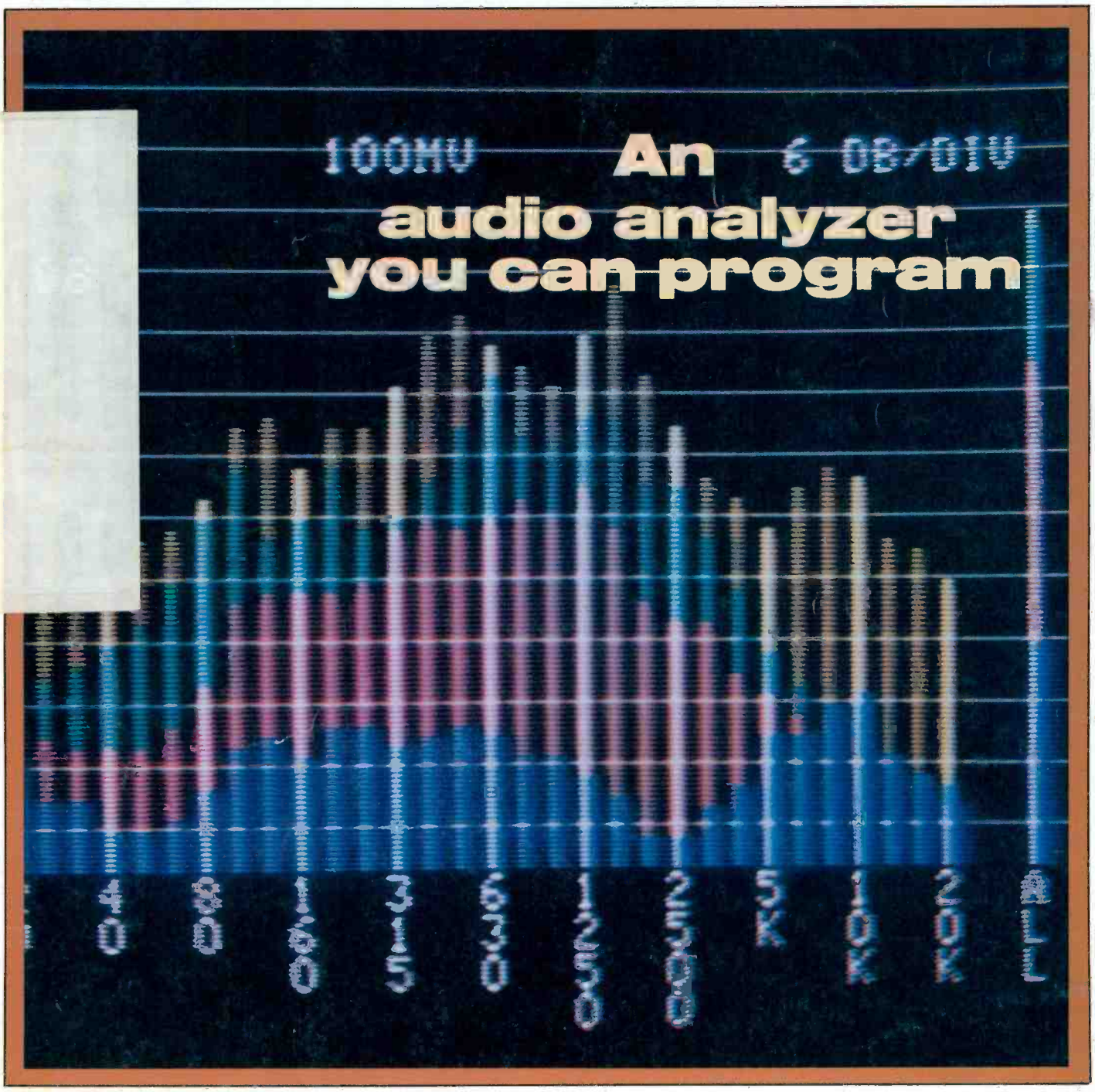
# ELECTRONIC™

## Servicing & Technology

JUNE 1983/$2.25

CRT problems or circuit defects?

Recommended audio test equipment

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No. 7 in a series
Zenith 9-90

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***Inadequate original resistor wattage in this horizontal oscillator module shot failure rates through the roof.***

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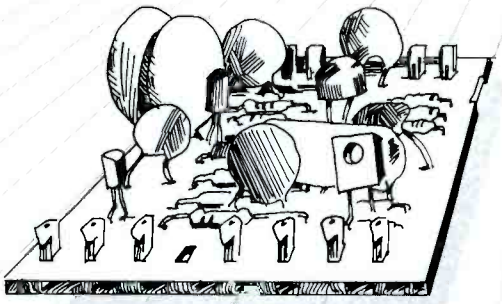

