VA48 will help you double your shop income next year and build a service reputation that will never go away.

How can I help you and your VA48 get together? Just drop a note to the Sencore Customer Service Department or call our toll-free WATS number 800-843-3338 today and ask for Rich Brockway. I will see that your VA48 is delivered to you immediately, on a 30-day money-back guarantee that it will do just what we say it will do. How can you lose? The only way you can lose is by not picking up the phone right now. Need financing? Perhaps I can help you there.

The VA48 TV-Video Analyzer is like having a miniature TV station at your fingertips for troubleshooting.

The VA48 provides all phase-locked signals for fast signal injection troubleshooting into every single stage of every TV, video tape recorder, MATV, CATV, or closed circuit TV. Makes all TV systems look alike for simplified IC troublshooting.

- **Patented Bar Sweep patterns** enable you to align all RF, IF, and Chroma stages from top of chassis. Cuts aligning and troubleshooting time in these sections to less than one half.
- **Crystal-controlled trap frequency markers** equip you to set all traps from top of chassis without removing a single nut or bolt. What a time-saver!
- **Phase-locked color bars, crosshatch, and dots** speeds up your convergence, troubleshooting, or alignment of any color circuit. No more "running" color patterns and no more guesswork as the entire TV stays locked in. Scope waveforms stay in sync for comparison of any stage to another stage, anywhere in the TV.
- **Only TV analyzer that provides all variable drive signals** for tube, transistor, and SCR TV sets as well. All drive signals are monitored on peak-to-peak meter for accuracy and to help determine defective stages.
- **Provides highly filtered 0 to 35 Volt power supply** for bias, troubleshooting automatic circuits, powering circuits with horizontal sweep derived voltages, and SCR checks.
- **One-third the cost of equivalent instruments** that have up to 60 separate test leads and non-synchronized signals. The VA48 is all phase-locked and all signals delivered from three circuit-matched test leads for only $975.

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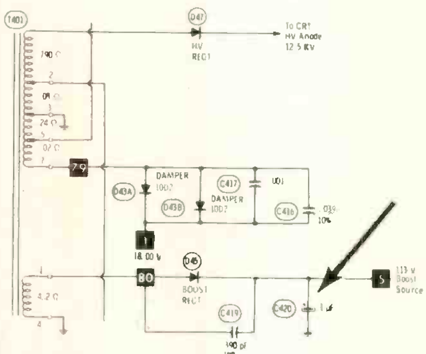
troubleshooting tips

Weak contrast
Panasonic B&W TR-642
(Photofact 1434-2)

The complaint was that the picture was very faint when the set first was turned on. When the TV was tested, the brightness control worked okay, the raster was normal, and the contrast control varied the video from weak to worse. After the set was operated for a time, the picture gained some contrast. However, all attempts to increase the contrast produced a smear of white compression, which was worse along the right edge.



While reviewing these symptoms, I decided some component was changing from the chassis heat, and so I used coolant spray on video-circuit components. There was no change until I accidentally sprayed C420, which was mounted near the video-output transistor. Instantly, the contrast went down to the amount obtained previously at turn-on.

C420 is the filter and bypass of the 113-V boost source, but the source measured only 65 V when the capacitor was warmed versus about 40 V after it was cooled. This voltage source supplies many points including the video-output transistor and the CRT screen grid, so it was obvious the low voltage was reducing the contrast.

As I removed the old electrolytic capacitor, I noticed powder around the positive lead (proving leakage of the electrolyte). Installation of a new C420 restored normal contrast.

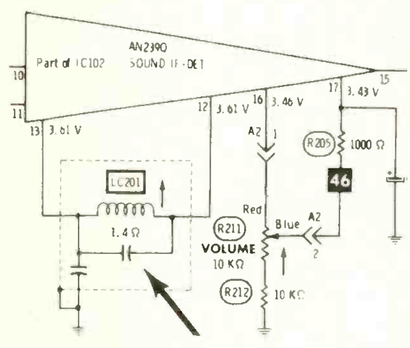
George M. Marechek, Jr.
Cheverly, MD

Sound fades
Quasar 19TS953
(Photofact 1715-1)

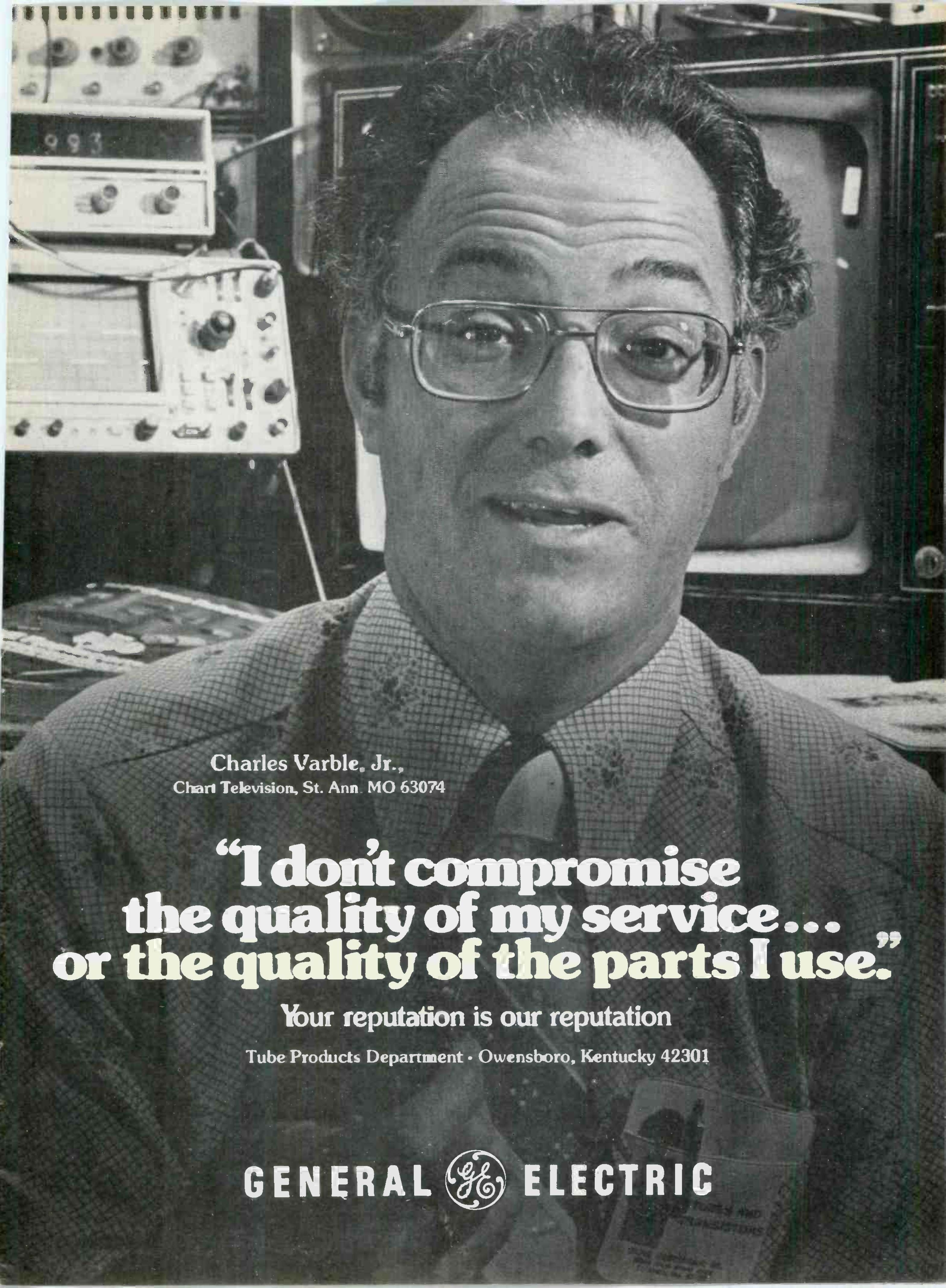
After about five minutes of operation, the sound faded away. Some problems have been reported with IC201 in this model. Evidently, we were not the first shop to attempt the repair, for the IC had been replaced already.

I suspected the problem was triggered by heat from the TV chassis, and I applied canned coolant to IC201. The sound returned to normal. Could the replacement be defective? Since that seemed unlikely, I cooled other sound components around that area. There was no change.

Suspicion returned to IC201, and when it was sprayed again, the sound came back but at reduced volume. Then I noticed LC201, a component located next to the IC. When I cooled LC201, the sound became normal.



LC201 contains the quad coil and two capacitors, so it certainly could



Charles Varble, Jr.,
Chart Television, St. Ann, MO 63074
"I don't compromise the quality of my service... or the quality of the parts I use."
Your reputation is our reputation
Tube Products Department • Owensboro, Kentucky 42301
GENERAL ELECTRIC

Troubleshooting tips

affect the sound volume. After it was replaced with Quasar part 51D72931A05 and the coil was adjusted correctly, the sound did not fade during a heat test lasting all day.

Richard Serrano
Madera, CA

Buzz in sound
Many models

Although this problem can occur in many different brands and models, the facts here apply to the Zenith 19EC22 chassis (Photofact 1413-3).

A noticeable buzz could be heard in the speaker, even when the volume control was turned to minimum setting. A new 150-214 audio module didn't help the buzz. Therefore, the defect was not on the module.

During the testing, I noticed the frequency of the buzz changed in step with the vertical-sweep frequency as the hold control was adjusted.

After much testing, I found a wire from the center lug of the vertical-hold control that ran near a capacitor which was mounted under the chassis near the audio module. The capacitor appeared to be wired to pin 6 of the 221-48 IC. When I redressed the wire away from the capacitor, the buzz was gone.

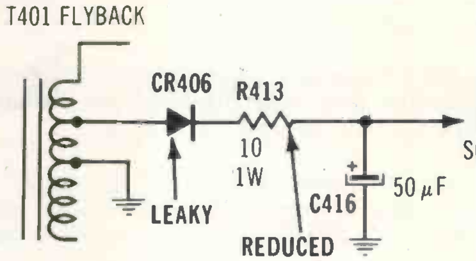
Remember to roll the vertical and notice if the tone of the buzz changes. If it remains the same, the buzz is from some 60-Hz source. But, if it varies with the sweep frequency, the buzz is coming from the vertical circuit. Trace all volume control and tone control components and wires to find any that are too near some vertical wire or component.

Joseph Ruzicka
Seward, Nebraska

symcure

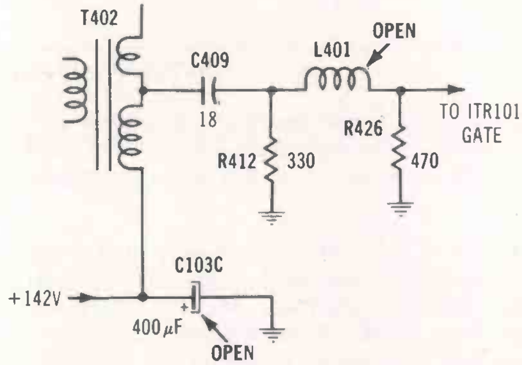
Symptoms and cures compiled from field reports of recurring troubles

Chassis—RCA CTC85
PHOTOFACT—1698-2



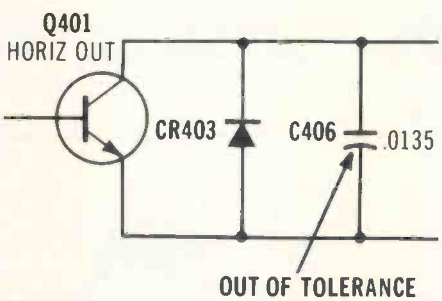
Symptom—Begins shutdown after 15 to 20 seconds
Cure—Check CR406 and R413; replace them if out of tolerance

Chassis—RCA CTC72
PHOTOFACT—1669-2



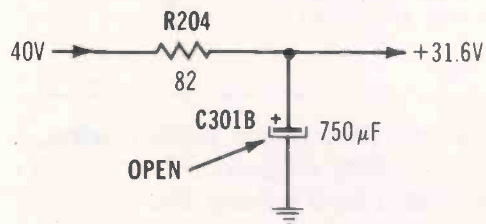
Symptom—L401 overheats and opens
Cure—If L401 is open, check filter C103C and replace if open

Chassis—RCA CTC85
PHOTOFACT—1698-2



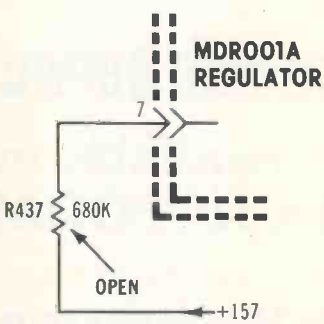
Symptom—Excessive brightness, perhaps with blooming
Cure—Check C406 and replace it if the capacitance has changed

Chassis—RCA CTC81
PHOTOFACT—1615-2



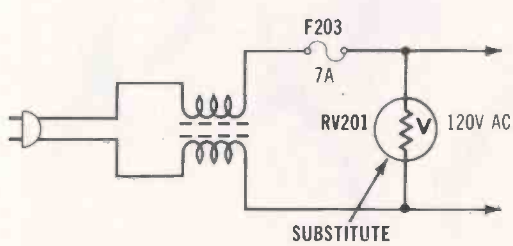
Symptom—Lines in picture are modulated by audio
Cure—Check filter C301B and replace it if open

Chassis—RCA CTC85
PHOTOFACT—1698-2



Symptom—Instability and pie-crusting followed by shutdown
Cure—Check R437 and replace it if open or increased

Chassis—RCA CTC90
PHOTOFACT—1710-2



Symptom—Intermittent noise lines in picture
Cure—Check RV201 by substitution, or by operating without it (RV201 clips power-line transients)

reader's exchange

There is no charge for a listing in *Reader's Exchange*, but we reserve the right to edit all copy. If you can help with a request, write directly to the reader, not to **Electronic Servicing**.

Needed: Schematic and service information for Akai model X-200D stereo tape deck. Will buy, or copy and return. *J. H. Pier, Route 2, Box 451, Shreveport, LA 71129.*

Needed: Out-of-print Photofact books MHF-1 through MHF-26, MHF-28, MHF-30 through MHF-32, MHF-36, MHF-40, MHF-41, MHF-44, MHF-45, MHF-47 and MHF-48. Also, need all out-of-print AR books. State condition and best price. *Christian TV & Audio, 6916 Silver Star Road, Orlando, FL 32808.*

For Sale: New Sencore PS-163 scope in box, $700; Heath 10D203 5-MHz triggered scope, excellent for $150; Sencore TF151A solid-state tester, $50; Heath IT3120 solid-state tester, $40. *Bill Bechtold, 7429 Frederick, Omaha, NE 68124.*

Needed: Power transformer 54-51-138826 for a model IA-1 Heath ignition analyzer, or a complete ignition scope in good working order. *(no name), 55 Main, Three Rivers, MA 01080.*

For Sale: Rider Perpetual Troubleshooters Manual, 64 books, best offer. Also, miscellaneous test equipment. *Mrs. Jeff Peltier, RR, Brenner, SD 57055.*

Needed: Sencore CB44, 27 MHz CB scope, and frequency counter in excellent condition. State prices. *Caswell Davis, Jr., 601 Delmar, Apt. 2, San Antonio, TX 78210.*

Needed: Service manual or schematic for Millivac ac voltmeter model MV-45A. Will copy and return. *T. Raj, 915 5th Street S.E., Minneapolis, MN 55414.*

For Sale: B&K-Precision model 801 capacitor Analyst, $75; Heathkit audio generator model IG-18, $75; Heathkit model IG-57A TV post-marker/sweep-generator with attenuator, factory assembled but never used, $150. *Edward Andryscyk, 100 Compton Avenue, West Keansburg, NJ 07734.*

For Sale: B&K-Precision model 1077B Analyst in original carton, with manual, slides and all leads,

$300. *Howard Mason, RD-1, 317 Dorchester Drive, Linwood, NJ 08221.*

Needed: Schematic for model D614-07A Lloyds hi-fi. Photofact MHF35 is no longer in print. Will pay copying and mailing costs. *Don Gross, RD 1, Cameron Mills, NY 14820.*

Needed: Manual for model 583A General Radio audio-output meter; manual for TS-175C/U frequency meter; Tektronix 11B2A and 10A2A scope plug-ins. *J. Allen Call, 1876 East 2990, South Salt Lake City, UT 84106.*

For Sale: Sencore VA-48 Video Analyzer, $750; Bell & Howell scope, $100; EICO 667 tube tester with CRT adapter, $40; EICO model 324 signal generator, $20; RCA WR64A color/bar generator, $15; Telematic test jig with 28 yoke adapters, 10 convergence loads and transverter, $150; 500 tubes, $500; Photofacts 500 to 800 with cabinets, ask price. *Heckard's TV, RD1, Box 88, Lewistown, PA 17044.*

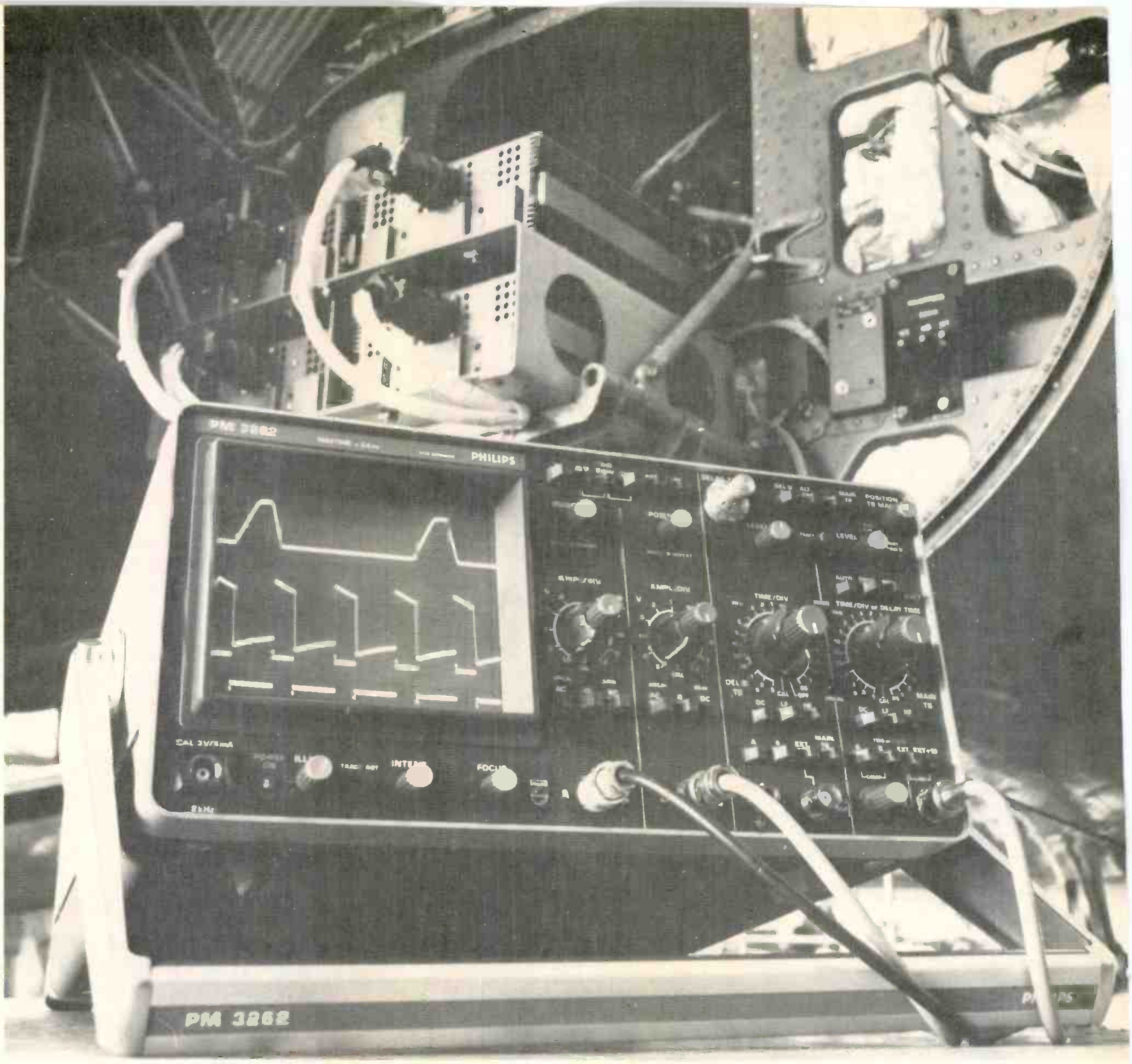
Needed: Model 739 Simpson probe kit for Simpson model 458 scope. State price and condition. *Arthur Blaha, 3855 West 65th, Chicago, IL 60629.*

Needed: Power transformer for model KG-600C Knight tube tester. *W. G. Parker, 4621 Jasper, Metairie, LA 70002.*

Needed: Schematic and parts list for a model 1500 B&K 40-W public address amplifier. Will buy, or copy and return. *Bud Fisher, 2472 Constantine Drive, Michigan Center, MI 49254.*

Needed: Service or operation manual for model 316 Tektronix and model 983 Weston scopes. Will buy, or copy and return. *Frank Dickinson, Bulsontown Road, Stony Point, NY 10980.*

