# ELECTRONIC™

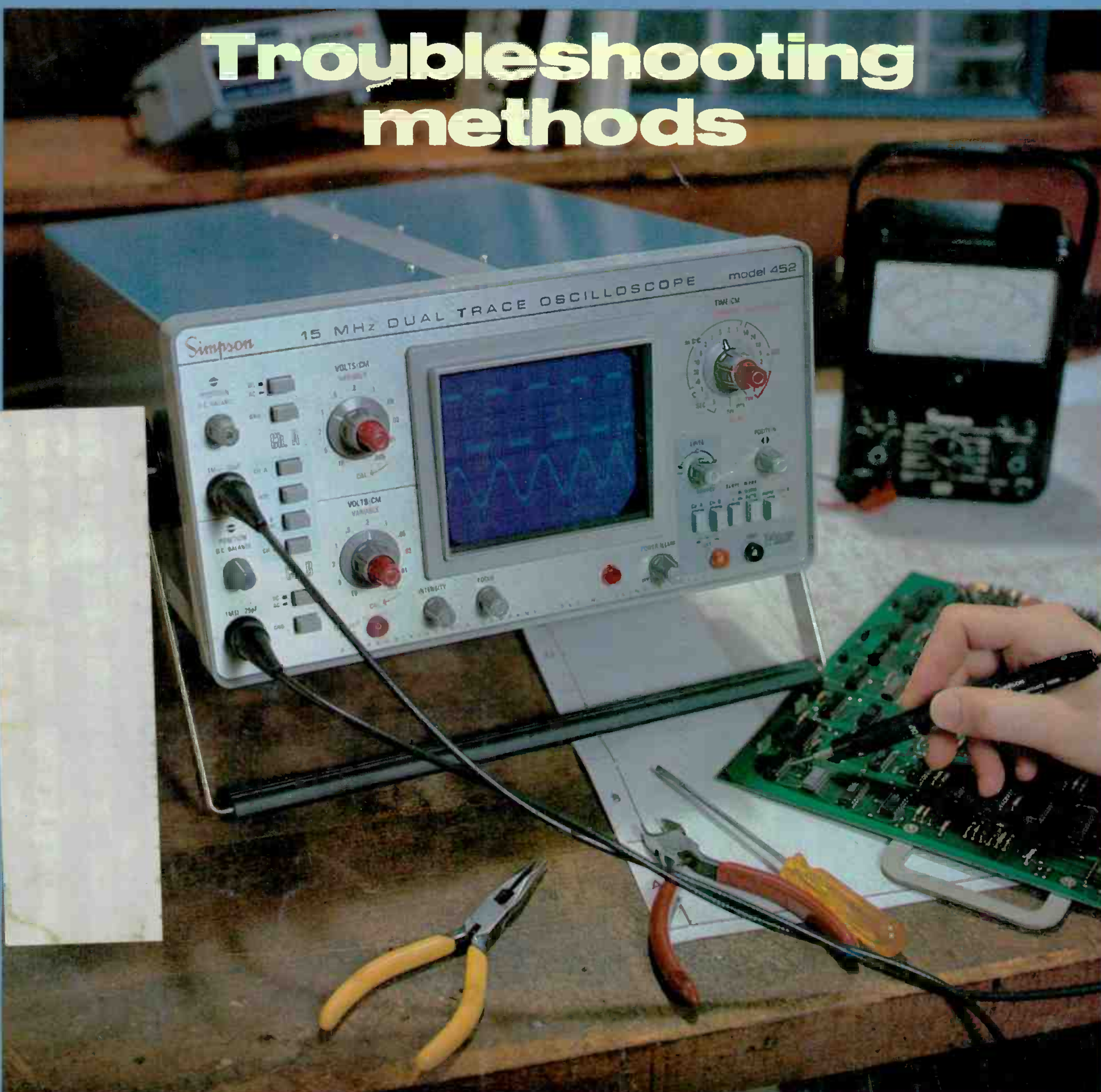
## Servicing & Technology

JULY 1983/$2.25

Simple servicing tips

Basics of CRT restoration

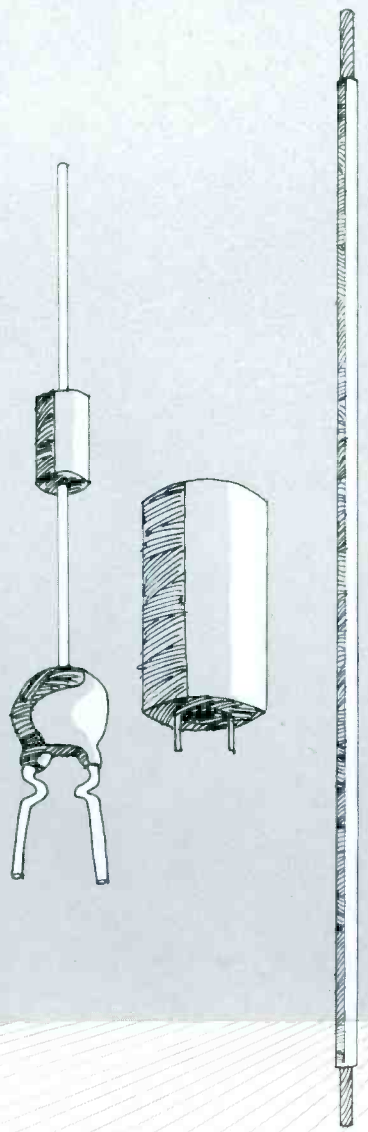
# Troubleshooting methods



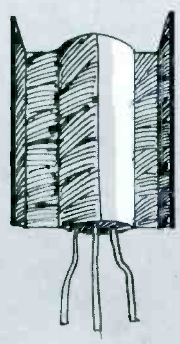
**PTS CORPORATION**
No. 8 in a series
Quasar MA to LA

# Module Update

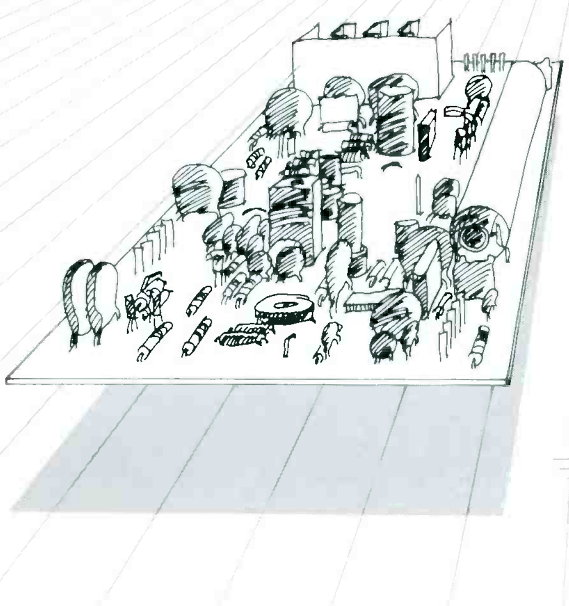
***The automatic addition of a regulator circuit in this color signal board automatically updates every MA to LA specifications.***



**A**utomatic updates are only one of nine steps in the PTS rebuilding cycle. After all updates and repairs are made every module is air tested in a live chassis and subjected to heat, cold and shock tests. You are assured of performance and reliability in actual use—backed up with a full year limited warranty.



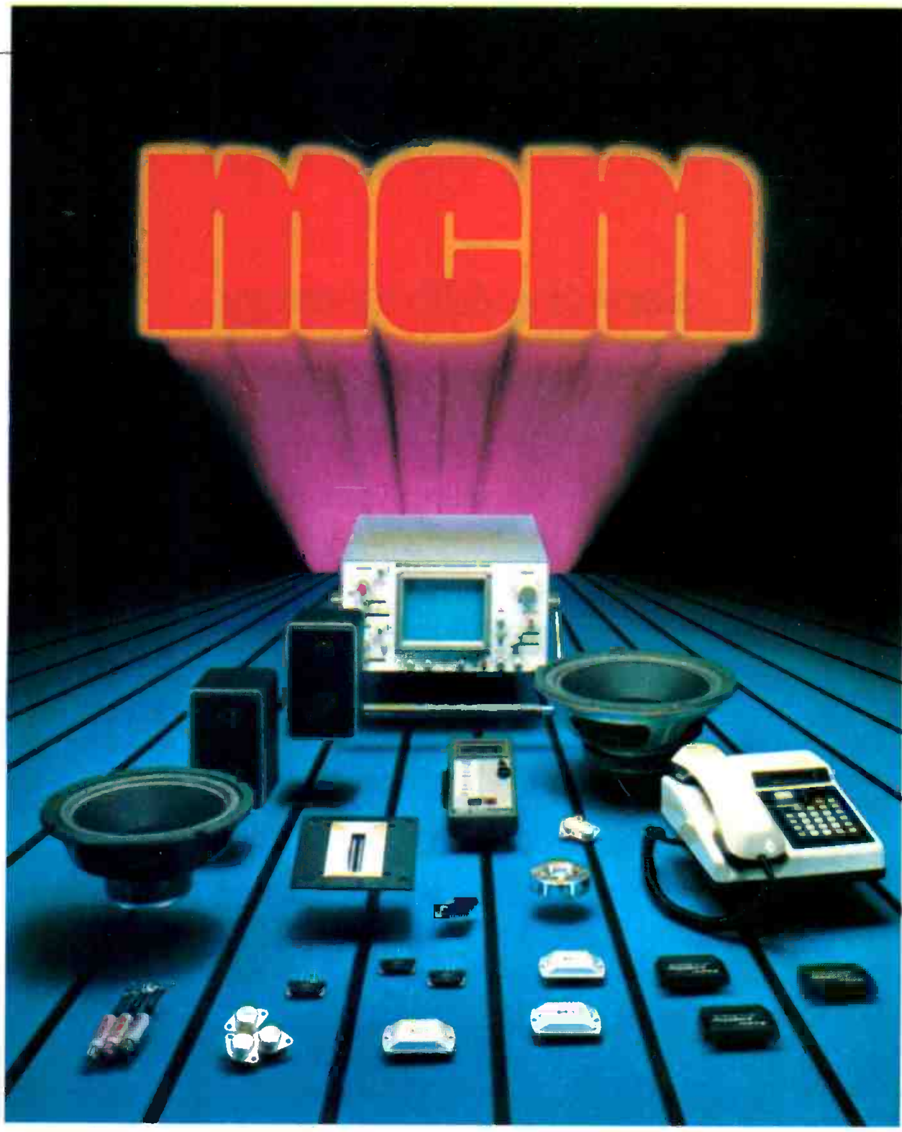
**T**his PTS automatic update improves both performance and availability. With universal parts, inventory requirements are reduced. And that means more of the modules you do need are available for immediate exchange.



**Y**ou'll find PTS quality rebuilt modules with automatic updates at over 1,500 locations nationwide. For the name of the location nearest you and your free copy of the PTS Price and Technical Information Guide, use the reader response card or write: PTS Corporation, P.O. Box 272, Bloomington, IN 47402.

PTS™ **PTS CORPORATION**

**Circle (1) on Reply Card**


mcm

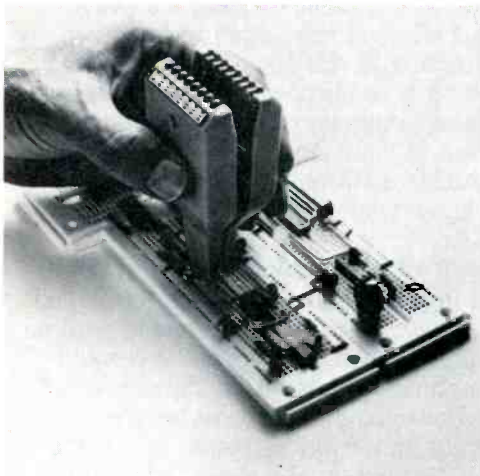
*The how-to magazine of electronics...*

# ELECTRONIC Servicing & Technology

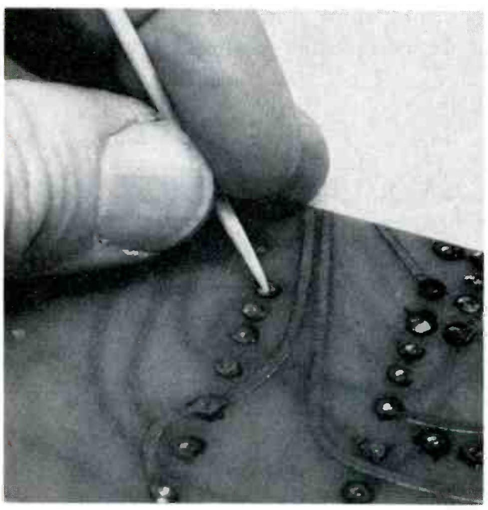
July 1983

Volume 3, No. 7


This Simpson model 452 15MHz, dual-trace oscilloscope is just one of the variety of instruments available for troubleshooting. See pages 8, 26 and 44 for articles on various types of troubleshooting. *(Photo courtesy of Simpson.)*



Page 26



Page 44

Page 50

# Departments



**Next month...**

**What's in the mystery package?** You may be able to service microcomputer-based products even if you don't know anything about microprocessors. This article explains how to pick a microcomputer's brain without spending a lot of money or study time.

# Editorial

## What's the trouble?

Troubleshooting lies at the heart of any electronic equipment servicing procedure. Just as a doctor can't effect a cure until he has accurately diagnosed a patient's disease, a servicer can't repair a piece of equipment until he's found out what's wrong.

Troubleshooting requires that a servicer bring several things to the task:

- A knowledge of circuit theory and operation of the equipment. The more you know about how a circuit should be operating, the easier it is to determine when it's not working right, and why.
- Test equipment. The nature of the problem will dictate what test equipment is needed. It may be as simple as a visual inspection or as complex as a multifunction oscilloscope.
- Manufacturer's servicing literature. No matter how much a servicer knows about general circuit theory, circuit schematics and product-specific information are invaluable in tracing circuit problems.
- Substitution components. In many cases, the best procedure to determine the faulty component is simply to substitute a known-good component and see if that cures the problem.
- Tools. The right tools are, of course, essential to disassemble the equipment, to remove and insert components, and so forth.

Sometimes a problem doesn't yield to straightforward troubleshooting procedures though, and the servicer has to resort to tricks. Or sometimes the needed circuit information or test equipment is not at hand and it's necessary to take a kind of backhanded approach to the problem.

This issue of **ES&T** brings you a number of tips, tricks and suggestions, that we think will help to pinpoint and correct a problem when other measures fail.

**Test your knowledge**

Research studies on learning invariably conclude that we quickly forget much of what we learn. That means we all need refreshers to reinforce our knowledge. Starting in this issue of **ES&T,** we will be publishing a series of quizzes, written by J. A. "Sam" Wilson, designed to help you keep your knowledge fresh in your minds. We hope readers find this a valuable addition to the magazine. Please let us know your feelings, one way or another.

**Mark your envelope, please**

While we're inviting your comments, let me ask you to do us a favor when you correspond with us. It would be helpful when you write if you could write the department you want on the outside of the envelope. For example, if you're having trouble with your subscription, please add *Att'n: Circulation* to the address. Likewise, add *Att'n: Reader's Exchange, Symcure, Troubleshooting Tips, Feedback* or *Features.* This will help us process the incoming mail, and will assure that your corrsependence is handled as quickly as possible.

Nils Conrad Persson

**ELECTRONIC Servicing & Technology**

Editorial, advertising and circulation correspondence should be addressed to: P.O. Box 12901, Overland Park, KS 66212-9981 (a suburb of Kansas City, MO); (913) 888-4664.



Member, Audit Bureau of Circulation

Member, American Business Press

ELECTRONIC SERVICING & TECHNOLOGY (USPS 462-050) (with which is combined Electronic Technician/Dealer) is published monthly by Intertec Publishing Corp., 9221 Quivira Road, P.O. Box 12901, Overland Park, KS 66212-9981. Second Class Postage paid at Shawnee Mission, KS 66201. **Send Form 3579 to P.O. Box 12952, Overland Park, KS 66212-9981.**

**ELECTRONIC SERVICING & TECHNOLOGY** is the "how-to" magazine of electronics. It is edited for electronic professionals and enthusiasts who are interested in buying, building, installing and repairing home-entertainment electronic equipment (audio, video, microcomputers, electronic games, etc.).

**SUBSCRIPTION PRICES:** one year $15, two years $26, three years $34 in the USA and its possessions. Foreign countries: one year $20, two years $30, three years $40. Single copy price $2.25; back copies $3.00. Adjustment necessitated by subscription termination to single copy rate. Allow 6 to 8 weeks delivery for change of address. Allow 6 to 8 weeks for new subscriptions.


ISSN 0278-9922

INTERTEC PUBLISHING CORP.

Circle (5) on Reply Card

# An electronic tutor

CAVIS (Computer Audio Visual Instruction System) is a teaching system that mixes videocassette pictures, audio, text and diagrams on a single TV screen. The student uses a keypad to respond to the TV display, and CAVIS adapts its teaching according to the response given. The system also logs the student's activity so the teacher can analyze the performance later.

Any existing training material on VHS cassette can be made interactive on CAVIS, and original material on film, slide and videocassette can also be transferred onto the system.

The basic system includes a cabinet with a microcomputer control and a VHS recorder, an alphanumeric editing keyboard for the teacher, a b/w screen printer, and a student keypad, color monitor and headphones. Optional equipment includes a page-size image printer, color image printer, TV picture videotex transfer unit, color TV camera, blank cassettes or discs for instructional programs and a telecine transfer unit.

Story and photo courtesy of British Information Services.

### Creating training material

The editing facilities built into CAVIS enable the user to create and revise training materials. No computer knowledge or keyboard skills are needed, and the screen displays messages to assist.

Text and diagrams can be typed into the system using the special color-coded keyboard and screen editing facilities. A screenful of such information is referred to as a page, and 200 of these pages can be stored on the presentation disc. These pages can be retrieved in half a second, which allows slow animation.

The trainer can add text and interaction to video sequences, and the sequences can be automatically reordered to suit the given training situation.

A new option for CAVIS enables conventional, high-contrast artwork to be captured by a TV camera and converted into a videotex image. CAVIS then accepts this image and stores it as a page.

### Course evaluation

CAVIS can provide a detailed graphical analysis of the student's performance that includes question responses, number of attempts for each question, and study-session duration. This information can also help the trainer discover which sections of the material are effective and which are defective, as well as which questions yield consistently correct answers and which are often answered incorrectly. With that knowledge, the trainer can continually revise the material.

# We've got it all together.







**Boker®**
**Crescent®**
**Lufkin®**
**Nicholson®**
**Plumb®**
**Weller,® Wiss®**
**Xcelite®**




Take a good look round this ad and you'll agree that "All together" is no exaggeration. Whether you're making or mending, cutting or joining, striking, measuring or stripping, there's a Cooper tool that's just right for the job. Don't take chances on tools. Specify Cooper and get 'em right the first time!

The Cooper Group PO Box 728 Apex NC 27502 USA Tel (919) 362-7510 Telex 579497

**CooperTools**

Circle (6) on Reply Card

# Search high & low

By Homer L. Davidson

**Tests of high- and low-voltage supplies should be the first priority in troubleshooting. Here are several examples from Ward's GGY chassis sets.**

As many as 80% of all problems in color TV receivers originate in the low-voltage supplies or the high-voltage systems, and obviously, other basic circuits cannot operate without dc power. Therefore, tests of these dc-voltage supplies should be the first priority during troubleshooting.

Ward's GGY models (Figure 1) operate from both rectified line power and rectified horizontal-sweep power. It is necessary, therefore, for technicians to understand which circuits receive power from these basic sources.

### Line-rectified power supplies

After it passes through a circuit breaker and the *on/off* switch, silicon-diode SC504 rectifies line voltage (Figure 2). Resistor R504 limits the charging surge of current and C520 is the input filter capacitor. Notice that this is half-wave rectification with 60Hz ripple superimposed on the dc voltage.

Power transistor Q502 is a series-type regulator. The Q500 regulator-driver transistor holds the base voltage of Q502 at a constant voltage, while Q502's base bias is determined by the adjustment of R514, which is called the *B+ adjustment* control. The 125V zener diode SC514 supplies constant voltage for control R514, and power for SC514 comes from the +164V source and the +146V source. The +164V source is rectified horizontal-sweep power, while the +146V source is rectified line power from SC504's cathode.

When the Q502 base voltage is held constant, any emitter voltage (+115V supply) variation, because of changing line voltage or fluctuating +115V-supply load, is a change of Q502's bias. Therefore,

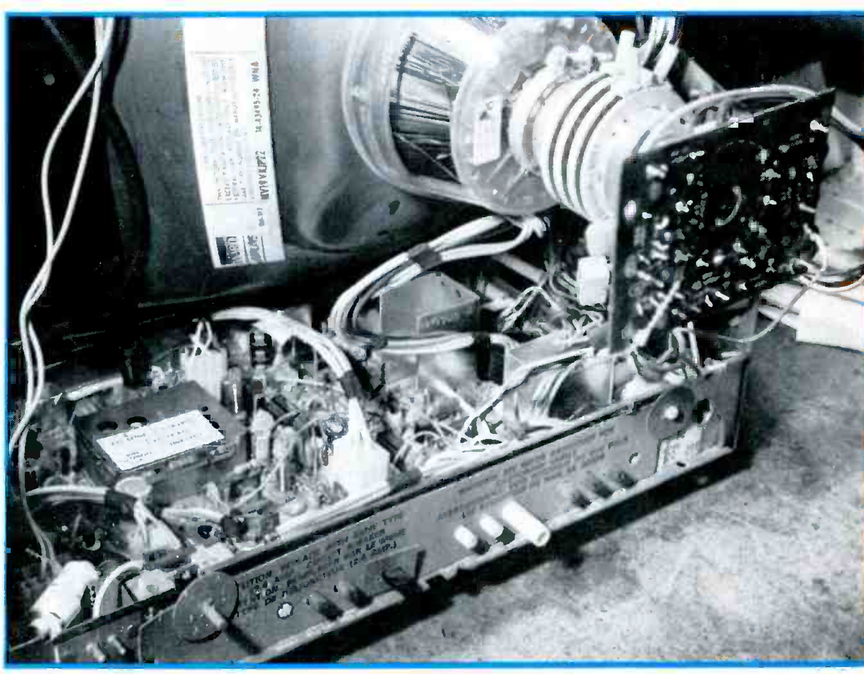


**Figure 1.** Most Montgomery Ward's GGY color receivers have the M25 chassis. Low-voltage components are at the extreme left in the picture, and the flyback and high-voltage tripler are at right.

# "I'll tell you what it takes to succeed in VTR repair service."

**"It takes know-how, and the right equipment to do the job. You obviously have the know-how, or you wouldn't be reading this magazine. The equipment? The same brand that factories use to build and test sets on production lines... LEADER!"**

## You need professional test equipment for a professional repair job.

Leader gives you test signal sources for every conceivable video and audio application – reliable and easy-to-use instrumentation that keeps you right on track. Audio sine/square wave generators cover 10 Hz to 1 MHz with low distortion.

To see what you're getting, Leader's LBO-517 50 MHz dual-trace oscilloscope is a natural. Put the input to a circuit on one trace, the output on the other, and actually see where distortion occurs, how much, and when it's corrected! You'll find more features on this oscilloscope than on many others regardless of price or manufacturer's claims. Or choose from a dozen other models.

The Leader frequency counter – in a rugged metal housing – can be used to adjust chroma frequency and vertical or horizontal synch circuits. Leader's large, bright fluorescent displays are easy to read. To round out your test bench, you'll need a wow and flutter meter, mirror-backed scale ac voltmeter, and a good quality field strength meter... all from Leader.

## With Leader, you've got what it takes...

... to do the job right and build a reputation as the person to see when problems develop. With Leader on your test bench, there's no limit to the jobs you can tackle, the service you offer... or the extent of your potential income.

## Two-year warranty. Evaluation units.

A history of high reliability permits Leader to provide a generous two-year warranty... backed by factory service depots on the East and West Coasts. A free, trial use of Leader instruments is available to all qualified companies.

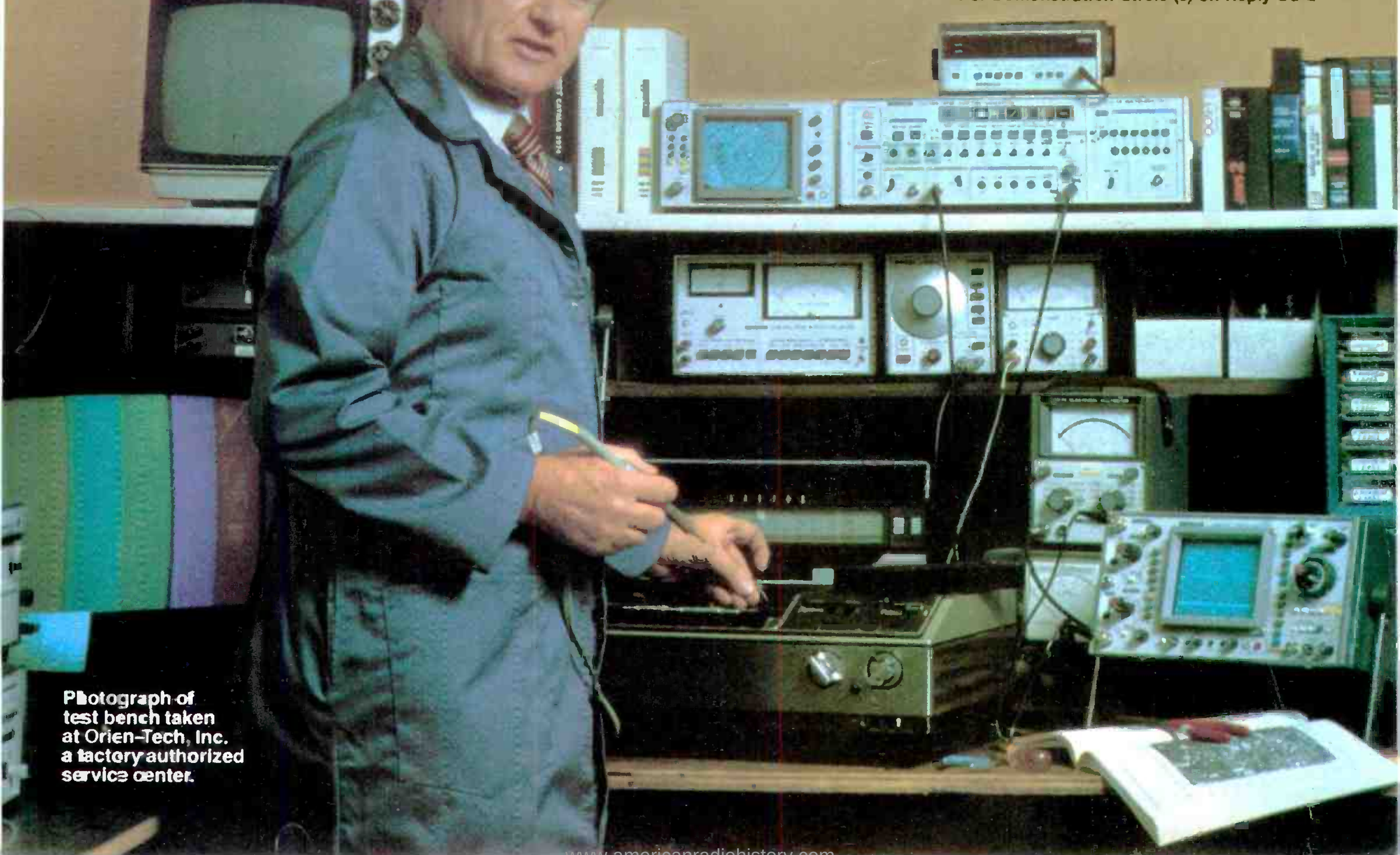
**Call toll-free (800) 645-5104 to request:** an evaluation unit, our 40-page catalog, the name of your nearest "select" distributor and additional information about how you can succeed in VTR Service.

## For VTR professionals who know the difference.

LEADER Instruments Corporation

380 Oser Avenue
Hauppauge, N.Y. 11788 (516) 231-6900
Regional Offices:
Chicago, Los Angeles, Dallas.

**For Information Circle (7) on Reply Card**
**For Demonstration Circle (8) on Reply Card**



Photograph of test bench taken at Orien-Tech, Inc. a factory authorized service center.

if the +115V supply voltage decreases, this is increased forward bias for Q502 that decreases its collector-emitter resistance. The lower resistance reduces the C/E voltage drop, increasing the +115V supply voltage. If the supply voltage increases, the action is reversed. The higher voltage is reduced Q502 bias that increases the C/E resistance, which reduces the voltage of the +115V supply.