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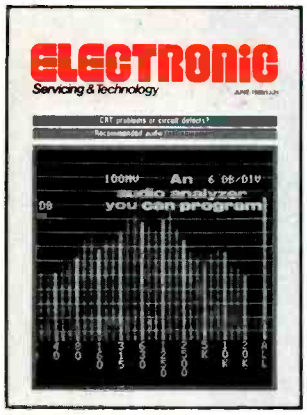
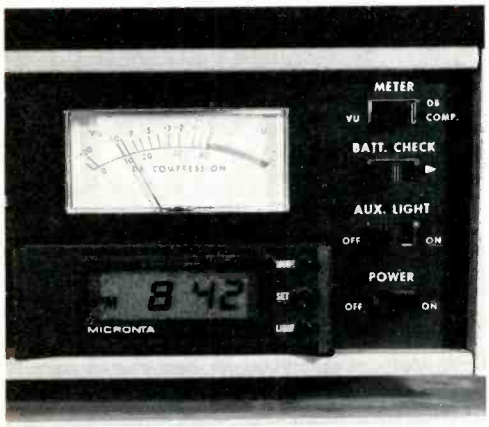
# ELECTRONIC Servicing & Technology

June 1983
Volume 3, No. 6




The screen of the Crown BDP-2 programmable audio microcomputer shows as many as eight variables at once in four colors. Among other tests, the BDP-2 will check frequency response, S/N ratio, dynamic range and channel separation. See story on page 8. *(Photo courtesy of Crown International.)*

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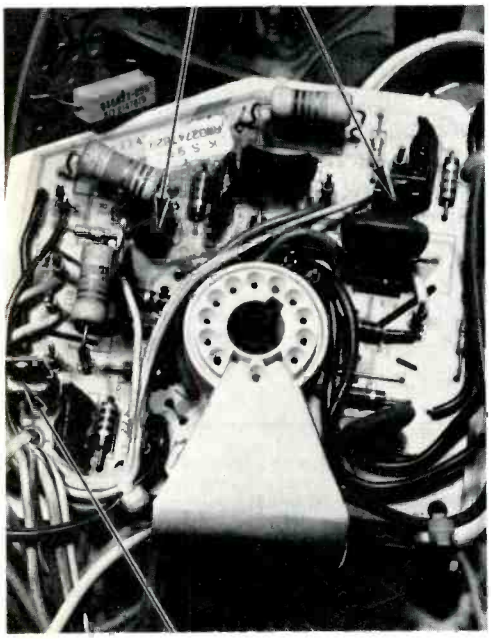

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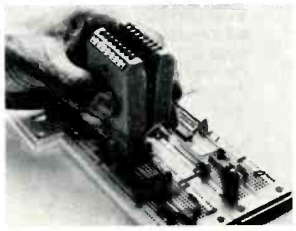
# Departments



**Next month...**



**Troubleshooting logic systems logically.** 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.

# Editorial

## Programming: Will cable have it all tied up?

TV technology continues to get better. In this issue, you can read about improvements in home video such as high-fidelity sound for Beta VCRs, surround-sound capability just like at the movies and, available in the near future, digital television.

These developments are only improvements to the vehicle, however. Just as with satellite television (TVRO, DBS, etc.), cable and MDS, these improvements make it possible for viewers to either receive a wider variety of programs or enhance the enjoyment of viewing and listening. Another concern, perhaps even more fundamental, is that of the program material. Assuming that viewers have a broader choice of program channels and can get it in high-definition video with high-fidelity surround sound, what will they bring into their homes?

This subject was discussed recently at the International Radio and Television Society's Faculty/Industry Seminar. A consultant, Charlotte Schiff-Jones explained video programs and their transmission media by pointing out that the average consumer doesn't care whether the oranges in the grocery store came by train or truck.

According to a news release that summarized the seminar activities, much of the discussion concerned what some of the new services available to consumers might be. Arnold Reymer of Reymer & Gersin Associates said that a survey of 7000 potential customers in five cities revealed that 67% would be interested in buying at least one of five services that have already been proposed. In order of preference, the choices were: "electronic yellow pages" (up-to-the-minute information on sales opportunities), home management and information retrieval, electronic banking, catalog-type shopping at home and electronic mail.

Ed Horowitz of Home Box Office provided the seminar participants with an overview of what he sees as coming up in new TV technology. He mentioned direct-broadcast satellite stations, multi-purpose "modular" attachments and greatly enhanced video and sound reproduction. He suggested that these enhancements might not be feasible over conventional broadcast bands, which would make cable and other new carriers even more practical.

The broadcast networks were also represented at the seminar, and they expressed a different point of view. Jack Healy of ABC Video Enterprises stated that his firm has entered into a number of exploratory partnerships with other corporations to learn more about what the public expects from the new technology. Neil Derrough, president of the CBS Television Stations, made it clear that VHF television will continue to exist and that CBS is very interested in the effect of new technology in broadcasting.

One very interesting view was expressed by Gerald M. Levin, group vice president of Time, Inc., described by some as "the father of pay cable." He stated that "without doubt, cable will be the dominant distribution medium in the country." He suggested that the "window is closing" on other technology; meaning that little hope remains for the economic potential of such competing forms of program delivery as subscription television, pay-per-view and DBS, because of the limited number of channels they offer, compared to the cable's more than 100.

Nils Conrad Persson


**ELECTRONIC Servicing & Technology**

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**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.).