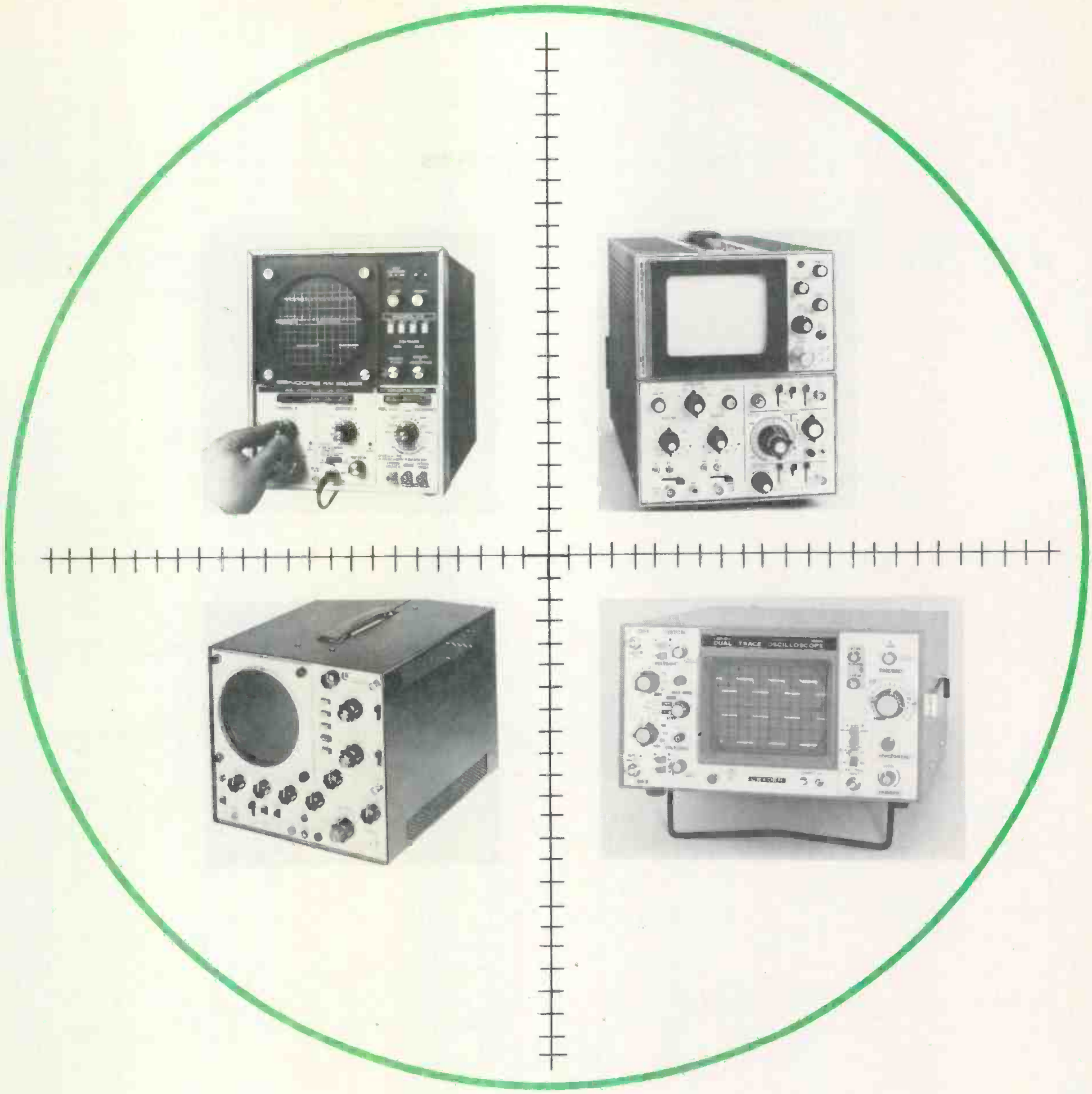
Needed: RCA 15GP22, 5BP4 and 7DP4 picture tubes. Also, RCA wire recorder and cartridges; RCA Berkshire tuner and amplifier chassis. *C. E. Sarver, 256 West 88th, New York, NY 10024.*



features of new scopes

By Carl Babcoke, editor, and the Electronic Servicing staff

Advances in oscilloscope technology made it possible to view waveforms that could not have been locked or displayed a few years ago. Improvements in stability bandwidth, faster sweeps, expanded waveforms and other new features have made older scopes obsolete at a time when present-day state-of-the-art technology demands the best performance. These explanations and the technical specification charts should help you in selecting the brand and model of scope that is best for your needs.



Many important improvements have been made in scopes over the years and older features or specifications have been eliminated. Those previous factors are not mentioned now, except perhaps to illustrate the superiority of new scopes compared to the many obsolete ones that continue to be used (or ignored) in electronic shops.

Tubes versus solid state—The battle between tubes and transistors is over. Tubes lost. No tubes (except CRTs, of course) are used in any newly introduced models.

Scopes with solid-state components share in the general advantages of other solid-state equipment (less internal heat, smaller physical size, lower power consumption and longer life with less maintenance). More importantly, they benefit from *increased stability.*

This stability is valuable because of former problems that are eliminated. The drift of vertical-amplifier gain now is very small, which allows the calibration control to be removed from the front panel. It's no longer necessary to calibrate the scope each time peak-to-peak volts are to be measured accurately. Also, the positioning or centering of the waveform is much more stable. Many of the new scopes will run for hours without falling out of lock. (Part of this improvement is from triggered sweep; but some is possible because of the solid-state devices.)

Recurrent versus triggered sweep—Latest test-equipment catalogs from scope manufacturers list almost no recurrent-sweep models. Of the five models offered by one well-known manufacturer, only one has recurrent sweep.

This overwhelming acceptance of triggered scopes proves they are easily worth the slightly higher price tag.

Perhaps the most unique difference between recurrent and triggered scopes is that recurrent scopes lock according to the *fre-*

Brand	Model	Vertical Sensitivity	Vertical Response	Rise Time	Signal Delay	Dual Trace	Dual Beam	Horiz. Sweep Time/Div.	Horiz. Amp Bandwidth	Expanded Sweep
B&K-Precision	1474	5 mV/cm	dc-30 MHz	11.7 ns	X	X		0.2 μs/cm to 0.5 s/cm	dc-1 MHz	X5
	1432	2 mV/div	dc-15 MHz	24 ns		X		0.5 μs/div to 1.5 s/div	dc-1 MHz	X5
	1472C	10 mV/cm	dc-15 MHz	24 ns		X		.5 μs/cm to 0.5 s/cm	dc-1 MHz	X5
	1471B	10 mV/cm	dc-10 MHz	35 ns		X		1 μs/cm to 0.5 s/cm	dc-1 MHz	X5
	1461	10 mV/cm	dc-10 MHz	35 ns				1 μs/cm to 0.5 s/cm	dc-1 MHz	X5
	1403A	10 mV/div	dc-5 MHz	70 ns				10 Hz-110 kHz	dc-250 kHz	
Ballantine Laboratories	1032A	5 mV/cm	dc-20 MHz	17.5 ns		X		1 μs/div to 0.5 s/div	dc-1 MHz	X10
	1010A	2 mV/cm	dc-15 MHz	35 ns		X		1 μs/cm to 0.5 s/cm	dc-500 kHz	X10
	1066B	5 mV/cm	dc-20 MHz	17.5 ns		X		0.5 μs/cm to 1 s/cm	dc-1 MHz	X10
	1040A	5 mV/cm	dc-40 MHz	9 ns	X	X		200 ns/cm to 2 s/cm	dc-5 MHz	X10
Dumont	1100P	5 mV/cm	dc-100 MHz	3.5 ns	X	X		0.05 μs/cm to 1 s/cm	dc-5 MHz	X10
	1050	10 mV/cm	dc-50 MHz	7 ns	X	X		0.1 μs/cm to 1 s/cm	dc-4 MHz	X10

Scope features

quency of the signal. However, a triggered scope sweeps for a definite period of *time* (after it's triggered) and shows whatever segment of a waveform is there during that time. A half-cycle or 9-⅓ cycles might be displayed, depending on the signal frequency. It's all the same to the scope.

Sweeping for a certain time rather than with a definite frequency allows triggered scopes to lock securely onto waveforms that can't be locked at all by recurrent types. Pulse trains and some video waveforms are examples. Recurrent scopes also can't show one-shot events, such as transients or a single damped-wavetrain.

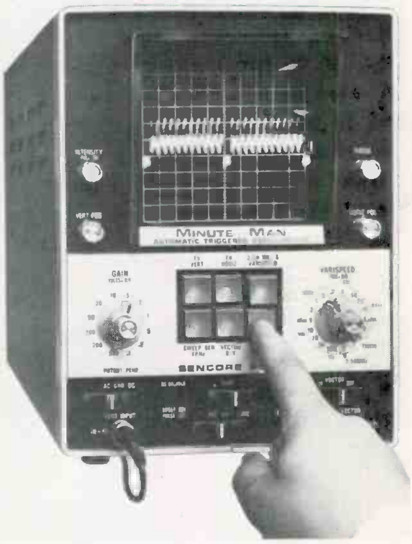
Additional information and illustrations are given in the *Tips For Using Scopes* article, found elsewhere in this issue.

Measures ac and dc—One big advantage of modern scopes is the option of reading ac or dc voltages (or both combined). This is made possible by dc-coupled vertical amplifiers having flat response from dc to the rated top frequency. Both ac and dc have the *same* calibration. A deflection of one centimeter (or one division) indicates the same dc voltage as it does peak or peak-to-peak ac voltages.

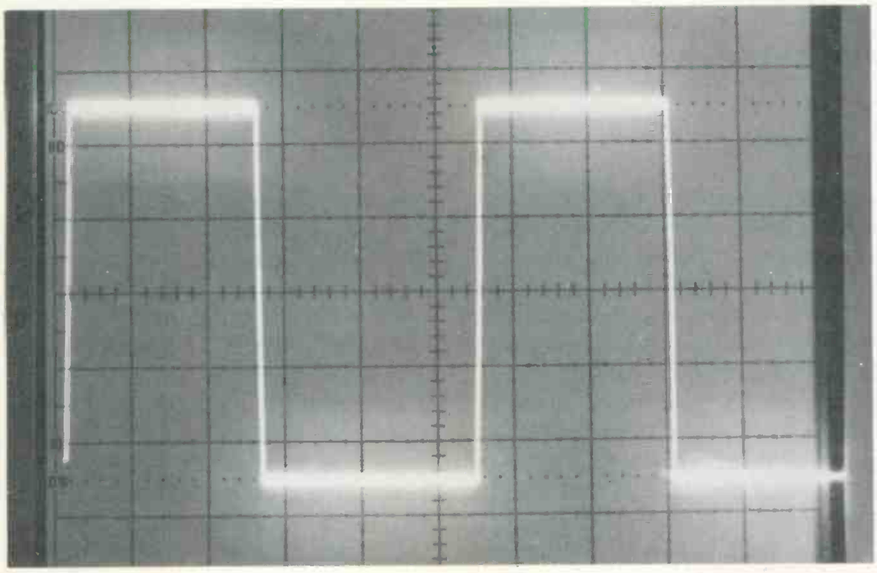
When an ac waveform without any dc is required, a front panel switch connects a coupling capacitor.

All of the new scopes surveyed have a switch for ac or dc operation. Again, there is no controversy, except to those who have never made any dc measurements with a scope. It is helpful to learn to make dc and combined ac/dc voltage measurements.

Delayed Sweep	TV Sync	Calibrated Waveform	Special Features	Reader service number
	X	X		38
	X	X	3-inch CRT - 120 Vac/12 Vdc operation, optional ext. battery	39
	X	X		40
	X	X		41
	X	X		42
			Recurrent sweep, 8.5 pounds	43
		X	Independent dual triggering	44
	Frame			45
	X	X		46
X	X	X		47
X		X	Internal graticule, beam finder	48
X		X	X10 vert gain beam finder	49



Six pushbuttons on the Sencore PS-29 "Minute Man" panel select the sweep times most often needed. Also included is the usual time/cm switch with frequency markings. Locking is automatic without any variable controls.



Brand	Model	Vertical Sensitivity	Vertical Response	Rise Time	Signal Delay	Dual Trace	Dual Beam	Horiz. Sweep Time/Div.	Horiz. Amp Bandwidth	Expanded Sweep
Dumont	1950	5 mV/cm	dc-50 MHz	7 ns	X	X		0.1 μs/cm to 2 s/cm	dc-5 MHz	X10
	1064	5 mV/cm	dc-60 MHz	5.8 ns	X	X		0.1 μs/cm to 1 s/cm	dc-4 MHz	X10
De Forest	6010	10 mV/div	dc-10 MHz	35 ns				0.1 μs/div to 5 ms/div	dc-1 MHz	X2, X5
Eico	435	50 mV/div	dc-4.5 MHz	70 ns				10 Hz to 100,000 Hz	dc-500 kHz	
	460	34 mV/div	dc-4.5 MHz	70 ns				10 Hz to 100,000 Hz	dc-500 kHz	
	465	34 mV/div	dc-8 MHz	40 ns				10 Hz to 100,000 Hz	dc-500 kHz	
	462	10 mV/div	dc-10 MHz	35 ns				1 μs/div to 100 ms/div	dc-1 MHz	
	480	10 mV/div	dc-10 MHz	35 ns				0.1 μs/div to 0.5 s/div	dc-1 MHz	X5
	482	10 mV/div	dc-10 MHz	35 ns		X		0.1 μs/div to 0.5 s/div	dc-1 MHz	X5
Gould	OS245A	5 mV/div	dc-10 MHz	35 ns		X		1 μs/cm to 0.5 s/cm	dc-1 MHz	X5, X10
	OS260	2 mV/cm	dc-15 MHz	23 ns			X	0.5 μs/cm to 0.2 s/cm	dc-1 MHz	X10
	OS1100	1 mV/cm	dc-30 MHz	11 ns	X	X		0.2 μs/cm to 2 s/cm	dc-1 MHz	X10

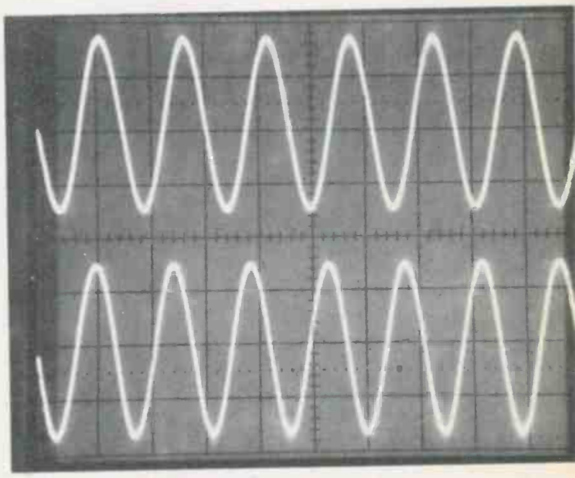
Scope features

Multiple traces—Two methods permit more than one trace to be viewed on the screen simultaneously. One way is to use a special dual-beam CRT which has two separate sets of vertical deflection plates and two electron streams. There are three advantages. It is *impossible* for the two waveforms to be out of phase, for only one sweep system and locking circuit are operating. Both traces are brighter than those of dual-trace, since both are present at all times without any time-sharing. The waveforms show no chopper interference at any sweep time and they have less flicker at slow speeds than does alternate sweep. One disadvantage is the higher cost compared to a dual-trace scope of equal specs.

Dual-trace is a time-sharing arrangement of alternating the two waveforms which then are applied to a conventional single-gun CRT.

However, two kinds of time-sharing are offered. For high-speed short-time sweeps, the two waveforms are viewed consecutively. That is, one complete trace shows the waveform of channel 1, while the next complete horizontal trace has the waveform of channel 2. Each trace is slightly less bright than one alone would be, because each one is seen only half of the time. This is called *alternate* sweep, which is not desired for low repetition signals because of the

Delayed Sweep	TV Sync	Calibrated Waveform	Special Features	Reader service number
X		X	X5 vert gain, internal graticule, beam finder	62
X		X	Internal graticule beam finder	63
	X	X	ac/battery power	64
		X	3-inch recurrent type with tubes	65
		X	5-inch recurrent type with tubes	66
		X	5-inch recurrent type with tubes, vector pattern	67
		X		68
	X	X		69
	X	X		70
		X		71
		X		72
		X		73



Dual-trace and dual-beam features allow two separate waveforms to be displayed at the same sweep speed. This is very useful for comparing the phase of signals and for fast troubleshooting of intermittents.

Model 1432 from B&K-Precision is a 15-MHz dual-trace portable scope that operates either from line voltage or 12 Vdc. It has a 3-inch CRT and a vertical sensitivity of 2 V/div.

Brand	Model	Vertical Sensitivity	Vertical Response	Rise Time	Signal Delay	Dual Trace	Dual Beam	Horiz. Sweep Time/Div.	Horiz. Amp Bandwidth	Expanded Sweep
Gould	OS3300B	1 mV/cm	dc-50 MHz	7 ns	X	X		100 ns/cm to 1 s/cm	dc-1 MHz	X10
	OS4000	5 mV/cm	dc-10 MHz	35 ns		X		1 μs/cm to 20 s/cm	dc-2 MHz	X1 to X10 Variable
	OS253	2mV/cm	dc-12 MHz	29 ns		X		0.5 μs/cm to 0.2 s/cm	dc-1 MHz	X5
	OS255	2 mV/cm	dc-15 MHz	23 ns		X		0.5 μs/cm to 0.2 s/cm	dc-1 MHz	X5
	OS4100	1 mV/cm	dc-500 kHz dc-10 kHz			X		100 μs/cm to 50 s/cm		X10
Heath	IO-4560	100 mV/cm	dc-5 MHz	70 ns				0.2 μs/cm to 20 ms/cm	dc-100 kHz	
	IO-4541	20 mV/cm	dc-5 MHz	70 ns				.02 μs/cm to 200 ms/cm	dc-100 kHz	
	IO-4205	10 mV/cm	dc-5 MHz	70 ns				0.2 μs/cm to to 200 ms/cm	dc-100 kHz	
	IO-4550	10 mV/cm	dc-10 MHz	35 ns		X		200 ns/cm to 0.25/cm	dc-1 MHz	X5
	IO-4510	1 mV/cm	dc-15 MHz	24 ns	X	X		0.1 μs/cm to 0.25/cm	dc-1 MHz	X5
	IO-4235	2 mV/cm	dc-35 MHz	10 ns	X	X		50 ns/cm to 0.25/cm	dc-2 MHz	X5

Scope features

doubled flicker. At very low speed times, only one trace can be seen at a time, and that's very distracting. Alternate trace is recommended for fast sweeps only.

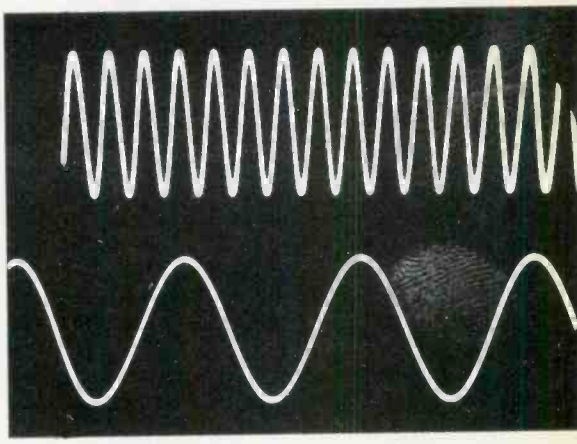
Chopped sweep also alternates between the two waveforms, but it does so by means of a chopper that operates between 100 kHz and 500 kHz. Each waveform is *sampled* alternately for a very short period of time, so the many small pieces of waveform blend together and appear to be continuous. However, if the waveform frequency is a submultiple of the chopper frequency, parts of the waveform will be missing. That's why the chopped mode should be used only for low-frequency signals, and never for higher sweep frequencies. Some scope models switch automatically from one mode to the other at a certain sweep time. Others allow the operator to make the decision.

Waveform-storage scopes—Storing waveforms on the screen of special CRTs can be done in three general ways: bistable; variable persistence; and *fast* mesh-transfer. Each of the three is superior for certain kinds of waveforms. Bistable can store waveforms for an hour or more and is particularly effective in showing fast leading and trailing edges. Storage by variable persistence is limited to about 30 s, but it greatly increases the brightness and contrast of dim low-rep-rate pulses, and efficiently stores single-shot events. For very-high writing speeds with either bistable or variable persistence modes, the fast mesh transfer system is essential.