Notice the 150Ω, 25W resistor (R526) that is paralleled between Q502's collector and emitter. The resistor adds a fixed resistance between collector and emitter that allows R526 to conduct some voltage and current to the +115V terminal, even when Q502 is cut off and has no C/E current. Although the voltage regulation of the +115V supply is good at the normal current, R526 allows the supply voltage to rise drastically if the current drain on the +115V supply is reduced to almost 0mA. This can happen if the horizontal-output transistor opens, or if another defect removes the B+ from the output transistor. You must remember this when you troubleshoot the regulated supply. Dropping a sample of the +115V supply through R404 and regulating the voltage with zener diode SC404 provides voltage for the horizontal oscillator.

There is no separate start-up circuit in the Ward's GGY chassis. Instead, the regulated +19.5V source (previously described) powers the horizontal-oscillator IC, and the 115V supply powers the horizontal-driver and horizontal-output transistors. In other words, the horizontal circuit should operate whenever the ac switch is turned on. Other circuits operate from dc voltages obtained by rectification of horizontal-sweep power. Of course, loss of horizontal sweep also eliminates all other low-voltage supplies.

Scope waveforms of the GGY regulator circuit are slightly different from those in other models. Ripple frequency at the SC504 cathode is 60Hz (not 120Hz as it is with a full-wave bridge) and the amplitude is higher (20VPP compared to many others having 3V to 4VPP). The addition of R504 between SC504 and its C520 filter capacitor is the cause. Also, on the SC504 cathode waveshape, the sawteeth have sinewave positive tips. The usual sawteeth are contributed by C520, the peak-reading input filter capacitor, while the sinewave tips are added by the 2.7Ω R504. Figure 3 shows several of these rectifier parts.

At the regulated +115V supply, a 59.95Hz (vertical-sweep frequency), 8VPP parabolic waveform is riding on top of the dc voltage. The parabolic waveform is added to the circuit at the Q500 base. After amplification by Q500, the waveform reaches the Q502 base and the regulated voltage at the Q502 emitter. The purpose of the parabolic waveform is to correct for side pincushioning distortion of the raster.

You must remember these unusual waveforms when troubleshooting with waveforms, or these variations from the norm might be mistaken for defects.

### Rectified horizontal-sweep supplies

Several sweep-rectified supplies are shown in Figure 4. Silicon diode SC530 rectifies horizontal power from terminal 23 of the T400 flyback transformer. C530 then filters the power to yield about +29.3V. Several lower voltages are derived by decoupling with resistor/RF-chokes and bypass/filter capacitors.

Transistor Q504 continuously monitors current from SC530. When the current exceeds a certain value, Q504 and SCR430 eliminate all horizontal sweep, which in turn stops all dc power coming from rectification of horizontal power (Figure 6).

The +164V supply (for the color power transistors that drive the CRT) is produced in two steps (Figure 5). The pin-21 end of the flyback winding usually is grounded, but in this circuit, it connects to the regulated +115V supply. Therefore, the output at diode SC510 is the sum of +115V and about +49V from the scan rectification of SC510. If the winding had no ac signal, the output of SC510 would be about +114.4V (+115V minus 0.6V diode drop), because the polarity of SC510 permits current to flow from the +115V supply. But SC510 rectifies the winding pulse waveform and that dc voltage is added in series with the +115V.

### Horizontal driver and shutdown

IC400 contains the transistors used in the horizontal-oscillator circuit (Figure 6). L418 has an adjustable core that is used as the horizontal-hold control. Horizontal-frequency square waves come from IC400 pin 15, and resistors R438 and R430 are the load resis-

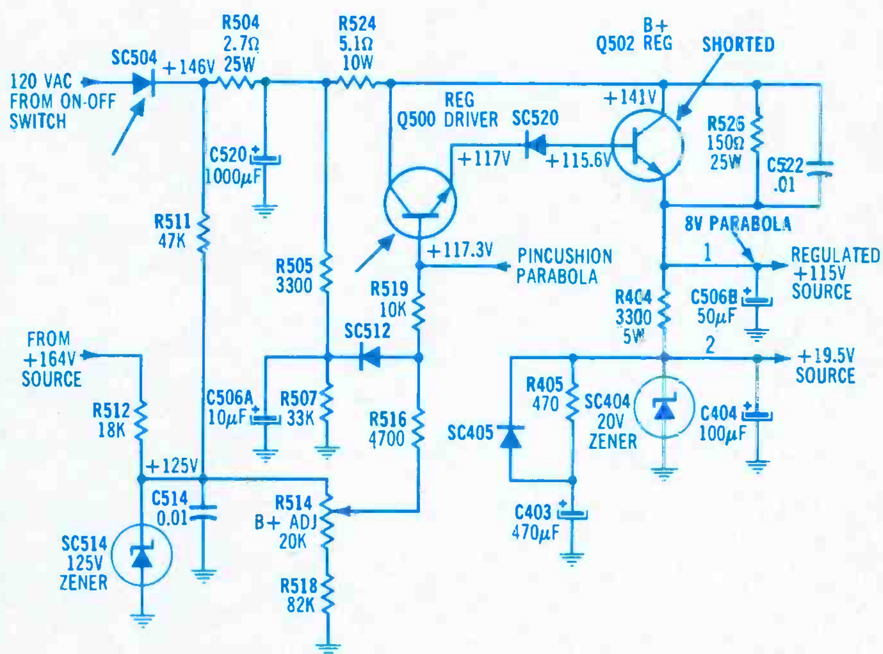
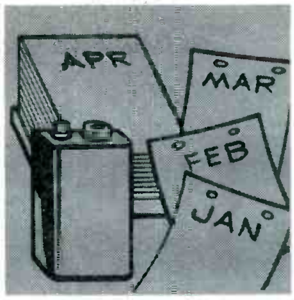



**Figure 2.** A single diode (SC504) rectifies line-voltage power, which C520 filters. The Q500/Q502 regulator produces +115V for the horizontal-output transistor. These components have caused several failures: diode SC504, regulator driver transistor Q500 and regulator transistor Q502.

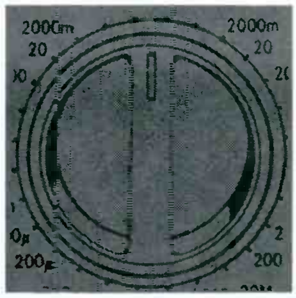
YOU SELECT FULL MANUAL
OR FULL AUTORANGING

500 HOUR BATTERY LIFE

HIGH CONTRAST LCD
SHOWS MEASUREMENT
AND FUNCTION

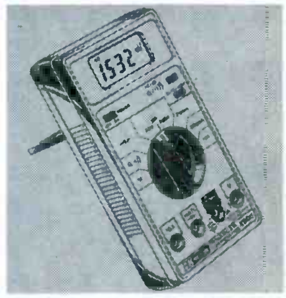




0.25% dc volt accuracy
Continuity beeper
Diode test
Transient and overload protected
High energy fuse



EASY TO USE... RELIABLE
SINGLE-ROTARY
CONTROL SWITCH

OTHER NEW
DMM MODELS
PRICED
FROM
$75.00




# New! A digital multimeter that lets you choose autoranging convenience or manual control

MODEL 2816
$150.00

To learn more about the 2816 and the complete line of new B&K-PRECISION DMMs, see your local distributor or call (1 312 889-9087).

B+K PRECISION DYNASCAN CORPORATION

6460 West Cortland Street • Chicago, Illinois 60635 • 312/889-9087

International Sales, 6460 W. Cortland St., Chicago, Illinois 60635
• Canadian Sales, Atlas Electronics, Ontario
South and Central American Sales, Empire Exporters, Plainview, NY 11803

Circle (9) on Reply Card

tors that bring in voltage from the +19.5V supply. Notice that the +19.5V supply comes from the line-voltage-rectified +115V supply. This is necessary for immediate operation of the horizontal-sweep circuit so the sweep-rectified supplies can operate also.

Two resistors (R430 and R438) make up the oscillator output load. Two are needed because of the SCR430 shutdown operation, which is described later.

Horizontal-rate square waves from IC400 pin 15 go through R440 and coupling capacitor C438 before reaching the Q400 horizontal-driver transistor's base. Notice that the Q400 base has no positive forward bias provided by a resistor from a positive voltage. Instead, the base and emitter function as a diode to allow shunt rectification. C438 is the input capacitor, the Q400 base acts as a diode anode and the emitter acts as a diode cathode that produces an average *measured* negative dc voltage at the base/anode. This action explains the −0.7V reading at Q400's base, which normally must have a positive bias relative to the grounded cathode. In other words, the oscillator square waves are shunt rectified, so when the Q400 base signal is eliminated by the SCR430 shutdown operation, the base has zero ac and zero dc voltages. Therefore, it draws zero collector current, and the horizontal-sweep circuit cannot operate.

When a normal square-wave amplitude reaches the Q400 base, the positive peaks function as a temporary forward bias that produces saturation collector-to-emitter current and high-amplitude square waves at the T440 driver-transformer primary. Thus, the T440 secondary applies drive signal to the horizontal-output transistor base, producing horizontal sweep and high voltage.

Next, we turn to the combined overvoltage and overcurrent monitors for the shutdown operation. Current from the +29.7V supply flows through resistor R532. The resulting R532 voltage drop goes through R536 and R534 to the base and emitter of Q504, the PNP current-sensor transistor. During normal current operation, Q504 has about 0.4V of forward bias, which is not sufficient for the production of collector current. Therefore, none of the emitter positive voltage travels to the collector, which is connected through R436 to the SCR430 gate, so the Q504 collector and the SCR430 have zero voltage, and the SCR cannot conduct. The signal from the oscillator reaches the Q400 base.

Increased current drain on the +29.3V supply raises the voltage drop across R532, and this increases the negative forward bias of Q504. When Q504 conduction begins, the collector current flows through 100Ω R437 and produces a positive voltage drop that passes through R436 and charges storage capacitor C432, which is connected between the SCR430 gate and its grounded cathode. When the gate voltage becomes sufficiently positive (around +0.7V or so), the SCR conducts and keeps on conducting until the television is shut off.

SCR430 conduction removes the supply voltage from the IC400 output pin 15, so no square waves are present at that pin or the base of Q400 horizontal driver. Because SCR430 is connected between the 1200Ω resistors R430 and R438, the short by SCR430 does not overload the +19.5V supply. Also, sufficient current flows through R430 to keep the SCR latched after a positive gate voltage triggers it. Therefore, once an overcurrent triggers SCR430 into conduction, the SCR conduction continues to eliminate the horizontal sweep until someone turns the receiver off and back on later.

When the flyback pulse amplitude is excessive, pulses from a flyback winding pass through coil L434 to zener diode SC434's cathode. If the pulse amplitude is less than the zener voltage, the zener passes no voltage or current. But when, because of a defect, the flyback voltage exceeds the zener voltage, the excess voltage passes through SC434, where it is rectified by diode SC435, and the

**Figure 3.** Several power-supply components are identified. Arrows at the top point to (from left) R526, R524, R504 and regulator-transistor Q502. Diode SC504 is identified by an arrow at the bottom.

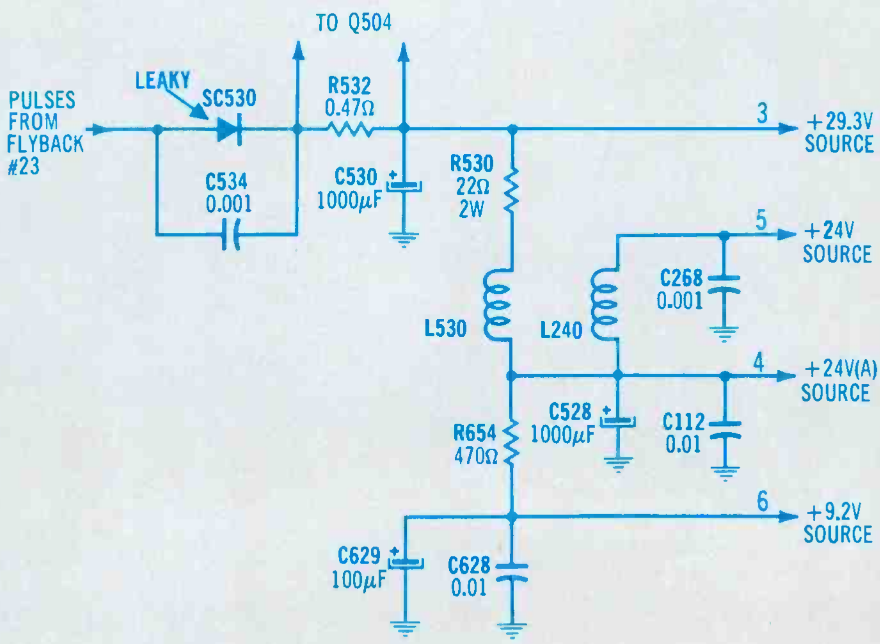



**Figure 4.** Four voltage sources come from the +29.3V sweep-rectified voltage. Diode SC530 has shorted or become leaky in several cases.

# The Smarter Thinking Cap™

Global Specialties Corp. 1973 10th Anniversary 1983

Now — a smarter way to measure capacitance!
Global Specialties' New
3002 AUTORANGING CAPACITANCE METER

Use the Thinking Cap™ to determine true capacitance in cable, switches, components, hardware and naturally, capacitors. From 1 pF to 19,990 µF, the 3002 provides highly accurate, uncomplicated capacitance measurement. In the lab or in the field . . . for quality control, production, inspection, design, or systems installations . . . You can rely on the Thinking Cap™. And THINK about this — at only $210 the 3002 is a SMART buy! Grab the telephone and call us TOLL FREE to find out how to get your Thinking Cap™ today!

- Handheld, battery-operated
- Measures capacitance from 1 pF to 19,990 µF
- 8 automatically selected ranges
- Typical 0.2% accuracy
- 3½ digit, 0.5 inch LCD display
- LED range indicators


## SPECIFICATIONS

| | |
|---|---|
| **Ranges:** | 8 automatically selected ranges from 1999 pF to 19.99 mF (full scale) |
| **Resolution:** | 1 pF in lowest range, 0.05% of full scale on all other ranges |
| **Accuracy:** | 0.2% of reading ± 1 count ± 1 pF from 1 pF to 199.9 µF; 1.0% of reading ± 1 count from 200.0 µF to 19.99 mF |
| **Display:** | 3½ digit, 0.5 inch LCD, low battery (LOBAT), over compensation indication (−), and 4 LEDs to indicate pF, nF, µF, and mF |
| **Reading UpDate Time:** | 350 ms to 19.99 µF, 200 ms to 1.25 s from 20 µF to 20 mF |
| **Controls:** | POWER (ON/OFF) switch, ZERO calibration adjustment to null out stray capacitance up to 100 pF |
| **Test Technique:** | Measures ΔT/ΔV (Dual Threshold slope integration) |
| **Power:** | 6 AA Alkaline or Nicad batteries or optional AC Adapter/Charger, 16 hours continuous use |
| **Dimensions:** | (LxWxH) 7.6x3.75x1.72 inches (193x95x44mm) |
| **Weight:** | 12 oz. (340 grams) without batteries |

**GLOBAL SPECIALTIES CORPORATION**

70 Fulton Terr., New Haven, CT 06509 (203) 624-3103 TWX 710-465-1227

OTHER OFFICES

San Francisco (415) 648-0611, TWX 910-372-7992,
Europe: Phone Saffron-Walden 0799-21682, TLX 851-817477

**Call toll free for details 1-800-243-6077 during business hours**

Circle (10) on Reply Card

positive voltage produced is stored in C432. If the C432 positive voltage exceeds the level needed to trigger the SCR430 gate, SCR430 conducts and eliminates all horizontal sweep, high voltage, and all dc-voltage sources that are produced by rectification of flyback signals.

Incidentally, some early-production M25 chassis produced low voltages of slightly different levels than those shown here. These voltages differ by only one or two volts, so it is not a serious problem. Also, a 123V SC433 zener diode in series with a 8.2KΩ R433 was added in each of a few M25 chassis.

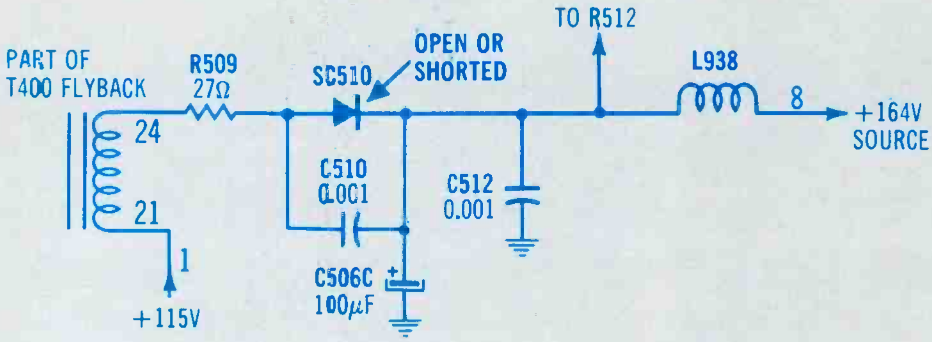



**Figure 5.** The +164V supply is produced by addition of the +115V source plus rectification by SC510 of sweep power from the flyback. Diode SC510 has a fairly high rate of failure. Always use a fast-recovery type of replacement diode.

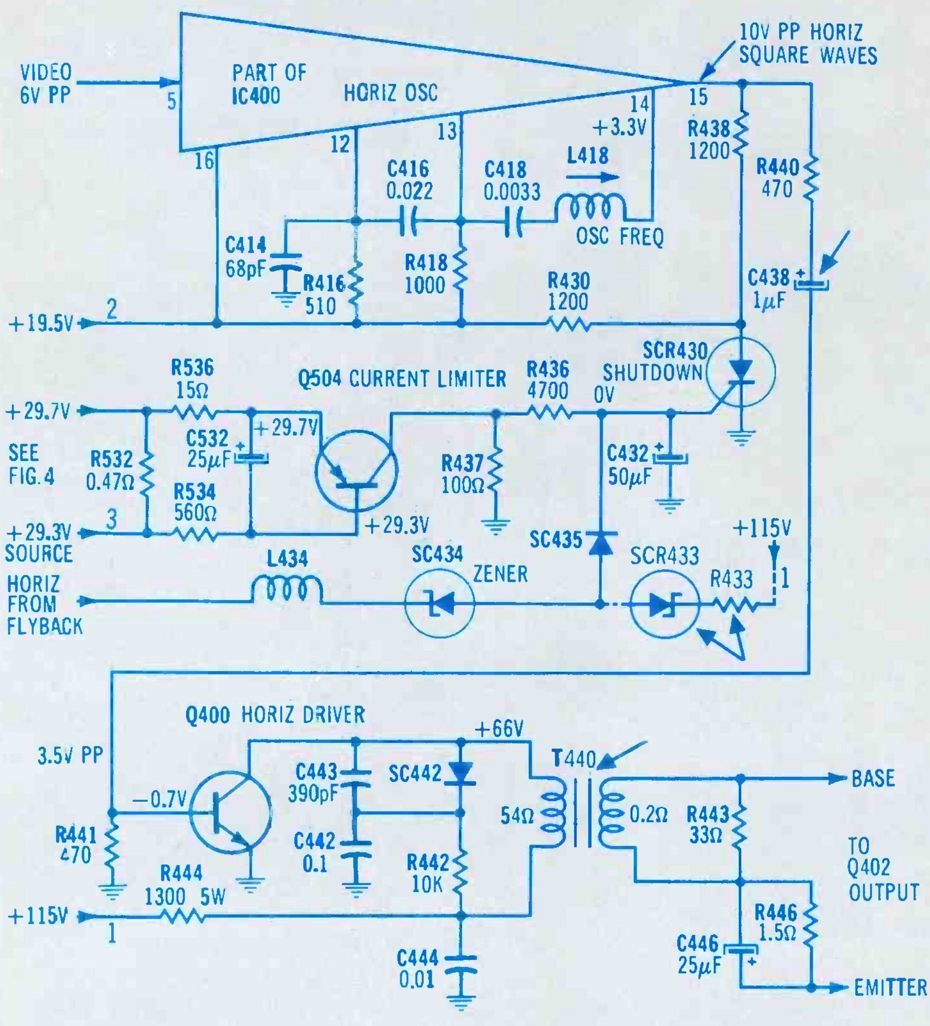



**Figure 6.** Square waves from IC400 horizontal oscillator are supplied to the base of Q400 horizontal-driver transistor when shutdown SCR433 is not activated. Overcurrent of the +29.3V source or excessive pulse amplitudes at the flyback trigger-on SCR430, which then grounds the junction of R430 and R438 to remove Q400's base signal (killing the horizontal sweep).

### Horizontal output and flyback circuits

Figure 7 shows a schematic of the horizontal-output transistor, yoke, flyback primary windings and the boost dc-voltage supply. One major difference from other models is that the horizontal-output transistor drives *two* flyback windings, one from the collector and one from the emitter.

Some surprising waveforms can result from these dual primary windings. For example, if you have a habit of scoping the Q402 horizontal-output transistor base drive *between base and chassis ground,* the drive might appear to be 400VPP negative-going pulses. Of course, that is impossible; you must test in another way. Both base and emitter of Q402 have the same large pulse signal relative to ground because they are connected together by the small inductance of the T440 driver-transformer secondary and the R446/C446 bias network. Actually, the base drive is between the base and emitter, then the emitter connects to a flyback winding (so the emitter power aids the collector power and its winding).

The only safe method of testing the Q402 drive is to remove Q402 and hang the scope with its hot probe at the base and the scope ground to the emitter.

There are no surprises in the wiring of the tripler, high-voltage, focus and automatic-brightness-level (ABL) circuits (Figure 8).

### Troubleshooting

Most of the GGY Ward's receivers have M-25 "hot" chassis; one side of the incoming 120Vac line is connected to the metal chassis framework. Add an isolation transformer (not an autoformer) between the 120Vac line and the receiver's power plug before any test instruments are attached to the chassis. Sparks can fly and components can be ruined if this precaution is not observed.

In addition to the high-voltage and focus supplies for the picture tube, GGY receivers each produce 10 low-voltage dc-voltage supplies.

The regulated +115V (+113V in a few chassis) is power for the horizontal-driver and horizontal-output transistors. The +115V source produces the zener-regulated +19.5V supply, and it powers the horizontal-oscillator IC. These two supplies come from rectification of 60Hz line power.

Rectification of horizontal-sweep power from the flyback transformer produces eight other dc sources. Some are derived by resistor or inductive decouplings. The following list of supplies includes the major circuits powered by each one:

- (CircuiTrace #3) This +29.3V source powers the audio-output transistors, the vertical-oscillator and driver IC, and two vertical-output transistors. Excessive current here can activate the shutdown operation.
- (CircuiTrace #4 and #5) These four +24.2V sources (separated only by one RF choke and wiring interlocks) power chroma and demodulator ICs, sound-IF and sound-driver transistors, the IF IC, three IF AGC transistors, two AFC transistors, and five video transistors.
- (CircuiTrace #6) The +9.2V source supplies pin 14 of chroma-processing IC600.
- (CircuiTrace #8) This +164V source supplies the vertical-height control and the red, blue and green output-amplifier power transistors that drive the CRT cathodes.
- (CircuiTrace #7) The +890V boost supply is filtered and applied to the higher voltage ends of the three CRT screen-grid controls.

A detailed knowledge about these dc power sources and the circuits that they supply can be of immense value when analyzing symptoms during troubleshooting.

The following actual case histories show how this circuit-operation theory is used in practical servicing.

**No sound, no raster or HV**

Loss of horizontal sweep removes all sound because rectified horizontal sweep powers the sound. Therefore, a total loss of horizontal deflection must be the first suspect for the above symptoms. Two quick scope waveforms proved the lack of horizontal signals at the Q400 driver collector and the Q402 horizontal-output transistor collector. The dc-voltage readings also proved both collectors had excessive supply voltages.

These measurements had reduced the possibilities to only two:

- A defect (or defects) in the horizontal-sweep system (perhaps the horizontal oscillator) was eliminating the sweep and high voltage. A shorted output transistor or damper diode was not possible because the breaker was not tripped.
- Excessive +115V supply voltage or excessive current on the +29.3V supply was causing shutdown of the horizontal sweep.

An analysis of the +115V regulated supply voltage was in order. The voltage measured almost +145Vdc, so shutdown seemed certain. If shutdown or failure of the horizontal oscillator removed all load (Q400 driver and Q402 output transistors), the +115V supply should have risen to only about +130V (although Q502 in Figure 2 is not conducting, R526 allows some voltage and low current to pass on to the so-called +115V supply).

Removal of the shutdown SCR430 (Figure 9) and subsequent operation with normal line voltage would have proved or disproved a shutdown condition in a hurry, but this could be dangerous to the television. Of course, the regulator circuit for the +115V supply regulates the picture width and the high voltage by varying the B+ voltage that is applied to the Q402 horizontal-output transistor. With excessive supply voltage from a regulator defect, the abnormal high voltage might ruin a

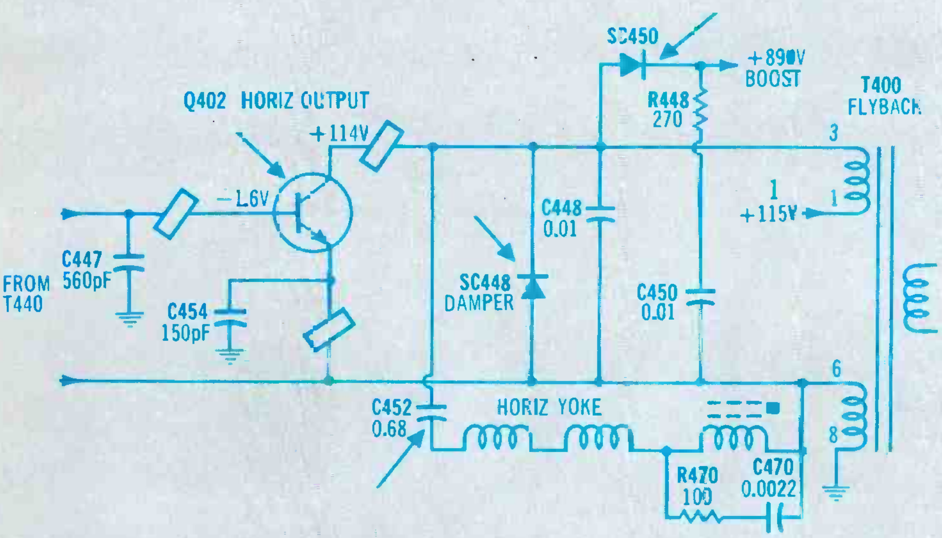



**Figure 7.** This partial schematic shows the complete horizontal-yoke wiring and the two flyback windings that the collector and emitter current of horizontal-output transistor Q402 power.

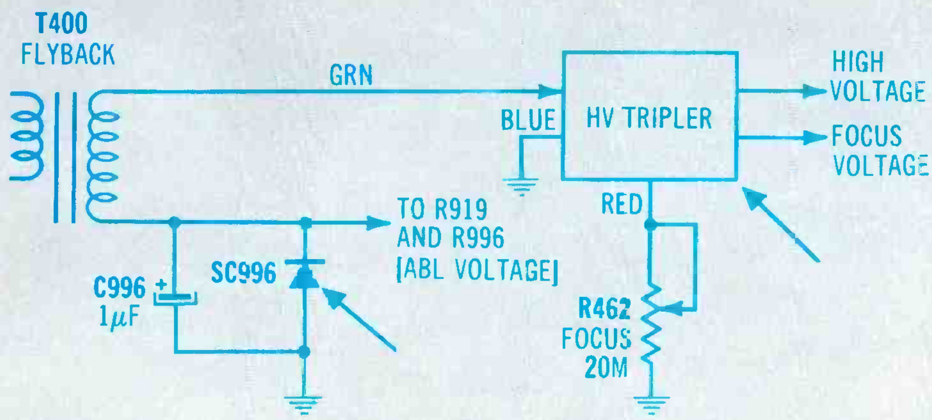



**Figure 8.** The high-voltage tripler and diode SC996 have the highest failure rate of any high-voltage components.

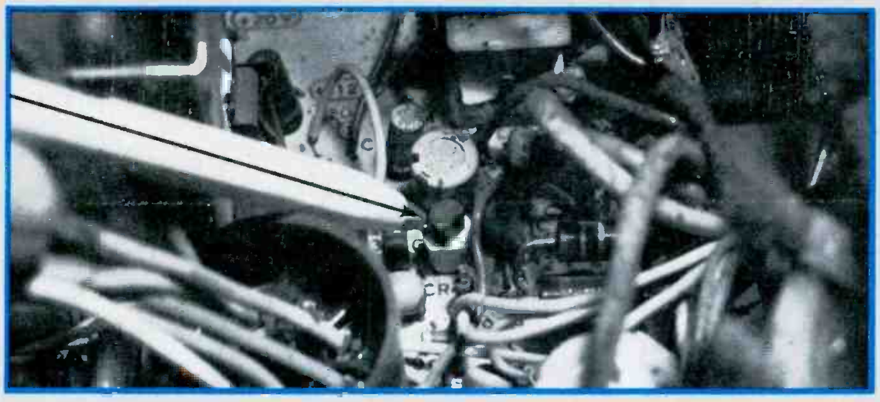


Figure 9. A pencil (with superimposed arrow) points to SCR430 in its socket. When the gate is triggered, SCR430 removes the base signal from driver Q400.

flyback, a yoke or a picture tube. Of course, it usually is safe to remove SCR430 after the line voltage is reduced to about 90Vac, because this should drop the high voltage by about 25%.