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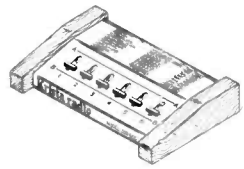

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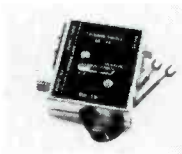

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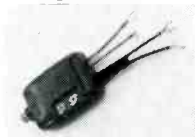

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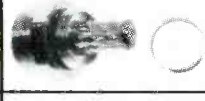

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Technology

# Programmable microcomputer

## Adding flexibility to audio analyzers

Sophisticated electronics equipment requires sophisticated test equipment to set up properly or to troubleshoot and analyze it. Unfortunately, most test instruments have limited functions, so a number of instruments must be assembled to adequately analyze or service some of the advanced electronic systems of today.

Fortunately microcomputers have given designers the raw materials to develop programmable instruments. With these minuscule processing devices, instruments have been designed that are capable of performing a wide range of testing functions.

However, programmability is not without its disadvantages. It requires a programmer who knows both the testing requirements and the language of the microcomputer.

An audio instrument offered by Crown International is designed to fit neatly between these two extremes: the non-programmable instrument with limited applications and the flexible but complex microprocessor-based unit. The BDP-2 audio microcomputer provides the flexibility of programmability but does not require that the user know how to program it.

### Programs

Standard programs for the unit include the following:

- *RTA (Real Time Analysis):* RTA displays the audio spectrum in one-third octave bands. The color and the type of plot are user-selectable under software control.
- *RT 60:* Measures the reverb time and displays in a line graph form. The color and the frequency desired are selectable under software control.
- *Test patterns:* Displays of color test patterns (bars, dots and crosshatch) to aid in adjusting color of the internal monitor and any other external monitor that may be connected to the BDP-2.
- *Filter auto-zero:* A standard BDP-2 program which automatically (upon power-up or command) auto-zeroes the internal filters.

Option programs include:

- *Stereo analyzer:* This program is particularly valuable for use in recording studios, where monitoring of sound signals for phase relationships and sum component data is critical in the mastering process.
- *Multiplexer:* The Input Multiplexer Program can be used in professional sound reinforcement systems to show the peak and average levels of up to 32 different signals simultaneously.

These may be easily added by replacing the rear panel plug-in model.

### Circuit theory

The accompanying diagram does not show all circuit connections because of circuit complexity, but there is sufficient data to understand the function of each circuit section.

Although the unit is capable of specific complex analysis functions, its basic design is rather simple. BDP-2 contains only three large systems: a microcomputer, a set of analog filters, and a video generator and monitor. This division of BDP-2's subsystems is relatively arbitrary; some parts (such as portions of the RAM) are shared and some (such as the button board and power supply) serve ancillary but necessary functions.

BDP-2 contains as its *brain*, a complete microcomputer system. Although it is not as fast as larger systems, this microcomputer is as capable of doing what even the largest computers do. The flexibility of BDP-2 derives in part from the versatility of the computer. The only difference between a BDP-2 measuring RT 60 and performing RTA analysis is in the program it is using.

BDP-2's computer uses a set of programs that are saved in read-only memories (ROMs). They tell

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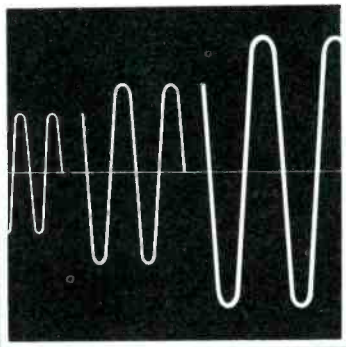

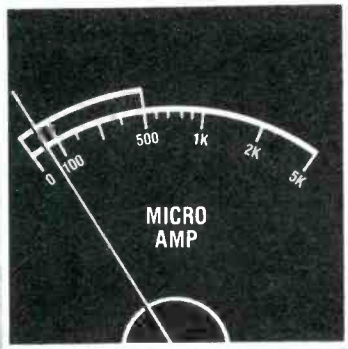


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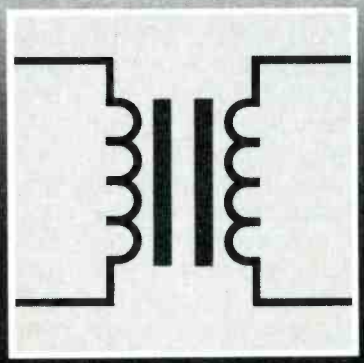
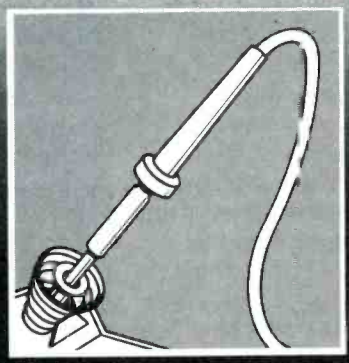


ISOLATED
OUTPUT VOLTAGE



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the processor the details of the operations necessary to produce the BDP-2's displays. Also included in the microcomputer subsystem are random-access memories (RAMs), which hold the screen display and the working data for the microprocessor.