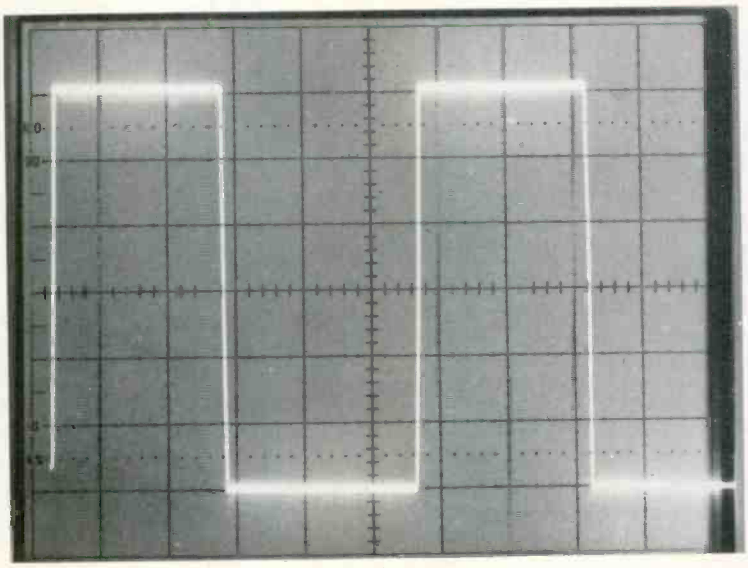
Digital storage—A conventional CRT can be used in scopes that store waveforms digitally. The analog voltage waveform is converted to digital signals that can be stored indefinitely. Frozen waveforms and wave trains that move as though they are being deflected are two features of digital scopes. There is no flicker at slow sweep speeds.

Perhaps the most serious limita-

Delayed Sweep	TV Sync	Calibrated Waveform	Special Features	Reader service number
X		X	Two timebases, internal graticule, beam finder, X5 vert gain	74
		X	Digital storage - normal, refresh and roll modes	75
		X		76
	X	X		77
		X	Digital storage X10 vert gain	78
			Automatic, uncalibrated horiz sweep	79
	X			80
	X		Two vertical attenuators for X-Y mode	81
	X	X	IO-4555 is similar, but single trace	82
	X	X	Post-deflection acceleration-4 kV	83
X	X	X	PDA with 10 kV - internal graticule	84



A 5X magnifier (expander) increases the horizontal sweep to 5 times screen width. Top trace is the sinewave signal needing magnification, while the bottom trace shows the same signal after the 5X switch is turned on. No other adjustments were made. This gives the effect of dividing the sweep time by 1/5 which spreads the waveform by a factor of 5.



This waveform illustrates two things. First, the model 935A Tektronix scope has a signal delay line so the leading edge of pulses can be seen. And the square wave shows proper compensation of the 10X low-capacitance probe when adjusted to the scope's calibration waveform.

Brand	Model	Vertical Sensitivity	Vertical Response	Rise Time	Signal Delay	Dual Trace	Dual Beam	Horiz. Sweep Time/Div.	Horiz. Amp Bandwidth	Expande Sweep
Hickok	515	10 mV/cm	dc-15 MHz	24 ns				0.5 μs/cm to 2 s/cm	dc-1 MHz	X5
	517	10 mV/cm	dc-15 MHz	24 ns		X		0.5 μs/cm to 0.2 s/cm	dc-1 MHz	X5
	532	10 mV/div	dc-30 MHz	11.7 ns	X	X		0.05 μs/div to 2 s/div	dc-5 MHz	X4
Leader	LBO-520	5 mV/cm	dc-30 MHz	11.7 ns	X	X		0.2 μs/cm to 0.5 s/cm	dc-1 MHz	X10
	LBO-515	5 mV/div	dc-25 MHz	14 ns	X	X		0.2 μs/div to 0.5 s/div	dc-1 MHz	X10
	LBO-508	10 mV/cm	dc-20 MHz	17.5 ns		X		0.5 μs/cm to 200 ms/cm	dc-800 kHz	X5
	LBO-302	0.01 V/div	dc-10 MHz	35 ns		X		1 μs/div to 0.2 s/div	to 200 kHz	X5
	LBO-507	10 mV/cm	dc-20 MHz	17.5 ns				0.5 μs/cm to 200 ms/cm	dc-250 kHz	X5
Leader	LBO-511	20 mV/cm	dc-10 MHz	35 ns				10 Hx to 100 kHz	dc-250 kHz	
	LBO-310A	20 mVp-p/div	dc-4 MHz	87 ns				10 Hz to 100 kHz	dc-200 kHz	
	LBO-514	1 mV/cm	dc-10 MHz	35 ns		X		1 μs/div to 0.2 s/div	dc-200 kHz	X5
Lectrotech	TO-60	0.01 V/div	dc-15 MHz	24 ns		X		0.5 μs div to 0.2 s/div	dc-0.5 MHz	X5
	TO-55	0.01 V/div	dc-10 MHz	35 ns				0.5 μs/div to 0.2 s/div	dc-0.5 MHz	X

Scope features

tion (other than cost) is in bandwidth. First applications were in medical equipment, where the waveforms are swept at slow speeds, and bandwidth can be narrow.

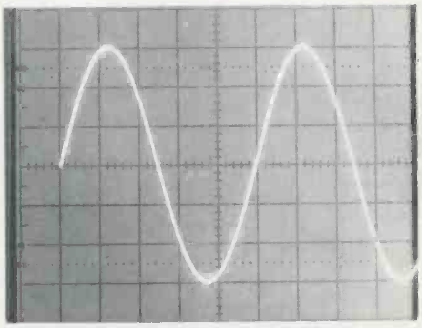
There are a few exceptions. The Gould model OS-4000 apparently can be operated as a conventional 10-MHz scope or with digital storage and refresh at slow sweep speeds. Digital sampling is done at a 1.8 MHz rate, and the storage uses a 1024 X 8 bit memory. Digital scopes are priced in the $4000 to $5000 range.

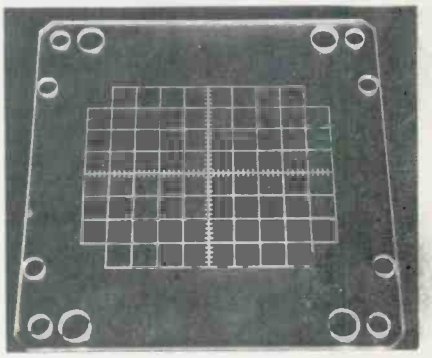
Delayed sweep—Another new feature is a second horizontal sweep. With the usual waveform on the screen, the operator selects (by a brighter area) the position and width of a *window* which includes the section of waveform to be expanded. When the delayed sweep is switched on, the screen shows only the part that was in the window, but it's expanded to cover the entire field.

Sometimes a similar effect can be obtained by using the usual sweep expander. But delayed sweep gives a more stable trace with less jitter, and it offers other advantages with certain waveforms.

Sweep expansion—Almost all triggered scopes have some means of increasing the width of the horizontal trace. Some have a switch that expands the sweep by a factor of 5. This is called "5X magnification." Although the width is increased electronically by fives times, 4/5 of it can't be seen. The part that can be seen is expanded as though a 5-times shorter sweep time is used. Any section of the expanded waveform can be viewed by adjustment of the horizontal-positioning control. Since the beam is seen for only 1/5 of the time, the trace is less bright.

Delayed Sweep	TV Sync	Calibrated Waveform	Special Features	Reader service number
	X	X		85
	X	X		86
		X	Full time X4 expanded horiz	87
	X	X		88
X	X	X	Delayed second sweep	89
	X	X		90
		X	3-inch CRT	91
	X	X		92
		X	Recurrent sweep	93
		X	Recurrent sweep	94
				95
		X		96
		X		97





Three types of graticules are used for CRT calibrations. (A) Tektronix and perhaps several others have black calibrations on the *inside* of the CRT. This totally eliminates parallax (error from reading at an angle). Some others have black lines on plastic external to the CRT. Both of these require external illumination (as shown) to make the lines readily visible. Many other scopes (B) have grooved lines in clear plastic. These are illuminated by edge-mounted bulbs. If you want accurate readings with external graticules, look straight into the center of the CRT screen.

Model MS-215 "Miniscope" from Non-Linear Systems operates for three hours on internal sealed lead-acid batteries requiring a charge. This dual-trace model has 10 mV vertical sensitivity and sweep times from 0.5 s/div to 0.1 μs/div.

Brand	Model	Vertical Sensitivity	Vertical Response	Rise Time	Signal Delay	Dual Trace	Dual Beam	Horiz. Sweep Time/Div.	Horiz. Amp Bandwidth
Non-Linear Systems	MS-15	10 mV/div	dc-15 MHz	23 ns				0.1 μs/div to 0.5 s/div	dc-200 kHz
	MS-215	10 mV/div	dc-15 MHz	23 ns		X		0.1 μs/div to 0.5 s/div	dc-200 kHz
Phillips T & M	PM3225	2 mV/div	dc-15 MHz	25 ns				0.5 μs/div to 200 ms/div	dc-100 kHz
	PM3226	2 mV/div	dc-15 MHz	25 ns		X		0.5 μs/div to 200 ms/div	dc-1 MHz
	PM3234	2 mV/div	dc-10 MHz	35 ns	X		X	0.2 μs/div to 0.5 s/div	dc-1 MHz
	PM3214	2 mV/div	dc-25 MHz	14 ns	X	X		200 ns/div to 0.5 s/div	dc-1 MHz
	PM3240	5 mV/div	dc-50 MHz	7 ns	X	X		50 ns/div to 0.5 s/div	dc-1 MHz
Sencore	PS29	10 mV/cm	dc-8 MHz	45 ns				0.2 μs/cm to 0.1 s/cm	
	PS163	5 mV/cm	dc-8 MHz	40 ns		X		0.1 μs/cm to 0.1 s/cm	
Simpson	4451	10 mV/cm	dc-12 MHz	30 ns				0.5 μs/cm to 0.5 s/cm	dc-800 kHz
	452	5 mV/cm	dc-15 MHz	24 ns		X		0.2 μs/cm to 0.5 s/cm	dc-1.5 MHz
Soltec	5100A	10 mV/div	dc-10 MHz	35 ns				0.1 μs/div to 0.1 s/div	dc-500 kHz
	5102A	10 mV/div	dc-10 MHz	35 ns		X		0.1 μs/div to 0.1 s/div	dc-500 kHz

Scope features

Delay line—When a conventional scope is called on to trigger (begin the horizontal sweep) at the leading or falling edge of a pulse or square wave, the edge has occurred already before the trace can begin to move. Therefore, this trailing or leading edge is missing from the waveform.

It's not possible to trigger the sweep *before* the triggering point arrives, so the opposite action must be taken. The vertical signal is delayed in time.

A sample of vertical waveform for the triggering circuit is taken from the vertical signal before it is sent through the delay line. And the time-delayed signal at the output of the delay line is amplified before it is used to deflect the CRT. Therefore, the leading or trailing edges of square waves or pulses can be seen.

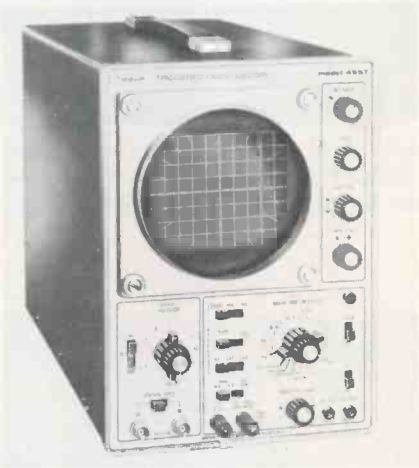
Calibration waveform—Most triggered scopes have a square wave signal that's available somewhere on the front panel. Usually, the amplitude has been factory adjusted to serve as a test of the vertical gain. But that's not the most important function. *The waveform is used to adjust the X10 low-capacitance probes.*

Normal X1 probes need no adjustment. Their response always is flat, although the added capacitance of the cable often detunes or smears the waveforms of critical circuits.

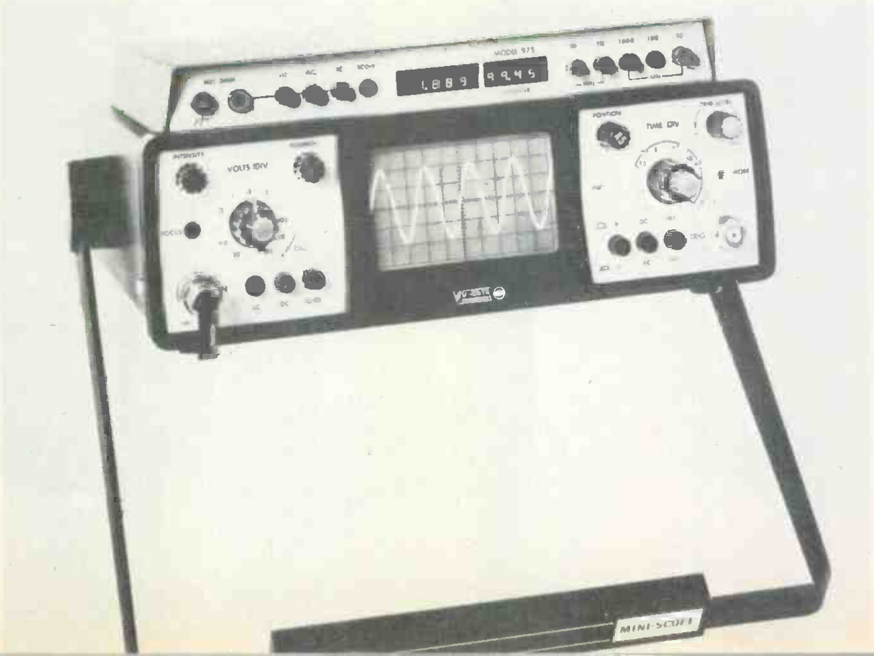
Low-capacitance X10 probes, however, operate by the *double* voltage-divider principle. A 9-M Ω resistor is placed inside the probe tip, and this in conjunction with the 1-MΩ scope input resistance gives a dc reduction of 10 times (output is 1/10 of the input). Without a variable capacitor across the probe resistor, the circuit becomes a low-pass (or high-frequency attenu-

continued on page 28

Expanded Sweep	Delayed Sweep	TV Sync	Calibrated Waveform	Special Features	Reader service number
			X		98
					99
X5		X	X		100
X5		X	X		101
X5			X	Storage dual beam	102
X10	X	X	X	Dual time base	103
X5	X	X	X	Delayed time base	104
X5		X	X		105
X5		X	X		106
X5		X	X		107
X5			X		108
		X	X	Internal graticule	109
X5		X	X	Internal graticule	110



Vertical sensitivity of 10 mV/cm and triggered sweep from 0.5 s/cm to 0.5 μs/cm are some specifications of the workhorse Simpson model 455T single-sweep scope.



A very unusual instrument is the Vu-Data PS-935/975 which combines a 35-MHz dual-trace scope with a digital multimeter and a frequency counter. Each can be used independently or all together. The units operate on line power, external 12 Vdc or from an optional pack fastened to the bottom.

people in the news

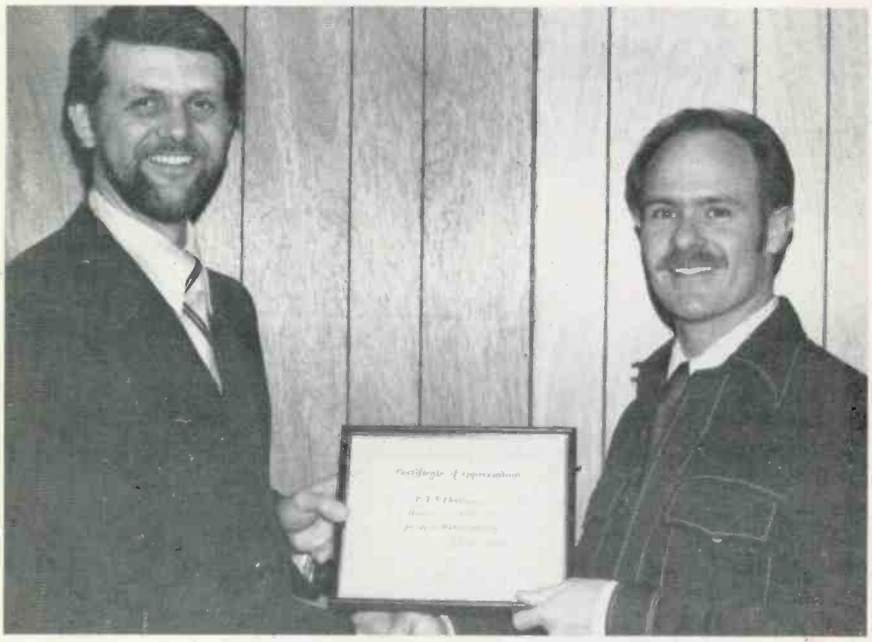
John Egan, the eastern regional sales manager for Anixter-Pruzan, received the Blonder-Tongue award from Glenn Stawicki (left) and John Picciallo of the Blonder-Tongue sales staff.

The sales staff at Anixter-Pruzan of Pinebrook, NJ has been awarded the Blonder-Tongue "Factory Authorized Stocking CATV Distributor" award of 1978-1979 for outstanding sales effort for the Blonder-Tongue line of CATV products.

Kanji Tamiya has appointed Joseph A. Lagore as president of the Sony Consumer Products unit of Sony Corporation of America. Mr. Lagore is a vice-president of Sony Corporation of America. (Mr. Tamiya, is executive vice-president), and he was executive vice-president of the Sony Consumer Products division.

RCA Sales Corporation has advanced Marvin E. Kramer to the post of executive vice president of sales; also, Arnold T. Valencia was appointed executive vice president of marketing operations. Both positions are new. Previously, Kramer was vice president of sales, and Valencia was vice president of warranty programs.

Don Rausch has been named PTS "Man of the Month" for outstanding performance as branch manager of the PTS-Omaha Servicenter. The award was announced by PTS President Roland Nobis and PTS Sales Manager Dick King.



Carlen DeJong presented the PTS "Man of the Month" award to Don Rausch, general manager of the Omaha PTS Servicenter.

Brand	Model	Vertical Sensitivity	Vertical Response	Rise Time	Signal Delay	Dual Trace	Dual Beam	Horiz. Sweep Time/Div.	Horiz. Amp Bandwidth	Expanded Sweep
Tektronix	T921	2 mV/div	dc-15 MHz	23 ns	X			0.2 μs/div to 0.5 s/div	dc-1 MHz	X10
	T922	2 mV/div	dc-15 MHz	23 ns	X	X		0.2 μs/div to 0.5 s/div	dc-1 MHz	X10
	T932	2 mV/div	dc-35 MHz	10 ns	X	X		0.1 μs/div to 0.5 s/div	dc-2 MHz	X10
	T935	2 mV/div	dc-35 MHz	10 ns	X	X		0.1 μs/div to 0.5 s/div	dc-2 MHz	X10
	T912	2 mV/div	dc-10 MHz	35 ns	X	X		0.5 μs/div to 0.5 s/div	dc-10 MHz	X10
	7104	10 mV/div	dc-1 GHz	350 ps	X	X		plug-in to 200 ps/div	dc-350 MHz	X10
U F I	CAG-22	10 mV	166 Hz							
V I Z	WO-527A	10 mV/cm	dc-15 MHz	23 ns				0.5 μs/cm to 0.5 s/cm	dc-1 MHz	X10
Vu-Data	PS935	5 mV/div	dc-35 MHz	10 ns	X	X		0.1 μs/div to 500 ms/div	dc-100 kHz	X10
	PS941B PS943B	10 mV/div	dc-20 MHz	18 ns	X	X		0.1 μs/div to 500 ms/div	dc-50 kHz	X5
	PS915A	10 mV/div	dc-20 MHz	18 ns				1 μs/div to 10 ms/div	dc-50 kHz	X5
Wavetek	1910	1 mV/div	dc-1.5 kHz			X		External source	dc-1.5 kHz	

Scope features *continued from page 24*

ation) filter which rolls off the higher frequencies at an alarming rate. With the capacitor, the circuit becomes two attenuators. One is made up of the probe capacitance versus the total capacitances of probe cable and internal scope wiring. This voltage divider *must* give the same attenuation as the resistive one (already described), else the frequency response will not be flat.

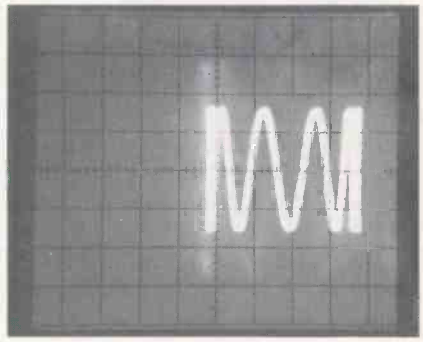
When the probe is compensated (that is, both voltage dividers are matched), the frequency response is flat from dc to the scope's top frequency.

Flat response is required to properly reproduce fast rise-time waveforms, of course. Equally important is that *only* flat response can provide the same amplitude measurement accuracy for sine waves of all frequencies.

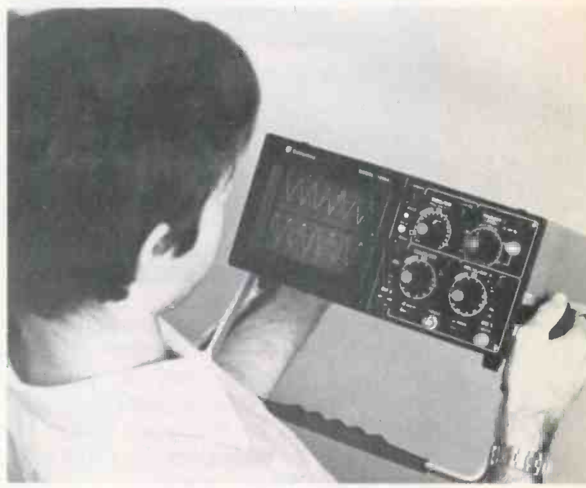
Extended high-frequency response—Unexpected problems are faced by scope manufacturers who attempt to widen the bandwidth beyond a certain point.