I decided a low-voltage regulator defect was likely and tested components there. Power transistor Q502 (Figure 2) was normal, but drive transistor Q500 was shorted between collector and emitter. The Q500 short applied saturation bias to Q502 at all times, resulting in an actual +115V supply of +140Vdc. Of course, the excessive supply voltage caused increased pulse amplitude at the flyback, which in turn triggered the shutdown circuit and eliminated all horizontal sweep.

Of course, after any regulator component is replaced, rotate the regulator B+ adjustment (R514) to provide +15V at the regulator output.

### Normal HV, no raster

There was an electrostatic pull on the picture tube's screen, and the high voltage measured more than 26kV, but there was no trace of a picture or raster. Also, there was no sound from the speaker of the GGY-16205A model.

Knowing that video-circuit defects can remove the raster, I first intended to test the video stages. Then I remembered the dead sound. A video defect does not remove the sound, unless it is a serious short that kills the common supply voltage. That line of thinking directed my attention to the power supplies, and only a few minutes were required to prove the +29.3V source was zero. Of course, the other supplies derived from that one were missing also. Rectifier SC530 (Figure 4) checked shorted during a series of ohmmeter tests. A suitable fast-recovery replacement brought back sound and picture.

### No horizontal-sweep

The loss of all functions except line-voltage rectification seemed identical to a failure of the startup step, but these GGY receivers do not have a startup circuit.

Therefore, I suspected a failure in the horizontal-sweep circuits. A shortcut for checking these circuits is to scope the Q400 collector (a convenient halfway point). Normal-amplitude square waves prove the circuit is not in a shutdown mode, but it is working correctly up to this stage. A total lack of signal at collector and base indicates a horizontal-oscillator failure or a shutdown condition.

In this case, the Q400 collector had no pulses or dc voltage, although the Q400 base was supplied with normal squarewaves. Therefore, shutdown had not occurred, but something was removing the Q400 dc voltage. Ohmmeter tests located an open primary winding in driver-transformer T440, and installation of a new transformer restored operation of the receiver.

I have found these open driver transformers in several of the M25 Ward's chassis. Also, it is advisable to check for leakage in the Q400 driver transistor.

### Intermittent operation

Almost any component in the horizontal system can cause erratic operation. Perhaps the best method is to connect a scope probe to a halfway point in the sweep system and wait until the intermittent occurs again. If the scope waveform remains after the picture disappears, the problem is further downstream. If the scope waveform and the TV picture disappear at the same time, the problem is upstream, toward the horizontal oscillator.

After many hours of time tests at several locations of the scope probe, the problem was pinpointed between IC400 pin 15 and the Q400 driver-transistor base. Alternate heating and cooling of those few components showed coupling capacitor C438 (Figure 6) was the intermittent component, and installation of a new capacitor stopped the erratic operation.

### Conditions causing shutdown

Two general conditions can cause activation of the shutdown circuit. One involves excessive pulse amplitude from the flyback winding that supplies the CRT heaters or excessive current on the +29.3V supply. The other possible cause is a defect in the shutdown circuit itself.

A GGY-16218A Ward's television had all the symptoms of shutdown. The dc voltages at collectors of Q400 and Q402 were too high, and no signal waveforms were present at either transistor. Removing SCR430 and applying line power for a short period of time produced normal operation, so shutdown seemed certain.

Some GGY receivers include zener diode SC433 and 8.2k R433 resistor installed in a spaghetti-type insulation and connected under the circuit board between the SC435 anode and the +115V supply (Figure 6). Both components were badly burned. When I disconnected them from the board and replaced the SCR430, the receiver operated normally without excessive high voltage. Most GGY receivers do not have these two components, so I omitted them in this case because I didn't note any deficiencies in operation. Perhaps they formed a backup clipping safety circuit.

Incidentally, an open C448 retrace-tuning capacitor (Figure 7) is one of the few component defects that can increase the high voltage and the flyback pulse amplitude enough to activate the shutdown circuit. Always check the capacitance of C448.

### Circuit breaker trips

The most likely causes of immediate tripping of the circuit breaker (when the receiver first is switched on) are a shorted SC504 line rectifier (Figure 2), a shorted Q402 horizontal-output transistor or a shorted SC448 damper diode.

A good shortcut is to remove the Q402 output transistor from its socket and notice if the breaker holds. If it does, the problem is in the horizontal-sweep circuit. If the tripping continues, the problem probably is located in the main power supply (Figure 2).

Continual tripping of a breaker sometimes weakens it. Therefore, while the breaker contacts are open following a previous tripping, it is helpful to connect a 100W light bulb across the breaker terminals. Damage to the breaker is prevented, and dangers of damage to the television are minimized by the current limitation of the bulb's varying resistance, while the visible light it emits can indicate the amount of current.

Other common causes of overload that trip the breaker are arcs or leakage inside triplers (Figure 8). Unsolder the tripler input wire coming from the flyback. If that relieves the overload, the tripler is defective and should be replaced. A dusty tripler is pictured in Figure 10. ES&T

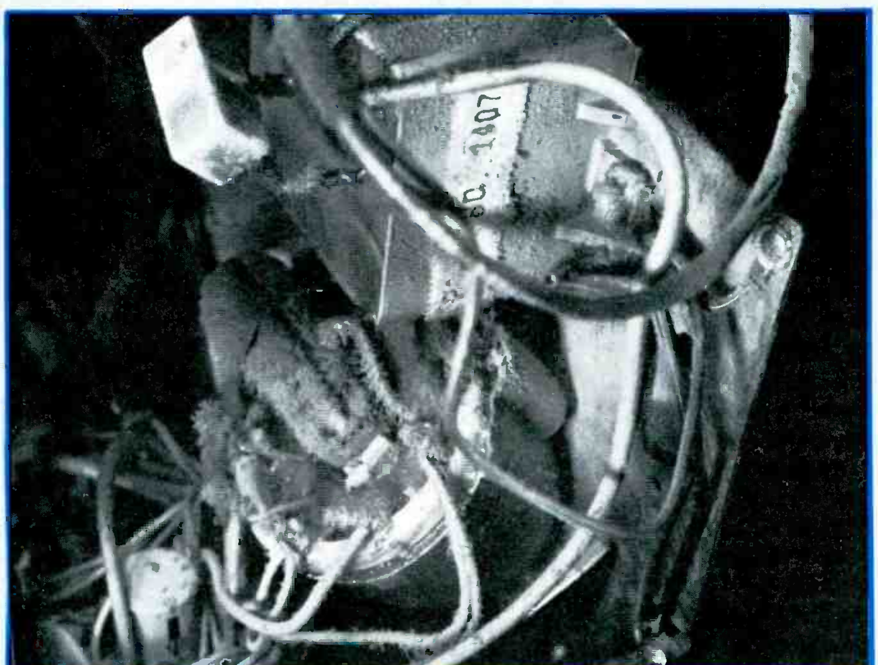


**Figure 10.** The high-voltage tripler is at the top, and the flyback is the large round object near the bottom. Notice the dust and dirt, which are fire hazards around high-voltage circuits.

# News

## Certification program available for audio-visual servicers

There is a gap in the service area of the Audio-Visual industry due to the limitations of established training programs. Technicians have had no scale on which to measure their skills and no level of achievement to aim for within their profession.

The Association of Audio-Visual Technicians (AAVT) has announced the beginning of the Certified Audio-Visual Service Engineer program (CAVSE).

The CAVSE program will give technicians goals to achieve in two sections. The first is a set of qualification points based on years of experience, writings and seminar attendance. The second part is a 200-question exam covering the service of still projection equipment, video, 16mm and 8mm projectors, tape recorders, sound systems, phonographs and basic electronics. Successful applicants must score a minimum of 50% on each section and 80% overall to pass.

This program is open to AAVT members and non-members. For information contact AAVT, P.O. Box 9716, Denver, CO 80210; 1-303-698-1820.

## Home computers to win in electronic game market

Traditional video game consoles and software sales growth will moderate markedly in the 1983-85 period as low-price home computers and entertainment/game software make inroads into their market, according to a new analysis from Frost & Sullivan.

Based on a retailer survey, the report predicts an average annual current dollar growth rate of 55 to 75% for home-computer hardware over the next two years and 60 to 85% for home computer software. Programmable video-game console sales will rise 20 to 30% a year and the cartridges to be played on them will rise 35 to 50%.

A much sharper curtailment may be taking place in the coin-operated electronic video game market. Unit sales are expected to fall 32% in 1983. Operator revenues will drop steadily from $7.0 billion in 1982 to $4.6 billion in 1987.

## Philips ECG introduces new warranty on picture tubes

The Distributor & Special Markets Division of Philips ECG has announced a change to its lifelong warranty program on Sylvania color picture tubes.

All Sylvania Color Bright 85 and all new AA picture tubes will now carry an inboarded 2-year limited warranty, with a lifelong warranty label option.

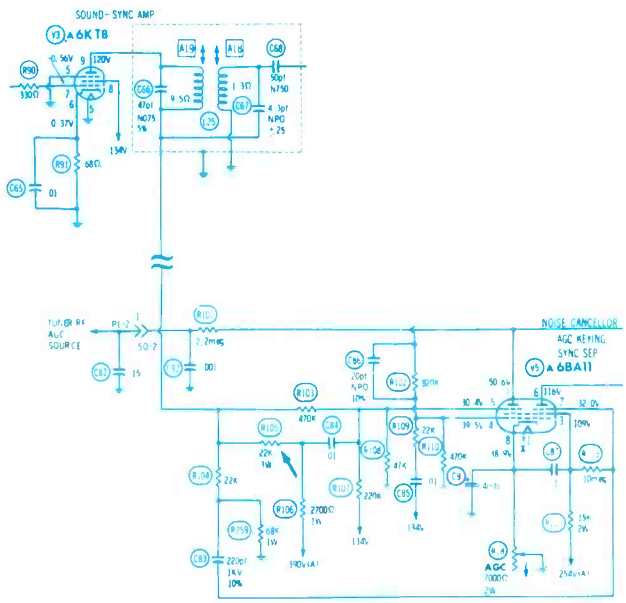
For further information on the program, contact your local Philips ECG representative, or Philips ECG, Product Marketing Department, 50 Johnston Street, Seneca Falls, NY 13148. ES&T

# Troubleshooting Tips

### No locking
### Zenith 14A9C50
(Photofact 1097-3)

Tube substitutions, AGC adjustments and other tests could not lock either the vertical or horizontal sweep. Usually, this symptom indicates a defect in the sync separator. Noise-cancellor, AGC-keying and sync-separation functions are handled in one V5 6BA11 tube, so those circuits seemed to be an excellent place to begin tests. Voltages at pin-2 plate, pin-6 plate, pin 4 and pin 5 were about half of the usual values. These readings indicated a problem, but did not show where it was.

In this Zenith chassis, the output of the third IF transistor is divided between the usual video detector transformer and diodes X10 and X8. These diodes demodulate the composite video. The demodulated signal is filtered into sound-IF signals and a video signal that is applied to the 6BA11 pin 5 for control of the AGC keying and sync separation function. The pentode half of 6KT8 V3 operates as a sound/sync amplifier, while the triode section functions as a sound-IF amplifier. I suspected the signals were correct at these stages because the sound was normal.



Further tests, however, pointed to that area, so I began to test all dc voltages at the V3 socket. The pin-8 voltage was within tolerance, but when the meter probe touched pin 9, the sound was killed, and the meter read 0V. Checking back through the circuit, I found an open R105, a 22KΩ, 3W B+ resistor. I replaced R105 along with tubes 6KT8 and 6BA11, which showed some leakage. The receiver now had locking, and routine adjustment of the AGC control produced a good stable picture. A long heat run produced no change in the normal performance.

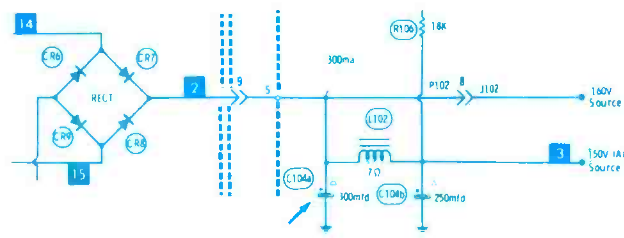
The misleading symptom was the normal audio, which indicated that the V3 stages were normal. Although both sound and composite video (containing the sync pulses) were evidently attenuated by the lack of plate voltage, another stage amplifies the sound signal. Therefore, the amplitude-leveling FM demodulation produced almost normal audio volume.

H. Havener
Ardsley, NY

### Picture lines and a squeal
### RCA CTC48H
(Photofact 1300-2)

The customer said that every time he turned on the television, it would begin operation with criss-cross lines on the screen and an audible squeal. After about 10 seconds, the trouble would stop.

At first, I thought that the problem might be in the pincushion-correction circuitry because the lines were criss-crossing, but applications of freeze spray to the pincushion components had no effect in starting or stopping the lines and squeal.



As I watched the picture develop lines the next time, I noticed that the pattern was visible only in a 3in horizontal area at the screen's center. Because the entire raster was not affected and because the freeze spray had had no effect, I concluded that the pincushion circuit was not the cause.

Next, because the squeal was coming from the horizontal system, I connected a scope probe to the horizontal-oscillator base. There was no disturbance in the oscillator signal when the lines appeared. I scoped the +150V supply because it feeds four sections of the horizontal/high-voltage section. The schematic showed a normal ripple of 2.7VPP, but when the squeal started, the scope showed about 135VPP of jumbled, unstable lines that disappeared after a few seconds, leaving the usual small ripple.

C104B filters this point, so I paralleled a new filter of the same capacitance across it and tried the operation again. Even after many tries, the lines and squeal did not occur, regardless of any reasonable line voltage.

Replacement of the multiple-section C104 filter can made the repair permanent.

James Arnold
Bay City, Michigan

# Readers' Exchange

**Needed:** Sencore VA48, call collect. *All-tronix & TV Svc., Lincoln, NE; 1-402-476-8164.*

**Needed:** Tekfax Vol. 1-5, and 7. *C. T. Huth, 146 Schonhardt St., Tiffin, OH 44883.*

**Needed:** Instruction manual for NJE Corporation model CR 60-9 or ECR 60-9 power supply (0-60V, 0-9A). Will buy original, buy copy, or copy and return. *Daniel J. Lynch Jr., 138 Washington St., Manlius, NY 13104.*

**Needed:** Admiral horizontal output transformer, P/N 79D130-28 (Sams 1113-1); Sony yoke, P/N 1-451-043-21 (Sams 1245-2); and Sears CRT driver bd., P/N 35-51300-1 (Sams 1498-2). *Clifford Hayes, P.O. Box 104, Alplaus, NY 12008.*

**Needed:** Tonearm counterweight for Sansui turntable, model #SR-212, serial #434121196. *William M. Suhy, 456 Burritt Ave., Stratford, CT 96497; 1-203-375-7563.*

**Needed:** Eico model 324 signal generator and model 377 audio generator. State price. *Ed Work, 80 Wright Ave., Belleville, Ontario, K8P 4E6 Canada.*

**Needed:** Sears 38-0219 technical manual for model 400.91743600 radio/phono/tape recorder, manufactured by Bigston. Will buy or copy and return. *P. F. Dales, 43 Park Circle NE, Atlanta, GA 30305.*

**Needed:** Ratio detector coil for a Sylvania D12-XX chassis, Sylvania part #57-23547-1 (Miller replacement #S1-1402). Will pay for phone call, shipping and price of coil. *Jeffry Blackmon, J-Tronic Electronics, 2107 Turnbull Road, Beavercreek, OH 45431; 1-513-426-0232.*

**Needed:** 5A CRT for Hewlett-Packard oscilloscope, model 150A. *Armando Petrinelli, P.O. Box 548, Newport, VT 05855; 1-802-334-2495.*

**Needed:** 30MHz scope or so; must be in good condition. *George Campbell, 44445 13th St. E., Lancaster, CA 93535.*

**Needed:** Cellulose film cap or substitute for Coronado b/w ac/dc television, 7 mfd. 50V, model 41-512-9H, part 5K-9. *Hornick R & TV, 4366 Eastport Drive, Bridgeport, MI 48722.*

**Needed:** Schematics for Dynaco A-431 transformer and Funai F-067 stereo receiver. *Fred Washington, 4004 Prospect, Kansas City, MO 64130.*

**Needed:** Manuals and schematics for Knight R/C and Paco Capacitor, model C25 testers. Will copy and return. *G. C. Wooten, 909 Cooper Ave., Lansing, MI 48910.*

**Needed:** Panasonic color flyback TLF-5018-1S or TLF-5019-1S for model CT-392. Also need a good used b/w CRT 16VDGP4 and Zenith b/w flyback 95-3332-01. *M. B. Danish, Mike's Repair Service, P.O. Box 217, Aberdeen Proving Ground, MD 21005.*

**Needed:** Operator's manual for Tennessee Electronics memory scan, 16 channels, model MS-1. Will copy and return. *Joe's TV, 242 Starke Ave., East Meadow, NY 11554.*

**Needed:** Tubes (or information on where to obtain them) for Bandes radio receiver, #17969, from Bandes Corporation, Newark, NJ. Two output tubes are missing, both are 4-pin tubes. *Robert F. Barrette, 2 Otto Lane, Westminster, MA 01473.*

**Needed:** High-voltage transformer for Hewlett-Packard model 175A oscilloscope, part #175A-11C; new or used. Also need used NTSC generator. *Paul Reindorf, CET, 7 Verano Drive, Santa Fe, NM 87501.*

**For sale:** B&K 415 sweep and marker generator, $200. *Globe Radio & TV Service, 3407 Arlington Ave., Riverside, CA 92506.*

**For sale:** Sencore YF33 yoke and flyback checker, $75, and Sencore TC162 tube checker, excellent condition, $100. *Denny's TV, Rt. #2, Jesup, IA; 1-319-827-1291.*

**For sale:** B&K TV analyst 1077B, fine condition, $375. *Stan Hayman, 19707 Turnberry Way, North Miami Beach, FL 33180.*

**For sale:** Sams Photofact CB series, 1-180, $1.25 each plus COD postage. Also like-new Nickol-tronics CB tester/analyzer, model 1375B, with 2-tone generator; make offer. *Carl S. Carlson, 639 Riverside Drive, Tarpon Springs, FL 33589; 1-813-937-4078.*

**For sale:** B&K 415 sweep and marker generator with all leads and instruction book; $195 or trade. *F. Lurry, 7805 Grand Ave., North Bergen, NJ 07047; 1-201-861-4055.*

**For sale:** Leader LFM-36A wow and flutter meter with 3kHz oscillator; excellent condition; $150. *Tom Hamilton, 2409 Gates Ave., Rendondo Beach, CA 90278; 1-213-371-5984.*

**For sale:** Jackson tube tester, model 658, $100; Triplett electronic volt-ohmmeter, model 850, $65; Sprague Tel-ohmike capacitor analyzer, model TO-5, $85 plus UPS shipping. *H. W. Oats, Rt. 5, 8359 Harding Highway, Lima, OH 45801; 1-419-229-2322.*

**For sale:** B&K Precision model 1077-B TV analyst, ser #39656; reconditioned and recalibrated by B&K. Shipping carton complete with instruction manual and cable, $225. Cashier's check or money order; will ship UPS. *James E. Christoffersen, Jim's TV Restorations, 239 Dead Tree Run Road, Belle Mead, NJ 08502; 1-201-359-2632.*

**For sale:** Sencore VA48 analyzer with accessories, $975, and Sencore LC53 Z-meter, $475. *Clint Gardner, 3156 Storms Creek Road, Urbana, OH 43078; 1-513-788-2795.*

**For sale:** Sencore CB49 analyzer, $100; FS134 F.S. meter, $75; and CB41 performance tester, $50. Never used. *Daley's TV, 305 North St., Preston, MN 55965.*

**For sale:** B&K model 510 transistor tester; excellent condition, with probes, manual and leather case; $85. Heathkit dual-trace scope, model IO-4205; excellent condition, with probes and manual (built by FCC First Class), $300. Heathkit function generator, model IG-1271; excellent condition, with manual; $120. *Sam W. Jacobs, Derry Electronics, Derry, PA 15627; 1-412-694-8822.*

**For sale:** Sams 350-1350 plus assorted others to 1800; cabinets included; $1000 plus shipping. *Paul Ramos, 2008 N. Highland, Amarillo, TX 79107; 1-806-381-0914.*

**For sale:** B&K 1077 analyst with cables and instructions, excellent condition, $190, and Tektronix 315D oscilloscope, no vertical, $35. *Gary Barzily, 84-39 120 St., Kew Gardens, NY 11415; 1-212-847-7965.*

**For sale:** Used TV and radio parts. Send SASE for list. *Robert's Radio & TV, Route 1, Kingdom City, MO 65262.*

**For sale:** Sams Photofact folders, $4.50 post paid; send information. Also new receiving tubes; send SASE for list. *Maurer TV, 29 S. 4th St., Lebanon, PA 17042; 1-717-272-2481.*

**For sale:** Sencore model CB42 CB analyzer with built-in frequency meter and digital readout. Will include two major attachments (dynamic mike tester, model 39G102 and RF switch, model RFS2005). Equipment never used; total package $550. *Barrett Electronics, 1036 Cypress Lake Drive, Fort Myers, FL 33907; 1-813-482-6352.*

**For sale:** RCA video dot generator, model WR46A, RCA color bar generator, model WR61B. Manuals and cables included; all in good condition; $50 each. Also fast check tube checker (Century), portable, $25. *Mack Kunzman, Jamke TV-Radio, 1051 Bale Lane, Calistoga, CA 94515.*

**For sale:** Old Sams Photofact folders 265-900, $1.50 each or $400 for all. Heath IG42 signal generator with manual, $50. Also Heath solid-state VOM, model IM 16 with manual and probe, plus high-voltage probe, $50. *M&M Electronics, 721 Maple Parkway, Dover, DE 19901; 1-302-674-4696.*

**For sale:** Tektronix 533 scope with type H plug in vertical unit, $125; B&K 440 CRT tester, $50; Heath IG62 color bar generator, $50. Could use a B&K analyst. *Donald Graves, Payson, IL 62360; 1-217-656-3811.*

**For sale:** B&K model 1077 TV analyst, $250 with manual. *Ronald MacKenzie, 41 Wheelwright Lane, Levittown, NY 11756; 1-516-731-4348.*

**For sale:** Eico model 944 flyback and yoke tester. Perfect working order, in original carton; $75. *Binder TV, 116 Wilder St., New Castle, PA 16102; 1-412-652-0234.*

**For sale:** RCA TV and audio service data, complete from 1955 to 1982, in 33 RCA binders, $350. *Carleton Sarver, 256 W. 88th St., New York, NY 10024; 1-212-874-3529.*

**For sale:** B&K 1077B analyst in mint condition, $350; Heathkit color bar generator IG-28, $95; and Heathkit 10-4510 dual-trace, 15MHz scope, $395. *R. C. LHereault, 1-205-262-8461 or 1-205-272-3465 (Alabama).*

**For sale:** RCA yoke #137542 for 19in XL 100, $35, and an RCA CRT tester, type W T 115A, $40. *Lyle's TV, 2018 Spring Ave., Hot Springs, SD 57747.*

**For sale:** Sencore TF-151 transistor and field-effect tester, $150; Mercury 801 CRT tester and reactivator, $50; Sprague Tel-ohmike TO-4, $75. *Paul S. Funk, 607 E. Cherry Lane, Souderton, PA 18964.*

**For sale:** B&K model 1077B TV analyst, $150, and B&K model 465 CRT tester, $50. *Moscow Radio & TV, Box 9088, Moscow, IA 83843.*

**For sale:** B&K 1077 TV analyst, $195; Electrotech SMG-39 sweeper-marker generator, $145; and Eico 235 professional VTVM, $45. All in good condition with cables and manuals. *Philip D. Kennedy, 9256 Holyoke Ct., Indianapolis, IN 46268; 1-317-872-6366.*

**For sale:** B&K matching set: 415 and 1077B. No scratches; all cables included; $800 for pair; might trade. *James E. Smith, Route 10, Box 216B, Columbia, MO 65202.*

**For sale:** Tektronix 536 instruction and service manual, $7.50; instruction and service manuals for type T, D and CA plug-ins, $6 each; instruction and service manual on 160 servicer adapters for Tektronix scopes, $7.50. Prices include shipping. *Doug McFarland, 260 Dayton Ave., Zenia, OH 45385.*

**For sale:** Quitting business sale: 1978 Ford van with 29,000 miles, electric appliance dolly with accessories and all test equipment, $8500. Call or write for complete list. *Charles Terry, 505 W. Oak, Lamar, CO 81052; 1-303-336-7304.*

**For sale:** Sams 400-900, scattered; Sams 900-2004 almost complete; and Sanyo service manuals. Includes cabinets; everything for $2000. *V. Rondeau,* *1315 Park Ave., Plainfield, NJ 07060; 1-201-753-6836.*

**For sale:** Sams Photofacts 800-2095 (minus 4), $2904.75; Hickok model 610A signal generator, $125; and McGraw-Edison model M-624 standard signal generator, $50. Plus shipping UPS. *Clarence McGinnis, P.O. Box 601, Morristown, TN 37814.*

**For sale:** Sencore SG165 stereo analyzer in excellent condition, with original box and manuals; $500. *TV Workshop, 2400 Augusta Road, West Cola, SC 29169; 1-803-794-1233.*

**For sale:** Precision model E-200-C RF signal-marking generator $50. Good condition but no cables or operator's manual. *Juan S. Sanchez, 410 Vanderbilt St., San Antonio, TX 78210; 1-512-534-5514.*

**For sale:** B&K model 801 capacitor analyst and checker, with manual; $75. *Stan Hayman, 14707 Turnberry Way, North Miami Beach, FL 33180.*

**For sale:** B&K model 415 sweep marker generator and B&K model 1077 TV analyst. Both used only twice; new condition. Make offer. *William J. Maida, 341 Isabella Drive, Longwood, FL 32750.*

**For sale:** Radio and TV schematics from 1955. Send model, manufacturer, chassis, etc., $4.50 postpaid. Also enclose SASE for receiving tube list. *Maurer TV, 29 S. 4th St., Lebanon, PA 17402.*

**For sale:** Heathkit shortwave receiver, model SW-717, with manual, $100. *J. Silver, 102 E. Pointe Lane, A-11, East Lansing, MI 48823; 1-517-332-6694.*

**For sale:** B&K 1077B analyzt, $425, and other miscellaneous equipment. Send SASE. *Al's Radio & TV, 9 Rachel Carson Lane, Centerville, MA 02632.*

**For sale:** Most Sams from 17-500, $1 each. take one or all; you pay shipping. *Milton Eitel, 1661 W. Republic, #41, Salina, KS 67401; 1-913-825-8455.*

**For sale:** B&K sweep marker/generator, model 415. Excellent condition, used once, $200. *Paul J. Allen, Rt. 1, Box 153F, Bland, VA 24315.*

**Needed:** Sencore VA48 analyzer. Will pay reasonable price for one in good condition, with manual and probes. Will also consider one in "not-working" condition. Will travel reasonable distance (New York and Pennsylvania) from central New Jersey to view and pick up. *Duane Loeffler, Box 455, Dover, NJ 07801; 1-201-366-1486, after 6 p.m.*

**Needed:** Service manual or diagram (or copy of diagram) for Tektronix oscilloscope 545. Needed badly; send COD or any which way. *Joseph Bobalick, 3011 Elm St., Weirton, WV 26062.*

**For sale:** B&K 1450 scope, $149; Sencore sweep generator, $39; and Sencore transistor checker TF46, $29. *WSEP, 318 South K St., Sparta, WI 54656; 1-608-269-2392.*

# Troubleshooting logic systems logically

By Joe Sloop

Although some kind of mystique has grown up around the digital world, and relatively little servicing information has been published, understanding and troubleshooting digital is often much easier than troubleshooting and servicing analog circuits. Normally, all you have to look for is the presence or absence of a signal. Though amplitude and waveshape are important in digital systems, the amplitude is usually what we refer to as a *high* or a *low* (ordinarily +5V or 0V) and the wave is a square wave. Naturally, with the simpler circuit comes simpler troubleshooting techniques. In this article, I will try to show some of the basics of digital servicing and give you a project to build for digital troubleshooting.