The input for the microcomputer system is a stream of digital data that is captured by a set of filters. Each filter separates a particular third-octave frequency band from the input signal. The third-octave signals are then fed to a logarithmic analog-to-digital converter, which converts the filter data into digital numbers that the processor can interpret. This gives a processor a set of up to 64 filter readings. Also the processor is capable of changing the input sensitivity of the filters, or of reselecting the source of the inputs.

Each of the filters, although precise, may drift slightly and need to be zeroed. The processor can do this automatically, upon command, within 10 seconds.

Some of the RAM memory is used to represent the graphic (color) and alphanumeric (number and letter) displays on the screen. These portions of memory are called multiport, or DMA (Direct Memory Access; the video displays generators have DMA to the RAM). The multiport RAM is continuously read by the video generator, which converts their contents into a video output.

The video generator actually consists of three separate generators for color graphics, alphanumerics and graticules. The three signals they generate combine (in digital form) into a single NTSC-compatible video signal. The video signal is then fed to the BDP-2 monitor and the *video out* jack. The monitor converts the video signal into a picture that the human eye can look at and perceive.

The BDP-2 is controlled by 16 push-buttons. These buttons use snap-action momentary contact to select programs and control the display from the front panel.

The power supply for BDP-2 is thoroughly filtered and regulated. IC regulators are used on every circuit board for protection against voltage spikes. ES&T

# News

### Winegard forms network of TVRO installers

Winegard Company has announced the formation of Satellite Antenna Specialists of America (SASA), a national network of professional TVRO installers.

According to Rick Coursey, executive director of SASA, the organization was formed to provide a much-needed professional TVRO installation group that is educated and experienced in the earth station business.

Coursey cited recent requests by various organizations that Winegard help provide professional installers nationwide. "We've had a national satellite business communications company request help for more than 1000 installations across the country, a DBS programmer offer to contract with us for professional installers and a major retailer inquire about a network of installers."

To join, interested individuals must fill out an application form certifying experience and knowledge of the TVRO installation business. Members will be approved by a SASA membership committee and notified by Winegard.

For more information write Rick Coursey, Winegard Company, 3000 Kirkwood St., Burlington, IA 52601, or call 1-319-753-0121.

### Cable companies would sell and service televisions

Officials of the National Electronics Sales and Service Dealers Association (NESDA) are urging members and others in the industry to help defeat a bill that would allow cable TV companies to enter the sales and service business nationwide.

Senate bill 66, proposed by Sen. Barry Goldwater (R-AZ), would remove control of cable TV firms from local agencies and give it to the federal bureaucracy. In the process, several restraints and potential benefits would also be discarded. Also, according to a compromise worked out between CATV representatives and a committee from the National League of Cities, cable companies would be allowed to sell, lease and service TV sets and other equipment in competition with local dealers. It would also negate the restrictions imposed against X-rated movies by some localities.

The negotiated compromise—hotly contested by most of the cities the league was supposed to represent—permits a 5-year grace period before any existing agreements would be abolished. But, after that, the bill and/or the negotiated amendments would mandate an annual rate increase of no less than 5%; more if the inflation rate exceeds that figure in a given year. Franchise fees the cable company pays to the city would be limited to 5% of total revenues. Also, the entire franchise fee paid to the city can be added to the customer's bill as a separate charge.

For more information on the bill and future developments, contact NESDA at 2708 W. Berry St., Fort Worth, TX 76109; 1-817-921-9061.

### *"Camcorder"* segment to overtake video market

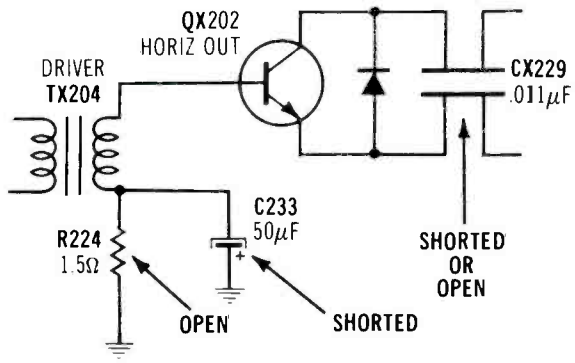
Self-contained, lightweight videocassette recorder/camera units will comprise fully half the consumer video market in 1992, with wholesalers shipping about $5.5 billion worth of equipment in that year. According to a research report by International Resource Development, this fast-growing "camcorder" segment won't begin to make itself felt until 1986 but nonetheless will kill off the traditional 8mm film market.