One problem involves the design of amplifiers that can give flat response from dc to several hundred thousand MHz. That's very difficult; however, a more serious limitation is in the scope CRT itself.

elayed Sweep	TV Sync	Calibrated Waveform	Special Features	Reader service number
	X	X	Beamfinder 12kV internal graticule	111
	X	X	Beamfinder 12kV internal graticule	112
	X	X	Beamfinder 12kV internal graticule	113
X	X	X	Beamfinder 12kV internal graticule	114
		X	Beamfinder internal graticule storage	115
X		X		116
			Digital storage adapter	117
	X	X	TV line selector trigger polarity indicator	118
		X	Available with DMM and freq. counter optional battery pack	119
		X	(PS9433 has two less horiz times) optional battery pack	120
		X	Optional battery pack miniscope available with DMM and counter	121
			12-inch CRT magnetic deflection special purpose scope	122



A few brands of scopes (such as Tektronix) have a beamfinder that returns the trace to the center of the CRT regardless of wrong centering or excessively tall traces.

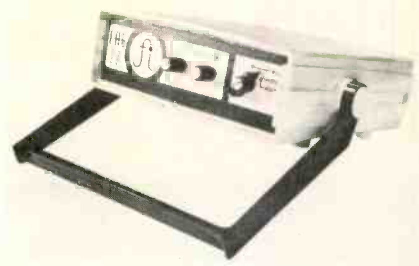


Ballantine model 1032A is a full-featured scope with a very unusual second triggering system that permits viewing two separate waveforms of different frequencies. Each dual-trace channel has its own independent trigger circuit. Other features include 20-MHz response and an X10 magnifier.

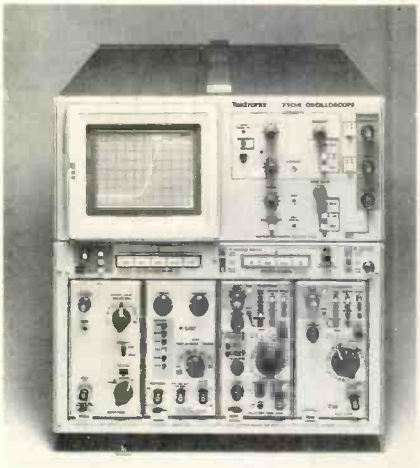
Look at it this way: a significant length of plate is necessary to provide sufficient electrostatic deflection. Unfortunately, at those extremely high frequencies, the signal phase might change during the time required for beam movement *along* the deflection plate's total length. In an extreme example, a 180° phase delay would *cancel* nearly all of the deflection. Less phase changes still *reduce* the deflection, which is equivalent to a loss of high-frequency response.

One solution is shown in the drawing of conventional and wide-band CRTs. Each vertical deflection plate is broken up into several. Then the individual plates are supplied with signals that have been delayed in time by a tapped delay line or transmission line. When the factors are matched correctly, the beam is affected by the same *relative* phase of signal. Thus, a combination of flat amplifier response and equal deflection for all frequencies provides the same amplitude for each frequency within the scope's bandwidth rating.

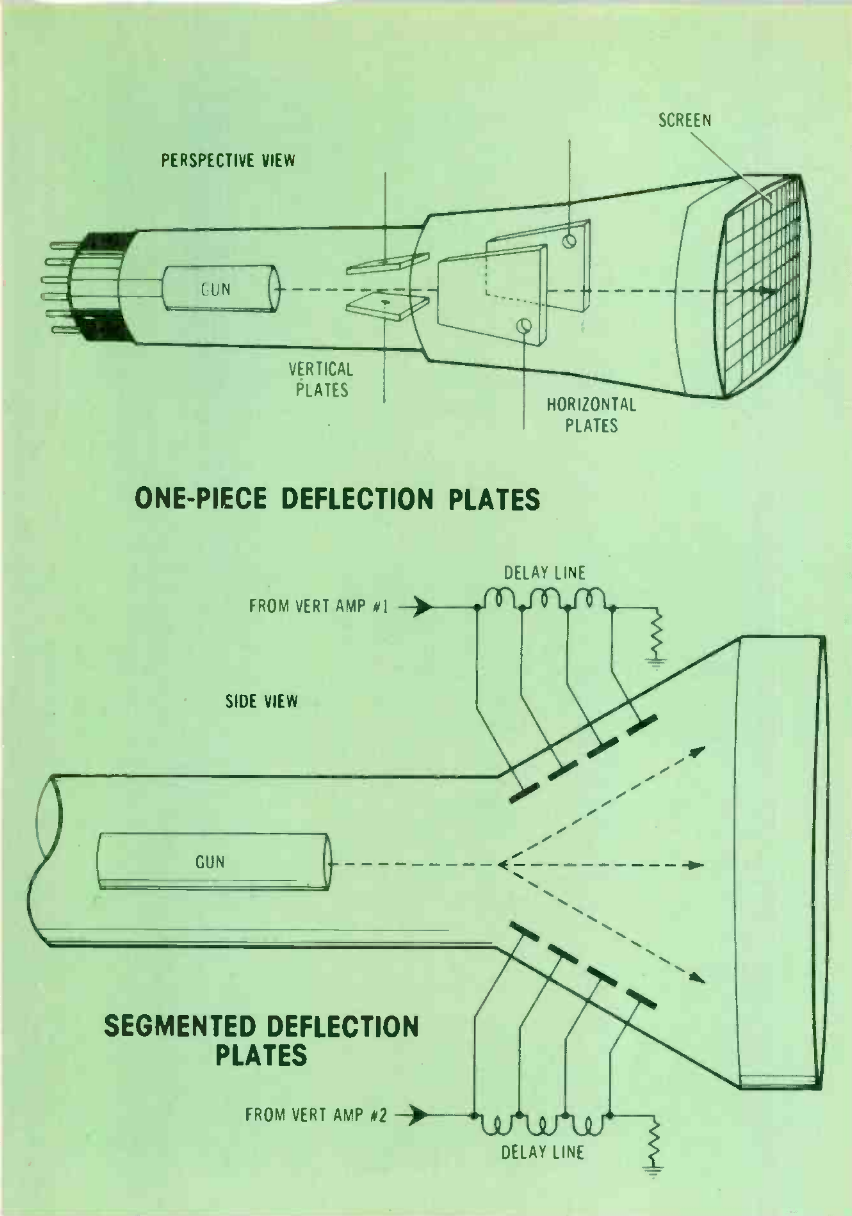
The indisputed champion of wide-band scopes is the Tektronix model 7104 which is rated at 1 GHz—and that is equal to 1000 MHz! That's a hundred times more bandwidth than a 10-MHz electron-



Model CAG-22 from UFI is a digital-storage device that can be connected to a triggered scope to obtain the benefits of low-frequency digital storage and display. Provides flicker-free waveform display and bright storage of transients or one-time events.



In the "Gee Whiz" category is the Tektronix model 7104, which is the only real-time model that can display a 1-GHz signal. This is pushing scope state-of-the-art to the outer limits. If you need one, it's a bargain at $19,485 with typical plug-in units.



Scope CRTs have a reduction of deflection above certain high-frequency limits. It's caused by a phase change during the time the beam passes the large plate. One solution is to use several vertical plates and apply a successively delayed signal to each small plate in turn.

Scope features

ic service scope. Before the 7104, the only scopes that could display 1 GHz waveforms did so by sampling; there were no realtime scopes for those stratospheric frequencies.

Comments

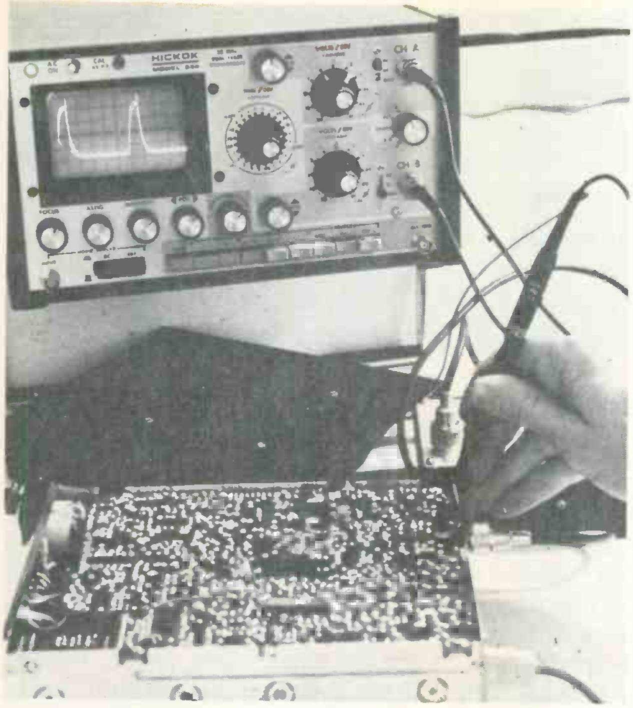
These facts about features of some new scopes were provided to help in deciding what kind of scope is needed now and in the future.

For audio, stereo multiplex, AM radio and TV servicing, a scope having a bandwidth to only 10 to 15 MHz is sufficient. However, for the new tuner-control and remote-control circuits using digital logic, a wider bandwidth is preferable. Of course, it is possible to examine a pulse waveform that has rounded corners and imagine what it would look like if displayed on a wider-bandwidth scope. But remember that the sweep times are matched approximately to the usable frequencies of each scope. In other words, a scope that's not intended for pulses or digital work probably will not have the short sweep times necessary to display those narrow pulses or the pulses that have large blank spaces in between.

For CB-radio diagnosis and digital analysis, the scope should have a maximum top frequency of at least 25 MHz. Of course, a 30 MHz to 35 MHz model is even more suitable.

Look to the future—Don't base the selection of a new scope on the features and bandwidths needed today and a year in the future. Instead, consider the trends in technology, make a good educated guess about the specs needed for at least five years, and only then decide which model and brand to buy.

These comparative charts of most scope models can help in selecting the one scope that best meets those present and future needs. Choose wisely, because scopes are becoming more indispensible every year. □



A communications technician is shown checking the noise-cancellation of a business-radio transceiver.

Better waveforms with wideband scopes

By Forest H. Belt, CET

For servicing many electronic products, recurrent-sweep 5-MHz scopes are totally obsolete. Even ordinary triggered scopes are barely adequate for some tasks. The proper analysis of defects in todays sophisticated electronic products demands the use of wideband triggered oscilloscopes. Here are suggestions for obtaining helpful waveforms, measuring the parameters, and interpreting those characteristics related to bandwidth.

Two examples

A communications technician recently repaired a business-radio transceiver. According to the customer's report the noise-blanker switch didn't eliminate the ignition noise. It might have been a difficult diagnosis. But it wasn't because the tech was equipped to solve it.

First, the technician connected his noise generator to the radio and verified that the noise-blanker function was not working. Then with his scope, he began tracing noise pulses through the blanker stages. These were discrete stages (not inside an integrated circuit), and that made the tracing easier. Quickly, he located the bad stage, and found a leaky capacitor in a pulse-forming network near the blanker output.

Knowledge and equipment—Two factors helped the technician solve this service problem quickly and profitably. First, he understands the operation and testing of noise blankers. Second, he uses a *wideband* triggered scope. The scope revealed a badly distorted waveform of the blanking pulses. Even mild ignition noise wasn't cancelled by the degraded pulses.

Viewing digital pulses—In another example, a digitally-controlled tuner was not working properly. Channel numbers appeared on the screen as they should, but the raster showed only snow.

A quick scan with a signal generator across the VHF channels proved to the technician that the varactor tuner actually was operating. However, it was tuned to frequencies without stations because the dc tuning voltages were all wrong. What caused the incorrect tuning voltages?

The technician next picked up the probes of his dual-trace wideband scope. By tracing the logic waveforms at test points in the digital control section, he soon uncovered the cause of the mistuning. One IC wasn't combining the pulses correctly. This changed the duty cycle of the output pulses. And, because the dc tuning voltages are determined by the duty cycle, the tuner was generating wrong frequencies.

Naturally, the technician needed to understand digitally-controlled tuners. But his ability to analyze digital pulses with his scope allowed him to find this defect without a lot of detours. He knew his wideband scope could display a faithful waveform of the pulses, so his analysis was not in doubt.

So...what is wideband?

Not very many years ago, a scope was considered to be "wideband" and good enough for TV work if it showed 3.58-MHz burst signals without serious attenuation. Such scopes were rated for bandwidths between 4 MHz and 5 MHz. Above those frequencies, the vertical amplifier response rolled off rapidly.

Today, most scopes have wider bandwidths and much flatter response curves. Many scopes intended for TV servicing now offer response to 10 MHz or 15 MHz at ±3 dB.

However, modern wideband scopes have response out to 25 MHz or higher. Improvements of stability from present-day solid-state devices make possible high-gain, direct-coupled and wideband vertical amplifiers at moderate cost.

This is fortunate, for proper servicing of newer electronic products *demands* scopes with wider bandwidths.

Rise time—Ordinarily bandwidth is thought to refer only to frequency response. However, that is not the only reason for extending the bandwidth of scopes. Of equal value is an allied characteristic called "rise time."

Rise time in scopes is a measure of how accurately the instrument reproduces pulses, especially the leading and trailing edges. (It is measured by the actual time required for the scope to trace between 10% and 90% of the pulse's total amplitude.)

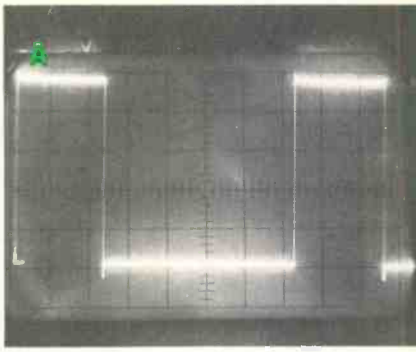
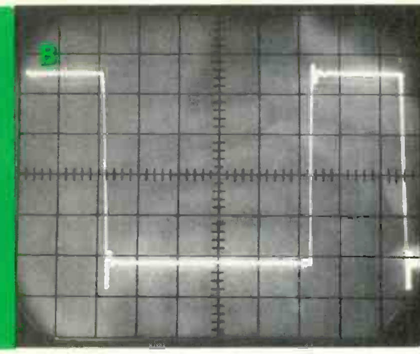


Figure 1 This good waveform (produced by a 30-MHz scope) has vertical leading and trailing edges (showing fast rise time), and sharp corners without ringing. (B) The same pulses on a 15-MHz scope have tilted leading and trailing edges (slower rise time), rounded corners with ringing, and no leading edge on the first pulse (it has no delay line).



Wideband scopes

Rise time is related to bandwidth. Wider bandwidth provides a shorter (faster) rise time. In turn, a shorter rise time allows the scope to produce a more faithful rendition of the actual pulse waveform.

The waveform photographs in Figure 1 illustrate the effects of two different rise times. Figure 1A shows the pulse rise time of a 30-MHz scope. Both the leading and trailing edges appear to be completely vertical and nearly invisible because the rise time is so short.

By comparison, the waveform of Figure 1B shows the same two pulses, but on another scope having a narrower (15 MHz) bandwidth and a longer (slower) rise time. The vertical lines are noticeably tilted and brighter than corresponding lines in the other picture. (This scope also has ringing at the pre-shoot and post-shoot corners from excessive compensation at too low a frequency.)

Another important difference between the two scopes—but one that's not related to the rise time—is the missing leading edge of the left pulse in Figure 1B. It's caused by lack of a vertical delay line in that scope. More about this subject later.

These waveforms make clear that even *moderate* reduction of bandwidth or a slower rise time can change the appearance of pulses enough to be significant.

Bandwidth vs. rise time—Rise time is a reciprocal (or inverse function) of bandwidth. Some examples will be given of this relationship.

A scope of 10-MHz bandwidth has a rise time of 35 ns. That sounds quite good. After all, it's just about one-third of a microsecond. But it's too slow for some kinds of present-day troubleshooting. Imagine trying to observe a waveform which has a rise time of only 10 or 20 ns. Such a waveform cannot be evaluated properly.

On the other hand, a bandwidth of 30 MHz provides a rise time of less than 12 ns. This minimizes errors when observing common digital pulses. However, to properly view pulses (such as glitches) in certain logic circuits, you might need an even wider bandwidth.

These are some of the reasons many TV manufacturers are recommending wideband scopes for servicing their receivers. Digital tuners, videocassette recorders, and IC count-down circuits have increased the demands on instruments and technicians alike.

One more comment about bandwidth. The standard for bandwidth is a frequency response flat within 3 dB. That is, the rolloff or peaking of the response must not exceed 3 dB between the specified limits. However, not all manufacturers follow this way of stating bandwidth. And specs can't be compared unless they observe the 3-dB standard.

Rise-time specifications all are rated by one standard, so far as I have found. So, rise time specs allow more accurate comparison of various scope models. As stated before, rise time is the time required for the scope to trace between the 10% and 90% voltage (amplitude) points of the waveform. Incidentally, rise time can be converted to bandwidth in megahertz by dividing the rise time (in nanoseconds) into 350.

Complex pulse waveforms

Merely owning a wideband triggered scope does not solve every servicing problem. It must be operated effectively and used constantly. Moreover, it is necessary to understand how to interpret what a quality scope can show. Beyond that, the operator should know ways of making the scope reveal *everything* about a waveform.

Think back to the transceiver problem and the special noise signal used by the communications technician. This noise signal comes from a Motorola model S-1359A generator, and it is a complex simulation of impulse noise found in automotive environments. If the noise signal is analyzed, a lot can be learned about how to produce helpful waveforms and how to interpret them with a wideband triggered scope.

Scoping the noise signal

According to a label on the noise generator, the repetition rate is 100 Hz. This means that one complete "cycle" of noise occurs 100 times per second. In other words, there are 100 noise *pulses per second* (PPS).

To properly display two pulse waveforms, select a *total* horizontal sweep time equal to the time of two "cycles." On a calculator, take the reciprocal of the repetition rate. This gives the time of one pulse. Then double it for two. *That's the time for sweeping the entire screen.* However, the screen has 10 divisions, so divide by 10 to obtain the time in seconds per division. These are the three calculations:

$$1 \div 100 = .01$$

$$.01 \times 2 = .02$$

$$.02 \div 10 = .002 \text{ seconds}$$

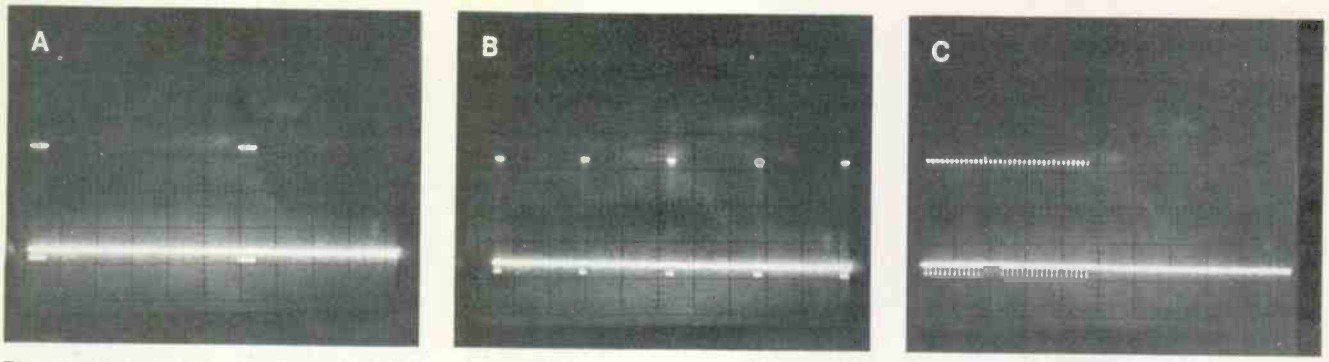


Figure 2 Using the simulated ignition-noise signal, this progression shows how pulse details can be revealed by shorter sweep times. (A) The pulses are stable, but appear blurred at 2 ms sweep. (B) A longer (slower) sweep time shows more pulses. (C) A fast 0.2 ms sweep time reveals that *what appeared to be* a blurred single pulse is a burst of very-narrow pulses.

Adjust the scope for 2 ms/div. However, understanding how the time is calculated, there is a shortcut. To obtain the time in seconds, divide 0.2 by the repetition rate in Hertz.

Of course, the waveform must be locked solidly. The method isn't given here, because it varies with the brand and model.

Figure 2A shows two pulses from the S-1359A. Slowing the sweep to about double time increases the number of pulses (Figure 2B). Neither sweep time reveals any detail of individual pulses. However, they are useful for measuring the repetition rate. (Reciprocal of the time of one "cycle" is the repetition rate.)

To expand one pulse and show the details, it is necessary only to shorten the sweep time. Figure 2C shows how a 0.2 ms sweep expands *one* pulse to fill almost half of the scope screen. Surprise! Previous waveforms indicated each pulse was solid, but actually each is made up of many narrow pulses. It is a burst of pulses.