### Digital troubleshooting "logic"

In digital troubleshooting, it is necessary to have:

- a knowledge of basic electricity/electronics,
- an understanding of the operation of the system being repaired,
- an understanding of basic digital circuits,
- an understanding of the test equipment to be used and
- a logical method of troubleshooting.

An understanding of system operation means that at least a functional block diagram knowledge is a must. For example, televisions are not all alike in circuitry but they do have similar block diagrams. If you are familiar with the general TV functional diagram, all makes and models can be approached with some degree of confidence. Likewise if you have a general knowledge of the digital device functional diagram, you may confidently proceed with digital circuit troubleshooting. A typical block diagram is shown in Figure 1.

All troubleshooting should be logical and methodical, and if you've ever thought about it, you probably have a set routine you use to isolate the fault. Here is a 5-point troubleshooting routine for digital circuits.

- Gain an overall knowledge of the system by studying the schematic, block diagram and service information.
- Check for voltages and signals that are *essential* for system operation. These may include B+, clock operation and special inputs required for the particular system.
- Diagnose which *function* is not operating – keyboard, memory, etc.
- By checking schematic or PCB roadmap, decide what type of circuits are used for the nonoperational function.
- Use test equipment to trace the signals associated with the defective function.

### Troubleshooting tools

The only way to do an efficient job at anything is to use the proper tool for the job. You don't use a screwdriver as a chisel or a pair of pliers as a wrench, so you shouldn't attempt to use an analog meter to troubleshoot digital. For troubleshooting digital circuits, only the scope or specialized digital test equipment is suitable.

The scope is always a useful tool. It has a capability no other piece of test equipment has – it will display signal waveshapes and their timing relationships to each other. Yet, in the majority of the digital troubleshooting cases, this is not necessary. Most times it will be sufficient to know only if the *high* or *low* digital pulse is present.

Specialized logic-testing equipment includes logic-monitor clips and system analyzers as seen in Figures 2 and 3. The less expensive and easier-to-use logic probe, seen in Figure 4, is probably used

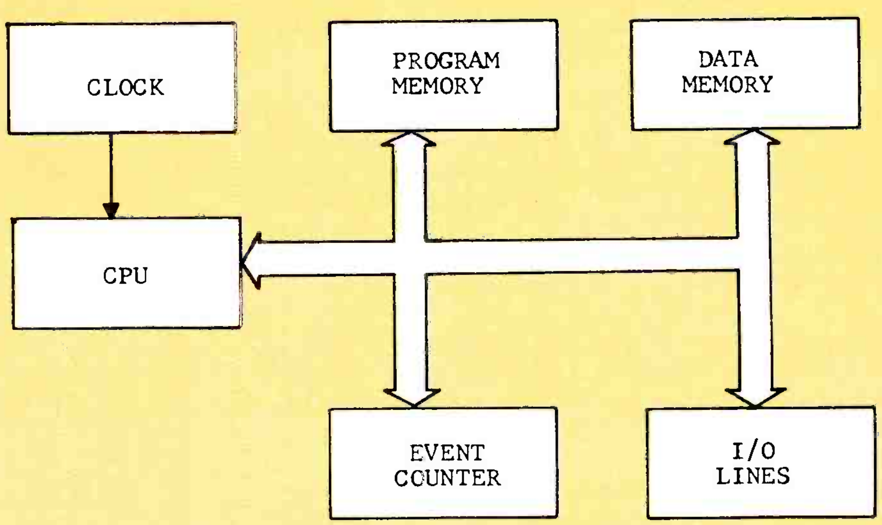



**Figure 1.** Familiarity with the system block diagram makes it easier to proceed with troubleshooting in an orderly manner.

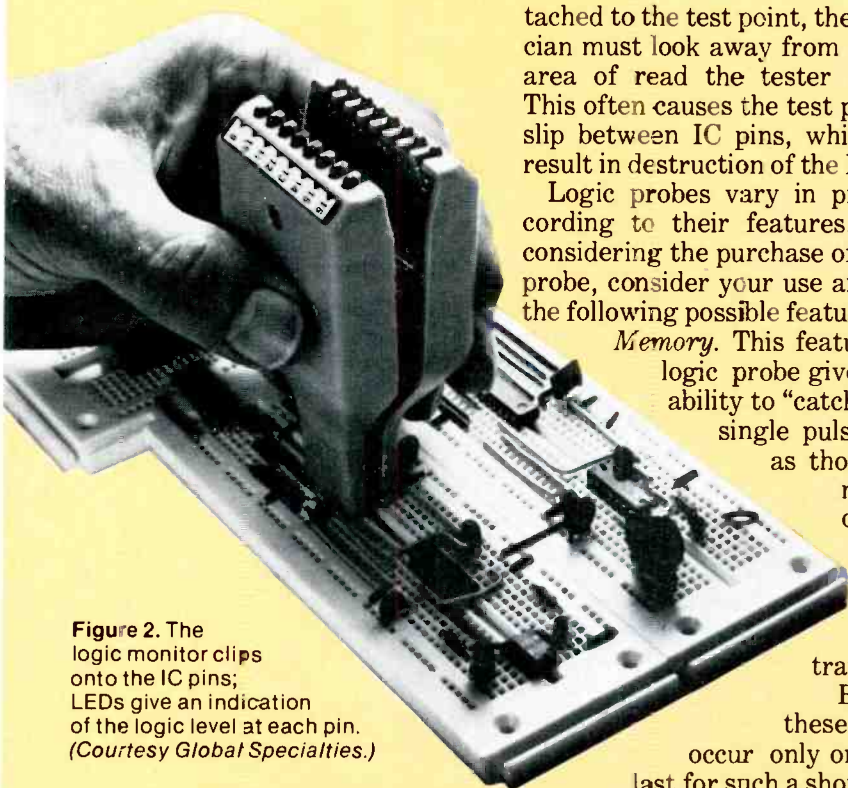


Figure 2. The logic monitor clips onto the IC pins; LEDs give an indication of the logic level at each pin. *(Courtesy Global Specialties.)*

more than all the others together. Naturally the logic probe will not do many of the things that the more sophisticated equipment will do. In most cases, however, it will fill the needs of the consumer electronic service technician.

### The logic probe

The logic probe indicates the logic state of the test point–*high* or *low*, or in terms of digital mathematics, a *1* or *0*. A TTL logic *low* can normally be thought of as being less than 16% of the circuit supply voltage (30% for CMOS). A TTL logic *high* will usually be above 48% of the circuit supply voltage (70% for CMOS).

A good probe will have indicators to show if the test point is *high, low* or *pulsing*. A better probe will have a *memory* function that will indicate the presence of a 1-shot pulse with time duration too short for the eye to see. Logic probe indicators are usually LEDs. Typically a separate LED is used to indicate each of these situations: a *high* input, a *low* input and a *pulse/memory* input.

One reason for the extensive use of the logic probe is its simplicity and ease of use. The technician has only to touch the test point with the probe tip and, while looking at the probe LEDs, determine the state of the test point. With other equipment, after the probe is attached to the test point, the technician must look away from the test area of read the tester display. This often causes the test probe to slip between IC pins, which may result in destruction of the IC.

Logic probes vary in price according to their features. When considering the purchase of a logic probe, consider your use and then the following possible features.

*Memory.* This feature of a logic probe gives it the ability to "catch" short single pulses such as those from memory or noise transients. Because these pulses occur only once and last for such a short time, the LED readouts cannot be seen to light. When you're looking for a glitch, you don't have to monitor it constantly if the probe has memory. When the glitch occurs, the memory LED will remain *on*, indicating that a pulse has been detected. The minimum detectable pulse width varies from probe to probe, and a probe should be chosen with a speed capability commensurate with your needs.

*Multifamily use.* Some probes can be used on TTL, DTL, CMOS, etc., while some are usable only on TTL and DTL, and others can be switched for use on TTL or CMOS.

*Input impedance.* Measurements must not be affected by probe attachment to the circuit. If the input impedance is too low, the gate being tested may be overloaded by current flowing into the probe impedance.

*Bad levels.* A probe should be able to distinguish between *high, low* and "illegal" inputs. For example, neither the *high* nor the *low* indicator should light when the probe is placed on a "floating" line. There is also an illegal state that must not be read as either a *1* or *0*. In TTL the maximum voltage output that can be used as a *low* is 0.8V; the lowest output usable for a *high* is 2.4V. This leaves the voltages between 0.8 and 2.4V as illegal. No TTL gate should have an output within this range, and if it does, the logic probe must not indicate it as a *1* or *0*.

### Logic probe circuitry

The simple logic probe of Figure 5 is nothing more than a single LED and its associated current-limiting resistor. When the tip of this circuit makes contact with a logic *low*, the LED is forward biased and lights. When a logic *high* is touched, the LED remains off. As you can see, this simple probe leaves a lot to be desired.

A typical commercially available probe has both logic *high* and logic


Figure 3. This system analyzer is a sophisticated, multipurpose instrument combining a DVOM, logic analyzer and signature analyzer in a single package. *(Courtesy B&K Precision.)*

*low* indicators. Such a probe can also be used to determine the approximate pulse duty cycle (percent of the time the pulse is *high*). If the pulse duty cycle is 85%, the *high* indicator should be quite a bit brighter than the *low* indicator. With some experience, you can be surprisingly accurate in determining duty cycle.

When the probe has a *pulse* indicator, it may blink at a regular rate or remain on, showing that the input is a pulse. If the input is a single, short-lived pulse, the *pulse* LED may remain on for a period of time set by a pulse stretcher network, to allow the user to observe the pulse. Some logic probes can detect pulses as short as 5nS.

### Using the logic probe

Connect the logic probe to the power supply operating the ICs you intend to check. This allows the internal circuitry of the probe to know what type of circuit is being checked and to then recognize the logic level applied to its input as being a *high* or a *low*. If the probe were to be connected across the 18V source of a CMOS circuit, for example, it is looking for *low* to be approximately 30% of that supply. *High* in this circuit would be about 70% of 18V, or 12.6V. If the probe were to be left connected to the 18V supply but used to check the output state of a TTL circuit, even the *high* 4.8V output of the TTL circuit would be sensed as being a *low* because it is less than 30% of the probe's supply voltage.

Once the probe is connected to the power supply, go to the center of the suspected circuit when possible, and use the probe to check for the presence of signal. It is always helpful if there is a changing signal so pulse activity can be spotted. If this is not the case, you will either have to know the correct logic state of the various gates to be tested or have the capability of changing the state of each gate in turn (more about this later). If changes are occurring, chances are good that the circuit is good from the input to this point. Make the same test in the center of the remaining half of the circuit. Each test cuts the amount of circuitry to be checked in half. In the most usual type of problem, you will soon come to an IC where there is a change in input logic levels but no output change. Let's say that point is between gates A and B in Figure 7. A logic pulser will help you continue with the diagnosis.

### The logic pulser

A companion piece to the logic probe, the pulser (Figure 8), senses the logic level at its tip and automatically generates a 1-shot pulse or a train of pulses of the opposite level. There is no need to unsolder pins or cut PCB leads. The pulser is ideal for generating that changing signal mentioned earlier.

Let's assume that the NAND gate, A in Figure 7, is stuck *high*. The output of gate B will be held *low* according to the NAND gate truth table. If the pulser is attached to the input of gate B and the logic probe to its output, gate B will be seen to be good. The pulser output will override the high input of gate B, causing its output to go *high*. Applying the same method to gate A will *not* cause the output to change states, so gate A is known to be defective.

The pulse probe will not change the state of an IC that has a short circuit. But then if a circuit is shorted, the best way to determine that is from the heat produced. Before any equipment troubleshooting takes place, it is wise to visually inspect the circuit for charred or bubbled ICs, to feel for excessive heat generation, and to smell for any present or past heat-produced odors.

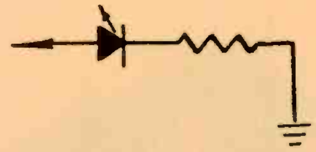


**Figure 5.** This circuit diagram illustrates the fundamental principle of the logic probe: When the tip of the probe touches a logic *low*, the LED is forward biased and lights.

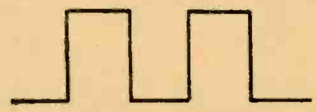
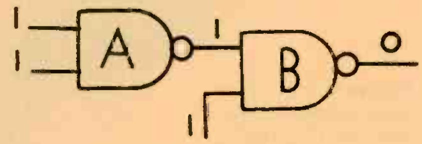


**Figure 6.** This pulse train has 50% duty cycle (it is at a *high* logic level 50% of the time).




| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

**Figure 7.** With logic *1* levels at both inputs, output of NAND gate A should be at logic *0*. Obviously, gate A is defective; it is stuck *high*.

### Typical logic circuit problems

Some of the more typical IC problems have already been mentioned: shorted outputs, stuck outputs, etc. Shorted ICs usually get very hot, while an IC with stuck outputs will appear normal except that the output logic level will not change. Often the circuit will be intermittent, "going bad" when it heats up to operating temperature. Circuit coolant will often bring such a circuit back to life until the effects of the coolant wear

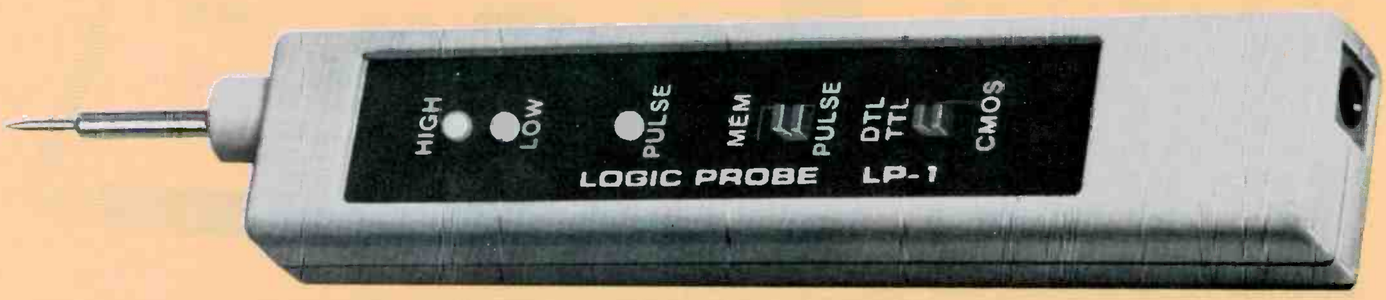



**Figure 4.** This logic probe combines the functions of a level detector, pulse detector, pulse stretcher and pulse memory in a single troubleshooting instrument. *(Courtesy Global Specialties.)*

off. At any rate, it's obvious when you've found such a problem IC.

Open connections inside the IC can cause the output to have an illegal state. If the logic probe shows neither a *high* nor *low*, measure the output voltage, check socket connections and PCB paths, and be sure the IC has a proper ground connection before replacing it. Fortunately, when ICs fail, they often fail completely, producing stuck outputs at the *high, low* or *illegal* states. For this reason, an indication of pulse activity at inputs and outputs is reason to believe the circuit is operating properly.


**Figure 8.** A logic pulser, when applied to a circuit point, senses the logic level and automatically generates a 1-shot pulse or a train of pulses of the opposite level. *(Courtesy B&K Precision.)*

There are other problems of a more complex nature. If the timing relationships go afoul, for whatever reason, there will be problems for which the logic probe cannot provide answers. A scope or a logic analyzer will be necessary to troubleshoot this one. Likewise if something inside an LSI IC decides to go its own way, there may well be outputs, but in the wrong sequence or code. This requires that the technician study the truth table carefully to determine if states are being skipped or if the output count is incorrect.

Power supply problems can cause difficulty too. At the risk of being repititious, one of the first steps in troubleshooting is to check the necessary voltages.

Though the digital circuit produces square waves, there are sometimes problems here too. Because it expects a square wave, the digital gate doesn't know what to do with an irregularly shaped square wave. A check of wave shape irregularities of course require a scope. Fortunately, these problems are relatively rare.

Now the idea of troubleshooting digital circuits is not completely foreign to you anymore. You should have an idea of what test equipment is needed at your level of service, how the logic probe and pulse probe work, the rudiments of logical servicing and the essentials of troubleshooting digital circuits. In a future issue, we'll feature a logic probe you can build that has *high, low, pulse* and *memory* indicators. It uses two commonly available ICs and can be built for about $5. ES&T

# Reports from the test lab:

# The Beckman HD-110 DMM

By Carl Babcoke, CET

*Each report about an item of electronic test equipment is based on examination and operation of the device in the* ***ES&T*** *laboratory. New and useful features are discussed, along with tips about using the equipment for best results. Personal observations are given about the performance or other important attributes.*

The Beckman model HD-110, a recent addition to its line, is a rugged, professional-quality, portable DMM that provided excellent performance without problems or complications. Evidently the *HD* of the model number indicates *heavy duty,* and the improved durability is an important new feature.

Basic dc-voltage accuracy is rated at 0.25%, and other features include an Insta-Ohms quick continuity indicator in the display, a special voltage-drop type of diode/transistor test, one-knob operation, excellent overload protection and extremely long battery life.

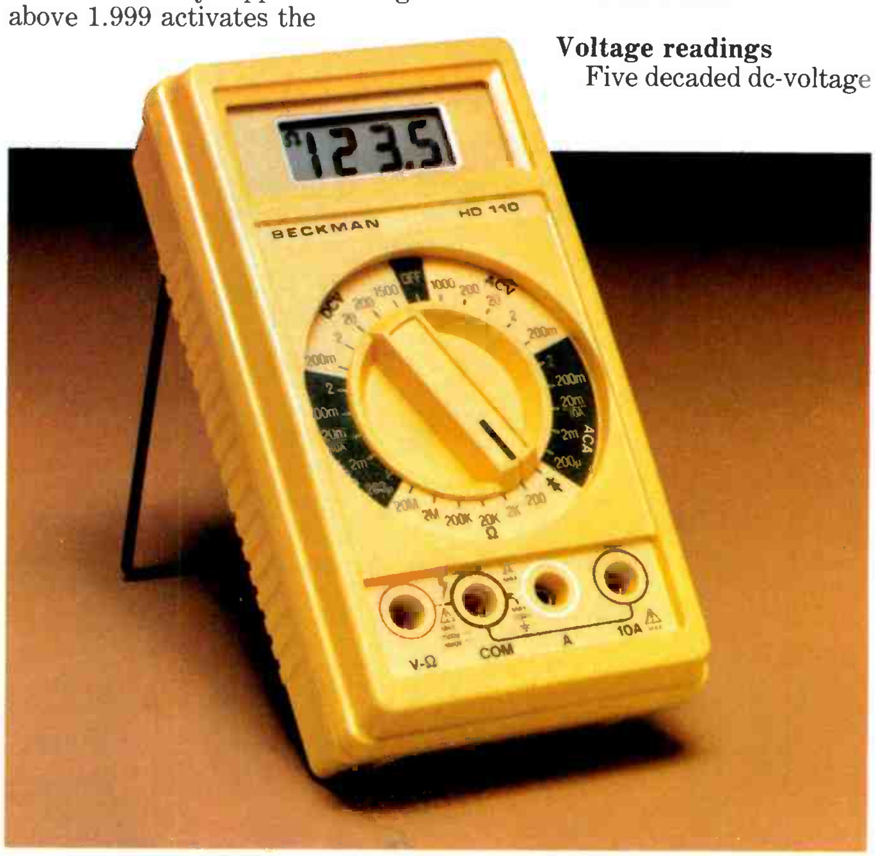
Power for the low-drain CMOS ICs and a liquid-crystal digital display is so small that a single 9V alkaline battery can provide up to 2000 hours of continuous operation. I used a similar model for almost three years before replacing the battery, and although the meter had been left on over several weekends, the battery still tested only slightly weak after I removed it.

Digits of the 3½-digit display are about 0.5in, with high contrast and good sharpness. One rotary knob (without end stops) selects all six basic functions in 27 ranges. Panel areas for *off, dc-ampere ranges* and *ac-ampere* ranges have yellow letters and numbers on a black background, just the reverse of the colors of other areas on the panel. The knob and its markings are recessed below the panel.

Maximum readouts are always one digit less than the marked range. For example, the 2Vdc range reads between 0.000 and 1.999. But any applied voltage above 1.999 activates the OL overrange indication. Similarly, readings of the 200V range are indicated directly up to 199.9V, while higher voltages activate the OL symbols.

The dc voltage and current readings have automatic positive or negative polarity symbols, and all ranges are zeroed automatically. Decimal position is determined by the range selected.

A wire bail on the back panel can be used for carrying the instrument or as a tilt stand.




Operation of the Beckman HD-110 rugged digital multimeter is simple. One large rotary knob selects all functions and ranges, and selecting any function turns on the battery power. Two jacks are used for all functions except current measurements. Basic dc accuracy is ±0.25%.

### Voltage readings

Five decaded dc-voltage

ranges have full-scale readings beginning with 200mV (0.2V). Although the highest dc-voltage range is marked 1500V, it is actually a 2000V range that should not have more than 1500V applied.

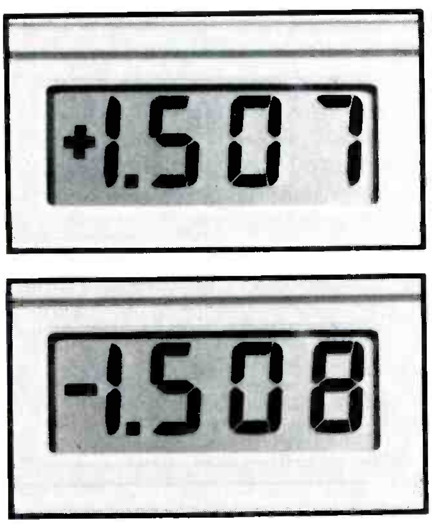
The accuracy of all dc-voltage ranges is rated at ±0.25% plus one least-important digit. However, this sample meter appeared to have better accuracy than that, when compared to several others.

Input impedance is 22MΩ, and an internal active filter is designed to remove all ac signals higher than 49Hz. Correct readings were obtained for half-wave rectified signals, and this indicates proper integration of even low-frequency dc waveforms. Not all DMMs can pass this test.

The ac voltages are measured in five ranges (200mV, 2V, 20V, 200V and 1000V). The 1000V range actually is a 2000V range that should not have more than 1000V RMS of sinewaves or 1400V peak applied to it. Higher voltages exceed the safety ratings.

The ac converter is average-responding for sinewaves, but it is calibrated for FMS sinewaves. Input impedance is 2.2MΩ for all ranges.

Frequency response was exceptionally good for a digital meter. All ranges are rated at ±0.75% plus 3 digits up to 2kHz, ±1.5% plus 5 digits to 5kHz, and ±2.5% plus 9 digits up to 10kHz. However, the sample HD-110 provided better high-frequency response. No fudge factors should be required for most audio measurements.



**Polarity symbols appear automatically.** These readings were obtained by reversing the probes on a D battery.

### Current readings

Ranges for both dc and ac current are 200μA, 2mA, 20mA, 200mA, 2A and 10A. There is one test-lead jack (labeled *A* for amperes) for all except the 10A range, which has a separate jack. One common jack operates for all functions.

Rated accuracy for all dc current ranges (except the 10A range) is ±0.75% of reading plus one digit (10A accuracy is ±1.5% plus 1 digit).

For ac current, the rating is ±1.5% of reading plus three digits for all but the 10A range, which has an accuracy of ±2% plus three digits.

Polarity signs operate automatically for dc current. Frequency response of ac current is the same as for ac voltage.

### Resistance readings

Six resistance ranges measure from 200Ω full scale (resolution of 0.1Ω) to 20MΩ full scale (resolution of 10KΩ), with an accuracy of ±0.5% of reading plus one digit for all but the 20MΩ range (±1.5% plus one digit).

The maximum open-circuit voltage across the test leads was about 0.4V, and the V-Ω probe was positive. When I connected a resistance barely above the point of overrange across the probes, the dc voltage was about 0.2V (not enough to cause conduction of a diode or transistor junction).

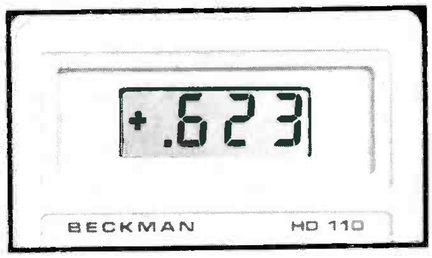
All ohmmeter measurements are low-power type, and circuit resistances can be checked without errors from solid-state conduction. When measurements are needed for transistor junctions or diodes, the separate diode test is used.

### Diode readings

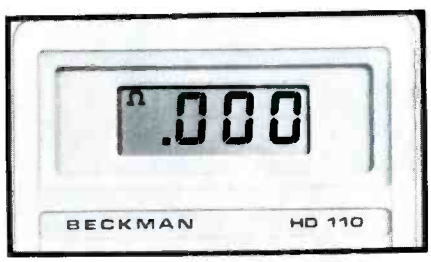
An important test that resembles resistance measurements is the diode test (marked by a diode symbol on the Beckman panel next to the 200Ω resistance range). When the operator applies a regulated constant current of 5mA to each diode under test, the dc-voltmeter function reads the resulting voltage drop that appears across the diode (up to a maximum of 1.999V).

This type of voltage-drop measurement gives far better tests than are possible with a high-power ohmmeter because an ohmmeter reading changes with each

**Any input signal** that would produce a readout above the selected range activates the non-flashing OL overrange symbol, as shown.



**This 0.623V reading** is typical of silicon diodes and many transistor junctions when the special constant-current voltage-drop diode test is employed. Bridge rectifiers and other in-circuit components can be tested accurately, as long as the paralleling resistances are not lower than about 400Ω.



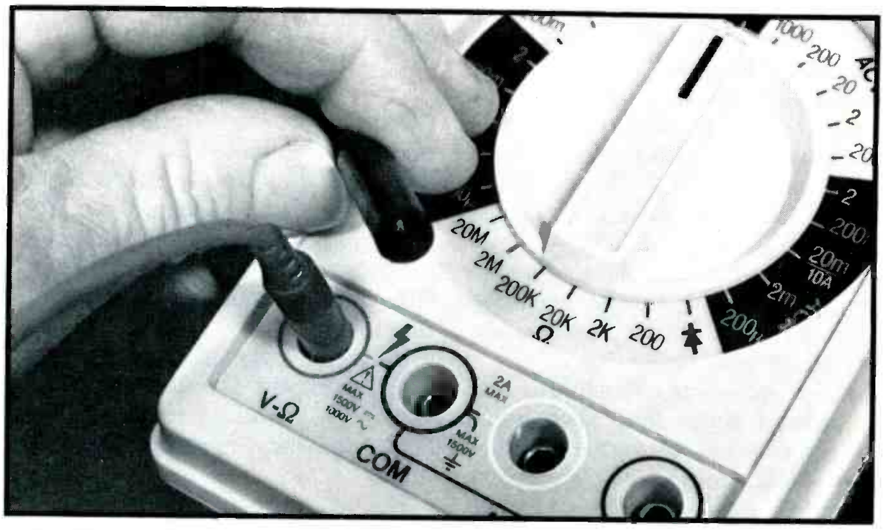
**Any continuity or resistance** across the test probes during resistance tests activates the ohm symbol in the upper-left corner of the LCD readout. The symbol appears and disappears faster than the digital readout can change, so the symbol can display erratic contacts or other intermittent conditions.

range. Also, low-value in-circuit resistances will produce incorrect or ambiguous readings more often with ohmmeter resistance tests than with these voltage-drop measurements.

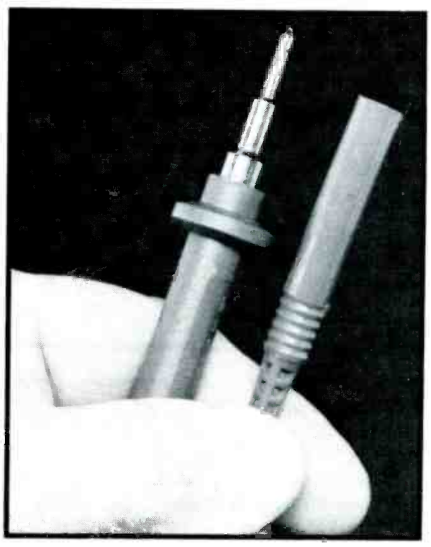
Very little analysis is necessary for interpreting voltage-drop readings. A normal germanium diode (or transistor single junction) reads between 0.2V and 0.3V, and most silicon diodes produce readings between 0.55V and 0.70V. An open diode causes overrange with both polarities when the test probes are cross-switched.