Sales of regular VCRs are also expected to decline under the onslaught of the camcorder, dropping to $800 million in '92 after peaking at more than $2.5 billion late in the '80s. In fact, IRD warns that "if the introduction of camcorders, with their sub-$1000 price tags, is not delayed for a sufficient period of time, they may replace VHS and Beta before manufacturers have reaped the benefits of their investments." The videodisc market, on the other hand, is not expected to be affected at all. ES&T

# Symcure

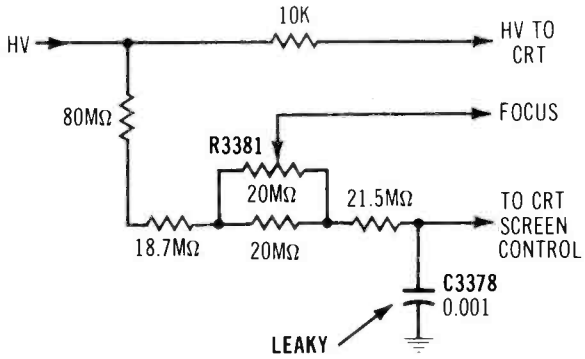
**Symptoms and cures compiled from field reports of recurring troubles**

**Chassis** – Zenith 25JC45 1
**PHOTOFACT** – 1676-2



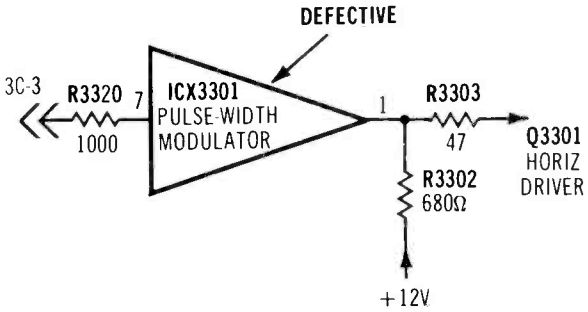

**Symptom** – Foldover vertical line at raster center, with narrow picture
**Cure** – Check R224 and C233, and replace if open or shorted.

**Chassis** – Zenith model K1960 2
**PHOTOFACT** – 1828-2



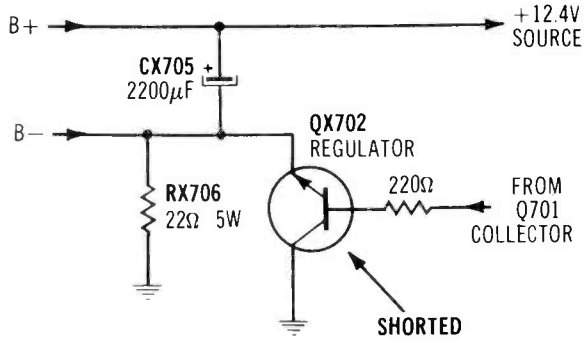

**Symptom** – Normal high voltage, but dark or no picture
**Cure** – Check capacitor C3378, and replace if leaky or shorted.

**Chassis** – Zenith model L1912 3
**PHOTOFACT** – 1920-2



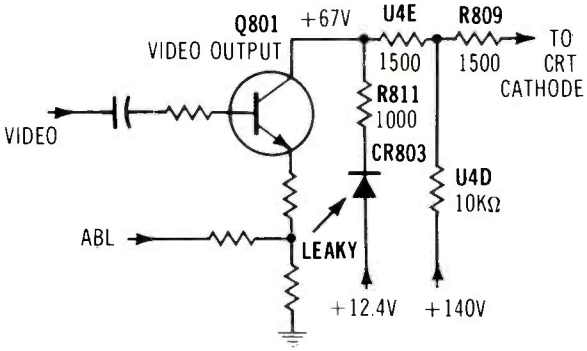

**Symptom** – No sound or raster
**Cure** – If horizontal drive is at 3C-3 but not at ICX3301 pin 1, replace pulse-width modulator ICX3301.

**Chassis** – Zenith model K121F (or chassis 9JB1X) 4
**PHOTOFACT** – 1808-2 (or 1712-2) B/W TV



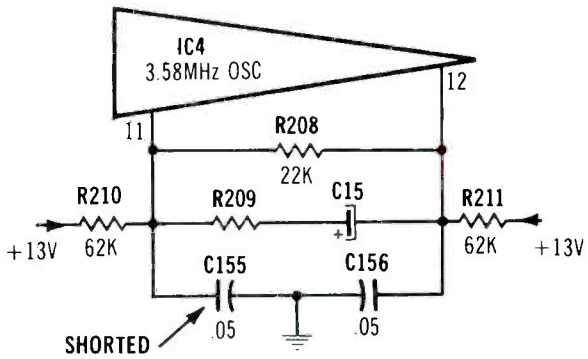

**Symptom** – Hum bars in picture, hum in sound and unstable locking
**Cure** – Check regulator transistor QX702, and replace if shorted C/E.

**Chassis** – Zenith model K121F (or chassis 9JB1X) 5
**PHOTOFACT** – 1808-2 (or 1712-2) B/W TV




**Symptom** – Excessive brightness with retrace lines
**Cure** – Check diode CR803, and replace if leaky or shorted.

**Chassis** – Zenith 19CC19 6
**PHOTOFACT** – 1215-3




**SymptomJ** – No color, luminance was normal
**Cure** – Check capacitors C155 and C156, and replace either if shorted.

# More on servicing Atari

By Kirk Vistain

An article on the repair of Atari video games that appeared in the January, 1983 issue of **ES&T** covered the basic operation and typical failures of the CX2600 and CX2600A. This time around, actual case histories of individual repairs will be reported. These have been compiled into five categories, based on the component responsible for the failure. I have tried to include brief descriptions of the actual troubleshooting procedure, in order to point out the limitations of commonly used methods of working on this microprocessor-based product.