This faster horizontal-sweep time enables measuring the burst duration. Full width of the screen is 2 ms, and the burst occupies about 4.6 divisions or 46% of the width. In round numbers, the burst width is slightly less than 1 ms. Although no details of the pulses in the burst can be seen, it is possible to count 35 of them.

So far, the pulse-waveform analysis (made possible by a wideband triggered scope) has determined these characteristics:

- the repetition rate in pulses-per-second, or the frequency in Hertz;
- repetition time in seconds, milliseconds, or microseconds (this is the inverse of repetition rate);
- pulse width (or duration), which sometimes is called *period.* It is the "on" time of each pulse; and
- the actual waveshape, including any overshoot, undershoot, rounding, ringing, slow rise time and other characteristics of a waveform.

There's more

Even more expansion can be made with the scope. Figure 3 illustrates three steps of expansion, showing 8 pulses, 2 pulses, and finally just one pulse.

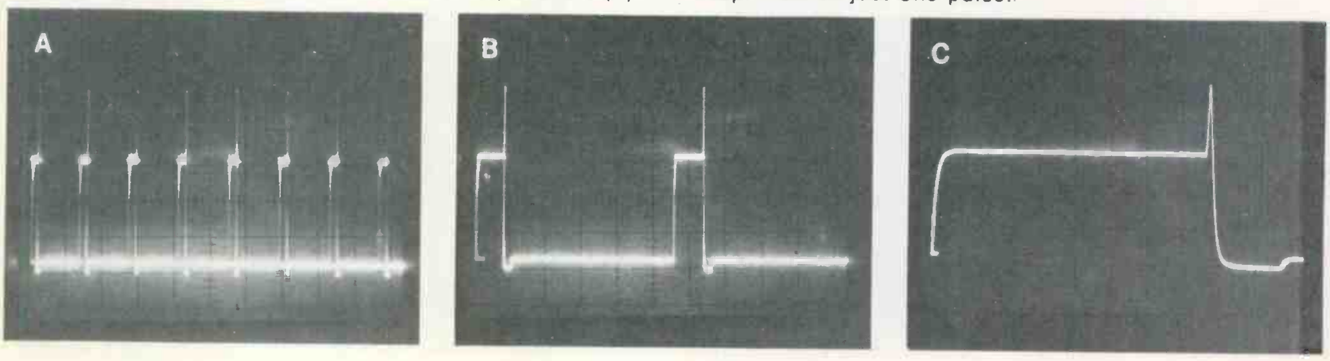
Waveform magnification of this kind is possible *only* by use of a triggered scope. Any practical sweep time can be selected, the starting point is the same for each waveform, and it's not necessary to lock the sweep for each new time. At best, a recurrent-sweep scope could show blurred "pulses" when synchronized to the basic 100-Hz repetition rate.

In Figure 3A, the time-base switch is set for 20 μs per division. Eight of the narrow pulses can be seen clearly. In fact, they are square-topped pulses, and each one has a narrow positive pulse at the falling side. The rep rate of these burst pulses can be measured approximately. Each requires about 28 μs, so divide 0.000028 into 1 to obtain the rep rate of 35,714 Hz.

However, the duration (pulse width) can't be calculated yet. For that, the display must be spread even more.

Move the time-base switch to 5 μs/div (Figure 3B). Now with two pulses on the screen, the rep rate is found to be 27.5 ms or about 36.5 kHz. Notice the increased accuracy. Also, the waveform can be studied in finer detail, especially the fast

Figure 3 Additional expansion shows details of the burst pulses. (A) Eight pulses are produced by a sweep of 20 μs. The square tops and overshoots are barely visible. (B) at 5 μs, only two pulses are on the screen, and details are more clear. (C) Sweep of 0.5 μs allows a detailed inspection of just one pulse.



preshoot at the top and the small overshoot at the bottom of each trailing edge.

Maximum accuracy and visibility of the entire pulse are obtained by changing to a sweep time of 0.5-μs/div. This shorter time shows the single-pulse duration to be 7.8 divisions. Multiplied by 0.5 μs, this is 3.9 μs. That's a very fast pulse! If it were allowed to run constantly (instead of in a burst), the rep rate would be about 246-kHz. Also, these sharp rise and fall times generate many higher harmonics—far into the megahertz region.

Duration of the overshoot at the bottom of the trailing edge (Figure 3C) can be measured by the 1.8 divisions it occupies. This calculates to about 0.9 μs. But its amplitude is comparatively minor, so this overshoot has little influence on the overall content of the signal.

Why signal delay?

In Figure 3C, look carefully at the positive pulse that is above the main pulse trailing edge. It can be seen clearly, but the width is too narrow for any measurement. If you try to spread it out by switching to a 0.1 μs time base, there is a bad problem. The triggering point remains at the upslope of the leading edge, and the whole 10 divisions of graticule represent 1 μs. However, the entire pulse has a duration of 3.9 μs, which drives the trailing edge and the preshoot pulse far off of the screen to the right. The pulse now can't be seen or measured.

Of course, the triggering point can be changed, which is easy to do. Just shift the triggering level to a higher point, above the flat top of the main pulse. The display now starts at the preshoot pulse and it can be widened as much as desired.

Unfortunately, if this is attempted on an ordinary triggered scope, there will be another insurmountable problem (Figure 4A). Although the scope is set to trigger on the positive upslope of the preshoot, the display on the screen begins on the downslope. The left part of the pulse is missing, so the pulse can't be measured.

This illustrates another advantage of scopes that have *signal delay*. Anytime it is necessary to view complex waveforms or pulses that have durations shorter than about 0.05 μs, a delay line is needed in the vertical-signal amplifiers.

Otherwise, the signal has gone through part of its own cycle or duration before the triggering system can get the horizontal sweep to moving. In many published waveforms this is represented as a missing leading edge of the first pulse (also, see Figure 1B).

The solution is a vertical-signal delay line that slows down the signal, giving the sweep time to start.

Don't confuse this signal delay with *trigger delay*, which is an entirely different feature found in more elaborate scopes. Signal delay often is included in scopes that have bandwidths above 20 MHz. Scopes of less bandwidth can't cope with extremely short pulses, anyway.

Figure 4B shows the preshoot pulse on a wider-bandwidth scope having a signal delay of about 50 ns (0.05 μs). Now the entire preshoot pulse is visible. Also, it can be measured. Rotate the vertical-position control to place the 20% points on the x-axis line of the graticule and the leading edge exactly at the left edge. The pulse duration is about 0.05 μs or 50 ms, which represents a signal of 10 MHz, if it were repetitive. That's why this test signal can simulate auto ignition so successfully.

Helpful alternative

Many triggered scopes have a 5X "expander" which can be switched on to increase the sweep width by a factor of five. The waveform is expanded, of course, but only a fifth is visible at any one time. To find any certain part of the expanded waveform, the horizontal-positioning control must be rotated until the desired section can be seen on the screen. Unfortunately, any locking jitter is magnified five times also. In addition, the waveform brightness is reduced severely. That's because the trace is missing from the screen for four-fifths of the time.

A unique feature of the **Hickok** model 532 (a 30-MHz scope chosen for this demonstration) is the full-time 4X expander. It's not necessary to switch it in, because it operates all of the time.

To demonstrate this operation, a progression from the waveform of Figure 3C to the Figure 4B waveform will be discussed.

Easy expansion—Figure 5A shows the complete pulse obtained at a sweep time of 0.5 μs. Previously, when the sweep was set to 0.1 μs in a futile attempt to magnify the trailing-edge preshoot, the preshoot

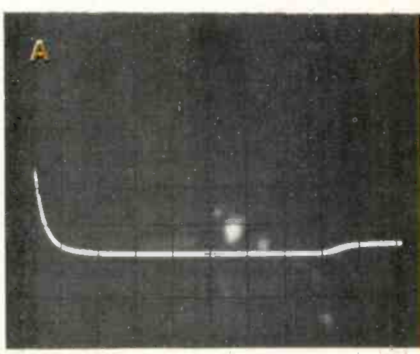
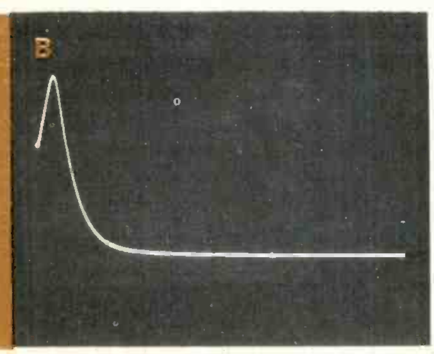


Figure 4 For examination of the trailing edges, triggering can be obtained from the positive preshoot that is there. (A) An ordinary scope without signal delay shows only part of the preshoot. (B) Wideband scope with signal delay shows all of the narrow preshoot so it can be measured.



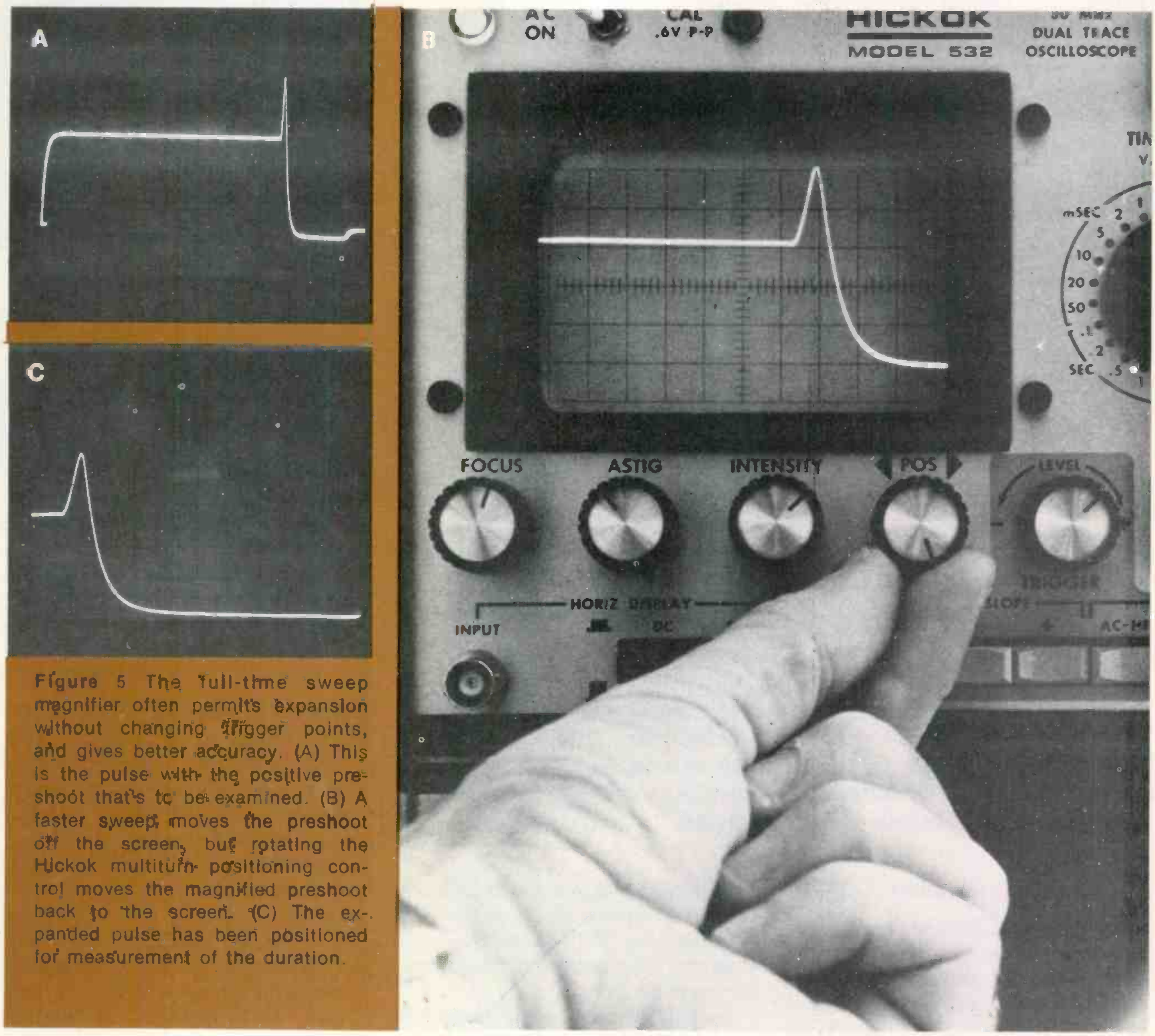


Figure 5 The full-time sweep magnifier often permits expansion without changing trigger points, and gives better accuracy. (A) This is the pulse with the positive preshoot that's to be examined. (B) A faster sweep moves the preshoot off the screen, but rotating the Hickok multiturn positioning control moves the magnified preshoot back to the screen. (C) The expanded pulse has been positioned for measurement of the duration.

was forced off of the right edge of the screen where it could not be seen or measured. This time the sweep time again is set to 0.1 μs, but the triggering won't have to be juggled to see the trailing preshoot. Just rotate the horizontal-positioning control, moving the waveform to the left (see Figure 5B) and stop when the trailing preshoot is positioned as shown in Figure 5C.

In this example, the final result was the same as that of the other method. However, not all waveforms will have a convenient positive pulse that can be used for auxiliary locking. One value of the constant 4X feature is that it allows expansion regardless of the waveshape.

No calculations are required to use the 4X feature. The sweep time is not changed, and the brightness of the trace is not decreased. These add to valid advantages.

Comments

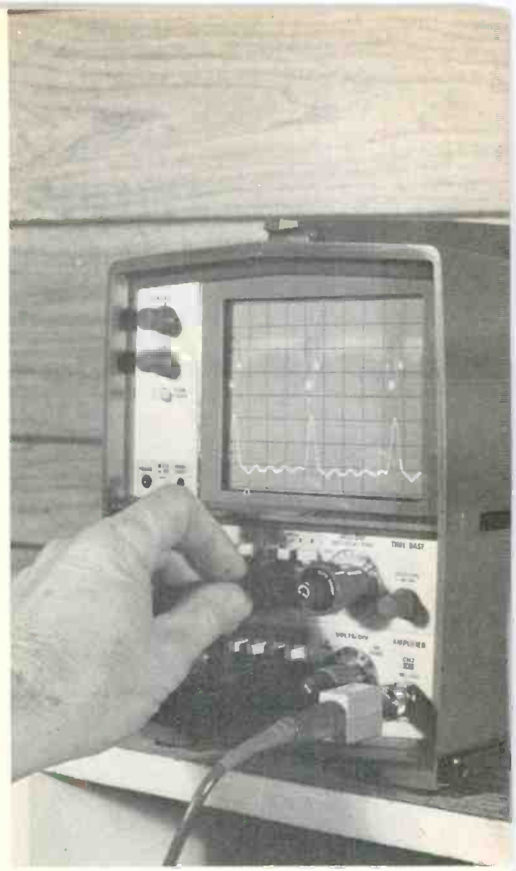
As you can see from these examples, a *wideband* triggered scope is not just an ordinary triggered scope that is beefed up. The differences are important.

Two of these advantages are shown in the waveforms of Figure 1. The scope of Figure 1B was a 15-MHz triggered model, but without a delay line. Therefore, the corners were rounded, some ringing was visible, and the rising and falling lines were tilted (indicating a slow rise time). Contrast those characteristics with the excellent pulses of Figure 1A which were produced by the Hickok 30-MHz scope.

Notice, too, that the wideband waveform showed the rising edge of the first pulse (because it has a signal-delay line) while that edge was missing in the other waveform.

These advanced features justify the price of a truly wideband scope right now. They will be indispensible in the near future. □

Tips for using scopes Part 1



Many of the illustrations were taken from this Tektronix model T935, a 35-MHz scope which is suitable for all types of electronic servicing.

Hours of diagnosis time can be saved if a good scope is used for all service problems that involve waveforms. This is especially true when the scope is stable, easy to use and has all of the needed features. The following suggestions provide both old and new tips about valuable uses for scopes.

By Gill Grieshaber, CET

The new oscilloscopes have much better specifications, can perform more functions, and operate almost automatically. They are a pleasure to use. However, they require an operator who knows which of many functions should be used for each measurement. Neither can the scope interpret the waveforms. The operator must do that.

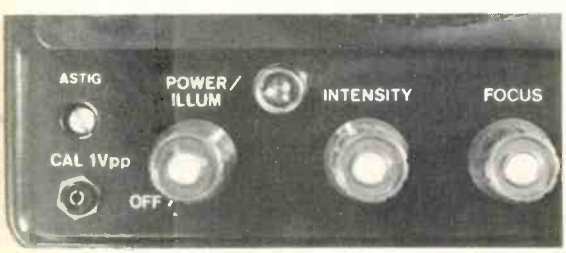


Figure 1 After the power is turned on, the intensity is adjusted above midpoint and the positioning controls are rotated to their center, a recurrent scope should show a horizontal line even without an input signal. In comparison, a triggered scope shows no horizontal line or waveform until it's triggered (or automatic triggering is in operation).

So, this information is directed to all scope operators, for it tells about the many jobs these scopes can do (some are not common knowledge) and how to adjust the scope to receive the right results.

Illustrative photographs were taken of the Tektronix model T935 and an older B&K-Precision model 1470. These models are pictured merely because the manufacturers volunteered to loan them for the article. However, other triggered scopes are similar, and the pictures should identify the various controls and their names.

Instantaneous graphs

Each oscilloscope display is an electronically drawn graph of amplitude versus either time or frequency. The most significant difference between *recurrent* and *triggered* scopes is that recurrent sweep operates at a repetitive *frequency*. Triggered scopes sweep for an adjustable period of *time*.

Examined in a superficial way, this distinction doesn't appear to be very important. If the waveforms are the same, who cares how they are formed? However, triggered scopes can perform functions and display waveforms that are impossible for recurrent types.

Recurrent sweep

The horizontal sweep of all scopes must be synchronized with the signal. In general, many unstable oscillators (such as the horizontal oscillator in a recurrent scope) can be locked to a standard signal by injecting into the oscillator a sample of the standard signal. Also, the oscillator can be locked to a sub-multiple of the signal. This is a type of direct sync which works fairly well when all conditions are optimum (and certain limitations are accepted). Unfortunately, it's often an unstable balance between compromises when used in scopes.

It is easy to show a line on the

CRT screen. Apply the power, turn up the brightness (Figure 1) and usually there is a horizontal line, even without anything connected to the probes. The focus control can be adjusted after a waveform is obtained; it has no effect on the brightness. Then the probes are connected to a source of signal. The vertical, sweep and sync knobs are turned until *some kind* of a waveform appears on the screen. A touchup of all adjustments completes the procedure.

However, if the signal frequency varies as little as 10%, the waveform jumps out of lock. Also, there are more limitations.

Figure 2 shows the sequence of waveforms obtained by changing from a locked single cycle of sine wave to two or more locked cycles. Notice that no usable waveforms are obtained between the locking points. The long retrace of recurrent sweep removes a significant part of the single cycle at the top of picture A. When the variable frequency control is turned toward a lower frequency, the waveform jumps out of lock and becomes a blur (center trace of A). Additional careful rotation of the frequency control brings in two cycles (bottom trace of A). Again the knob is turned CCW for a lower frequency and a point of false locking (with two superimposed waveforms) is obtained (top trace of B). More rotation brings a locked waveform of three cycles (center trace of B),

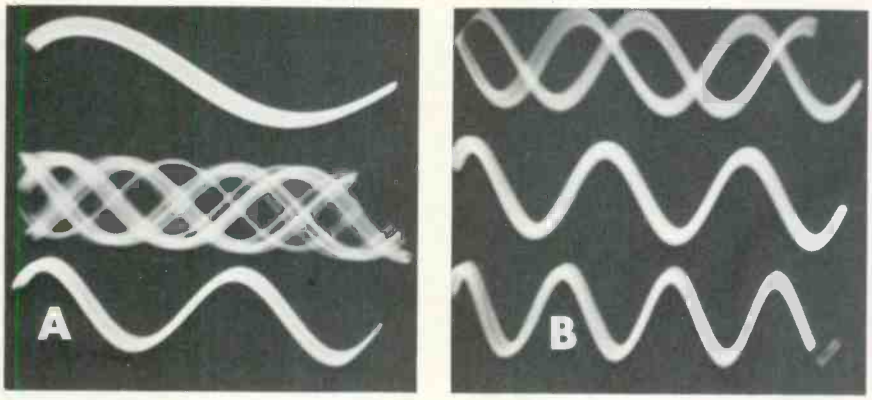


Figure 2 One limitation of recurrent scopes is that they can show only complete cycles, and relocking is required to obtain a different number. Beginning with a single sine wave (top trace of A), a CCW rotation of the frequency vernier to a lower frequency breaks the lock, and the waveform moves rapidly (center trace of A). Additional rotation locates another locking spot with two sine waves (bottom trace of A). Another CCW adjustment gives a false locking with two separate waveforms (top trace of B). Finally, more rotation of the frequency control results in three complete sine waves, as shown by the center trace of B. More sine waves may be obtained by additional CCW rotation (bottom trace of B).