Identification of non-defective diode anodes and cathodes is easy. When the operator obtains a characteristic voltage (by trying both polarities), he connects the black test lead now to the minus element (diode cathode or N element of a transistor) and the red lead to the positive element (diode anode or P element of a transistor). A normal diode will show a characteristic voltage in the forward-bias polarity and an overrange open in the reverse-bias polarity. When both polarities show overrange, the diode junction is open. If both polarities produce readings below 0.5V, a low-value resistance is paralleling the diode, or the diode is leaky or shorted.

The accuracy of the diode test is rated at ±0.25% plus two digits, which is much better accuracy than is needed for most diode tests.




**In the HD-110 DMM,** the banana jacks are recessed to prevent fingers from touching them. When the insulated banana plug is inserted (at left), no bare metal is exposed. Metal in the banana-plug common lead (shown held in fingers) is so far inside the insulation it barely can be seen.



**A ridge on the hand-held meter probe** (at left) stops fingers from touching the metal probe tip, thus eliminating one type of electric shock hazard. An insulated alligator clip or a sharp needle tip can be screwed into the probe, replacing the conventional tip when desired. The banana plug (at right) is covered by plastic to prevent shorts.

### Insta-Ohms indication

These previous resistance and diode tests give excellent accuracy, but there is one shortcoming that is common to most digital meters: *the readings change slowly.* For most measurements, one reading per second is as fast as necessary, but erratic or intermittent continuity or resistance readings can be ignored completely by the periodic digital updates.

Some manufacturers install an audio tone to alert when a resistance is erratic. Beckman's solution is to include an ohms symbol (Ω) in the upper-left corner of the readout. When the operator selects ohmmeter function, any resistance (between a dead short and about twice the overrange value of the range in use) causes the ohm symbol to appear. When the probes are removed or the resistance opens, the symbol disappears long before the digital readout goes to zero.

Operation of the ohms symbol is not quite instantaneous, but it is rapid. The Beckman manual says the change occurs in about 100ms. During tests in which I rapidly touched and separated the probes, the symbol accurately followed the continuity.

### Comments

Mechanical protection against bumps or falls includes a high-impact plastic case, a shock-mounted digital display, and O-ring sealing around the switch shaft. Metal shielding inside eliminates most stray signals from outside the case.

All voltage ranges are protected to 1500V by the circuit design. Spark gaps give protection between 1500V and 6kV. Resistance ranges are protected to about 300V, and the current jack has a 2A fuse. Remember that these safeguards are for accidents. Never deliberately apply voltages above the ratings to any range or function.

A welcome surprise was the kit of test probes with accessories. Beckman has had safety-type probes for some time, and these have ridges on the probe insulation, to prevent fingers from slipping, and the meter ends have no exposed metal. In addition, the probe kit has screw-in alligator clips in red and black insulation, screw-in banana plugs and screw-in needle point plugs.

The DMM comes complete with an installed 9V battery. Optional accessories include a padded vinyl carrying case, a 50kV HV probe, a 200MHz RF probe, a temperature probe and two current clamps for power wiring.

Beckman model HD-110 is a rugged professional-quality portable multimeter that provided excellent performance without problems or complications. ES&T

# Books

*Editor's note: Periodically **Electronic Servicing & Technology** features books dealing with subjects of interest to our readers. Please direct inquiries and orders to the publisher at the address given for each book, rather than to us.*

**Crash Course in Digital Technology, by Louis E. Frenzel; Howard W. Sams & Co.; 198 pages; $19.95.**

This text-style programmed course offers a solid foundation in digital fundamentals to hobbyists, students, industrial training programs and those with even a minimal understanding of electronics. It is written in a programmed learning format using brief informational frames and frequent self-tests. It is a learning tool, rather than a reference, and is illustrated with photography, diagrams and examples.

Published by Howard W. Sams & Co., 4300 W. 62nd St., Indianapolis, IN 46206.

**Television Symptom Diagnosis, An Entry Into TV Servicing, by Richard W. Tinnell; Howard W. Sams & Co., 175 pages; $12.95.**

In some cases, TV receiver servicing demands a penetrating understanding of the nature of electromagnetic waves, composite video behavior and the very nature of electronic theory. In most cases, however, the technician uses only a few areas of technical know-how.

The purpose of this book is to present three of these areas in a manner that will allow the reader to diagnose most TV troubles. The three areas the author covers are;

- the ability to observe and recognize symptoms in the TV picture and sound,
- an understanding of the TV receiver system that allows the technician to relate trouble symptoms to a particular section of the set, and
- a sufficient knowledge of electronic circuitry to allow isolation of the problem to an individual component.

Published by Howard W. Sams & Co., 4300 W. 62nd St., Indianapolis, IN 46268.

**SCRs and Related Thyristor Devices, by Clay Laster; Howard W. Sams & Co.; 136 pages; $12.95.**

Anyone involved with the design, installation or maintenance of electronic power-control equipment needs to know what thyristors are and how they work.

This book explains how the various thyristor devices are made and how they operate. Enough semiconductor theory is included to make the explanations understandable, and applications of the devices are discussed and thyristor control systems are covered thoroughly. To bring the coverage up to the minute, a section on microprocessors and the interfacing of thyristors to digital control circuits is included.

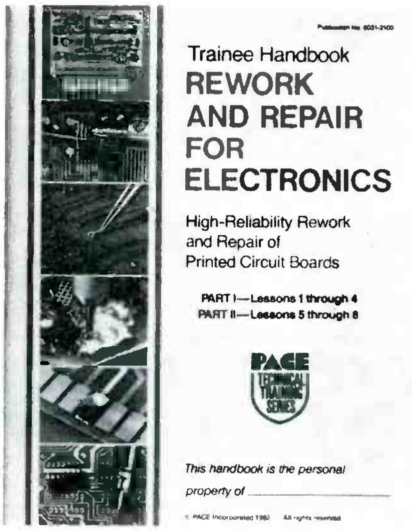
Published by Howard W. Sams & Co., 4300 W. 62nd St., Indianapolis, IN 46268.

# Products

## Rework and repair handbook

The *Pace* handbook, *Rework and Repair for Electronics,* includes eight lessons and should be useful for anyone who already has the ability to perform high reliability soldering.

The lessons cover concepts of repair, elements of PCB construction, component removal, solder extraction with continuous vacuum, removing conformal


Trainee Handbook
REWORK AND REPAIR FOR ELECTRONICS
High-Reliability Rework and Repair of Printed Circuit Boards
PART I—Lessons 1 through 4
PART II—Lessons 5 through 8
PACE TECHNICAL TRAINING SERIES
This handbook is the personal property of ____________

coatings, repair of damaged PCBs and plated-thru holes, refurbishing/replating repaired or worn edge connectors, and preventing electrical damage to sensitive components.

The handbooks are available for $15.50.

**Circle (120) on Reply Card**

## Oscilloscopes

*A. W. Sperry Instruments* has introduced a new line of easy-

service oscilloscopes – AWS models 315P and 620C. Model 315P is a portable, ac/dc, 15MHz, dual-trace oscilloscope with a built-in battery pak. Model 620C is a 20MHz, dual-trace oscilloscope with built-in component checker for use on resistors, capacitors, diodes, digital circuits and more.

Both models come complete with operating instructions, ac linecord (model PC-1) and two (1x, 10x) test probes (model TP-60).

**Circle (121) on Reply Card**

## Wow/flutter meter

*Leader Instruments* has introduced a new wow and flutter/drift meter, model LFM-3610, designed for the service and testing of turntables, record/playback equipment, VTR and other tape transport devices.

The LFM-3610 has selectable flutter test frequency ranges that permit the operator to quickly isolate the trouble area to the capstan, motor or belt. The LFM-3610 will measure drift, wow and flutter either separately or in combination. Its frequency selector measurement mode reduces the troubleshooting and testing

time normally associated with complex electromechanical devices.

**Circle (122) on Reply Card**

## Dual-trace oscilloscope

A new 10MHz, dual-trace oscilloscope featuring 2mV/div vertical sensitivity to 10MHz, with selectable 1mV/div sensitivity to 7MHz, is an addition to the *B&K-Precision* line.

In the single-trace mode, model 1476A can be used to measure dc voltage, peak-to-peak voltage, time, frequency, pulse width, relative voltage and relative period. In the dual-trace mode,

measurements include time and phase difference.

**Circle (123) on Reply Card**

## Computer cleaning supplies

*CMPI* now offers a complete line of inexpensive products for virtually any personal computer or minicomputer cleaning application. The Mini Clean family of products includes a variety of separate items such as solvents, presaturated pads, sleeves, urethane swabs and head cleaners.

Users can also choose special Mini Clean kits designed for magnetic head, hard disc, CRT and general surface cleaning tasks. Additional head cleaning kits are available for single-sided and double-sided drives in either 5¼-inch or 8-inch size.

**Circle (125) on Reply Card**

## DMMs

*Hitachi Denshi America* has entered the DMM market with three new meters.

Models VR-3510 (0.1%), VR-3525 (0.25%) and VR-3550 (0.5%), all 3½-digit products, are multi-function DMMs with protection from transients up to 6KV. LCD function displays include

measurement of a 10A ac/dc current, ac/dc voltage, resistance, diode test and continuity test with audible tone. Additional features include the ability to measure temperature, capacitance and selectability of auto or manual ranging.

Circle (126) on Reply Card

### Display monitors

Two compact display monitors that offer a sharp, professional-level graphic image at affordable prices are now available from *Comrex International.* Model CR-5400 is a 9-inch monitor with a resolution of 800 lines per inch. It is ideal for portable computer applications. Model CR-5600 is a 12-inch monitor with a resolution of 1000 lines, and is well suited for desktop computer applications.

Circle (124) on Reply Card

### Phones and accessories

Two FCC-approved telephones have joined the phone installation accessories line of *GC Electronics.* The Contiphone, the newest addi-

tion, includes completely modular connections that make adding this phone to a modular system as simple as plugging it in. The Contiphone comes in either pulse-dialing or touch-tone-dialing models. The Econoline phone is a one-piece pulse-dialing telephone with modular connections and automatic redial.

GC's line of telephone installation accessories provides all the basics for installing residential systems, whether upgrading a standard (4-prong) system, adapting modular phones to a standard system or changing to a fully modular set-up.

Circle (75) on Reply Card

### Power supply/leakage tester

A new isolated, variable ac power supply/leakage tester with a soldering-iron temperature-control feature, available from *B&K-Precision,* can be used in the service shop, electronics laboratory and electronics school.

Model 1655 features an isolation transformer to eliminate shock hazard while servicing hot chassis equipment; variable ac source from 0 to 150V; leakage tester to provide OSHA, UL and CSA power-line leakage test capability; two load current ranges (0-2A and 0-4); 0-5000$\mu$A leakage scale expanded in the commonly used 100-500$\mu$A portion and a solid-state variable soldering iron temperature control with a 100W rating.

Circle (76) on Reply Card

### Handheld counter-timer

The new 5000 counter-timer, from *Global Specialties,* combines


all of the important features and performance capabilities of a bench-top unit with the convenience of a portable, battery-operated instrument.

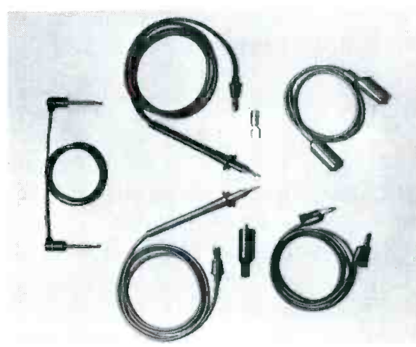
The 5000 is designed to measure frequency, period and pulse width with accuracy and reliability. It features full signal conditioning, including attenuator (x1, x10, x100), slope selection (+ or − edge for pulse width measurement), ac or dc coupling and variable trigger level.

Circle (77) on Reply Card

### Joystick overhaul kit

*Pfanstiehl* has expanded its Pfantone video accessories line with the addition of an overhaul kit for joysticks and a 12ft joystick extension cord.

The overhaul kit is for the Atari single-firing-button joystick, and includes an exact-replacement printed-circuit board, as well as a replacement spring for the firing



button. The extension cord is adaptable to the Atari type-9 pin male and to the Atari type-9-pin female. It can be used with any 9-pin-format joystick including Atari, Coleco and others.

Circle (78) on Reply Card

### Test prods and patch cords

A new line of test prods and patch cords from the *E. F. Johnson Company* features solderless crimp-on connections for strain relief and long life.

The 154 different combinations of interconnects, colors and lengths conform to the latest Underwriters Laboratories and American National Standards Institute safety standards, and are available in one-piece packages.

Circle (79) on Reply Card

# Simple servicing tips

By Carl Babcoke, CET

Two basic changes in electronic technology have made troubleshooting much more difficult and expensive. Tubes have been replaced by solid-state components, and circuit boards of smaller sizes are loaded with many components per square inch.

Solid-state components have several significant advantages over vacuum tubes. They do not weaken gradually with time, as was true with tubes, and they produce less heat and reduce power requirements. However, there is a vital tradeoff: Solid-state devices are susceptible to sudden failures from various kinds of overloads. For example, a transistor can short from excessive current before a meter can indicate any danger or a fuse can protect the junction.

This Achilles heel of transistors, diodes and ICs must be protected during repair jobs by the proper tools and techniques, as described here.

Copper wires on circuit boards are becoming narrower and more delicate as the density of components increases. Therefore, smaller areas are available for connections of test probes and generator cables to testpoints, component leads, wiring pads or IC pins. These small and crowded points change a minor slip of a test probe into a major disaster in many cases. In fact, if the suggestions given are not followed, the expense of repairing the damage caused by accidents during servicing can exceed the expense of repairing the original defect.

A related problem is the damage to the circuit-board wiring that is inevitable when excessive heat is produced by a soldering iron.

"Hot-chassis" TV receivers can sustain severe damage if grounded test equipment is connected to them directly without an isolation transformer. Most new test equipment has a 3-pronged power plug that grounds the equipment to the power-line ground. This protects the operator from certain kinds of electrical shock, but it does *not* prevent receiver damage when receiver ground and equipment ground leads are connected together during tests.

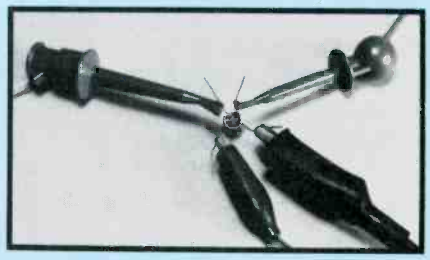
Another technician's nightmare is wondering whether or not it is safe to apply full power to a stereo or TV receiver. One common defect is a shorted power transistor, which is easy to replace. But if the transistor was ruined by a circuit defect that has not been corrected, the new one will be zapped instantly when power is applied. Methods of testing with limited voltage or current will be explained.

## Probes and clips

The first priority during diagnostic voltage readings and other electronic measurements must be the protection of the circuits undergoing tests. If you use a large, old-fashioned test probe and it slips and shorts together two points, the overload can ruin several solid-state devices instantly, producing shorts or opens. When that happens, the diagnostic problems are greatly multiplied.

The solution is in two parts. First, line voltage should be removed from the equipment under test. Second, an insulated-hook probe should be connected to the point before the line voltage is switched on and the reading obtained. Of course, the power should be switched off while the probe is removed and placed at another point.

When the leads or other measurement points are far apart, almost any alligator clip or test



A

B

**Figure 1.** Use probes and clips according to the clearances around testpoints. (A) When leads are widely spaced, almost any probe or connector can be used without danger, including larger alligator clips. (B) Taking readings on ICs by using a conventional meter probe (at left) is hazardous: component damage may result if the probe slips. A safer way is to turn off the power and attach an insulated hook-type probe before turning power on and making the measurement.

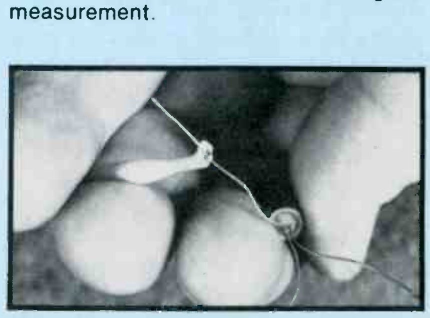


Figure 2. An insulated hook-type probe attaches securely to any component lead without exposing enough metal to cause shorts.

probe can be used safely (Figure 1). However, sufficient space is a luxury seldom found in new equipment. For these less-than-ideal conditions, the best probe is an insulated-hook type (Figure 2). An internal spring attempts to pull the hook back inside the insulation, so little metal is exposed as the lug or lead wire is grasped securely. This secure connection eliminates the problem of erratic continuity that gives varying and misleading readings while it protects against accidental shorts.

These insulated-hook probes can be obtained separately so you can add them to existing probe assemblies, or some complete probe kits have them already installed. They are offered in many hook sizes and body lengths. The Pomona Maxi-Grabber, for example, is about 6in long, so the hook can be engaged about 5in from where you are pressing the button to extend or retract the hook. This is helpful in crowded areas.

Many newer scope probes use the same hook principle, and they too are strongly recommended. Just remember to turn off the power during the time any probe is installed or removed. Make this a habit, and you will save much time and money because fewer repair jobs will be damaged during testing.

Another severe problem that interferes with power-on testing of voltages on some types of plug-in modules is that the access space along the top or bottom is not sufficient for conventional meter probes. In the example in which three RCA MAD001 video-driver modules are plugged in side by side with little space between, one solution is to remove a module from its socket and attach a hook probe to the proper component lead before reinstalling the module and making the measurement. Alternately, short, right-angle pieces of solid wire can be soldered to all desired testpoints on the module's wiring side. A hook probe then is connected to the extended testpoint (Figure 3) before the module is replaced and power turned on for the voltage measurement. These small pieces of wire can be left soldered to all circuits except the few (such as tuners and IF) in which added capacitances might degrade the performance.

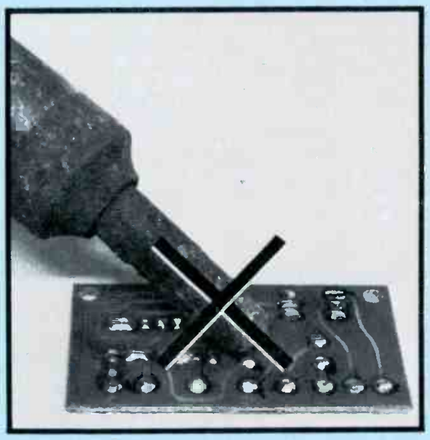
### Testing IC voltages and resistances

Because IC pins are tiny and have narrow spacing, IC voltage and resistance tests are made with difficulty and some danger to the components. Shorts and erratic contacts are common when ordinary meter probes are used. For ICs whose performances are not degraded by added small capacitances, a good solution is to use an IC test clip (Figure 4). Such a clip has an internal spring to hold the rods at the bottom against the IC pins, while the tops of those rods are elevated high above the clutter of other components where insulated-hook probes can be attached for dependable measurements.

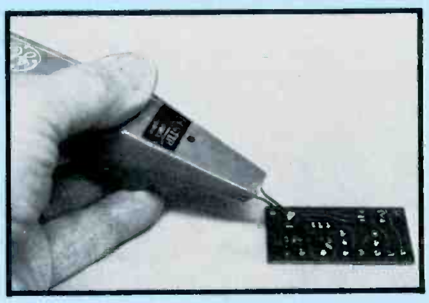
Test clips (such as the Pomona Dip Clip pictured in Figure 4) are available in sizes to fit most ICs with various pin counts. I strongly recommend these IC test clips for the convenience, safety and dependability they provide.

Manufacturers of some DMMs are changing the traditional

**Figure 5.** The design of some test probes minimizes the possibility of electric shocks. A plastic collar on the probe at left prevents fingers from sliding down the probe handle and touching the metal tip during measurements. The male banana plug (at right) is covered by plastic so no bare metal is exposed at the meter. This probe comes with Beckman meters.



**A**



**B**

**Figure 6.** Use a soldering iron that is appropriate for the task. Do *not* use a large 100W to 150W iron (A) or soldering gun on a circuit board. (B) A small iron with rechargeable battery is good for service calls or when ac leakage might cause damage to FET devices.

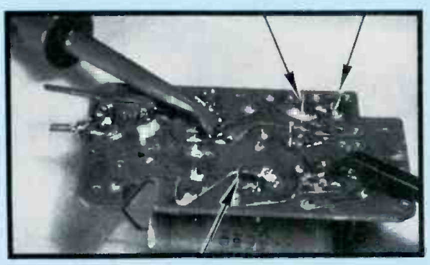


**Figure 3.** Where power-on tests must be made but there is a lack of room, solder short, right-angle pieces of solid wire to all testpoints and then attach a hook probe to them in sequence. Arrows point to several added wires.

**Figure 4.** Voltage and resistance tests at IC pins are easier and safer when a clothespin type of test clip is used, as shown. A spring holds the clip in place with the rods at the bottom touching the IC pins.

shapes of test-probe handles and plugs (Figure 5) to protect technicians from electric shocks by covering exposed metal with plastic.

**Tests by heating and cooling**

An excellent method of identifying many intermittent solid-state components is to alternately warm and cool one device at a time. Frequently, a heat rise causes a defective transistor, IC or diode to stop operating. If so, a short blast of canned coolant often restores the operation instantly. This proves the defect is heat triggered. Next the heat-sensitive component must be identified. Heat and cool sparingly, because it is easier to pinpoint the bad component that way.

Although a small increase of transistor temperature can be achieved by any of several ways, a safe, practical method is to warm a fairly large area with warmed air from a blower (such as the Wahl Thermal Spot). After the intermittent begins, *one component at a time is cooled* by a short blast of canned coolant, using the plastic extension tubing to *pinpoint* the spray. Repeat the warming and cooling for better accuracy.

*This method ordinarily requires far less time,* while often providing better accuracy than obtained by any other.

**Safe unsoldering techniques**

Circuit boards are sturdy enough when left alone, but they can crack from strain, including hairline cracks around rivets, and they can be damaged easily by improper desoldering. These boards are constructed of a solid sheet of thin copper, bonded by an adhesive to the board material. The circuit wiring pattern is achieved by dissolving the unwanted copper in an acid bath, leaving copper-strip *wires.* Unfortunately, excessive heat can melt the adhesive, allowing the weak, flat copper wires to separate from the board. These separated wires have almost no strength. Repairs can be made, but they often are unsightly and perhaps not satisfactory.

Therefore, the best advice is *never* to allow a board and its copper wires to reach a dangerous temperature during soldering and desoldering operations. I strongly recommend a thermostatically controlled iron as the best insurance against board damage. A standard low-wattage iron might not damage boards, but it probably could not solder larger joints properly. A temperature-controlled iron (Figure 6) has a 50W to 60W element that is cycled on and off as required to maintain a constant tip temperature, regardless of heat loads. When the tip is applied to a large joint that drains more heat, the *on* cycle becomes longer so the average heat is maintained without change. Controlled irons, therefore, can solder delicate and heavier joints equally well.

Incidentally, a very-low-wattage uncontrolled iron is likely to damage a board. With a normally hot iron, a joint can be soldered quickly, and the tip removed from the board, then afterwards the heat is dissipated rapidly so the adhesive is not disturbed. But a low-temperature tip must be pressed against the joint before the joint is soldered. *Neither low-temperature or excessively high-temperature irons should be used on circuit boards.*

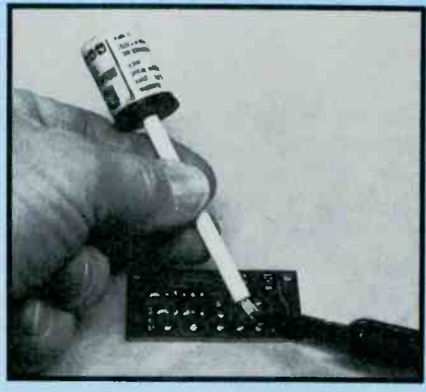


Figure 7. This wick dispenser tool contains copper braided wire that can soak up solder from circuit boards.

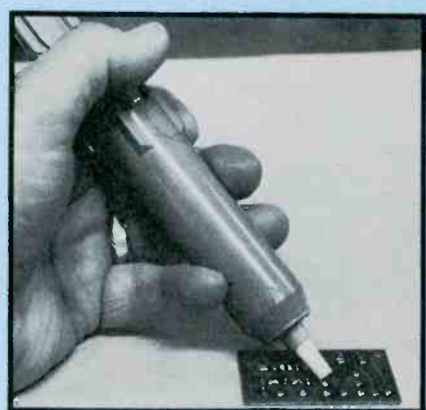


Figure 8. Spring-propelled vacuum pumps can remove solder from joints effectively, but some types might produce static electricity. This should be investigated before using any vacuum tool on FET or CMOS ICs.

In previous years when circuits were simpler, solder removal was easier. If the part was small, heat was applied to the joint and then the part was rapped against the bench, causing the excess solder to splatter from the joint. Obviously, this is not wise when a tiny joint near the center of a large circuit board is to be unsoldered. Solder splatters can cause erratic operation and expensive callbacks.

One effective method of remov-

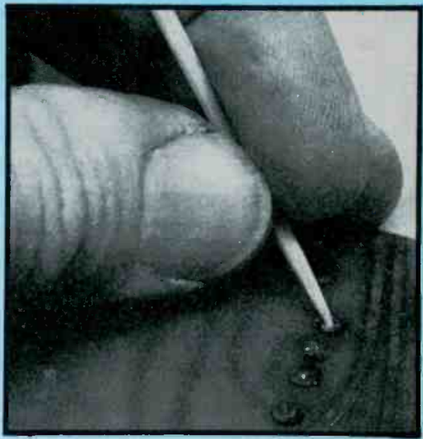


Figure 9. Braid and vacuum desolderers sometimes leave solder in circuit-board holes. An emergency method that works well on some boards is to push a toothpick in the hole while the solder is still liquid.

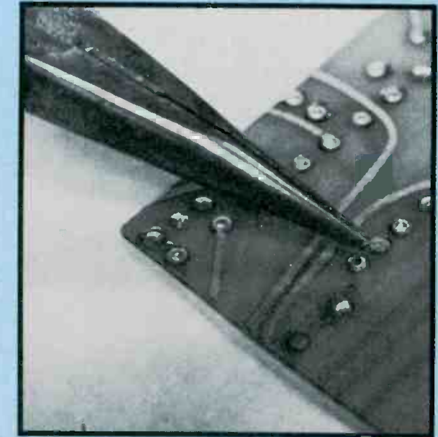


Figure 10. After braid or vacuum desolderers have removed all possible solder from a joint that has a component lead, but the lead remains stuck, use long-nose pliers to shake the lead in all four directions. When a soft pop is heard, the pin will be free and ready for removal.

ing old solder is to touch braided copper to the joint and then heat the braid (Figure 7). Melted solder will enter the braid by capillary wick action. Then the braid's end is cut off and discarded, along with the solder. Some braid is treated with rosin, and comes in a convenient container.

Another tool removes molten solder by vacuum power, which often sucks solder out of holes (Figure 8). Many brands, types and sizes are available. Each is armed by movement of a lever that compresses the vacuum chamber volume. When the soldering iron is removed from the molten solder, the tool's tip is placed instantly on the solder and the trip released. A spring-driven plunger expands the chamber space, creating a vacuum, which pulls the liquid solder into the tip (it can be removed later when cool). Several attempts often are required to remove enough solder.

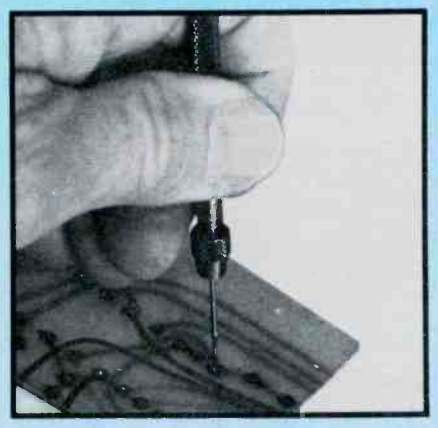


Figure 11. An excellent way of removing solder from board holes is to drill it out with a tiny drill bit, as shown. This drill and holder came from Total Technology, of Mooresville, NC, but you might find a comparable bit at local electronic distributors.