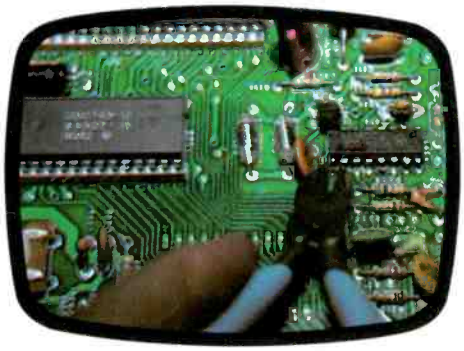
### RAM/IO chip, A202

*Case 1.* The customer complained that Pac-Man turned black and wouldn't eat the ghosts. The little man in Donkey Kong shifted all the way over to one side and didn't move. Other games seemed to operate properly, and the problem appeared only after several minutes of playing.

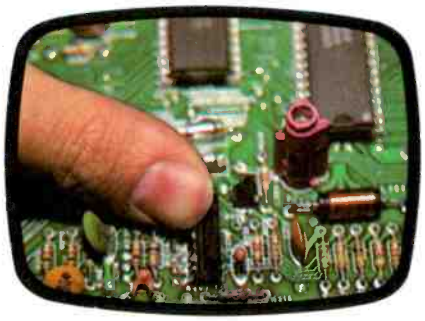
When I first tested the unit with the game Missile Command, all functions seemed normal. I knew the problem was reported as game-specific, so I procured a Pac-man game, disassembled the unit to get at the ICs, and prepared to test. Sure enough, after about five minutes, the Pac-Man character went dark. Using a can of freeze, I determined that the symptom was thermally sensitive. Freezing the MPU chip immediately remedied the problem. I confidently replaced it, retested, and was amazed to see that the trouble persisted! So much for logic. Next the RAM was replaced, and the game played normally, even after the original MPU was put back into service.

Two things to remember: A defective VCS can work normally with one or several games, and improperly with others. The fact that you can thermally cycle a component and cause the symptoms to come and go is not proof that component is defective. Part replacement is the best test.

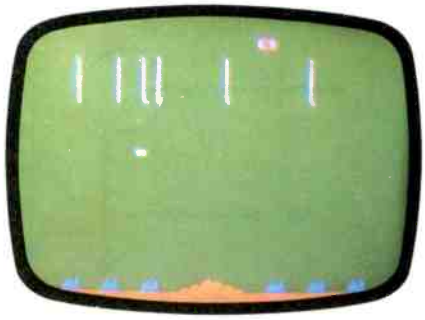
*Case 2:* "Left joystick won't move player," was the complaint on this one. Testing indicated that the cursor went left and stayed there when a game was reset. This is often caused by a leaky pull-up capacitor. I decided to test the voltage at pin 14 of the RAM IC, because this is the one that corresponds to leftward movement of the left joystick.



**The first step** in hex buffer removal is to sever all pins on one side of the IC.



**The body of the IC** is bent back and forth until the pins on the other side snap off. This produces a clean break, and a new hex buffer can then be soldered right to the top of the motherboard.



**This is the normal** playing field for Atari's Missile Command game. The number at the top is the score, the six white vertical lines are missiles, and the white bar is the aiming cursor.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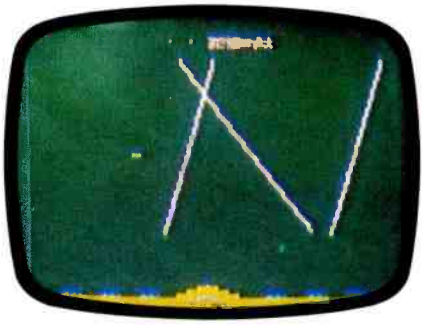


**The distortion** in the score at the top of the screen was the result of a defective RAM.

Surprisingly, the voltage was +5Vdc. Because these inputs are active low, that meant no "move cursor left" command was being given to the chip. Pushing left on the joystick caused pin 14 to go low. Letting the stick center changed it to high. The RAM was simply ignoring the pin input. A new IC solved the problem. Logic works sometimes! Not only that, but some symptoms aren't intermittent.

*Case 3:* Pac-Man strikes again! This time he played the game solitaire, moving around the field regardless of where the joystick was placed. After a few seconds, he would eat himself. While all this happened, a high-pitched squeal over-rode the normal audio. This is probably what drove Pac-Man to suicide.

Dropping the psychological approach, I tried several other games, including Missile Command, Asteroids and Barnstorming. Each played correctly. Because past experience led me to believe that these games exercised the entire RAM, it was eliminated as a suspect and the TIA seemed the likely culprit. I replaced it with no luck. A new RAM turned the trick, though.

When troubleshooting Atari units, remember that the RAM can produce some befuddling problems. You might want to replace it first, because its failure rate is the highest of all the LSIs.

### TIA, A201

*Case 4:* In the previous article, I claimed that intermittent or distorted sound was *almost always* caused by the 820pF sound capacitors. It's a good thing I said "almost." The complaint on this unit was, "Video OK, but sound distorted or intermittent."

I automatically replaced C206 and C207, and powered the unit up for test. As expected, all was working well. I let it burn-in while I left to refill my coffee cup.