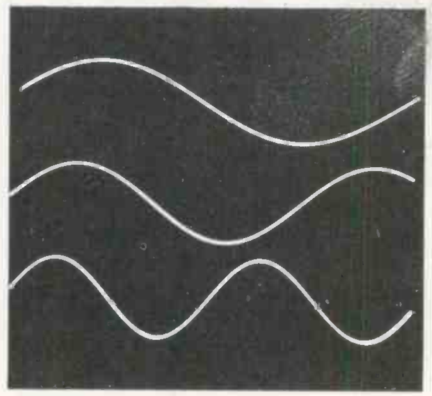


Figure 3 A triggered-sweep scope can be adjusted for any fraction of one cycle or almost any number of cycles. Within the range of the variable sweep-time control this change in the number of cycles is continuous. No relocking is required.

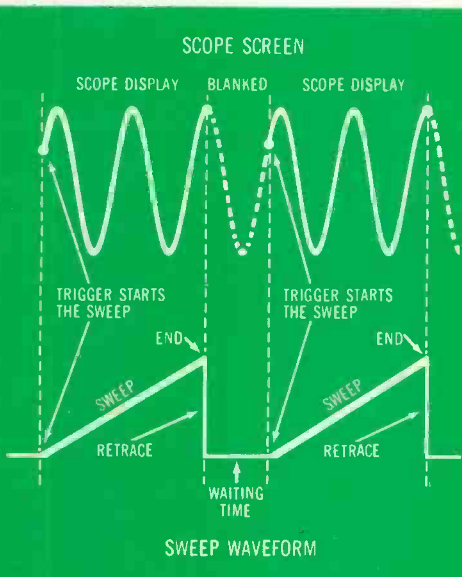


Figure 4 With a triggered scope locking the waveform is done by proper triggering, not by locking an oscillator (it doesn't have an oscillator). The "level" control is adjusted for a certain voltage. When the signal voltage reaches this voltage level, the trigger circuit starts the horizontal sweep. In the drawing two groups of sine waves show the signal displayed during two horizontal sweeps while the sawtooth waveshape below is the horizontal-deflection waveform. Adjustment of the "time/div" switch has programmed the sweep to operate for a specific length of time. When that time has elapsed, the sweep stops and retraces rapidly. In this case, the sweep occurred during slightly less than two complete cycles (and only that much of the waveform is displayed on the CRT screen). Then the triggering circuit waits (with the CRT brightness blanked) until the signal waveform again reaches the programmed triggering-voltage level. Length of this inactive time depends on the waveform; it might be short or moderately long. Next time the signal amplitude reaches the programmed point the sweep is triggered for another timed deflection (showing almost two cycles again). At the end of that sweep time, retrace occurs and the waiting time begins. This is the operation during two sweeps. Triggering can occur only when one more condition is satisfied: the right signal-voltage level must be reached when the signal slope is positive-going or negative-going, according to the way the "slope-level" switch is adjusted.

and finally four cycles can be obtained (bottom trace of B). Of course, two cycles result when the sweep frequency is exactly half that of the signal frequency.

Notice that it's impossible to obtain less than one cycle (or anything except *complete* cycles) with recurrent sweep. By contrast, Figure 3 shows that any number of cycles or fractions may be obtained easily with triggered sweep.

Triggered sweep

Locking the waveform of a triggered scope actually is accomplished by proper triggering. The triggering circuit is adjusted for a certain voltage level. When the vertical signal reaches that preselected voltage, the trigger is activated, and this "triggering" starts the horizontal sweep which then continues for a certain period of time (selected by the scope operator). At the end of the sweep time, the sweep stops, retraces instantly and waits in an inactive state until it is triggered *again* by another section of the signal that has the *same* polarity and voltage (Figure 4).

The length of time spent in the inactive or waiting mode is determined primarily by the character of the signal, and is affected indirectly by the sweep time, but not at all by the scope design or its adjustments. If the proper triggering voltage arrives immediately after the previous sweep has stopped, the waiting time is short. If the end of sweep and the triggering voltage point are separated by a considerable space on the waveform, the waiting time is increased comparably.

Not super-sensitive—The triggered sweep is not a delicate balance which is upset by minor variations. Two items contribute to the stability after locking is achieved.

One is that minor variations of the sweep time have no effect on the locking (because the next triggering does not depend on the end of the previous sweep). This is not true of recurring sweep, for the slightest variation of signal duration or repetition will destroy the locking.

Also, it's easier for a triggered scope to find a programmed *voltage* level in most any kind of signal waveform than it is for a recurrent scope to find a compatible *frequency*.

The lineup of triggering controls in Figure 5 seems complicated. But all except two can be preset.

Duties of the "source" and "mode" controls often are divided differently with more or fewer knobs. For the pictured scope, the "source" switch selects the origin of the triggering voltage, such as Channel 1, Channel 2, 60-Hz line or external. This triggering voltage often is taken from the vertical signal, but it can come from another signal of identical repetition rate. For example, video waveforms can be triggered (locked) dependably by selecting a vertical-sweep or a horizontal-sweep waveform that's brought in through the external-input jack.

Not all scopes have two functions provided by the "mode" switch. In the "auto" position, the sweep

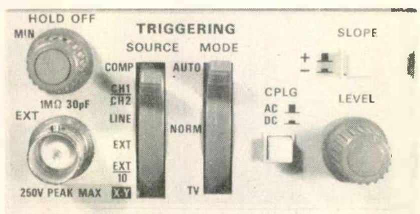


Figure 5 This area contains the triggering controls. The "source" switch selects the origin of the signal that is to supply the triggering voltage. At the left is the "ext" socket for bringing in either external signals to be used for sync or a signal for the X-Y mode. Forget about the "hold-off" knob. It's used only with certain kinds of pulse trains. A choice of "auto" (free running) triggering, "normal" triggering or a "TV" sync separator combined with auto triggering is given by the "mode" switch. The "cplg" switch selects either ac or dc coupling of the trigger signal. The "level" and the "slope" polarity controls together select the voltage point where sweep triggering occurs. Other scopes have more or fewer controls but the operation is similar.

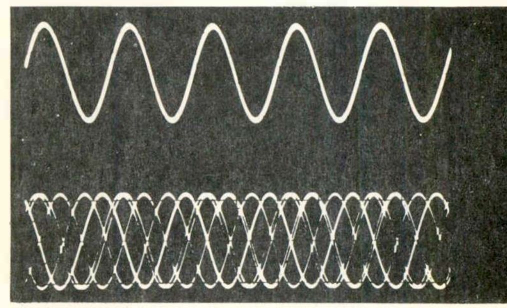


Figure 6 When this one kind of automatic triggering is used, the appearance (top waveform) with a locked signal is conventional. But when there is no input signal the circuit supplies a free-running oscillator that furnishes a base line. Or, if the waveform is not properly triggered, an out-of-lock display will be seen (see bottom waveform). This helps by indicating a waveform is there but is not locked. (Normal trigger operation allows no line or waveform unless the triggering is right.) Auto operation in other scopes might affect the triggering in different ways so consult the instruction book that comes with the scope.

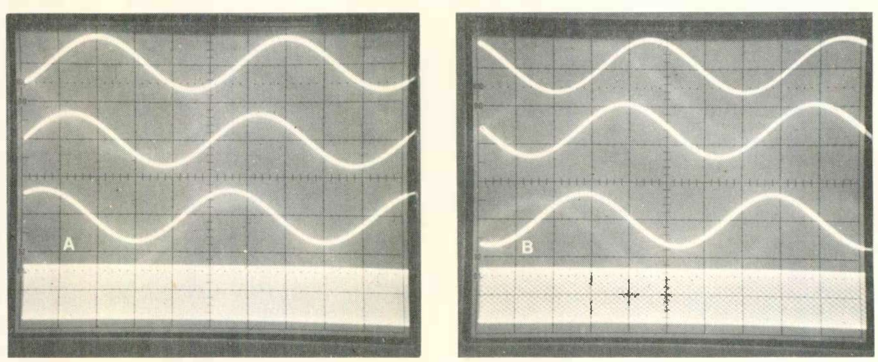


Figure 7 When the slope-polarity switch is in the "+" position, proper locking can be obtained at any point on the positive-going slope of a waveform except near the peaks. When the trigger-level control is turned to start the triggering too near the tip the locking becomes unstable. And when it's adjusted at or beyond a peak no locking is possible. (B) The same operation applies to the "-" setting of the slope-polarity switch, except the triggering is on the negative-going slope.

operates as a free-running oscillator. So the screen shows a horizontal line across the screen with no signal, or an out-of-lock waveform if the signal is not correctly triggered. "Normal" mode is the one all triggered scopes have. Without correct triggering (locking), there is no sweep or any brightness on the screen.

"TV" position of the mode switch connects a sync separator (similar to those in TV receivers) that supplies vertical and horizontal sync to the triggering circuit. Triggering then occurs from this sync, and not from a voltage level of the video. I highly recommend the TV sync feature because video is very difficult to lock properly without it (especially at vertical rate).

Incidentally, the auto mode allows the locking of a triggered scope to be done very much as though it is a recurring type. Without proper triggering (locking), the waveform moves rapidly across the screen. When normal triggering is achieved, the waveform is steady as though locked. Present users of recurring scopes and beginners will like the auto feature.

In Figure 6, the upper trace of sine waves is being triggered properly (call it locked), while the bottom trace shows loss of triggering but with a sweep supplied by the automatic circuit (call this unlocked).

Level and slope controls—The "level" control adjustment determines the voltage level that triggers the sweep (there is no oscillator). Therefore, it is the principle means of obtaining a stable waveform. The "slope" switch selects either the positive-going slope or the negative-going slope of the triggering signal. This is similar to the toggling or enabling of digital circuits where the action occurs *only* at the leading or trailing edge of the driving waveform.

Separate controls for these two functions allow the operator to select which slope causes the triggering (and also which slope is seen at the beginning or left edge of the waveform).

Range of the level control—Follow the next discussion carefully, for it will explain why an amplitude change sometimes ruins the locking, and how to obtain displays that are more stable.

Figure 7 shows the broad range of non-critical adjustments for correct triggering (locking) of sine waves. Only the slope switch and the level control are adjusted for the sequence.

For the waveforms in Figure 7A, the slope switch remains in the "+" position. A level control adjustment that causes triggering on the positive slope near the negative peak's tip is shown by the top trace of A. In the next-lower trace, clockwise rotation of the level control has moved the triggering point up to the waveform's vertical center and moved the cycles to the left. Continued clockwise rotation (see next-to-bottom trace) moves the triggering point up near the tip of the positive peak while the cycles again are moved to the left. (This sideways movement of the sine-wave cycles is very noticeable when the sequence is done rapidly.) Finally, a slight additional clockwise rotation of the level control eliminates the triggering (locking), and the auto-sweep operates to show the waveform as a moving blur (bottom trace).

For the Figure 7B waveforms, the slope switch is changed to "-" position. Continuing from the previous explanation, a slight CCW rotation of the level control brings the stable waveform of the top trace, with triggering occurring on the negative slope near the positive peak. More CCW rotation of the level control moves the cycles to the left and begins the trace near the vertical center of the waveform (next-to-top trace). Another CCW rotation of the level control moves the triggering point down near the bottom of the negative slope at the negative peak, and also moves the cycles to the left (next-to-bottom trace). Finally, a slight additional CCW level control rotation eliminates the triggering, and the bottom trace shows the loss of locking that indicates the auto-sweep is showing a rapidly moving signal.

This sequence is difficult to describe in words and probably sounds very complicated, but it can be done simply and easily. I strongly recommend that you try it for yourself; it will clarify the triggering operation.

The main point of Figure 7 is to

Scope tips

show that the triggering point may be selected anywhere along *either* slope and provide stable triggering (locking), except near both positive and negative peaks. If the level control is adjusted for a voltage that's above or below the waveform, no triggering is possible regardless of other adjustments.

Arranging for stable triggering— It's possible and desirable to preset the level control to a position that makes proper triggering almost a certainty with sine waves.

Refer to the A picture of Figure 8. Begin by adjusting for a stable large sine wave that has its triggering point about a third of the amplitude down from the positive peak as shown. Now, slowly reduce the vertical gain and notice that proper triggering (locking) is lost when the amplitude drops barely *below* the triggering point. No part of the signal extends up to the voltage selected as the trigger. Therefore, triggering cannot occur.

Figure 8B changes the conditions slightly. Again, display the same original sine wave amplitude as before, but rotate the level control to place the triggering point as close as possible to the zero point at the vertical center of the waveform. This time when the amplitude is reduced, correct triggering is maintained almost to zero amplitude.

Therefore, when first trying to obtain any kind of waveform, adjust the level control to the exact center of its action. This center can be found as in Figure 8B by rotating it to the point that places the sweep starting point at the center of the signal amplitude. Perhaps a pointed small bit of masking tape could be stuck there to mark the center.

This small precaution will speed up finding a triggering point regardless of the waveform or its amplitude. When the best method is used, correct triggering (locking) can be done much faster than with recurrent scopes. And the stability is far superior. For example, after it has been triggered to a certain signal, the scope can be turned on and off repeatedly (even off for hours) and at each turn-on, the waveform again will be "in lock" without needing adjustments. Or, the signal frequency can be changed radically; the number of cycles displayed will be different, but no triggering adjustments will be required.

Selecting sweep time

As mentioned before, sweep time is not a factor in proper triggering. A different sweep time changes the number of cycles on the screen, nothing more. Of course, the nearness of triggering and sweep-time switches on the panels of most scopes probably gives a false impression that their functions are related.

Every triggered scope has a knob

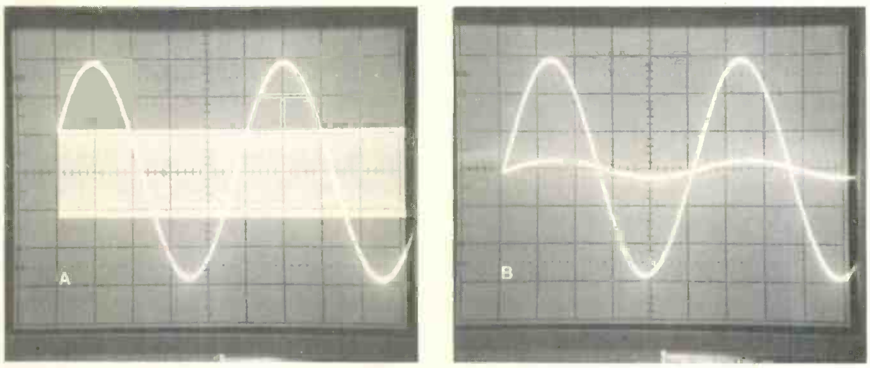


Figure 8 Triggering is not possible when the signal level drops below the voltage level selected by the trigger-level control. (A) When the trigger level was about three-fourths up the slope, the triggering was eliminated when the signal amplitude was reduced below that point. Of course, auto triggering showed an out-of-lock waveform. (B) However, when the triggering point was adjusted to the vertical center of this symmetrical waveform, a larger reduction of level did not disturb the triggering (locking).

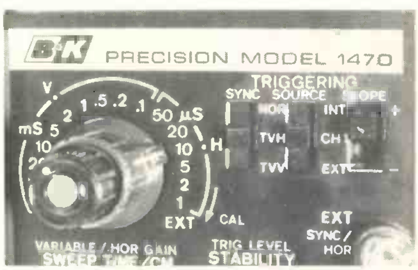


Figure 9 In the B&K-Precision the "sweep-time/cm" switch supplies sweep between 100 ms and 1 us. The variable knob gives an uncalibrated but true increase of sweep time. In addition, a fixed X5 horizontal magnification can be switched in to give the effect of a 5-times decrease of sweep time. These are only two of the variations found in different models.

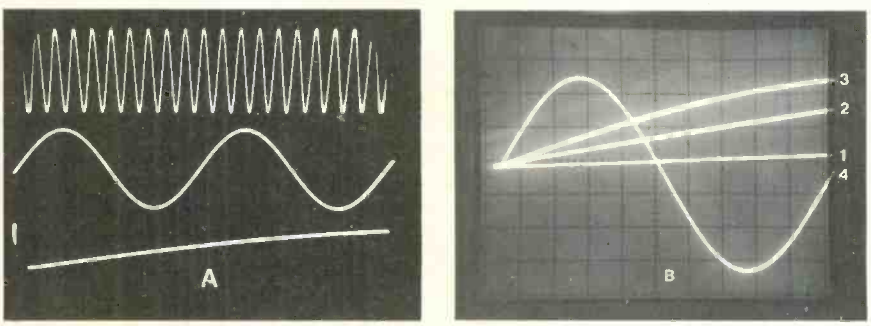


Figure 10 Changing the sweep time to give a different number of cycles does not affect the triggering (locking). (A) When two sine waves were triggered at the vertical center, the sweep time could be increased by 10 times (top) or decreased by 10 times (producing only a slope as shown at the bottom) without loss of locking. (B) In the same way triggering with the sweep-time too short shows only a line which tilts, becomes a curve and finally develops into a sine wave as the sweep time is made longer. Resetting of the triggering is not necessary.

labelled "sec/div," "sec/cm," or "sweep-time/cm." The figures beside each switch position (see Figure 9) represent the amount of time (in seconds, milliseconds or microseconds) required for the writing beam to travel horizontally between any two adjacent graticule lines (one division or one centimeter).

For example, the switch in Figure 9 is turned to the 10 μs position (one of the best sweep times for horizontal-frequency TV waveforms). Each division or centimeter of the graticule is swept for a time of 10 μs. The entire width of the graticule requires a sweep duration of 100 μs.

Two examples of various sweep times are shown in Figure 10. The center trace of Figure 10A has two sine waves that were properly triggered and swept at a 2 ms time. Then, without any adjustment of other controls, the time/div switch was turned to 20 ms, and the screen showed 20 sine waves (top trace). Next, the switch was rotated for a short 0.2 ms, producing a waveform (bottom trace) that resembled a crooked line. Actually, it was about one-fifth of a cycle.

Triggering was not interrupted because the level control had been set to place triggering at the vertical center of the waveform.

In the Figure 10B picture, the time/div knob for trace 1 was set to a sweep time that was too short for the signal frequency, and the display was nearly a straight level line. For trace 2, the next slower sweep speed was selected. Another slower speed showed a curve (the quarter cycle in trace 2). Finally, the scope operator moved the switch two positions slower and a nearly complete single sine wave was revealed. Slower sweeps would have produced more cycles.

Notice that the triggering occurred (and the sweep began) at the same point each time.

For unknown signal frequencies, sequentially adjust the amplitude and the various trigger controls until *any* kind of stable display is obtained. Then vary the sweep time to produce a manageable number of cycles on the screen.

A beamfinder is helpful if no waveform can be seen. Excessive gain with square waves, for example, might drive the tips off of the screen. And of course, unlocked square waves appear to be two parallel horizontal lines on the screen.

In addition to the time/div switch, all triggered scopes have a variable-sweep control. Some have a concentric knob that provides calibrated sweep time when it's turned fully clockwise until a switch clicks. When rotated to the left, it increases the sweep time; however, the amont is not known. For many measurements, the exact time is not critical. But whenever maximum accuracy is needed, the control must be turned to the calibrate position.

Another feature of triggered scopes is an optional widening of the horizontal sweep. When an X5 magnification switch is turned on, the width of the horizontal sweep is increased to five widths. Repetition rate of the sweep is not changed, and neither is the sweep time. However, the beam travels five times as far in this same time, so the effect is nearly the same as dividing the sweep time by 5. In effect, 1 μs has become 0.2 μs, for example. Illustrations will be given next month.

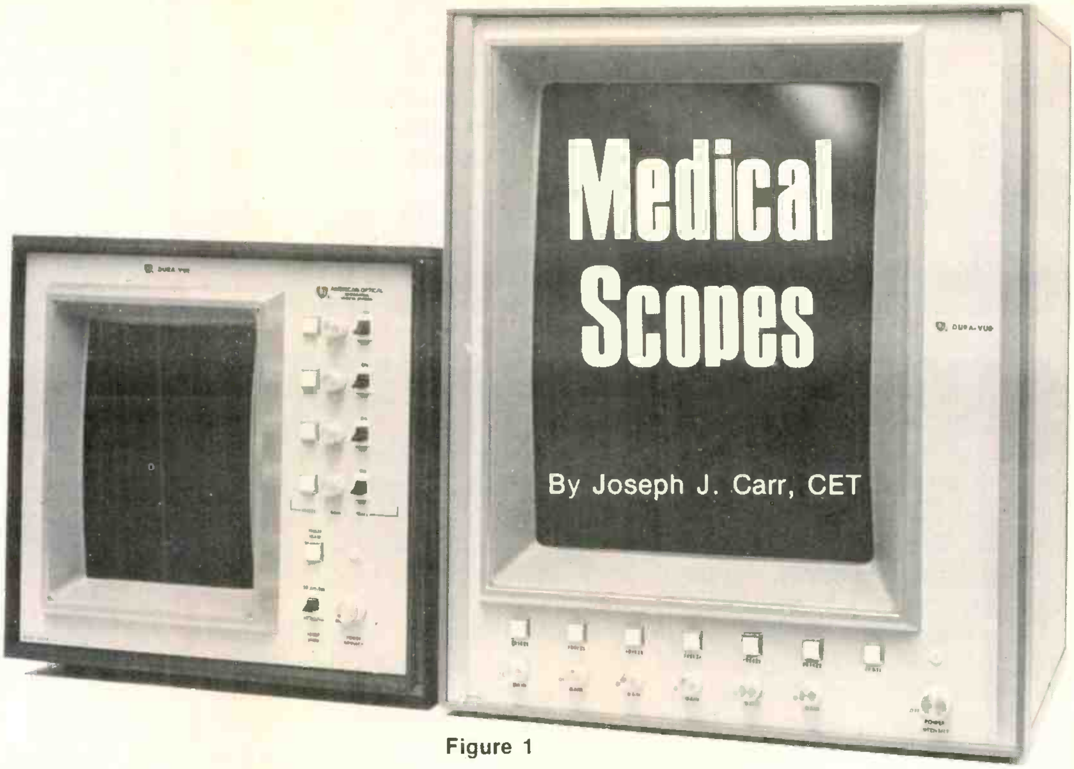
There are a couple of differences. The other four-fifths of the sweep continues to operate, but it's off the screen. Any portion of this expanded waveform can be seen by adjustments of the horizontal-positioning control. There is one tradeoff. Because the trace is on the screen only one-fifth of the time, the visible trace has less brightness. Of course, that's another reason to choose a scope that has too much brightness when used for non-magnified waveforms.