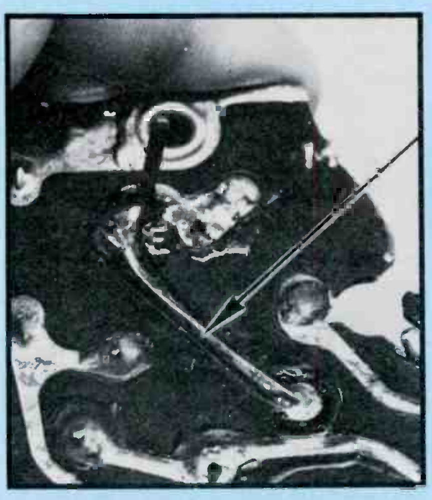


Figure 12. Don't repair an open in a board's copper wire by resoldering the wire. Instead, solder solid wire to the original flat wire from one component to another.

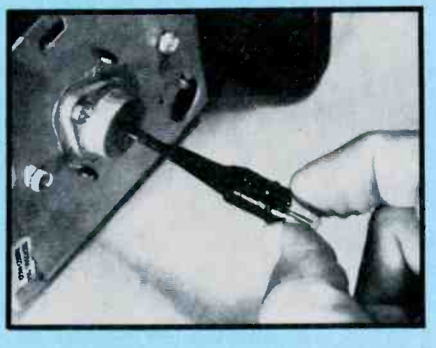
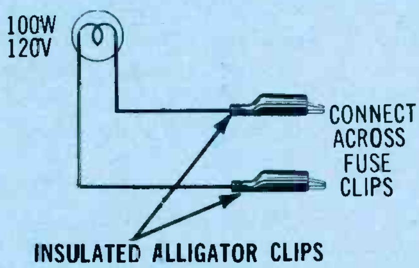


Figure 13. A good quick test for horizontal pulses is to use a small neon bulb, as shown. Touching the single lead to a horizontal-output transistor's collector is safe when the bulb is taped thoroughly and nothing but the glass is touched by a technician's fingers. Do not touch the lead to in the input pulses of a tripler.




A

B

Figure 14. One method of obtaining time for locating the source of serious shorts and overloads is to limit the voltage or current. An ordinary 100W light bulb reduces both voltage and current. In addition, the bulb shows the extent of the overload by its brightness. The schematic could not be more simple, but it is recommended that you mount the bulb socket on something that is not easily tipped over. Also, insulate the alligator clips for safety.

In an emergency, a sharp-tipped wooden toothpick can be used to push out the solder from a board's hole (Figure 9).

After most of the solder is removed, but a transistor lead (for example) remains stuck, use long-nose pliers to pinch the lead as you gently move the pliers sideways to break loose the solder bonds (Figure 10). Then the lead wire should be easy to remove.

If the unsoldered hole is still blocked by some solder, a hand-powered drill bit (Figure 11) can remove the solder, leaving a hole large enough for insertion of a transistor lead without any bending or other difficulties.

Another valuable tool is a visual magnifier. These come in many types, but a simple reading glass often is sufficient. When only one joint is bad and can be found with a magnifier, there is no need to solder *all* joints on a circuit board. A badly tinned joint probably will not be improved by casual resoldering.

If a length of copper foil becomes damaged and no longer adheres to the circuit board, it should be replaced by a piece of #18 or #20 solid wire. Solder the wire to component leads or circuit pads (Figure 12) at the ends, and dress the wire over the original path.

Remember that all metals to be soldered should be tinned first; this reduces the soldering time and minimizes the possibility of board damage. A well-soldered joint should be smooth and fairly bright. Old solder or insufficient heat will produce a rough joint that might deteriorate later, causing more problems.

### Neon-bulb sweep indicator

One of the quick tests from years ago that saves time for today's technicians involves the lowly neon bulb (Figure 13). A well-insulated piece of short, heavy wire is soldered to *one* terminal, and the wiring and socket of the bulb are taped thoroughly. Then the glass of the bulb is held in the fingers while the wire is held *near* a flyback or touched to a horizontal-output transistor's collector. Capacitance between the fingers and one neon plate is sufficient to light the neon.

Be careful not to touch the base or the wire to avoid a severe shock.

Do not touch the wire to the high-voltage pulse output from any flyback; the danger of arcs and shocks are too great for this test.

### Current-limiting bulb

Another old idea that continues to save time and money is the 100W incandescent light bulb that is substituted for an *open* fuse or circuit breaker. Figure 14 shows a photograph and a schematic of the bulb and its socket.

Two benefits can be obtained by using this light bulb to limit voltage and current when testing for shorts and overloads. First, the bulb brightness gives an instantaneous indication of the power flowing through the bulb. Second, the resistance limits the maximum current and wattage that can flow, even with a dead short. For example, if a bulb is substituted for an open circuit breaker in the ac-line power to a TV receiver, a 0Ω short in the receiver would apply only 120V at about 0.8A of current to the bulb. It would show normal brightness. Notice that no damage occurs to either the television or the light bulb.

The figures in Table A show another advantage of a light bulb over a linear power resistor: Bulbs have the effect of stabilizing the current by varying their resistance. Lower currents reduce the internal resistance. The normal small currents of a receiver produce a low voltage drop, while higher overload or short currents produce a higher voltage drop that limits the current. This varying bulb resistance provides more protection during overloads than is possible with linear resistors.

Connect this light bulb in any high-current circuit that has a near short circuit. If a color television has a fuse protecting the horizontal-output transistor and the fuse blows instantly each time the set is turned on, the bulb should be connected across the fuse holder (instead of a fuse). Almost full brilliance of the test bulb proves excessive current. Then the tripler, damper, horizontal-output transistor and other prime suspects should be disconnected one at a time until the bulb brightness drops significantly. The disconnected part that reduced the current is the most likely suspect.

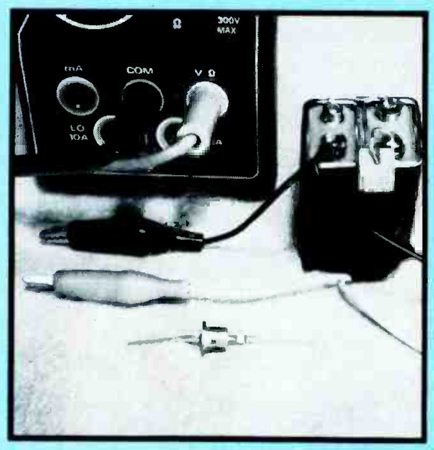
Similarly, the bulb can be clipped across the terminals of a line-power circuit breaker (if the breaker contacts are open – otherwise one terminal of the breaker must be disconnected). The current-limiting effect usually protects the receiver components so tests can be made more leisurely. The value of this technique cannot be overstated.

### Testing diodes

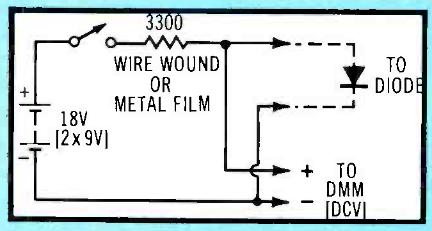
During the past few years, several DMM manufacturers have added an excellent diode test to their instruments. This function applies a constant current (between 1mA and 5mA) to a forward-biased diode junction. The resulting voltage drop provides an indication of several important characteristics of each diode. A low reading in both polarities indicates a short or excessive leakage; the diode is bad. A full battery-voltage reading proves the

| LIGHT BULB RESISTANCE | | |
|---|---|---|
| **RMS ac voltage** (measured) | **Amperes of current** (measured) | **Resistance in ohms** (calculated) |
| 120.5 | 0.833 | 144.66 |
| 100.1 | 0.755 | 132.45 |
| 60.1 | 0.569 | 105.62 |
| 30.9 | 0.398 | 77.64 |
| 15.25 | 0.279 | 54.66 (very dim bulb) |
| 10.71 | 0.239 | 44.81 (dark bulb) |

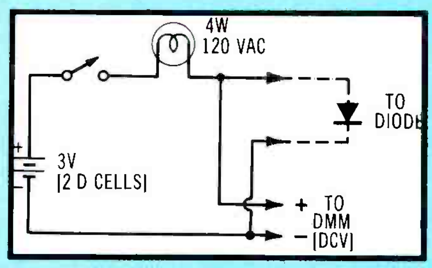
**Table A.** These measurements of bulb current at various voltages show that the resistance decreases with reduced bulb brightness. Therefore, the current is limited more when the short or overload is more severe. For this reason, a bulb gives better protection than could be obtained from a linear power resistor.




A




B




C

**Figure 15.** An excellent test for diodes and transistor junctions (A) is measuring the forward-bias voltage drop. The test works well in-circuit, also. (B) One test circuit has only two 9V batteries, one resistor and connecting wires. The higher battery voltage allows the testing of LEDs and other higher-voltage diodes. (C) This variation by M. C. Holman tests single transistor junctions and low-voltage diodes with satisfactory accuracy. It has two D cells for power. The battery life is excellent, but the circuit cannot test higher-voltage devices.

diode is open. A reading between 0.2V and 0.3V indicates a nondefective germanium diode or transistor junction. Similarly, a reading between 0.55V and 0.70V indicates a silicon junction or diode. Reverse resistance also can be estimated by the voltage drop.

Figure 15 shows a picture and two schematics of adapters that you can build and use to check diodes by their forward voltage drop. The figure 15B schematic is one I designed for an article in the July 1980 **Electronic Servicing.** High supply voltage and a high-resistance series resistor provide a constant current that varies little, regardless of diode current. One advantage is that LEDs, high-voltage multiple diodes, phase-detector diodes and some zener diodes can be tested. However, it requires two 9V batteries.

Figure 17C is a variation proposed by M. C. Holman of Clifton, TX. The incandescent lamp gives a reasonable amount of current limiting and requires only 3V of battery supply. Of course, no diodes having a barrier voltage higher than about 2V can be tested. Our thanks to Holman for this circuit variation.

Either circuit uses a dc-voltage meter as a readout. I prefer using the 2V range of a DMM. However, a VTVM or even a VOM can be used without reducing the accuracy excessively.

Try this circuit. It is very helpful, particularly because it operates well until the paralleling resistances decrease below about 500Ω. Bridge rectifiers can be tested in-circuit. After you have decided it is a practical feature, perhaps you will want to buy one of the DMMs that have the feature built in.

### Reducing line voltages

As stated before, testing for overloads in solid-state equipment requires some method of preventing additional damage to all components while power-on tests are made. Using a light bulb to limit the current is one approach. Another method is to reduce the incoming line voltage by using a variable-voltage transformer. This does not limit the current, but the line voltage can be lowered to between 40V and 70V, which is enough to protect many circuits.


**Figure 17.** Sencore model PR-57 Powerite also supplies metered variable ac voltages, but in addition, measures wattage, performs leakage safety checks and provides isolated power.


**Figure 16.** This old variable-transformer/ac-meter combination has provided adjustable voltage between 0V and 120V RMS for years. However, it has no isolation function, so it is dangerous to use with hot-chassis receivers.

Figure 16 pictures an old setup I have used for many years. It includes a United Transformer Varitran that provides output voltages variable between 0V and 120V RMS when the input voltage is 120V. Output voltage is monitored continuously by an RCA power-line monitor. This meter is not particularly accurate, but most waveform distortions do not degrade the readings, and the light damping allows the pointer to follow rapid power-line voltage fluctuations.

This unit, however, does not have an isolation feature, and the dangers of shock and equipment damage must be considered. I have a 1:1-ratio transformer with a 120V isolated secondary for times when I work on a *hot* chassis.

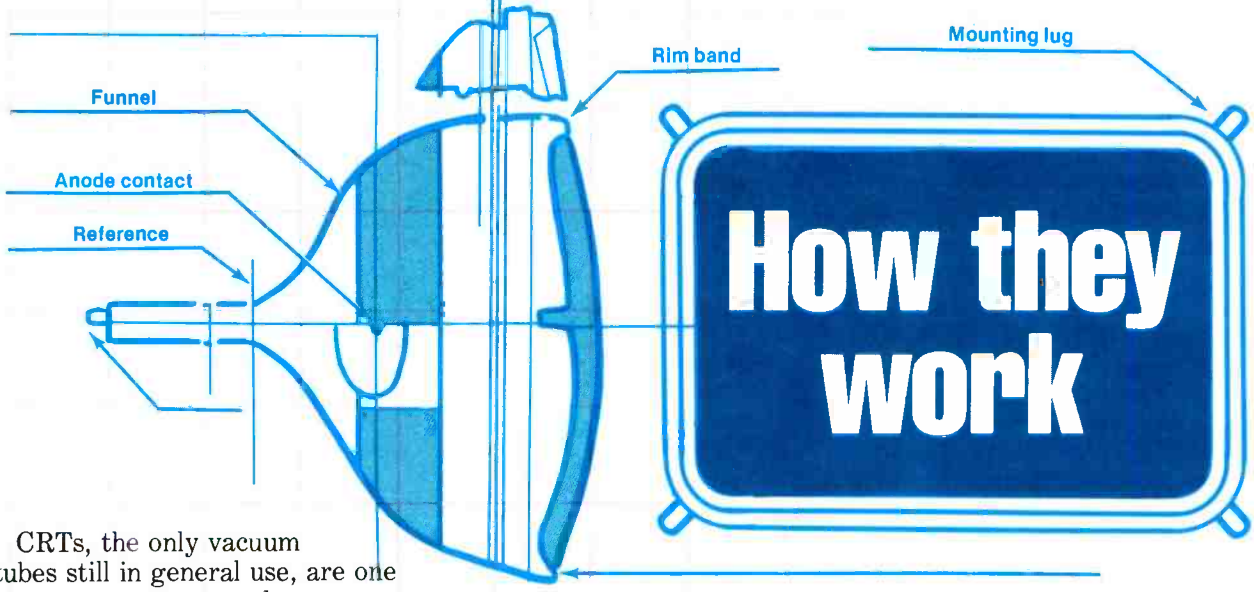
Of course, all these practical features and many more are found in a commercial product: the PR-57 Powerite from Sencore (Figure 17). In addition to the variable voltage, isolation from incoming power and meter readout of output voltage functions, the Powerite can indicate wattage (when the power factor is high) and also provides a meter readout of leakage from the isolated power to various outside grounds and other metallic connections. This latter test is essential to prove compliance with the national safety standards.

### Comments

Many of the suggestions shown here have been described in previous **Electronic Servicing & Technology** articles. Few of the methods or products are new, but all are worthy of additional consideration. Technicians need all the help they can obtain to service the new solid-state equipped products. ES&T

# CRTs: How they work

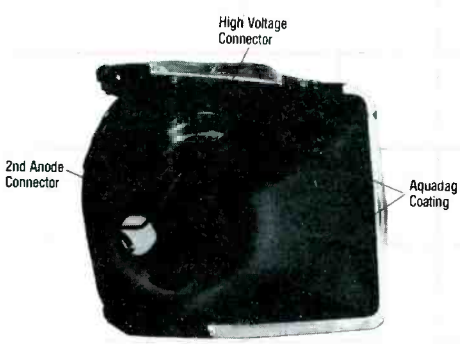
**A CRT (cathode-ray tube) is an electron-beam tube in which the beam can be focused to a small cross section on a luminescent screen and varied in position and intensity to produce a visible pattern.**
(Definition from IEEE Standard Dictionary of Electrical and Electronics Terms.)




CRTs, the only vacuum tubes still in general use, are one component guaranteed to wear out, but you don't necessarily have to discard them when they fail. Modern cathode recovery systems let you restore most bad CRTs to extend their useful life by months or years.

### What makes the CRT work?

A CRT has three major sections: the electron-gun triode assembly (the gun), several accelerator grids (the anodes) and the phosphor-coated screen. The gun forms and controls an electron beam, which is accelerated by the high voltage on the anodes until it has enough velocity to strike the screen and produce light. The amount of light emitted by the phosphor depends on the electron-beam current at any instant. Internal plates or external coils deflect the beam vertically and horizontally, moving the electron beam to any active area of the screen.




**The high voltage** connects to the aquadag coating and to the last accelerator grid of the electron gun.

### Electrons in space

The funnel-shaped glass between the thin neck and the flat screen, called the *bell,* is coated inside with a layer of carbon, called the aquadag (dag), to which the high voltage is connected. The dag forms a high-voltage field inside the bell that reduces the effects of external fields on the electron beam. Many technicians believe the high positive voltage on the dag attracts the electrons to give them the high velocity needed to strike the screen, but this is not quite true.

The electrons are already moving at close to their maximum velocity by the time they enter the bell, because the high voltage on the dag also connects to the last accelerator grid in the CRT neck. (Note: This grid and the focus grid are also called "anodes.") After this grid speeds the electrons toward the screen, the beam "coasts" through the large void of the bell. The dag does not increase the velocity of the electrons because its voltage attracts the beam equally from all directions. If this were not true, the electrons would travel directly to the dag and never reach the screen.

The dag collects the electrons after they strike the screen. This prevents electrons from piling up near the screen and forming a negative charge, which would repel additional electrons away from the screen and reduce the light intensity. The electrons collected by the dag drain off through the high-voltage lead and return to the cathode through the high-voltage power supply to complete the circuit.

### Hurling electrons at the screen

The spacing between the last grid (frequently called the second anode) and the focus grid (the first anode) is only about ½in. The potential between these two elements may be as high as 25,000V in a CRT with a 30,000V high voltage and 5000V focus voltage. This large change in voltage through such a small distance causes an enormous increase in the velocity of the electrons passing between the two anodes. The focus anode produces a similar (although smaller) increase in velocity because its positive potential is usually much higher than that of the second grid of the electron gun. The focus anode also, as its name implies, focuses the electrons into a tight beam to produce a small spot of light on the CRT screen.

The velocity of the electrons striking the phosphor depends on the voltage and spacing of the accelerating anodes. The voltage on the first and second anodes is fixed, meaning the velocity of the electron beam is a constant. Velocity does *not,* therefore, control the brightness of the CRT. The brightness is affected by the *number* of electrons (the beam current) hitting a point on the screen. This controlling action is the function of the triode that makes up the rest of the electron gun.

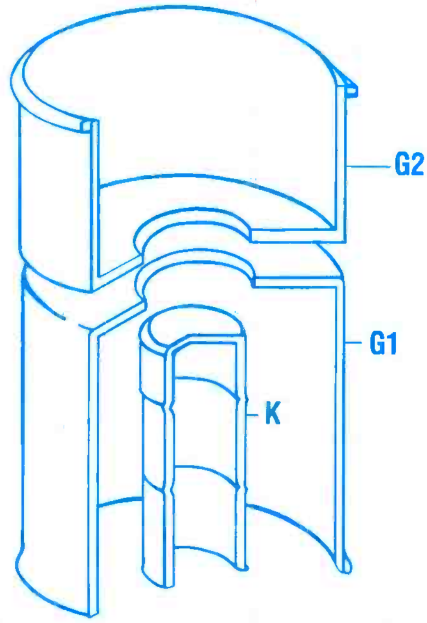
### Forming the beam

The cathode is the source of the electrons that form the beam. It is coated with a material such as barium or thorium oxide that gives off a large number of electrons when heated by the filament. These electrons form a cloud around the cathode.

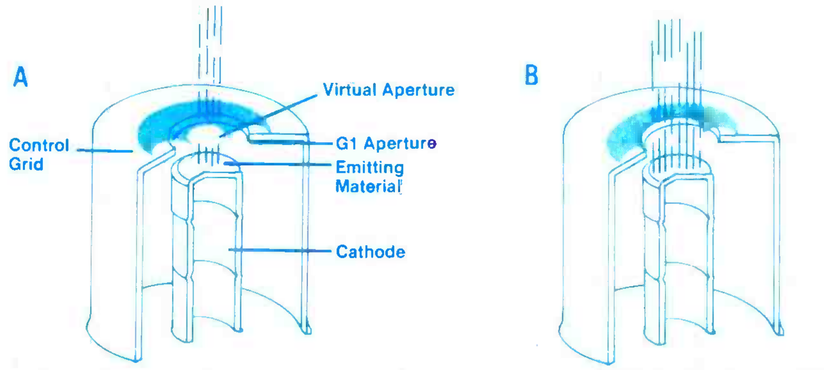
Two small metal cylinders with holes in their centers are placed directly in front of the cathode. These grids are called "G1" and "G2."

A positive bias on the *screen* grid (G2) pulls the electrons through the tiny hole in the *control* grid (G1). This shapes the electrons into the small round thread needed to form the tiny spot of light on the CRT screen.

The screen grid typically has a voltage between 200V and 600V, considerably lower than the voltage on either of the anodes. An electron floating between the cathode and G2 doesn't feel the effects of the high anode voltages because G2 blocks most of their attractive effects. As the electron moves to the hole in the middle of G2, however, this shielding action stops, and the first anode (focus grid) pulls the electron away from G2. Then, the second anode pulls the electron away from the first anode and hurls it toward the screen.




**The positive bias** on the screen grid (G2) pulls the electrons from the cathode (K) through the tiny hole in the control grid (G1) to form the electron beam.




**The G1 bias** controls how much of the cathode surface contributes electrons to the electron beam. Left, the center contributes electrons with a high negative bias. Right, most of the cathode supplies electrons during low bias conditions.

The shielding action of the screen grid allows us to control the intensity of the electron beam with relatively small signals.

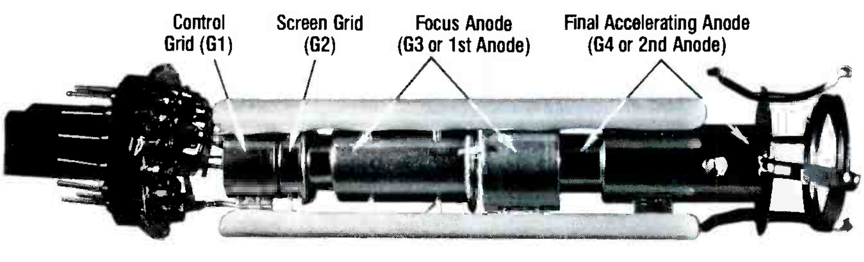
### How the control grid works

The control grid, G1, limits the amount of beam current pulled from the cathode by using a negatively charged field to repel electrons back toward the cathode. When the negative G1 bias is strong enough to completely stop the electron beam, it effectively closes the small hole in G1. This condition is called *cutoff* and results in no beam current at all reaching the CRT screen.

Reducing the bias on G1 causes the CRT to come out of cutoff. The positive G2 voltage overpowers the negative G1 bias, allowing some current to flow. Further reducing the G1 voltage allows even more current to flow.

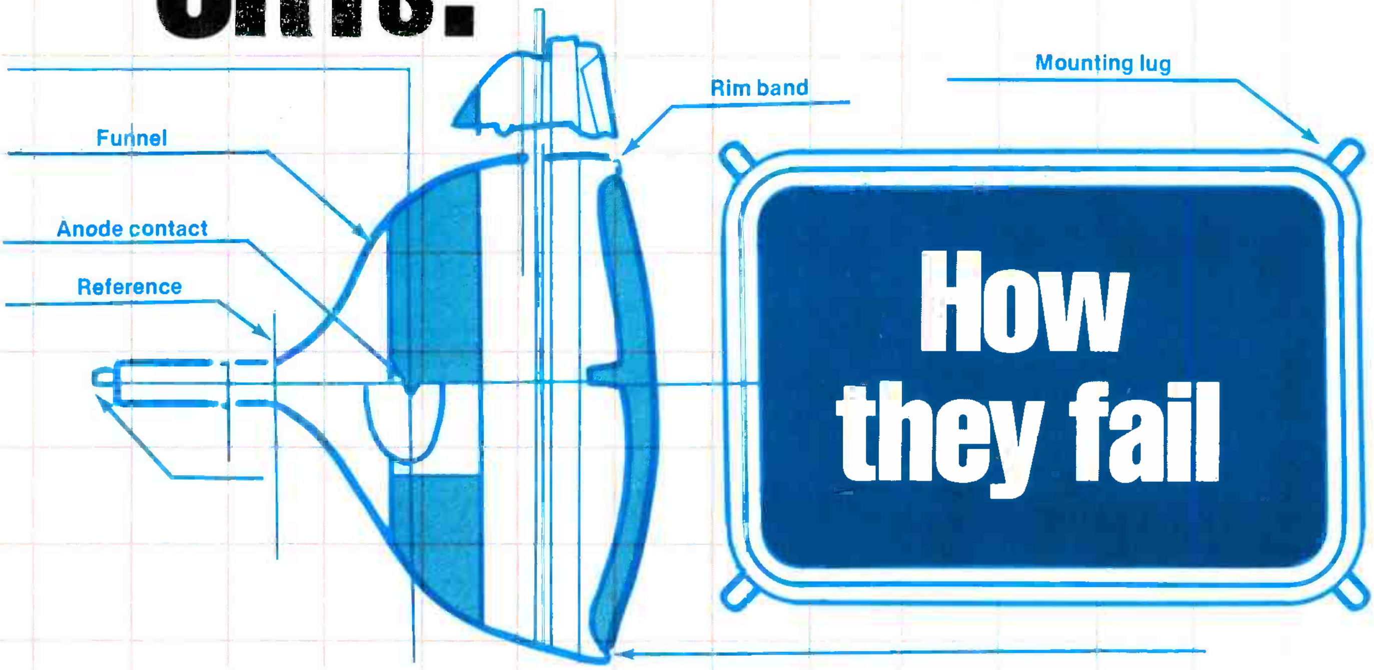
The field from the negative bias on G1 is equally distributed around the control-grid aperture. Effectively, the bias reduces the size of the hole in the center of the control grid. We call the effective size of the hole the *virtual aperture.* The virtual aperture is larger with a small bias and smaller with a large bias. This opening and closing action is similar to an iris in a camera lens opening or closing to control the amount of light passing through.

The smaller dimension of a highly biased control grid allows only a small section in the center of the cathode to supply electrons to the electron beam. Reducing the G1 bias increases the beam current by opening the virtual aperture and allowing a larger area of the cathode to contribute electrons. Removing the bias altogether allows the entire cathode surface to emit electrons. But this is an abnormal condition. Zero bias produces such a high beam current that the electron beam striking the CRT screen scatters, causing spot width to increase and resulting in "blooming."



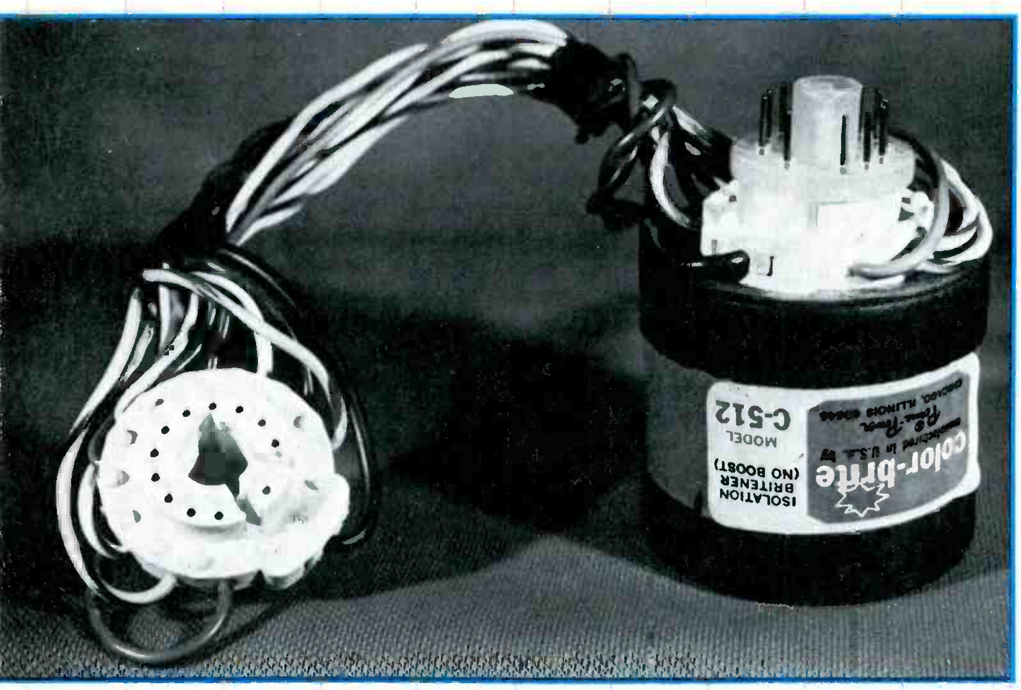

**Notice how close** the second anode is to the first anode. The close space and large voltage difference accelerate the beam toward the screen.

# CRTs: How they fail




Most CRT failures involve the electron gun, but beyond that, failures are limited to burned phosphors, loose shadow masks and arcing. Each of these produces distinctive symptoms that generally cannot be confused with an electron-gun failure.

Most technicians think of CRT electron gun failures in terms of two types: shorts and low emission. Each of these categories, however, includes several failure modes.




**An isolation transformer** connected to the filament eliminates the interference from an H-K short in a 60Hz powered chassis. Scan-derived filaments usually don't show a problem because their power source is already isolated.