On returning, I ran the Atari 2.6 diagnostics. I was surprised to notice that the second tone of the sound test was missing, even though the other was perfect. The book says to check continuity between TIA pins 12 and 13 when you have this symptom. I measured a dead short, which is normal. Logic said that the TIA chip was bad because one tone was normal, which you would not expect if the sound oscillator were malfunctioning. TIA replacement cured the trouble.

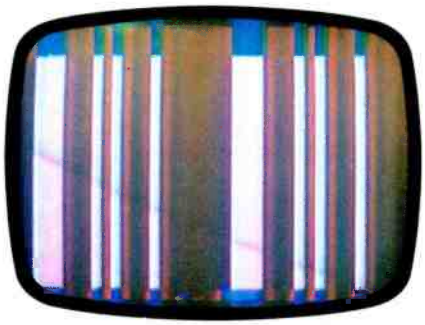
In repair, just because the last 100 units with a given symptom needed specific parts, you can't assume that the next one with the same complaint invariably has the same bad parts.

**With Atari units, the RAM can produce befuddling problems. You might want to replace it first, because its failure rate is high.**

*Case 5:* "I can't read the score," the customer told me. When tested, the actual symptom was a set of vertical bars, about ½in wide, one of which obstructed and garbled the score. Other functions seemed normal. As usual I suspected the RAM, but the diagnostic cartridge showed no "X" or other diagonal pattern, as it should if the RAM is malfunctioning. Going on this information, I decided to replace the TIA chip first, which solved the problem.

### Microprocessor unit

*Case 6:* When is an MPU like a RAM? When it gives an "X" on the 2.6 diagnostics. I tested this one at the front counter while the owner watched. The screen-filling defective RAM indicator came up immediately. The customer was obviously thrilled that I could diagnose so quickly. Unfortunately, putting in a new RAM didn't change a thing. The Atari manual is definite on this point: The "X" pattern indicates a bad RAM. I figured I had received a defective new part, so another one went in with the same results. I carefully inspected the socket pins, and sprayed them out for good measure, but without luck. At this point, I decided to take some of my advice and shotgun the ICs. A new MPU fixed it.



**These vertical lines** were also caused by a flaky RAM.

Believe it or not, sometimes even the service manual is wrong.

*Case 7:* The customer complained of a gray screen after several minutes of play. When I tested the unit, the actual symptom was the typical colored bar pattern, along with a high-pitched squeal, which usually appears if you power the VCS up without a game cartridge in it. No amount of wiggling the test cartridge caused any change on the screen.

It looked as though the J200 socket had to be replaced, but because the job was more than I had patience for that day, I began replacing ICs. A new MPU brought things back to normal. Maybe it's a good idea to do the easy things first, even if your instincts tell you something else is bad. It's usually an IC.

### Power supply

*Case 8:* The color faded out on this VCS. Sometimes it took several hours, other times several minutes. Colored bars also drifted across the screen every now and then.

I replaced all the ICs, and the problem disappeared–for awhile. Then a new symptom occurred: The picture began to smear. I decided to check the power-supply voltage, but it measured in spec, with little ripple. Unconvinced, I

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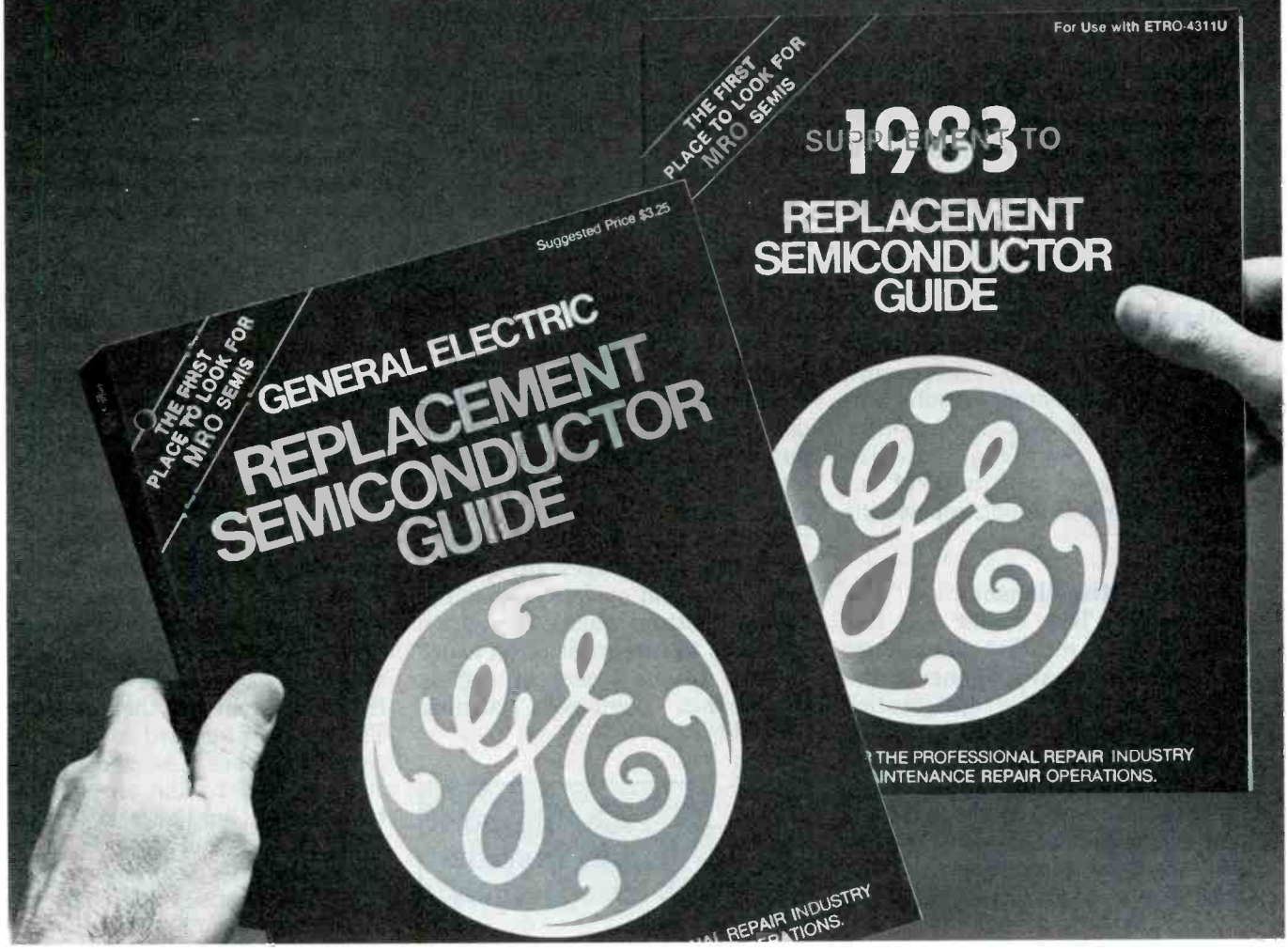