Next month

Some of the important topics in Part 2 next month include the operation and calibration of probes; how to use time-base calibrations to measure frequency (including TV vertical and horizontal); the time settings for often-used frequencies; how alternate and chopped modes of dual-trace work; how to measure rise time and look at the VITS and VIR signals; how to measure dc voltages and a mixture of dc and ac; and many other measurements and analysis of waveforms. □

Medical Scopes

By Joseph J. Carr, CET



(Courtesy of American Optical)

Figure 1

The scopes used by the medical profession are not the same as service scopes. An experienced biomedical electronic technician tells how medical scopes are different.

Most medical-electronics waveforms are viewed on *oscilloscope* (scope) cathode-ray tubes (CRTs). When permanent traces are needed, similar waveforms are recorded on moving tape of strip-chart recorders (*oscillographs*). But the trouble and expense of the recorders discourage other uses. Strip recorders are far outnumbered by scopes.

These scopes range between large multichannel models (that allow the simultaneous monitoring of as many as eight patients, as shown in Figure 1) to small single-channel types. This covers a variety of features and circuits.

How are medical scopes different?

Medical scopes are not the same as electronic-service scopes. The major differences and similarities follow.

Sweep speeds—Medical scopes are used to display waveforms produced by physiological functions. Most of these change slowly. The human heart, for example, normally operates at 40 beats per minute (BPM) to 130 BPM. That's between 0.66 and 2.2 "cycles" per second. So, medical scopes must have very slow horizontal-sweep rates.

Typical sweep speeds are 25 mm/s, 50 mm/s, and 100 mm/s.

The standard for electrocardiograph display is 25 mm/s. On a conventional CRT screen of 10 cm, this translates to one sweep every four seconds. A heartbeat of 60 BPM produces four complete waveforms across the entire screen at all times. (According to triggered-sweep ratings, that's a sweep *time* of 0.4 S/div. For recurrent-sweep scopes, it corresponds to a sweep *frequency* of ¼ Hz. Incidentally, the formula ¼ Hz = 4 s, doesn't make much sense until Hertz is translated to its literal meaning. Then it reads ¼ cycles/s = 4 s/cycle.)

Sensitivity—Several sensitivities of vertical gain are found in medical scopes. However, each scope model usually has only one. If the scope is used as a display device for other instruments, the sensitivity typically will be between 0.5 V/cm to 2 V/cm. Scopes used for direct EEG or ECG monitoring (without other instruments) have sensitivities of a few millivolts or microvolts per centimeter.

Phosphor specs—One easily-apparent difference between TV-service scopes and medical scopes is the color and persistence of the phosphor inside the CRT screen.

Service and lab scopes must display fast-rise-time or varying-amplitude waveforms that are traced at rapid sweep speeds. So, the phosphors must have short persistence. That is, the brightness must fade rapidly after the writing beam has moved away.

If medical low-frequency waveforms and sweep speeds are displayed on a CRT having short persistence, nothing can be seen except a single bright dot that leisurely moves up and down as it proceeds slowly from left to right. No waveform details can be perceived under those conditions.

The brightness of a long-persistence (P7) phosphor in a medical scope fades slowly so the waveform can be seen as a long "comet tail" following the moving spot. When the beam reaches the right side, the left edge of the trace is almost extinguished. But it can be seen well enough to allow a satisfactory diagnosis of most waveform irregularities.

Incidentally, the phosphors chosen for medical scopes glow with

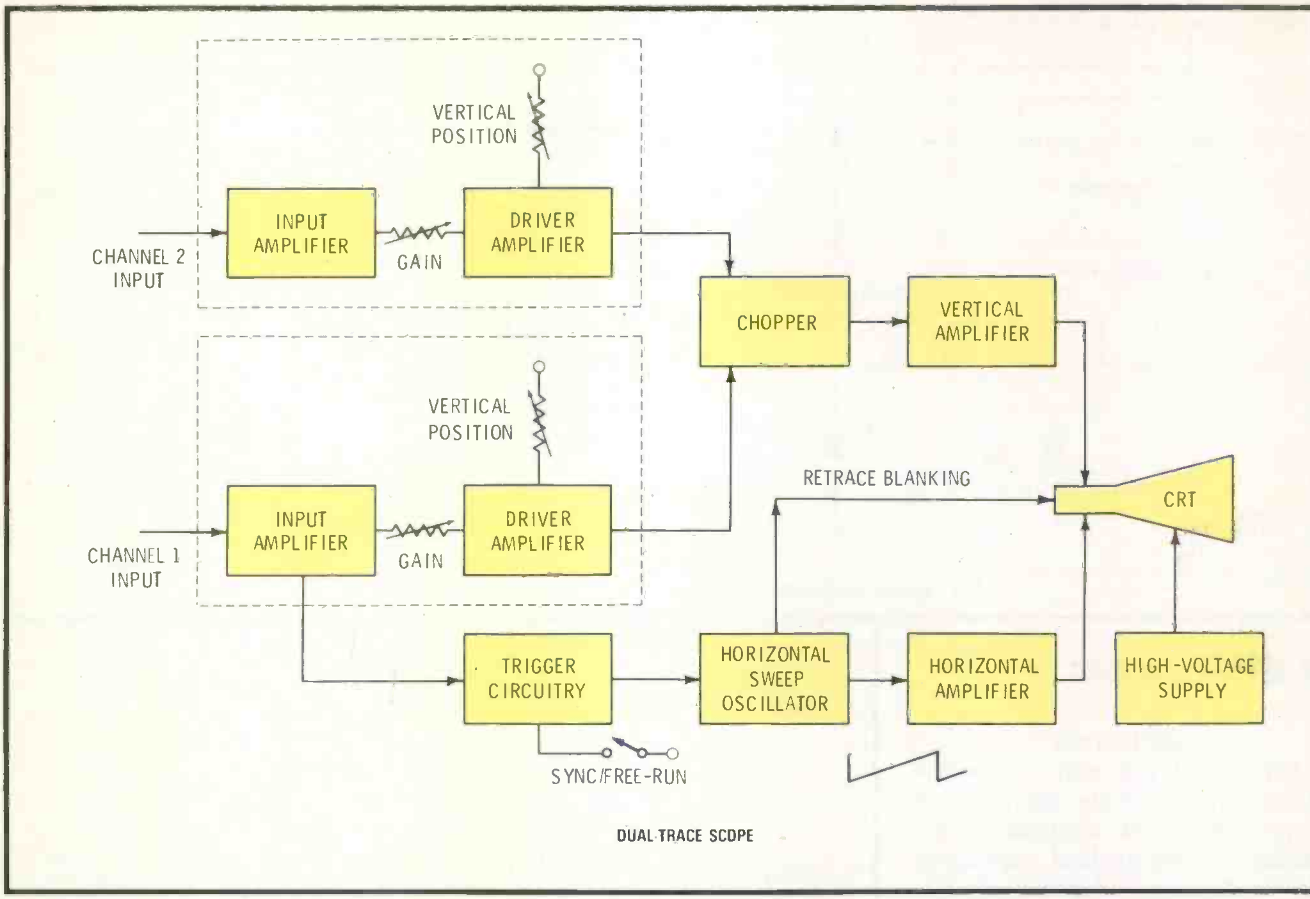


Figure 2 The block diagram of a service scope and a "bouncing-ball" medical scope are just alike. There are major differences of sweep speed, bandwidth and phosphor persistence.

large amounts of yellow and blue-violet tints. Some manufacturers add filters that reduce the yellow, thus the trace appears to be violet. Others filter out the violets and blues leaving a bright yellow waveform. However, the *same* CRT might be used in scopes showing either tint. Don't be surprised to see a blue or violet color from the rear of the CRT, but a yellow trace through the filter in front!

"Bouncing-ball" displays

Non-memory types of medical scopes usually are called "bouncing-ball" models, because of the moving spot with the fading trace that follows it. The majority of older scopes are of this type.

Figure 2 shows the block diagram of a bouncing-ball medical scope. This specific scope is a 2-channel model. However, single-channel versions are essentially the same, except for the chopper and the extra vertical amplifier.

Probably you will notice no distinctive differences between service and medical scopes from their respective block diagrams. All medical scopes have triggered sweep.

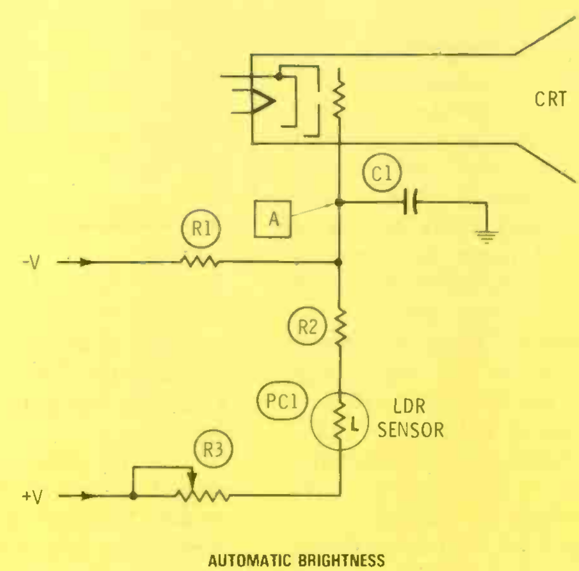
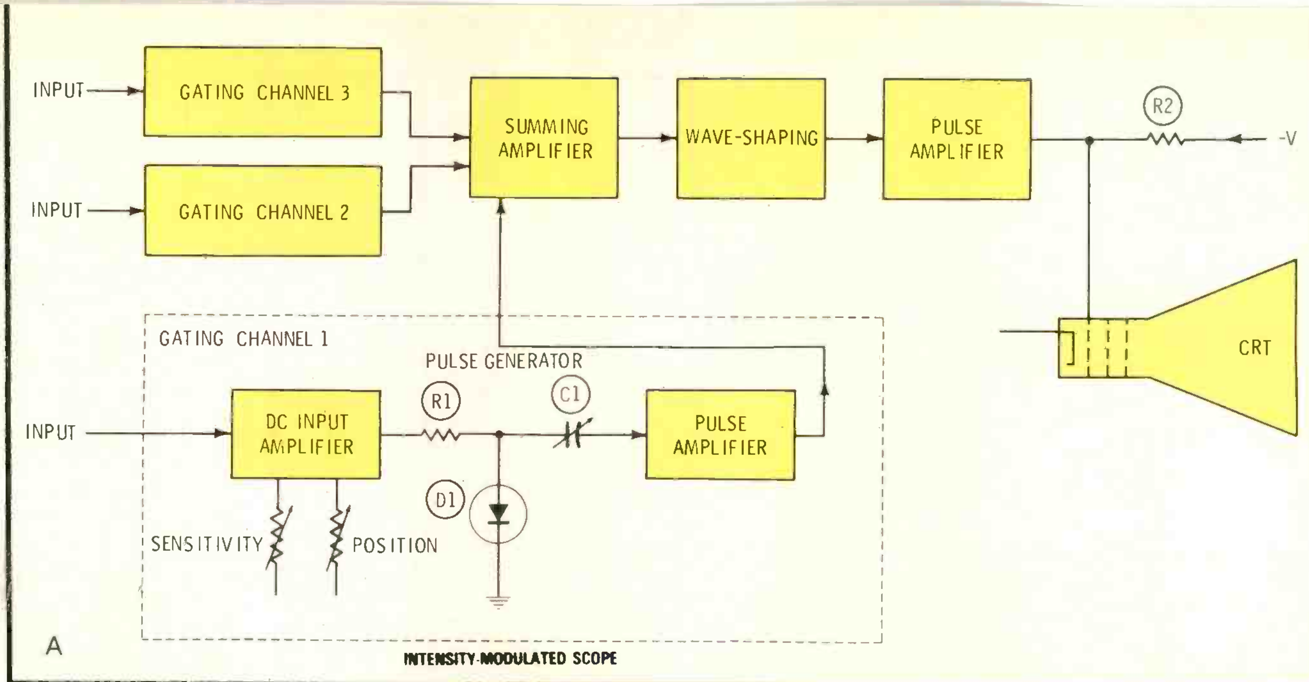


Figure 3 Ambient light falling on a photocell adjusts the brightness of many scope models by varying the CRT grid bias.



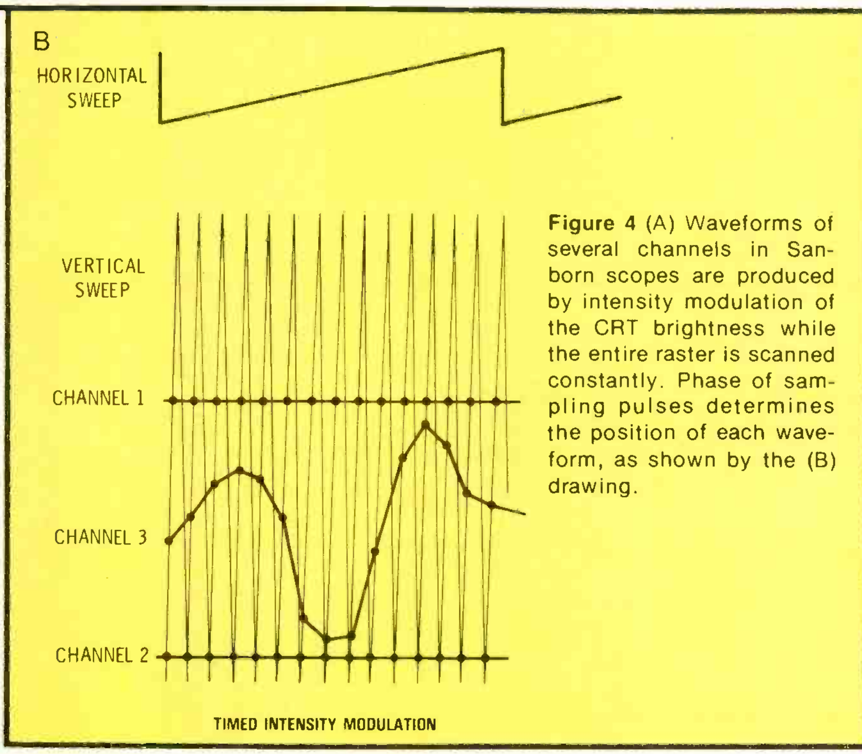


Figure 4 (A) Waveforms of several channels in Sanborn scopes are produced by intensity modulation of the CRT brightness while the entire raster is scanned constantly. Phase of sampling pulses determines the position of each waveform, as shown by the (B) drawing.

Medical scopes

Deflection

Because of the wide bandwidth signals handled by service-type scopes, they have electrostatic deflection. Some medical waveforms can be displayed adequately by flat response only to 200 Hz, and none requires more than 3000 Hz. Such narrow bandwidths are well within the ability of magnetic yokes. Therefore, the majority of medical scopes are deflected magnetically, since equal performance can be obtained in a shorter CRT.

Automatic brightness

Some medical scopes include a photocell that adjusts the CRT brightness according to the amount of light in the room. An intensity setting that's appropriate with both bright fluorescent lights and some daylight would prove an annoying distraction at night when the room is darkened so the patient can sleep. Therefore, these automatic brightness features are very practical, and not an unneeded luxury.

An example of automatic brightness is illustrated by the schematic in Figure 3. A photoresistor controls the grid bias of the CRT.

Grid bias of the CRT is produced by a delicate balance of voltages from positive and negative sources, so the grid has the proper negative voltage relative to its cathode.

When the ambient light reaching the photocell is strong, the photocell resistance increases the amount of positive voltage fed to the grid circuit, and the negative grid bias is decreased. Reduced negative grid bias allows the CRT to draw more gun current and produce a brighter trace.

Of course, when the room is darkened, photocell PC1 resistance increases, and less positive voltage is sent to the grid circuit. In turn, less negative voltage is cancelled, which increases the CRT negative bias and decreases the waveform brightness.

Multichannel scopes

A conventional *chopper* electronic switch allows the scope of Figure 2 to display two waveforms on a conventional CRT. A high-repetition-rate square wave alternately connects one vertical signal and then the other to the vertical amplifier. This is *sampling* of the waveform, which reconstructs each waveshape out of many short lines. These lines are not very visible because of the long persistence of the phosphor and the lack of synchronism between signal and chopper frequencies.

More than two channels can be accommodated by adding another electronic switch and increasing the switching frequency. Also, there is a different method, which is described next.

Pulse-timing operation—Another way of obtaining several vertical channels in a scope that's equipped with a conventional CRT is to use the pulse-timing circuit of Figure 4. Originally, the design was pioneered by Sanborn (now it's manufactured by Hewlett-Packard).

A 3-channel scope with pulse-timing circuits is shown in the block diagram of Figure 4A. Details are shown only for one channel, but the other two are identical.

Because the waveforms are not produced by varying the amount of deflection (as it's done in service scopes), **the raster is scanned by both vertical and horizontal sweeps at all times.** The waveforms are formed by intensity modulation which permits CRT current only at proper times.

This kind of raster scanning can be compared to deflection in a TV receiver. However, there are important differences.

About three seconds are required for the horizontal sweep to move the beam completely across the screen. That much is similar to the operation of other medical scopes.

The vertical sweep works somewhat like the horizontal sweep does in TVs (except the beam is moved vertically rather than horizontally). In fact, the Sanborn version uses a 6CD6/6CB5 TV horizontal-output tube as a vertical-output tube that drives a regular *flyback* transformer (replaceable by a Triad D-604). Frequency of the vertical sweep is not critical, since it is not locked or synchronized, but usually it is adjusted above 15 kHz to minimize squeals that some people find annoying.

Each vertical channel has a dc amplifier, a tunnel-diode pulse generator and a pulse amplifier. Pulses from all channels are summed in the main channel, and after shaping are applied to the CRT control grid.

Timing of each pulse generator depends on the instantaneous signal that's applied to the pulse generator. This signal is made up of the input analog signal (after amplification) plus a dc voltage from the positioning control. With zero voltage applied, the time between pulses will occur at a constant (resting) rate. A positive or a negative voltage causes the pulses to be produced faster or slower.

The CRT is biased to cut-off until a pulse reaches the grid. Consequently, pulses that arrive at an earlier time make dots of light nearer the top of the screen, while the slower-arriving pulses cause the lighted dots to be seen lower on the CRT screen.

An analog signal affects this channel line in the same way, except the voltage is varying. Therefore, the pulses arrive earlier or later, moving the line of dots up or down to form the waveshape.

Figure 4B shows horizontal lines of dots for channels 1 and 2 because they have no analog input signal. Channel 3 dots trace the shape of the analog input signal. Of course, the number of vertical lines in the drawing has been minimized to make the operation clear. Actually, there are about 45,000 vertical lines across the total screen. So, the lines appear to be continuous.

Most repairs to this type of scope will be in the vertical-sweep system. Bad damper or output tubes, shorted flyback transformers and oscillator problems cause most of the service work.

Non-fade models

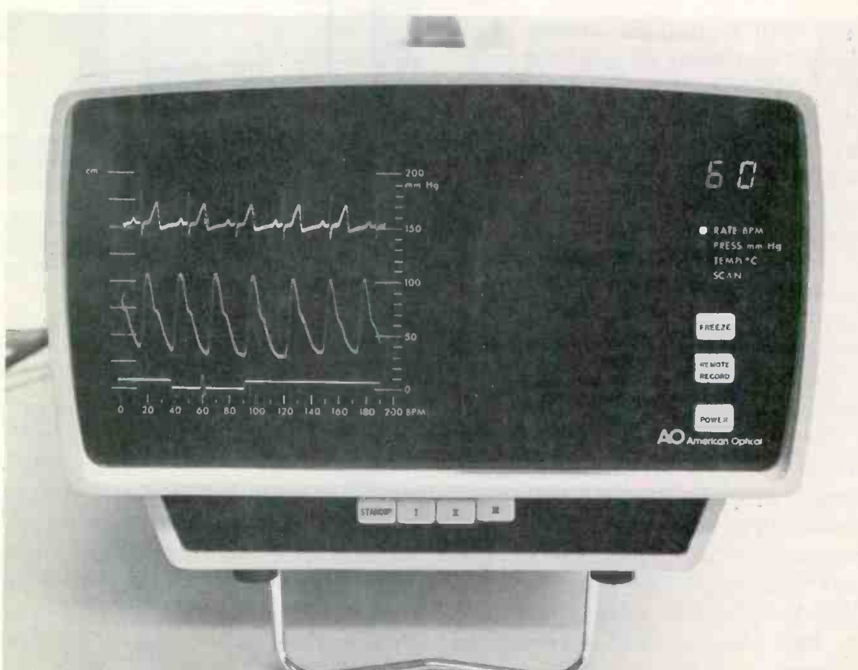
Even long-persistence phosphors can't eliminate fading of the left part of a waveform as the beam reaches the right edge. This creates problems for doctors because many small details of the waveform are transient and sometimes not repeated for some time. Therefore, bouncing-ball scopes force them to guess about some waveform anomalies.