### Open filament

As with any electron tube, the cathode cannot produce free electrons if the filament does not produce heat, and nothing can be done to repair an open filament, short of rebuilding the tube.

### H-K short

A heater-to-cathode short occurs when the filament comes into direct contact with the cathode, or when a flake of conductive material becomes lodged between the two elements.

If the filament is powered from the 60Hz ac line, an H-K short produces a *hum bar* across the CRT because the 60Hz ac power signal modulates the cathode. There is generally no symptom if the CRT is powered from the horizontal flyback transformer (scan-derived power).

### G1 shorts

Most control-grid (G1) shorts are caused by a conductive flake of cathode material lodged between the cathode and the control grid. Shorts between the control grid and the screen grid (G2) are less common because of the larger spacing between these elements.

A G1 short usually causes loss of

control of the CRT beam. Some shorts cause visible retrace lines because the short prevents complete cutoff of the electron beam during retrace. Other shorts cause the electron beam to run wide open, resulting in a bright red screen, for example, if the red gun is affected.

### Dynamic shorts

A dynamic short is one that is only present during CRT operation. In most cases, heat or the CRT operating voltages cause a metal element to distort to cause the short. The close spacing between CRT elements in new, compact CRT designs results in more dynamic shorts than in the older, larger CRTs. A dynamic short may affect operation as soon as the CRT is turned on or after it operates for several minutes. The chassis symptom indicates a CRT-related problem such as loss of control of one color, poor focus, retrace lines or loading of high-voltage power supplies. The CRT often tests good on a CRT tester because of the intermittent nature of the short.

### "Gassy" tubes

Most technicians call a tube gassy if it shows bright, silvery whites and deep blacks with few shades of gray. The condition is not usually caused by "gas," but by a worn cathode.

The constantly changing G1 virtual aperture often causes the emitting material to wear out faster in the center of the cathode than at the edges. This happens because the center contributes electrons almost all the time, while the outer cathode areas only supply electrons during peak white periods. A CRT with this condition produces bright whites, but the beam current becomes non-linear in relationship to the G1 bias for shades of gray.

For example, consider a CRT designed to reach cutoff (beam extinction) with 70V of negative bias. As the center of the cathode wears out, the electron beam may cut off with only 50V of bias (normally a level representing a gray picture element). The CRT still produces normal brightness because the emission with a large virtual aperture (low bias) is still high. Thus, the picture has bright whites and deep blacks but virtually no shades of gray in between. The correct term for this condition is poor "gamma," or the ability to correctly reproduce different shades of gray.

### Cathode poisoning

A CRT with reduced brightness or contrast usually has a layer of positively charged ions covering the cathode-emitting material. The ions result from the air in the CRT (no vacuum is perfect) reacting with the cathode-emitting material. The ions reduce or completely shut off the number of emitted electrons. This condition is called cathode poisoning.

If the poisoning affects the entire cathode surface, the CRT shows reduced brightness over the entire contrast range. At other times, contrast is reduced because the poisoning is worse on the outer cathode edges, meaning only the white levels are affected. In these tubes, the poison builds more slowly at the center of the cathode because the constant beam current keeps the center area cleared of ion contamination. This is the opposite of the gamma problem discussed earlier.

### Air-contaminated tubes

A CRT that has lost most or all of its vacuum generally will have open filaments because the filament burns within several seconds when heated in air. Some CRTs, however, develop a slow air leak that may take weeks or years to lose all the vacuum. These CRTs may show one of two conditions:

*Short life after restoration.* Air contamination causes the cathode surface to become covered with ion poisoning quickly. These CRTs often respond well to restoration. When tested the next day (or several days later) the CRT tests bad because the cathode has become repoisoned. There is no repair for this tube other than replacement.

*Blue glow.* A tube with slightly more air may show virtually no image on the CRT screen. A blue glow may appear around the control grid when the filament is hot and bias voltage is applied. The glow stops when the G2 voltage (screen voltage) is reduced below the normal bias level.

The air in the tube is acting similar to the gas in a gas-filled regulator. It does not conduct until the voltage potential causes the air to ionize. The ionizing air then offers a low resistance path, which prevents the electrons from getting past the control grid, causing no beam current to reach the CRT

**A "gassy" CRT** results when the center of the cathode wears before the outside edges, causing non-linear gray-scale response.

screen. The high current condition continues until the voltage is lowered to a point that allows the ionization to stop, but the tube is then in cutoff, so the cathode current drops to zero.

You may not see this condition until after you have restored or rejuvenated the CRT, making you think the condition is caused by the restoration or rejuvenation, but this is not the case. The air severely poisoned the cathode, and restoring or rejuvenating the CRT simply clears enough of the poison from the cathode surface to allow the ionization to take place. The tube is ruined and must be replaced.

### Stripped cathode

A "stripped" cathode has lost most or all of its emitting material. An old-fashioned rejuvenator, which may apply momentary cathode currents of several amperes, is one common cause of stripped cathodes.

The cathode may also become stripped by repeated use of a restoring system over a period of months or years. Each application of restoration extends the CRT life, but for shorter and shorter periods of time as the amount of cathode material becomes exhausted. A stripped cathode produces virtually no beam current, resulting in poor brightness or contrast. Once the cathode is stripped, nothing can be done to improve the emission.

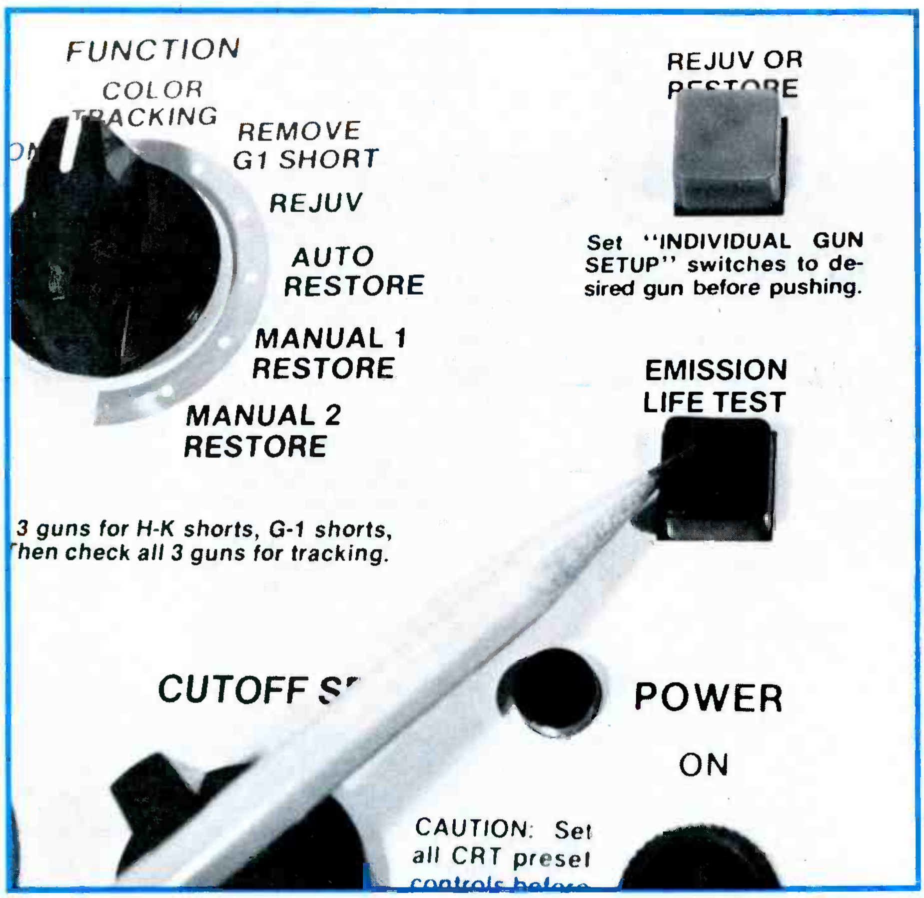
### Temperature-sensitive cathode

A cathode always emits fewer electrons if its temperature is lowered. Two conditions cause the temperature-related reduction in cathode current to be more severe than usual: a reduction in the amount of cathode-emitting material or a thin layer of ion poisoning that barely affects the beam current at normal temperatures.

In the first case, remember that a "healthy" cathode liberates many more electrons than required by the electron beam, even for periods of peak beam current. Normally, a slight reduction in the cathode temperature reduces the number of freed electrons, but the temperature must be lowered quite a bit before the beam current is affected. As the cathode material wears, the electron reserve becomes smaller. The cathode is eventually unable to provide enough electrons to supply the beam current, even at normal cathode temperatures. Finally, the cathode is stripped of nearly all active emitting material, and the emission drops to near zero.

This, by the way, is the basis for the emission-life test on CRT and receiving-tube testers: The tester either reduces or removes the filament voltage. The emission current drops off more quickly in a tube with a cathode that has almost run out of emitting material than in a good tube. The rate or amount of current drop relates to the expected remaining life of the cathode.

In the second case, the cathode acts exactly the same when used or tested as the tube we just covered. A light layer of ion poisoning allows normal emission current when the tube has the proper filament voltage, but causes a rapid drop in emission when the filament is slightly cooled. The difference between this tube and the one with failing cathodes is that the poisoned cathode can be improved with restoration.



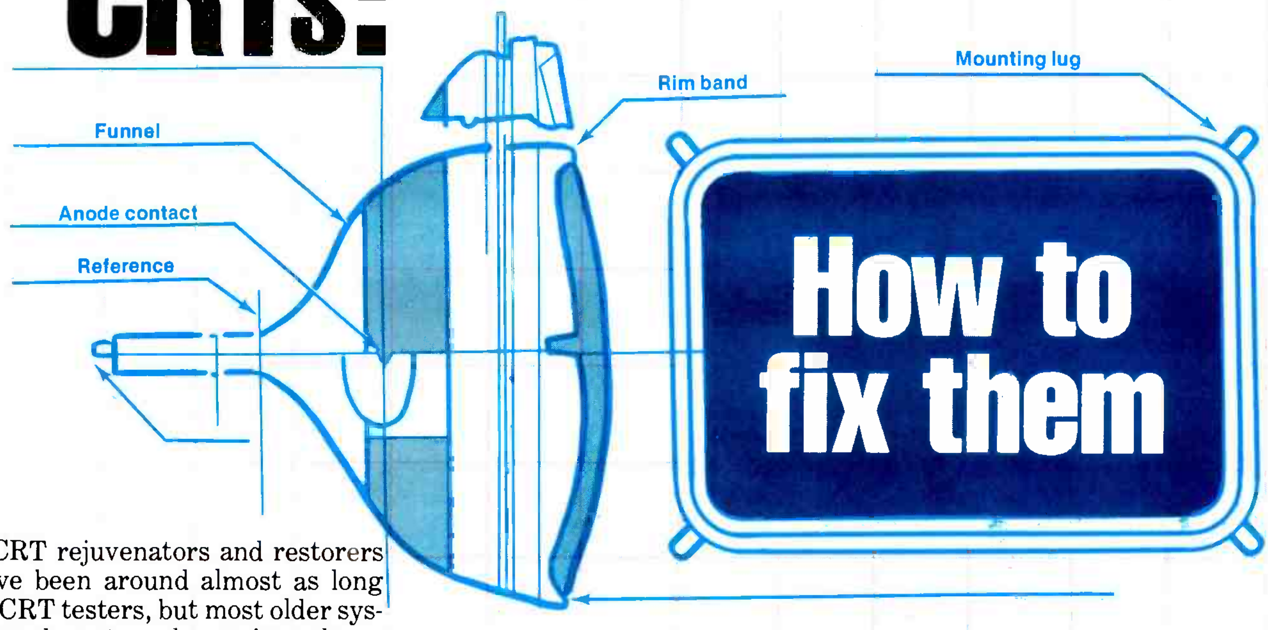

**The life test** on a CRT tester reduces the filament voltage to isolate temperature-sensitive cathodes, which indicate light poisoning or depleted emitting material.

### Color tracking

A color CRT (or the three separate monochrome CRTs of a projection system) may have plenty of emission and otherwise test fine on a CRT tester but may still produce a poor picture because the three colors do not balance. This color-tracking problem is usually easier to identify on a monochrome picture, as some of the picture elements show a color.

CRT manufacturers specify that one color gun of a good CRT should not be more than 55% stronger or weaker than any other gun. The receiver or monitor designer then uses this specification to design the CRT bias circuits. If a CRT falls outside the 55% limit, the screen and drive adjustments on the back of a color monitor or receiver may not have enough range to allow the weakest and strongest color to be balanced so that they produce correct color balance.

# CRTs: How to fix them




CRT rejuvenators and restorers have been around almost as long as CRT testers, but most older systems do not work consistently on newer CRTs. The main problem with the older systems is that they apply too much current and therefore damage more tubes than they improve. Many CRT testers on the market still use the old high-current circuits. A few newer units, however, offer safe current levels that are effective on new CRTs. There are three types of cathode recovery: shorts removal, rejuvenation and restoration.

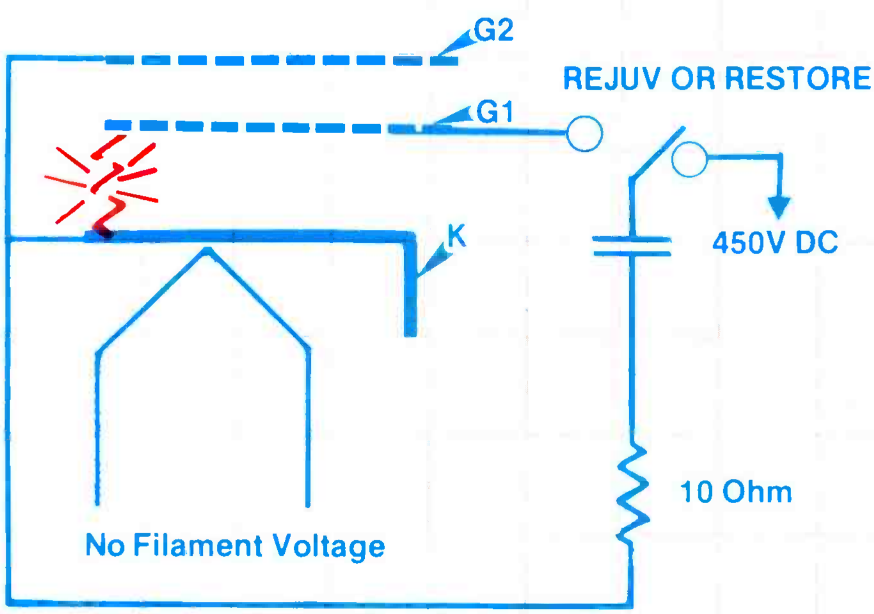
### Shorts removal

A G1 short is usually caused by a flake of cathode material lodged between the cathode and G1 or between G1 and G2, so you can usually vaporize this material by feeding a high current through it.

Most restoring systems charge a capacitor to a high voltage (about 450V) and then discharge it through the shorting material. The power to the filaments is removed during the discharge to prevent possible damage to the filaments or to the cathode. The capacitive-discharge system is self-protecting because a direct short simply discharges the capacitor faster than one with resistance. There is no chance of damaging delicate CRT gun elements with overheating because the process stops as soon as the capacitor has discharged.

Other systems feed a continuous ac current, limited by a resistor or light bulb, through the shorting material. A direct metal-to-metal short, however, blows out the light bulb in some of these systems.

Don't try to remove a short between the heater and cathode. The surge of current needed to remove the short almost always burns the filament open, resulting in a dead tube. H-K shorts are best isolated with an isolation-type picture tube brightener when the CRT filament is powered from an ac line transformer. The brightener does not remove the short, but isolates it from ground so there is no common connection between the filament power source and the control grid circuit to cause picture distortion.




**Shorts to G1** are vaporized by discharging a large capacitor through the shorting material.

### Reactivating the cathode

Besides removing shorts, all other forms of cathode recovery attempt to improve the cathode emission current. Properly controlled, this can be effective, with success rates as high as 90%.

The positive ions that sometimes poison the CRT surface result when the cathode reacts with the tiny amount of air inside the CRT. These ions can often be driven from the cathode (and turned back into free-floating gas molecules) if the cathode is heated to a much-higher-than normal temperature. The CRT manufacturer uses a similar process (called activation) to clear the cathode surface of ions when the tube is first built or rebuilt. CRT cathode recovery may be done with rejuvenation or restoration.

### Rejuvenation

Rejuvenation used to be the most common cathode-recovery system. A rejuvenation circuit looks similar to the capacitive-discharge shorts removal circuit except that power is applied to the filament. The capacitor connects between the cathode and G1 with a resistor in series to limit the current. The bias from the capacitor forces the cathode to conduct current. A cathode with bad poisoning restricts the current, causing the capacitor to discharge slowly. A cathode with more conductive surface area discharges the capacitor quickly, which clears an opening in the poisoned layer.

Capacitive-discharge rejuvenation applies high cathode current for a short time. The high current and short time makes the rejuvenation affect a small area of the cathode. Once a small section of the cathode clears of ion poisoning and begins to conduct heavily, that small conductive area quickly discharges the capacitor before other areas are cleared of poison.

Older rejuvenator designs applied so much current to the cathode that they often removed good cathode-emitting material along with the poisoning ions. Many applied so much power that they stripped some cathodes to the bare metal, resulting in zero emission current. New systems, however, limit rejuvenation current to safe levels. The new Sencore CR70, for example, places a 1000Ω resistor in series with the capacitor to limit the rejuvenation current, compared to only a 10Ω resistor or no resistor at all in older systems. Also, the new unit does not increase the filament voltage to step up cathode activity during rejuvenation. The older systems increased the filament voltage by as much as 50%, which results in an increase in emission current of up to 200%. Thus, the new CR70 system applies nearly 2000 times less current than some old rejuvenating systems. This lower current is effective and safe.

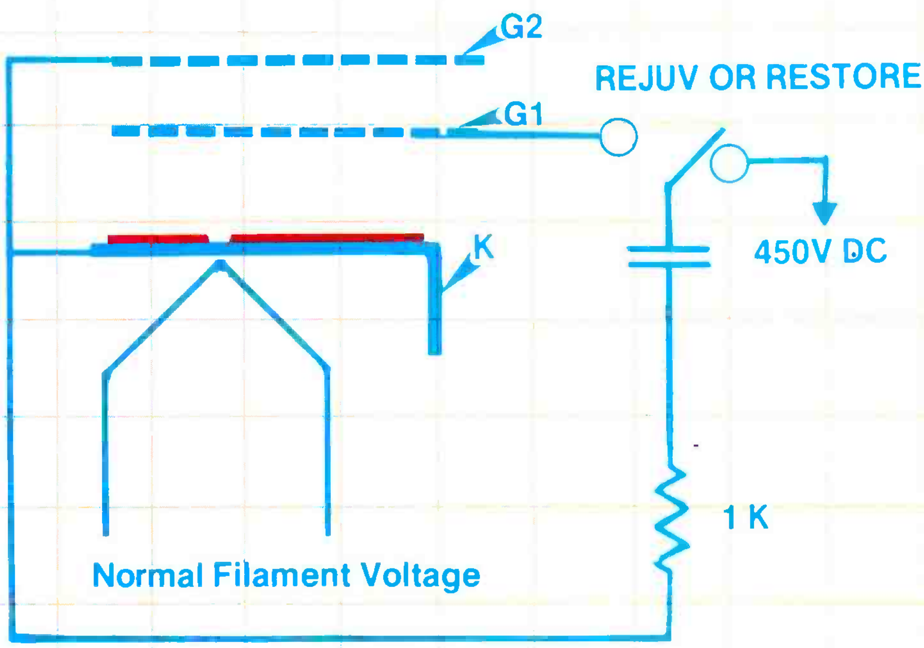
### Restoration

Restoration is similar to rejuvenation in that a higher-than-normal beam current is drawn between the cathode and the control grid. Compared to rejuvenation, this current is drawn at a much lower level for a much longer period of time.

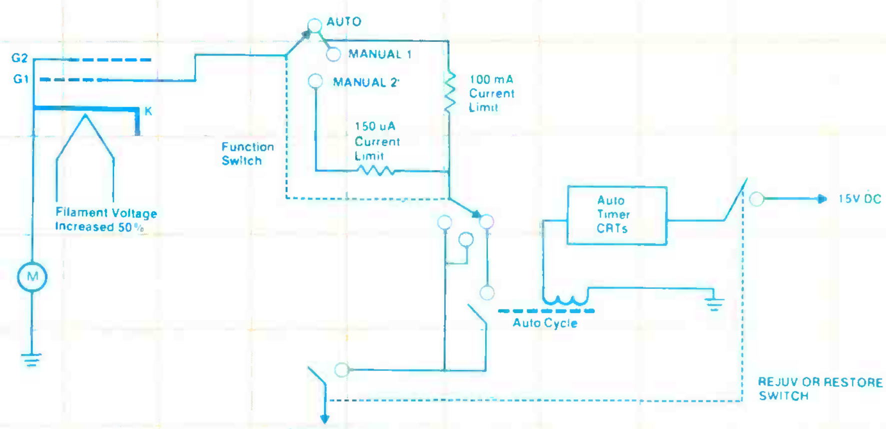
Restoration causes a current of about 100mA to flow from the cathode to G1, compared to the several amperes possible with some rejuvenation systems. This current is high enough to cause the cathode to heat to well above its normal operating temperature, and is low enough to prevent stripping emitting material from the cathode.

Restoring current is applied for several seconds. The higher-than-normal current flowing from the cathode for the long period of time causes restoration to affect nearly all the cathode surface. The amount of cathode surface conducting current may start in a small area, and then grow as more and more of the surface begins to clear of the ion poisoning. Thus, most of the surface eventually becomes activated.

Some CRT cathodes are so badly poisoned that a restoration system will not draw enough cathode current to produce the extra heating




**Rejuvenation** discharges a capacitor through a current-limiting resistor to open a small area in the cathode poisoning.




**Restoration** applies a much lower current than rejuvenation for a much longer period of time to affect more of the cathode surface.

needed to remove the poison. In these cases, a shot of capacitive-discharge rejuvenation can be used to open a small area of the cathode. Then, switching back to restoration allows current to be drawn from this freshly opened area. Heat from the open area spreads to the surrounding cathode surface to reactivate a larger and larger area.

### Correcting CRT failures with cathode recovery

*General poisoning.* This cathode problem is the easiest to correct with a cathode recovery system. Many times, a single application of restoration is all that is needed to clear the poison. When the poison is extremely bad, a single shot of rejuvenation may be needed to start cathode current so restoration can be used to finish the job. The only time general poisoning is a real problem is when it is caused by excessive air in the tube, which may cause the tube to fail again in a short period of time.

*Edge poisoning.* This tube may be a little more stubborn, requiring the restoring current to be applied for a longer period of time to ensure that the outer cathode areas are properly heated. In most cases, however, the tube can be returned to near-new conditions. In this case, rejuvenation would be the *worst* thing to try. The rejuvenation current will only pull current from the good center area and not begin to touch the outside areas that need improvement.

*Light poisoning.* This tube generally passes all of the tests on a CRT tester except the life test. A single application of restoration current generally brings the tube back to like-new operation.

*Gamma problems.* You may not be able to bring a cathode that is worn in the center back to a brand new condition, but the gamma problem can usually be improved. A cathode with a worn center often has poisoning around the edges also. Restoring the cathode clears the surface outside the worn area, bringing the tube closer to its original specifications.

*Depleted emitting material.* This tube probably will check bad on the cutoff and/or emission test. Application of restoring current may improve the emission and cutoff results, but the life test will show a rapid drop in emission. This simply tells you that the tube will give a fair picture for now, but that the depleted emitting material will cause a rapid deterioration of picture quality. The more emission drops, the sooner the tube will fail.

### Conclusion

A good CRT analyzer should not only tell you a tube is "bad," it should also also indicate the particular type of failure a bad tube is experiencing. Knowing the specific problem guides you when using a restoring system to improve most weak or shorted tubes. Because there are many different types of CRT failure, there should also be several different methods of shorts removal, rejuvenation and restoration for maximum cathode recovery success. The current levels, however, must be properly controlled for maximum safety on the delicate cathodes used in modern CRTs. ES&T

**Test Results**

| Cutoff | Emission | Tracking | Life | Cathode Beam Building Procedure |
|---|---|---|---|---|
| Good | Bad | | | Auto Cycle; Manual 1 if still weak |
| Bad | Good | | | Auto Cycle |
| Bad | Bad | | | One shot Rejuv, then Auto Cycle |
| Good | Good | Good | Bad | Auto Cycle |
| Good | Good | Bad | | Auto Cycle lowest gun |

**Matching the cathode** recovery process to the CRT failure increases the chances of improving a bad CRT.

# Test your electronic knowledge

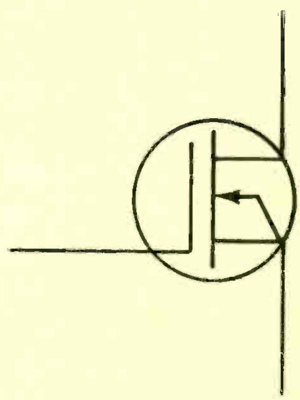
**By Sam Wilson**

These questions are similar to questions used on the various CET tests. All questions on the actual CET test are multiple choice, and a grade of 75% or better is required for passing. These questions are related to the Associate Level test section called *Electronic Components and Circuits*. The answers are given on page 60.

1. Which of the following is not normally operated with a reverse voltage?
   A. tunnel diode
   B. varactor diode
   C. zener diode

2. Which of the following is a semiconductor equivalent of an inductor?
   A. inductosyn
   B. corillator
   C. amplihenry
   D. gyrator

3. Which of the following best describes the symbol shown in the figure?



   A. N-Channel MOSFET
   B. P-Channel MOSFET

4. The characteristic curve of a neon lamp is most like the characteristic curve of
   A. a Shockley diode.
   B. an SCR.
   C. a diac.
   D. an inductosyn.

5. To convert a microammeter to a voltmeter, you would need a
   A. diode.
   B. shunt.
   C. varistor.
   D. (None of these choices is correct.)

6. Which of the following components normally has a 2-way bus on its data line?
   A. RAM
   B. ROM

7. Which of the following components is most likely to be found across the primary of an output transformer?
   A. variac
   B. varistor
   C. varactor
   D. variometer

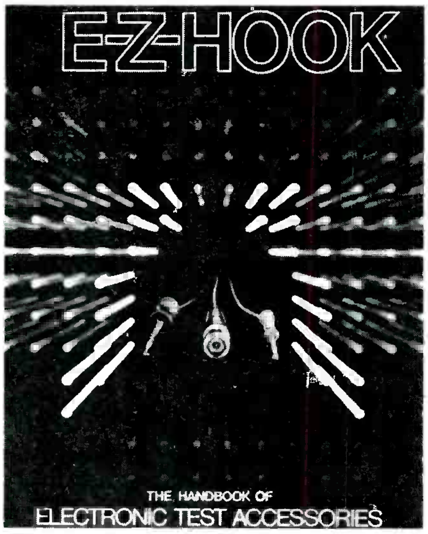
8. Which of the following combinations has a higher value of time constant?
   A. A 27 meg resistor and a 150nF capacitor
   B. A 25K resistor and a 170$\mu$F capacitor.

9. To increase the frequency of a parallel L-C circuit you could move the capacitor plates
   A. closer together.
   B. farther apart.

10. In which of the following are you most likely to find a decoder?
   A. an A/D converter
   B. a D/A converter
   C. a display circuit
   D. a 2-phase $\mu$P clock circuit.

# Literature

Hundreds of time-saving solutions to common testing, hook-up and assembly applications are offered in a new 106-page catalog of electronic test accessories, published by **E-Z-Hook.** The "Handbook of Electronic Test Accessories" contains specifications, configuration diagrams, applications examples and ordering information on E-Z-Hook's complete lines of products, including DIP testing accessories, continuity and voltage testers, multi-lead assemblies, test leads, wire products, jumpers, probes and patch cords, component adaptors, coaxial test accessories, cables and connectors.




Circle (112) on Reply Card

A new wall chart that facilitates the task of identifying the correct ECG replacement transistor, especially for types not cross-referenced, has been published by the Distributor & Special Markets Division of **Philips ECG.** The silicon transistor selector guide covers 197 NPN and complimentary PNP devices, and is a handy adjunct to the ECG Semiconductor Master Replacement Guide 212L. Devices are grouped by case styles and give corresponding ECG types in order of increasing breakdown voltage.

Circle (104) on Reply Card

A new 35-page application note on the TDA 4700/4718 control ICs for switched-mode power supplies has been issued by **Siemens.**

The application note describes the functions of the TDA 4700 and 4718 and provides detailed information for the developer with regard to the dimensioning of the IC peripheral circuitry. Principal application and third application circuits are covered in detail, followed by information for the symmetry of push-pull circuits and for synchronization.