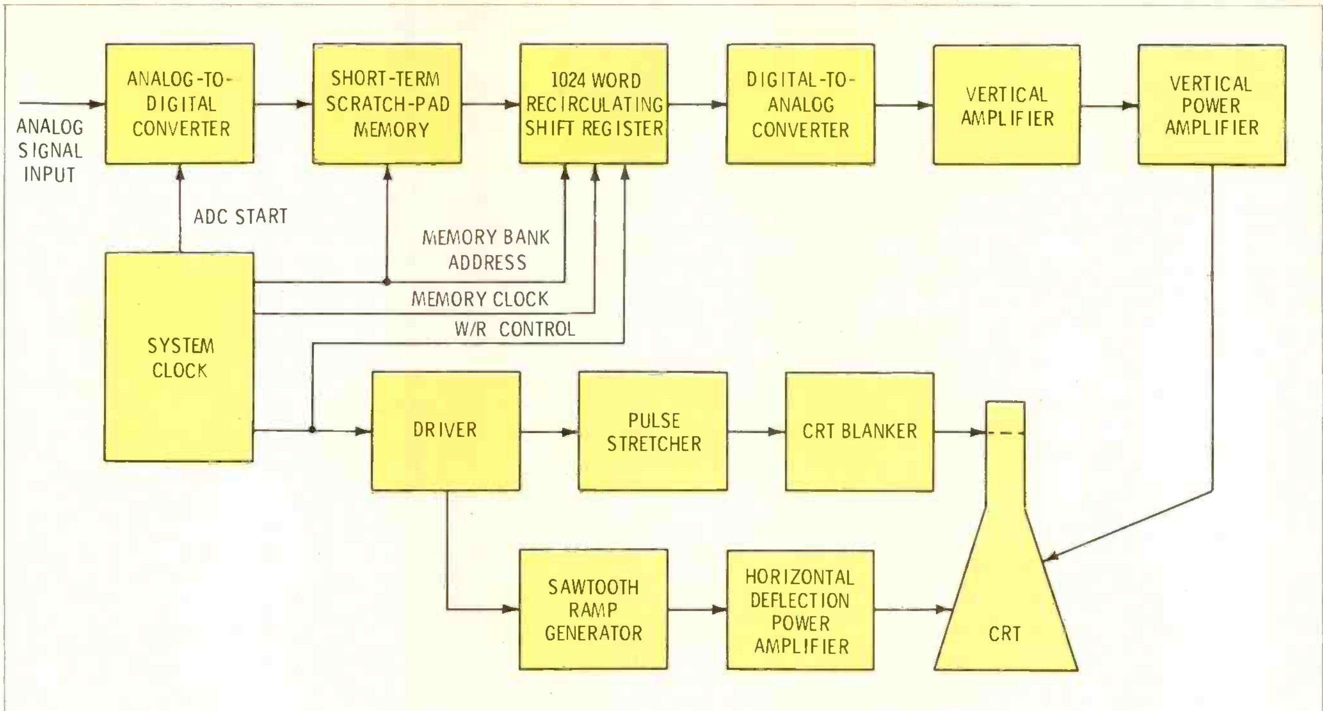
The problems are solved by a special non-fade (digital) type of medical scope that uses an analog-to-digital (A/D) converter to change the analog signal voltages into digital equivalents which can be stored in various kinds of memories. When needed for display, a memory signal is decoded by a digital-to-analog (D/A) converter. The resulting analog signal is amplified and viewed on the CRT. With constant digital refreshing, the real-time waveforms move across the screen with full brightness. Stored non-refreshed digital signals can *freeze* a waveform for detailed study.

Keep in mind that these non-fade scopes are not like the *storage* scopes used in laboratories and for research. Storage scopes use a CRT of special design which holds the last trace on the screen for a time.

A portable ECG monitor manufactured by American Optical is shown in Figure 5. This non-fade scope displays ECG, arterial pres-

Figure 5 This digital non-fade scope operates on batteries while displaying ECG, arterial pressure and patient temperature.





DIGITAL NON-FADE SCOPE

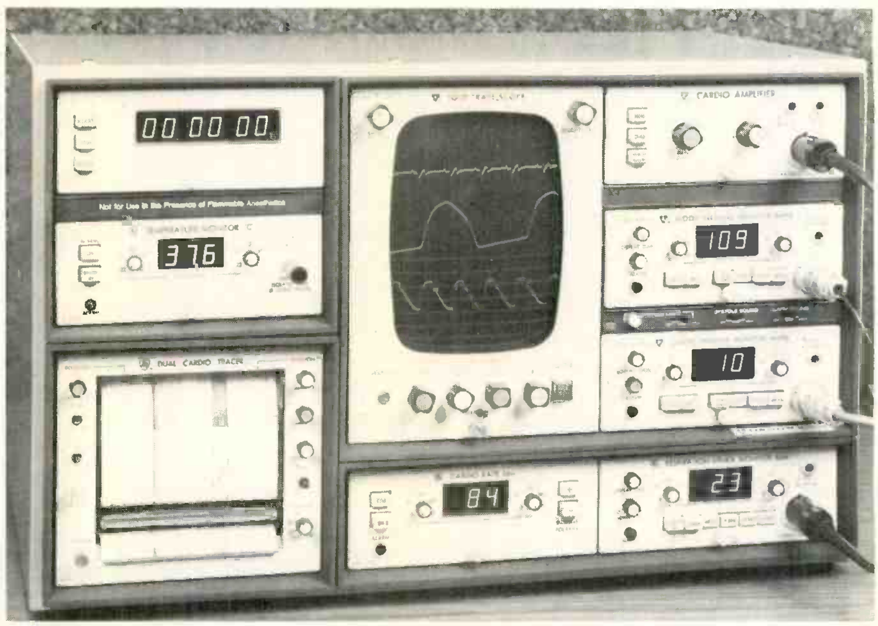
Medical scopes

sure and patient temperture while operating from internal batteries. Notice the button labelled FREEZE. It holds the current display on the screen even after the input signal has been disconnected.

Digital scope circuits—Figure 6 shows the block diagram of a typical single-channel non-fade scope, and the block diagram of a 4-channel scope is given in Figure 7.

In both scopes, the analog input signals first must be digitized in an A/D converter. Consider an example of an 8-bit A/D converter which can represent 2^8-1 (255) different levels of amplitude. Therefore, it's convenient for the A/D converter to have a full-scale capacity of +2.55 V, so the decimal equivalent of the binary word is numerically the same as the voltage it represents. In binary, full scale is 11111111 (or +2.55 V) half scale is 10000000 (+1.28 V) and zero is 00000000.

Output of the A/D converter is stored in two stages of a random-access memory (RAM) integrated circuit (the same type as used in microcomputers). A small "scratch-pad" memory holds four successive 8-bit words, while most of the data is held in a 1024-word main memory.



One rack holds a strip-chart recorder, two blood-pressure monitors, cardio amplifier, respiration monitor, temperature module, cardio-rate module, a timer and a four-channel scope. Similar monitors are used in intensive-care units (ICU) and operating rooms.

Data in the scratchpad memory is the most recent, and for practical purposes represents the real-time signal amplitude. A scope deflection system responds only to analog voltages or currents, so a digital-to-analog converter is provided to decode the memory output and supply the analog signal to the vertical scope amplifiers.

A multi-phase-system clock synchronizes the action of this circuit. It generates an ADC START pulse to initiate one A/D conversion, and the results are stored in the next sequential location of the scratch-pad memory.

A memory read/write line commands the memory either to write data into or read data out of the

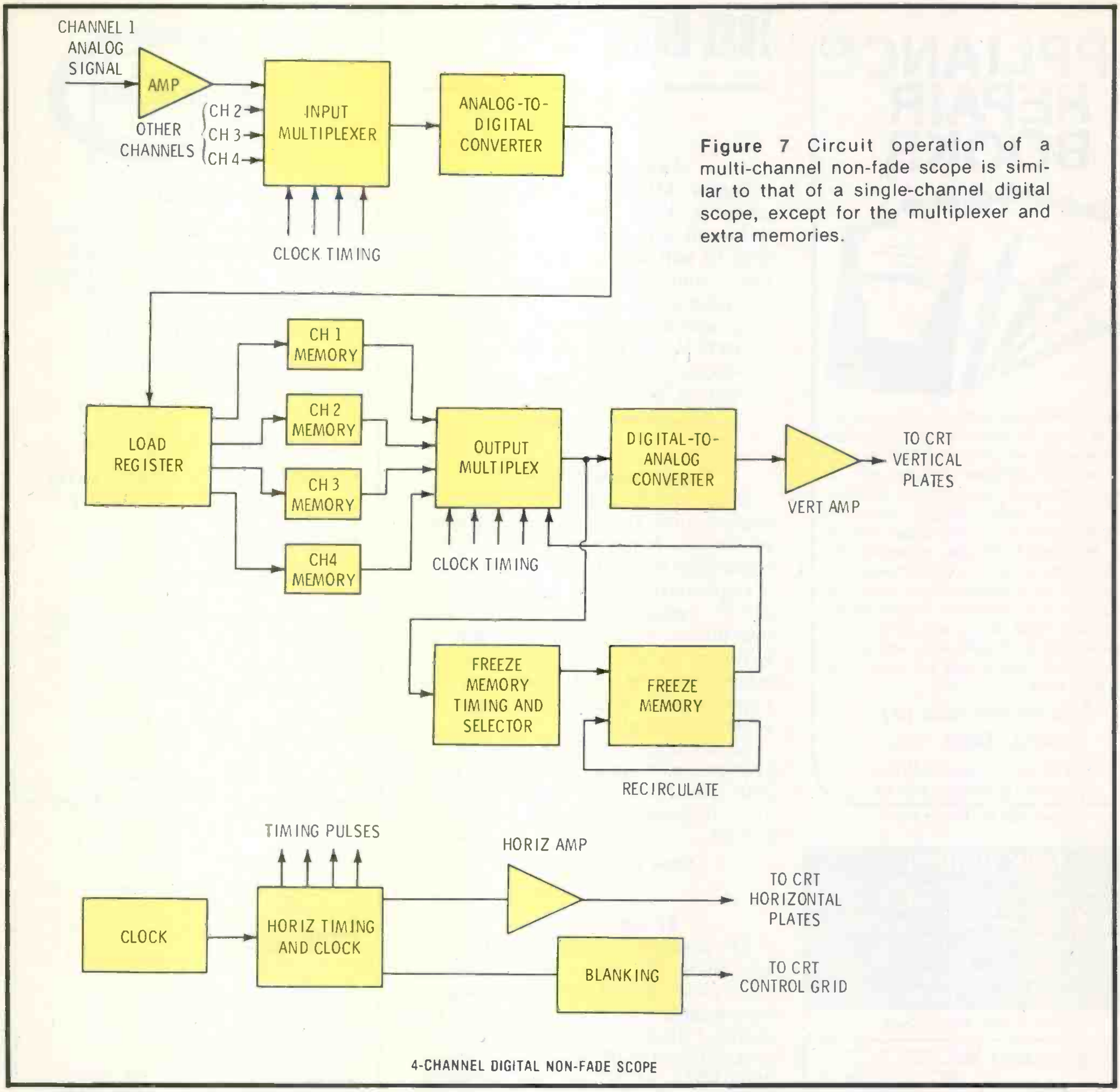


Figure 7 Circuit operation of a multi-channel non-fade scope is similar to that of a single-channel digital scope, except for the multiplexer and extra memories.

memory location addressed by the address lines. The memory is scanned by incrementing the address lines with clock pulses (a binary counter is used as an address generator). These same clock pulses are used to control the horizontal sweep.

The refresh rate usually is around 64 times per second. During refresh, the W/R line will be in READ mode, and the memory is scanned by successively incrementing the address generator. Each successive memory location contains an 8-bit digital word which represents an amplitude point on the input waveform, so the digital-to-analog converter output will follow the original waveshape.

At the beginning of each scan, contents of the scratchpad memory are loaded into the first four locations in the main memory. This provides a continual update of the data, and makes the display *appear* to sweep like a regular scope.

A multiplexed 4-channel non-fade scope is shown in the block diagram of Figure 7. It is essentially similar to the previous example, except for needing four memories to accommodate the four channels, and requiring both analog and digital multiplexers.

The memory-freeze circuitry is capable of transferring the contents of any one of the channel memories to a separate memory bank that is not updated by the input signal data. This memory has its output fed back to its input, so it will recirculate the same data continuously without any updating. The effect is to provide a display that's frozen on one waveform. The freeze memory is viewed on a separate multiplex channel, so its trace will appear at the bottom of the screen. Thus, it's possible to see the real-time trace and a frozen segment at the same time for waveform comparisons.

Comments

This general information should have clarified the important differences between service and medical scopes, and provided sufficient facts to help you service them. □

test equipment

Analog multimeter

Soar's ME-221 multimeter is a portable VOM with a drop-proof case and a taut-band meter that is said to withstand shocks to 50 Gs. Four functions are read on a mirrored scale.

Ac and dc voltages are measured to 1000 V, current to 250 mA and resistance to 500 K Ω .

Price of model ME-221 is $30.

Circle (50) on Reply Card

Capacitance substituter

Direct mechanical-digit readout of capacitances from 100 pF to 99.9999 µF is a feature of the CS-300 capacitance sub box from **IET Labs.**

Capacitors of 4% tolerance and 100-V rating are used in the instrument. The capacitance desired is dialed by six side-by-side thumbwheel switches. The readout is the capacitance, without addition or other mathematics.

Model CS-300 sells for $99.95. A similar resistance substituter (RS-200) covers 1Ω to 9,999,999 Ω in 1-Ω increments, and it sells for $89.95.

Circle (51) on Reply Card

RF millivoltmeter

RF measurements to 300 µV can be made by the RF-801 "R.F. Millivolter" manufactured by **Helper Instruments.** Response is said to be within 1 dB from 20 kHz to 520 MHz and within 1.5 dB from 520 MHz to 1000 MHz. At 3 GHz, the response is down, but the readings still can be used as indications of comparative levels. Full-scale ranges are 0.0001 V (1 mV), 0.003 V, 0.01 V, 0.03 V, 0.1 V, and 0.3 V. Up to 100 V can be measured by using the 50-dB probe adapter which is supplied. Probe impedance is 100,000 Ω paralleled by 2 pF.

Calibrations are in RMS volts and dBm. Model RF-801 sells for $590 with probe, 50-dB probe adapter and 50-Ω terminated BNC connector.

Circle (52) on Reply Card

Digital multimeter

Six functions in 34 ranges are available on the **Sinclair** DM-350 digital multimeter. Basic accuracy of the 3½-digit instrument for dc voltages is 0.1%, and the intensity of the display can be adjusted. In

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addition to the usual 10-MΩ input impedance, the basic dc range can be selected to have a 1000-M Ω resistance.

Dc voltages from 100 µV to 1200 V are measured, as are ac voltages from 100 µV to 750 V (up to 20 kHz), ac and dc current both from 1 nA 10A, and resistance from 100 M Ω to 20 M Ω.

Model DM-350 sells for $139.

Circle (53) on Reply Card

Pulse generator

Pulse repetition rate and width are both variable from 1 µS to 1 S. One-shot pulses can be obtained from a pushbutton, or can be triggered from an external signal. The model 400 pulse generator from **Cincinnati Electrosystems** is said to have rise and fall times of 10 ns from the quasi-complementary VMOS FET output stage with an output impedance of less than 5 Ω.

Model 400 pulse generator is a small instrument (4"x2-7/8"x 1-9/16") that sells for $59.95.

Circle (54) on Reply Card

Color TV test generator

WR-515B Signalyst offered by **VIZ** is said to provide 34 significant tests for servicing color TVs or video equipment.

Patterns from the Signalyst include these: regular color bars; color bars without burst (for easy color locking); color bars with luminance bars; red, green or blue colors that cover the entire raster; a color trio; gray quad; dots; hatchdots and superpulse. These can be interlaced or non-interlaced, and a 4.5 MHz sound carrier can be added, if desired.

Separate BNC sockets are provided for video and RF/IF signals. Video of either polarity is adjustable by a level control. Chroma level is adjusted separately. A special feature is the RF/IF level attenuator, which can reduce the maximum 200,000 µV of RF to a low 20 µV, which is about the amplitude of snow. All signals are crystal controlled.

Vertical and horizontal pulses are available for triggering scopes. The 75-Ω output cable has a snap-on head for 300-Ω applications, and the operating manual has extensive coverage of possible applications.

Model WR-515B sells for $249. ☐

Circle (55) on Reply Card

the marketplace

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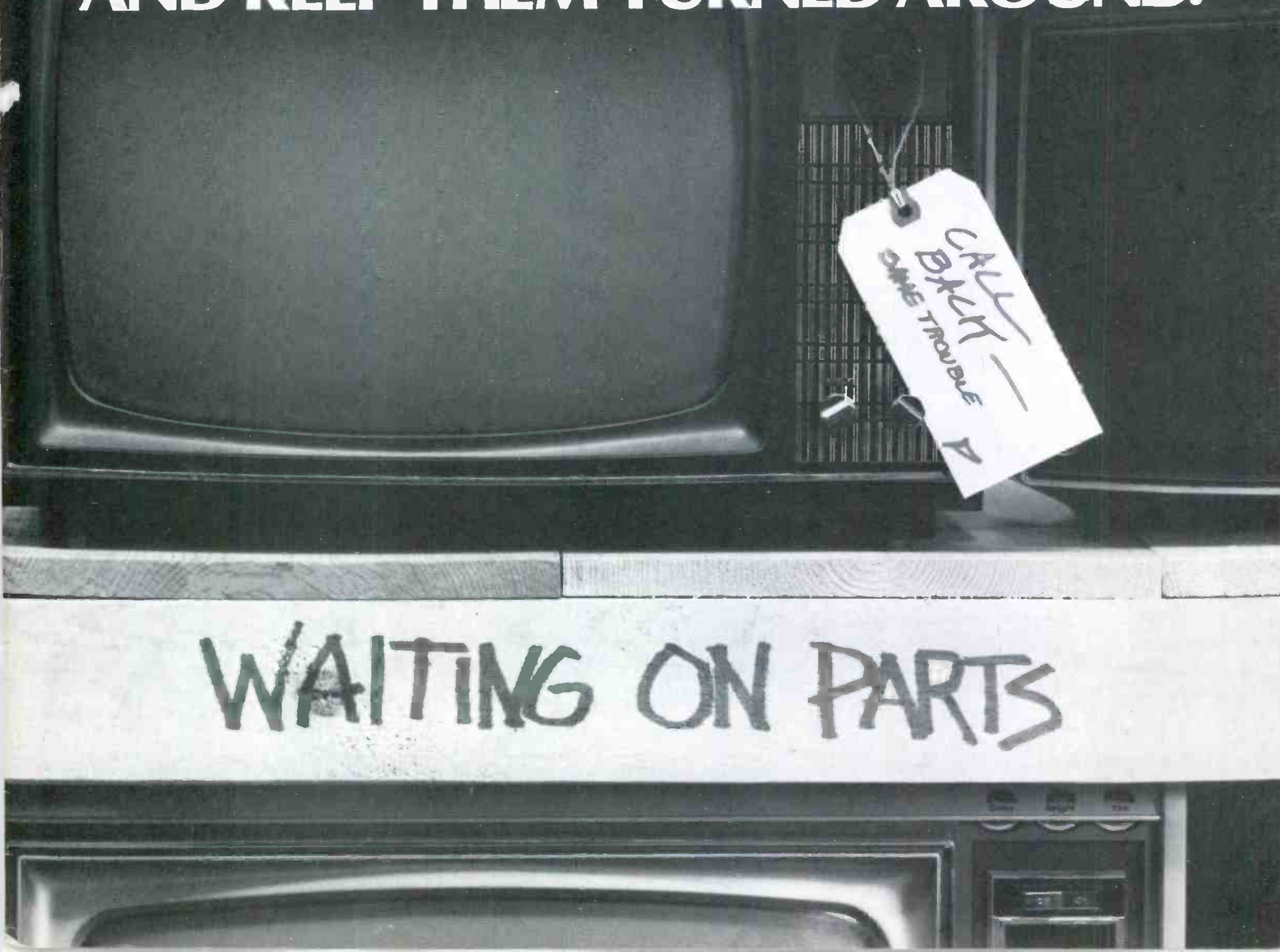
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