Circle (105) on Reply Card

A new, revised and expanded 200-page PC-drafting-aids technical manual and catalog is available from **Bishop Graphics.** The *Bishop Graphics Printed Circuit Drafting Technical Manual & Catalog 107* is divided into two separate sections—an expanded product catalog and an updated technical manual. Time-saving section selector tabs denote each individual product category, and facilitate fast location of a desired item or product.


Circle (106) on Reply Card

A 35-page *Service and Operating Handbook* covering the use of RAC-10 Mark II and RAC-10 Mark II DNR automatic cassette changers is available from **Benjamin Electroproducts.**

This illustrated handbook in-

# Marketplace



cludes all necessary operating information on the cassette changers and details specifications, technical characteristics, installation data, repair, cleaning procedures, maintenance, instructions and warranty covering the systems. Schematic diagrams depicting the operations of each of the units are clearly defined, and a replacement parts list is also included.

**Circle (100) on Reply Card**

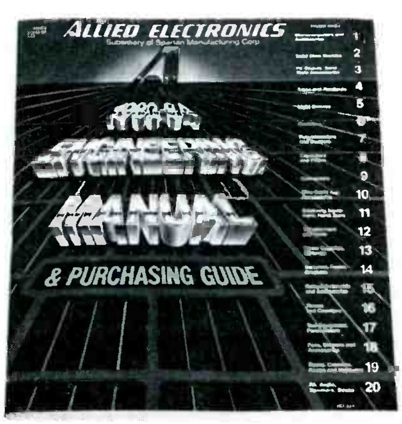
**Continental Resources** has issued its 1983 *Electronic Instrument Rental Catalog,* which includes analyzers, generators, meters, oscilloscopes, recorders and telecommunications equipment. All items appear with full specifications and monthly rental rates, and are available for immediate delivery. Instruments are tested, calibrated and guaranteed to meet manufacturers' specifications, while adhering to all NBS certification regulations.

**Circle (101) on Reply Card**

**Allied Electronics'** 1983-84 *Engineering Manual and Purchasing Guide* is a current, state-of-the-art guide for anyone who uses or specifies electronic parts, including engineers, buyers, teachers, technicians, plant maintenance people and hobbyists.

Page after page of illustrations, dimensions, technical data and specifications, full descriptive explanations and prices provide all the information needed for product selection. It also includes bulk pricing or large-quantity buyers.

Products included are solid-state devices, ICs, chips, test equipment, wire, cable, microcomputers and software, PC boards, tubes, readouts, light devices, resistors, pots and controls, capacitors, connectors, soldering equipment and other items.




**Circle (102) on Reply Card**

**Perma Power Electronics** has released a free data sheet describing its long-strip, industrial, multiple-outlet strips. The new literature describes 10 Sockets Plus outlet-strip models, which provide up to 24 outlets for plugging in tools, test instruments and appliances. The units are ideal for assembly line, product burn-in or test station and other similar applications.

Each of the new models is protected against overloads by a built-in 15A circuit breaker and has a master switch and indicator light. Each has either a 6 or 12 ft. double insulated line cord. All units feature U-ground outlets, with electrically-wired ground and phosphor bronze dual wiping contacts.

**Circle (103) on Reply Card**

ES&T

## Answers to quiz

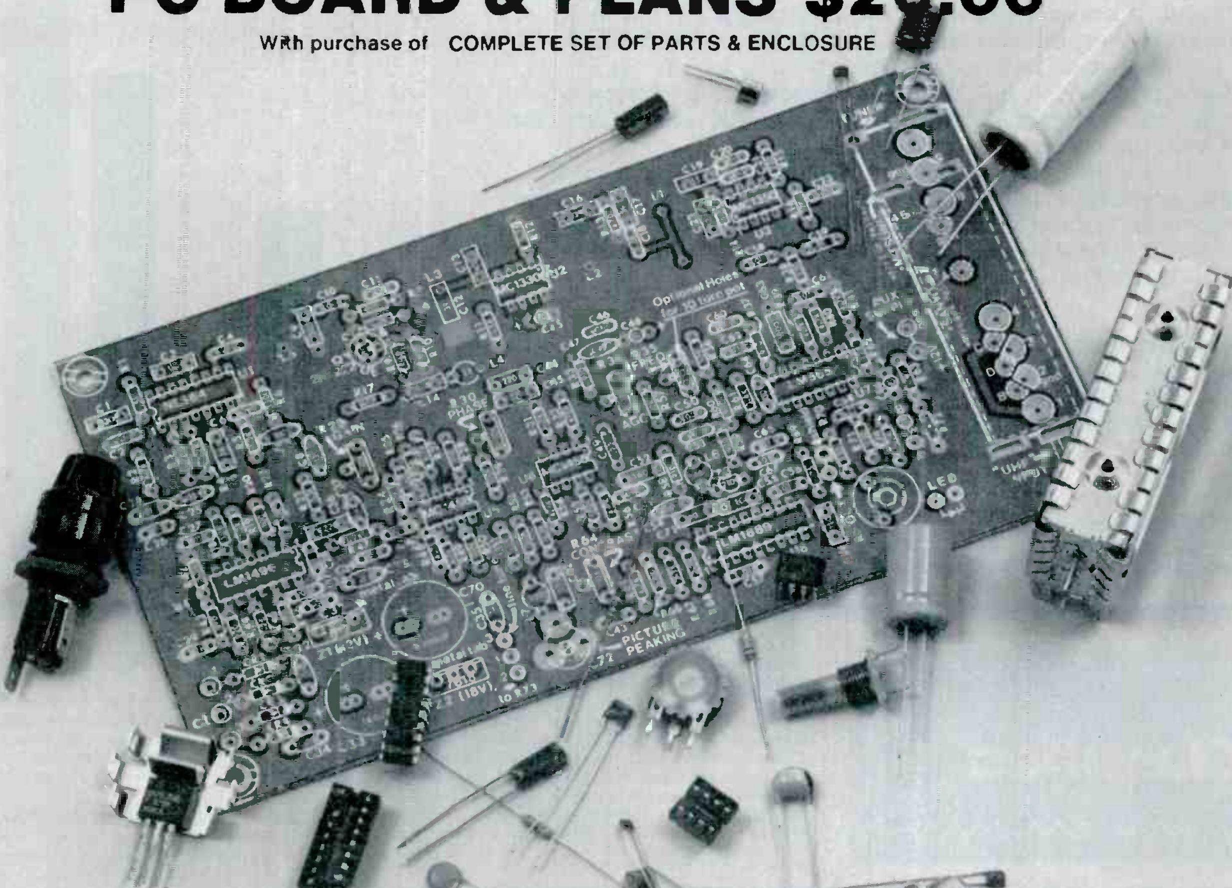
1. *A*
2. *D*
3. *A* Remember that the arrow on semiconductor symbols points to an N region. In this case, the arrow points to the channel that is made of N-type material.
4. *C* Both are bilateral breakover devices.
5. *D* A multiplier is required.
6. *A* You can take data out of a ROM but you can't put data into a ROM.
7. *B* The voltage-variable resistor protects the power transistor from counter voltages.
8. *B* For A: $T = 27 \times 10^6 \times 150 \times 10^{-9} = 4.05$ sec
   For B: $T = 25 \times 10^3 \times 170 \times 10^{-6} = 4.25$ sec
9. *B* The equation is:
   $$fr = \frac{1}{2\pi\sqrt{L \times C}}$$
   When you move the plates of a capacitor apart you **reduce** the capacitance. Anything you do to reduce the denominator of a fraction will increase its value.
10. *C*

# "The Deluxe II"

## Is The Ultimate In UHF Sine Wave Converter Technology

## PC BOARD & PLANS $20.00

With purchase of COMPLETE SET OF PARTS & ENCLOSURE



The latest state of the art electronics combined with the excellence in printed circuit manufacturing creates this high performance UHF Sine Wave Converter kit that outperforms the imitations by a long shot.
Engineered for reliable stability and outstanding reception clarity, uninterrupted modulated audio and fully illustrated instructions with the amateur in mind.

BETA ELECTRONICS, 1700 E. DESERT INN ROAD, SUITE 222, LAS VEGAS, NEVADA, 89109

TOLL FREE **1-800-782-2701**

| QTY | DESCRIPTION OF ITEM | COST EACH | SHIPPING EACH | TOTAL |
|---|---|---|---|---|
| | PC BOARD, PLANS, PARTS & ENCLOSURE | $152.99 | $4.95 | |
| | PARTS & ENCLOSURE ONLY | $132.99 | $4.95 | |
| | PC BOARD & PLANS ONLY | $30.00 | $1.50 | |
| | | | GRAND TOTAL | $ |

PLEASE PRINT CLEARLY

SEND THIS ORDER FORM

NAME ____________________

ADDRESS ____________________

QUANTITY DISCOUNTS AVAILABLE

CITY/STATE/ZIP ____________________ ORDER DATE ________ MO. DAY YR.

☐ VISA ☐ MST. CARD CARD NO. ____________________ EXP. DATE ________

FOR IMMEDIATE DELIVERY MONEY ORDERS OR CERTIFIED CHECKS PREFERRED — PERSONAL CHECKS ALLOW 4 WEEKS FOR DELIVERY

# Classified

Advertising rates in the Classified Section are 50 cents per word, each insertion, and must be accompanied by payment to insure publication.

Each Initial or abbreviation counts a full word.

Minimum classified charge $10.00.

For ads on which replies are sent to us for forwarding (blind ads), there is an additional charge of $3.00 per insertion to cover department number, processing of replies, and mailing costs.

Classified columns are not open to advertising of any products regularly produced by manufacturers unless used and no longer owned by the manufacturer or distributor.

## FOR SALE



**TUBES FOR TV AND RADIO**—35¢ ea. Washington TV Service, 1330 E. Florence Ave., Los Angeles, CA 90001. 1-83-12t

**COMPLETE JERROLD WIRELESS REMOTE/DESCRAMBLER**—full warranty, $159.00. Complete Oak descramblers, full warranty, $169. Trap/filters in line type, $49, 2 min. installation, SG613 transistors, only $6.99. Original Toshiba 2SC1172B, only $1.99 with hardware. 100/450, 80/480, 200/300, 40/450, 25 1st only $1 each mixed or single lot. Super special while they last 800-860 41 each safety caps Zenith type, 10 lot only $2.50. Bulk 2SC1172B only 50 lot, $1.69. Redcoat Electronics, 104-20—68th Drive, Forest Hills, NY 11374, (212) 459-5088. 5-83-tfn

**CABLE CONVERTERS, DECODERS.** Free catalog! APS, POB 263, Newport, RI 02840. 6-83-12t

**COLOR PICTURE TUBES** direct from manufacturer. Prices from $55 to $75 exchange. One year warranty. Send your old tube ups to ATOLL Color Tubes, 6425 West Irving Park, Chicago, Illinois 60634. Phone: 312-545-6667. We also sell equipment for rebuilding CRT's. 6-83-3t

**SUBSCRIPTION TV MANUAL,** covers both sine wave and gated sync system, only $12.95. Includes theory, circuits, waveforms and trouble shooting hints. VIDEO GAME CARTRIDGES are easy to duplicate, average cost per game is only $10.00. Plans $9.95. Information $2.00, refundable. Random Access (formerly D & S Enterprises), Box 42770A, Phoenix, AZ 85080. 6-83-tfn

**2SC1172B's, 50 LOTS—$1.69;** 2SC1308K's, original Sanyos, 50 lots—$1.99; Cheater cords, 25 lots—35¢; pol- and non-polarized. 1,000 ft. reels of RG 59 U. Coax Cable—$39/roll. Minimum order $75. Redcoat Electronics, 104-20 68th Drive, Forest Hills, NY 11375, 212-459-5088. 10-82-tfn

**ELECTRONIC SURPLUS: CLOSEOUTS, LIQUIDATIONS!** Parts, equipment stereo, industrial educational. Amazing values! Fascinating items unavailable in stores or catalogs anywhere. Unusual FREE catalog ETCO-011, Box 762, Plattsburgh, NY 12901. 6-78-tfn

**SCRAMBLED TELEVISION,** encoding/decoding. New book. Theory/circuits, $9.95 plus $1 shipping. Workshop, Box 393ES, Dept. E, Bethpage, NY 11714. 7-80-tfn

**SPRING SPECIALS** on Popular Electrolytics—40/450V—75¢; 80/450V—85¢; 100/450V—95¢ 200/300V—$1.05. Quantity 20 lot only. Minimum order of $50. SUPER SPECIALS. Bulk Zenith safety capacitors 800-860, 12 lot only $2.50 each. REDCOAT ELECTRONICS, 104-20 68th Drive, Forest Hills, NY 11375, 212-459-5088. 10-82-tfn

**REPLACEMENT COLOR YOKES-DEALERS ONLY.** Zenith 95-2501-2532-2887 etc. $22.95. Magnavox 361380-1 etc. $24.95. Sylvania $24.95. American-made fuses in bulk-example 3AG 2 regular price .23 each our price .12 each. Factory packaged GE transistors at discounts. Example GE-20 regular price $1.10 our price .65. Request circular on your letterhead. David Sims Enterprises, Inc., 665 East Jericho Tpke., Huntington Sta., NY 11746, 800-645-5030, NY State (516) 549-3925-1592. 10-82-tfn

**TUBES**—Receiving, Industrial and Semi-conductors, factory boxed. Free price list. Low; low prices. **TRANSLETERONIC INC.**, 1365-39th Street, Brooklyn, NY 11218E, 800-221-5802, 212-633-2800. 5-82-tfn

**TV TROUBLE ANALYSIS TIPS.** Over 300 symptoms/remedies by circuit area; tough ones over the years. Save time and money. Send $12.50 to CHAN TV, 8151 Grandview Rd., Chanhassen, MN 55317. 5-82-tfn

**PRINTED CIRCUIT** boards from your sketch or artwork. Affordable prices. Also fun kit projects. Free details. DANOCINTHS INC. Dept. ES, Box 261, Westland, MI 48185. 5-81-tfn

SONY-PANASONIC-RCA-ZENITH-EXACT REPLACEMENT PARTS-LARGE INVENTORIES-SEND PART OR MODEL NUMBERS-WILL UPS OR COD-GREEN TELERADIO DISTRIBUTORS, 172 SUNRISE HIGHWAY, ROCKVILLE CENTRE, NY 11570. 5-82-tfn

**AUTOMOBILE RADIO** and tape replacement parts: Delco, Chrysler, Philco-Ford, Motorola, Panasonic and many others. Large inventory. Laran Electronics, Inc., 3768 Boston Road, Bronx, NY 10469. (212) 881-9600, out of New York State (800) 223-8314. 5-79-tf

**INDIVIDUAL PHOTOFACT FOLDERS** (not sets) under #1200. First class postpaid $3.00. Loeb, 414 Chestnut Lane, East Meadow, NY, 11554. 6-83-3t

## FOR SALE (CONT.)

**CB RADIO BOOKS,** kits, modifications, free catalog. APS, POB 263, Newport, RI 02840. 6-83-12t

**QUITTING BUSINESS:** Test equipment, Sams, parts, $4125. Send SASE for list. Curtis Electronics, 204 Allen St., Huntsville, TX 77340. 7-83-1t

**MISCELLANEOUS SUPPLIES** including numerous new unopened and repaired Quasar panels. Half Price! 1092 Sams Photofacts between #700 and 1962 includes file cabinet, etc. Watt Sloan, Rt #1, Box 327, Union Grove, NC 28689. Ph 1-704-592-2235. 7-83-1t

**B&K model** 1077 TV analyst, $250 with manual. Ronald MacKenzie, 41 Wheelwright Lane, Levittown, NY 11756, 516-731-4348. 7-83-1t

**1600 SAMS PHOTOFACTS:** 301 back issues, Electronic Servicing, 1951–1981. Sell separate, make offer, owner retiring. 7-83-1t

**SALE:** With manuals & probes, B&K 1465 scope, $500; Sencore SC60 scope, $1300; 415 B&K marker generator, $225; 1077 B&K analyst, $300; E200D B&K generator, $100; H.P. 608D generator 10-420 MHz, $350; Heath SSB adapter, $50; Simpson 383A capacitor checker, $25; EICO 320 sig gen, $50; Fluke 803D voltmeter, $50. $2950 value, sell all for $2500. E. Palmer, 5760 S. Brosius Ave., Tucson, AZ 85706, 602-294-7946, 602-746-6129. 7-83-1t

**MAKE TELEPHONE** answering machine servicing simple & professional. Without tying up your phone lines, our ring simulator will activate any machine on the market. You can hear the outgoing message, give your message, and also have the availability to check machines that have remote capability. Send your check for $85.00 made payable to PSI, INC., to cover cost of machine shipping and handling, or call: (201) 845-6669. PSI, Inc., is located at: 34, Route 17 North, Paramus, New Jersey, 07652. 7-83-1t

**ATTENTION TECH/SHOP OWNERS**—Profits getting smaller with increasing cost of parts? Take advantage of our buying power and huge inventory on well known electronic products and replacement parts. Prices below dealer cost. Write for information. United Service Assoc., Old Grand Union Shopping Ctr., Rt. 9W, Stony Point, N.Y. 10980, 914-942-2173. 7-83-4t

**SENCORE POWER SUPPLIES** UPS164, Stereo Analyzers SG165 B/K E2000, 1471B, E310B and more. Many in cartons. Half price. List available Apex Magnavox 1606 NE 205 Terrace Miami, FL 33179. 7-83-1t

## BUSINESS OPPORTUNITIES

**DEALERS EARN EXTRA PROFIT** selling cable TV converters, Video accessories and other great items in our brand new dealer catalog. Request a FREE copy on your letterhead. ETCO. Wholesale Division, Dept. 535, Box 840, Champlain, NY 12919. 9-82-12t

**NORWALK, CALIFORNIA ESTABLISHED TV AND STEREO SERVICE AND SALES** very busy money maker, excellent location, low rent, very good lease, 2300 square feet, 10 minutes to beaches and Los Angeles. $40,000 includes inventory, large enough for living quarters, owner retiring, phone 213-863-1919. 11-82-tfn

**HIGH PROFITS—LOW INVESTMENT:** with our CRT rebuilding equipment. Complete training and technical assistance. Guaranteed result. Atoll Television, 6425 W. Irving Park, Chicago, Illinois 60634; PH. 312-545-6667. 5-83-3t

**SYNTHETIC LUBRICANTS:** For land and air dealers wanted. Unlimited opportunity, territory, box 6422, Portsmouth, VA 23703. 6-83-2t

**ESTABLISHED TV SERVICE** and Repair shop. Florida Gold Coast. Name, inventory, equipment, Sams, customers & truck. $20,000.00 takes all. Owner retiring. Florida TV Headquarters, 520 SW 6th Ave., Hallandale, Fla 33009. 305-458-3824. 7-83-2t

**TV TUNER REBUILDING BUSINESS,** LOS ANGELES, CALIFORNIA 23 years same location, other interests, requires sale very reasonable, (213) 342-4745. 7-83-tfn

**"TELEVISION PLUS** authorized service center 8-Manufactures, EVE 516 599-4374." 7-83-1t

**NAPLES, FLORIDA** TV Sales Service Business, established 9 years, price $39,900, terms. William Morris Company Realtor, 813/597-8149. 7-83-1t

**LEARN TO REPAIR** HOME VIDEO GAMES IN YOUR OWN SHOP! Did you know that more than 9 million HOME VIDEO games have been sold? Now you can learn to repair! Atari, Coleco, Intellivision, or Atari 400/800 computers in your own shop. Our courses are taught on VIDEO TAPE (Beta or VHS) and come with a manual containing all the necessary technical information you will need to do repairs. For more information or to order, call: Electronic Institute (800) 221-0834 (outside N.Y.) or (212) 377-0369 (in N.Y.) Customized live in shop training courses are also available, call for more information and price schedules. 7-83-tfn

## WANTED

**WANTED FOR CASH:** 50, 53, 6AF6, 6HU8, 304TL, 4CX1000A, 4-1000A, all transmitting, special purpose tubes of Eimac/Varian. DCO, Inc., 10 Schuyler Avenue, North Arlington, New Jersey 07032. Toll Free (800) 526-1270. 5-82-tfn

**TELEVISION SERVICE SHOP** in Florida or California. Call or write ATOLL TV, 6425 West Irving Park, Chicago, IL 60634; Ph. 312-545-6667. 6-83-3t

**NEEDED:** VA 48 $750 to $850 depending on condition. Ken Cale Appliance, 1612 NE Division, Bend, OR 97701. (503) 382-5241. 7-83-1t

**WILL BUY** extra accessories/attachments for Don Bosco Stethotracer Test instrument. Murray's Repair Service, 8842 Grange Hill Road, Sauquoit, New York 13546. 315-737-7192. 7-83-1t

**WANTED MFG SOURCE**—For re-manufactured color picture tubes. Will buy in semi-trailer lots. Must be capable re-building new 20mm types i.e. RCA bonded yoke etc. For more information, write or call Mr. Walters, (918) 543-8849, P.O. Box 186, Inola, OK 74036. 7-83-1t


**ELECTRONIC**
*Servicing & Technology*

**Advertising Sales Offices**

**NATIONAL SALES MANAGER**
*Greg Garrison*
P.O. Box 12901
Overland Park, KS 66212
Phone: (913) 888-4664

**LONDON, ENGLAND**
*John Ashcraft & Co.,*
*John Ashcraft*
12 Bear Street, Leicester Square
London WC2H 7AS, England
Phone: 930-0525 Telex: 895-2387

**AMSTERDAM, Holland**
*John Ashcraft & Co.*
*John J. Lucassen*
Akerdijk 150A
1171 PV-Badhoevedorp, Holland
Phone: 0-2968-6226 Telex: 18406 HARKE NL

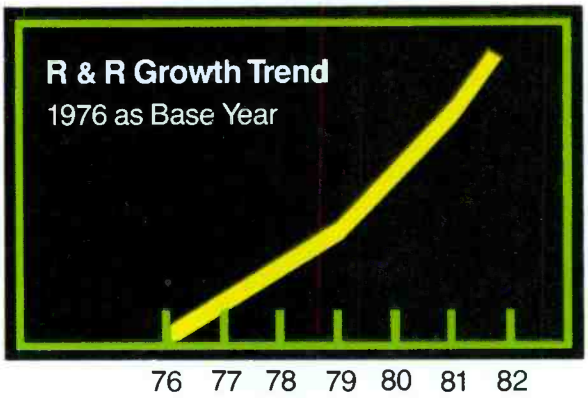
**TOKYO, JAPAN**
*International Media*
*Representatives, Ltd.*
*Sumio Oka*
2-29, Toranomon 1-chome
Minato-ku, Tokyo 105, Japan
Phone: 502-0656

**NORWOOD, AUSTRALIA**
*Hastwell, Williamson, Rouse PTY. LTD.*
P.O. Box 419
Norwood, S.A. 5067
Phone: 332-3322
Telex AA 87113

**TAIPEI, TAIWAN, R.O.C.**
*Antony Liu*
*Long Life Advertising Agency Co.*
P.O. Box 17-134
Taipei, Taiwan, R.O.C.
Telephone: (02) 561-6629
Cable: Photop Taipei


# Advertisers' Index

## We got bigger because we're better.




## Now we're better because we're bigger.

Year in and year out, Zenith's remanufacturing business gets bigger and bigger. And 1983 appears to be no exception.

That is why we are forecasting our remanufacturing business this year to be bigger than last year. Our remanufacturing business next year to be bigger than this year. And our remanufacturing business in the foreseeable future to be bigger and better each succeeding year.

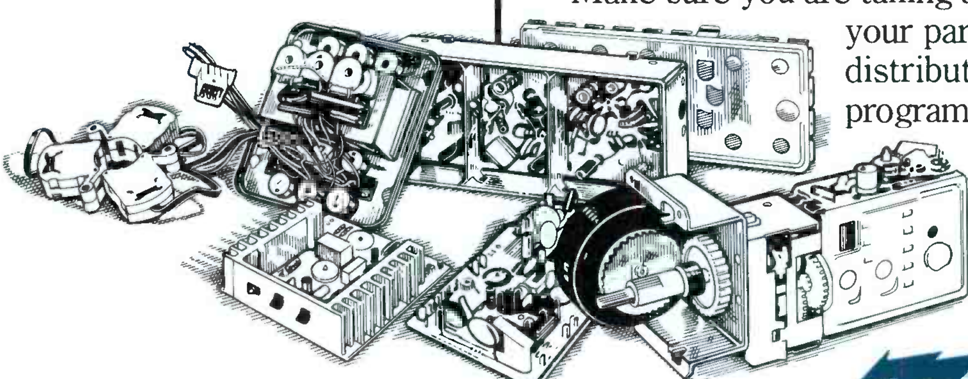
But it's one thing to forecast and quite another to increase production year after year. That's why we at Zenith are thinking in terms of larger facilities and newer techniques in remanufacturing to meet the demand of the marketplace.

You should be as ready, willing and eager to look into the future as we have and, having seen the kind of growth we anticipate, position yourself as we have to meet and capitalize on it.

Right now you should be in the habit of purchasing a Zenith repaired and reconditioned replacement at your participating Zenith distributor's — with an exchange allowance in most instances — for every tired and worn-out module, tuner, channel selector and subassembly you remove from a Zenith TV.

Exchanging with your Zenith distributor is the one sure way to receive a genuine Zenith replacement part repaired, reconditioned and serviced for reliability by people as knowledgeable as those who made the original. And also a replacement updated to incorporate the latest factory technical improvements.

Make sure you are taking advantage of your participating Zenith distributor's exchange program. Call now and tell the Zenith Parts Manager we sent you!



**Zenith Radio Corporation/Service, Parts & Accessories Division**
**11000 Seymour Avenue/Franklin Park, Illinois 60131**

ZENITH®

The quality goes in before the name goes on.®

# Double Your Troubleshooting and Testing Productivity . . . Or Your Money Back!

**Six-digit readout:** Automatically tracks every CRT test. We call it digital autotracking. It's patent pending.

**Bright dual-trace CRT:** 60 MHz (– 3 dB); 100 MHz (– 12 dB).

**Delta PPV, Time, Freq:** Measure any part of a waveform for PPV, time or frequency using Delta measurements. Just dial in the waveform section you want to measure and push.

**Simplify Freq ratio tests:** Automatically compare input/output ratio of multiply/divide stages from 1:1 to 1:999,999 with the push of a button.


**Autotracking DCV, PPV, Freq:** Measure DCV to .5%; PPV to 2%; freq. to .001%. Just push a button for either Channel A or B.

**One probe input:** One probe input per channel for all measurements - digital and scope - with 5 mV to 2000 V measuring range. (2 lo-cap probes provided.)

**Super sync:** ECL provides rock-solid sync trigger circuits with only 4 controls; includes TV sync separators for video work.

**U.S. Patent Pending**
**Financing Available**

**The first scope with push button digital readout.** If you use general purpose oscilloscopes for troubleshooting or testing, we can double your present productivity with the SC61 Waveform Analyzer, the first instrument to turn every conventional scope measurement into an automatic digital readout.

**No more graticule counting.** Connect only one probe to view any waveform to 100 MHz. Then, just push a button to read DCV, PPV, frequency and time — automatically!

There are no graticules to count or calculations to make, which speeds every measurement.

The digital readout is from 10 to 10,000 times more accurate as well.

Plus you have everything you want to know about a test point, at the push of a button, which speeds troubleshooting tremendously.

A special Delta function even lets you intensify parts of a waveform and digitally measure the PPV, time or frequency for just that waveform section.

And it's neat. No more tangled leads, piles of probes or dangling cords. The SC61 is an entire test station in one unit.

**The one and only.** There are other scopes with digital readout, but none of them completely automate every conventional scope measurement so you can automatically analyze any waveform without counting one single graticule. Totally automatic waveform analyzing at the push of a button. It will make all the difference in your productivity.

**Double your productivity.** When we say the SC61 will double your productivity, we're being conservative. We've seen cases of three, four, even ten time increases in productivity with this first-of-its-kind, automated oscilloscope. Every situation is different, however, so try the SC61 and judge for yourself. Here's our offer.

**Money back guarantee.** If the SC61 does not at least double your productivity during the first thirty days, you may return it for a full refund, including freight both ways.

**Call today.** Get the entire SC61 Waveform Analyzer story. Call toll-free today, and ask for our eight page color brochure. It could be the most productive call you make this year!

**Phone Toll-Free**
**1-800-843-3338**
*Alaska, Hawaii, Canada and South Dakota call collect (605) 339-0100*

**SENCORE**
3200 Sencore Drive, Sioux Falls, SD 57107

**For Information Circle (2) on Reply Card**
**For Demonstration Circle (3) on Reply Card**