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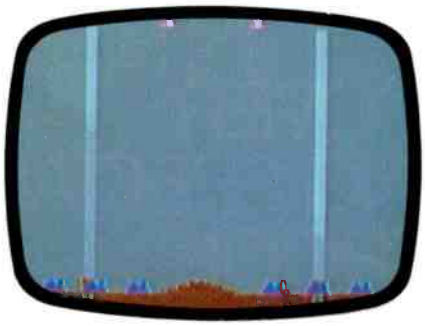


**More RAM** trouble is shown in this photo.

hit the regulator with a blast of freeze and watched the output voltage drop erratically to 4.8Vdc. A new 78MO5 eliminated the symptoms, and I put the original LSI back in. The VCS then tested normal.

It's interesting to note that replacement of the LSI in this unit changed the symptoms, even though there was nothing wrong with the original component. That's power supply trouble for you. Also, this isn't the only time that the regulator output measured good with a DVM but wasn't. When in doubt, replace the part.

### Miscellaneous

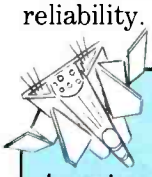
*Case 9:* The owner of this CX2600 told me that the picture collapsed sideways whenever the trigger button on the right joystick was depressed. Apparently the left worked OK. I duplicated his complaint. Because this was not the *A* version, I suspected the hex buffer, through which the trigger signals must pass to get to the TIA. It also functions to buffer the sync. A new one did the trick.

*Case 10:* My immediate diagnosis was a defective RAM when this 2600A came in with a complaint of a dead left controller port. Broken pins or foil traces usually kill only one direction of movement. All the same, I scrutinized the J202 connections and pins. All seemed OK, so I replaced the RAM, with no success. Measuring pins 14 and 15 of A202, I observed that no change occurred when the joystick was operated. The dc-voltage always read 4.8. I went back to J202 and measured pins 4 and 3 while operating the controller. The pins went to ground as designed, when the stick was moved in the appropriate direction.

Obviously there was a break in the foil between the IC and the port. Strangely, when the joystick was tried again, the cursor moved normally. This wasn't the first intermittent I had seen, so I decided to solder in jumpers to bypass the defective foil. However, upon heating one of the J202 lands, I noticed that the pin was loose. This should have been noticed in the mechanical check, but it was tricky. The pins were actually broken inside the port's plastic housing. With J202 replaced, all was well. It's not a bad idea to probe the port pins from the top to be sure they are continuous.

### Tips

The Atari CX2600 and CX2600A both employ double-sided board construction. This makes part removal and replacement more difficult than from single-sided boards. If you want to remove a component from, say, a garden-variety FM IF strip, all you do is desolder with wick or vacuum pump, and remove the part. This method doesn't work well on the Atari games unless you have a powerful vacuum device. Solder gets hung up between the component leads and eyelets connecting top and bottom traces. Repetitive attempts to remove it often cause damage to the traces or eyelets themselves, obviously harming reliability.



Probe the port pins from the top to check continuity.

It is possible, of course, to do this work with common repair-shop tools. I use a Weller WTCPN with a PTP7 tip and an Edsyn Soldapult. Remember that you won't be desoldering the actual LSI devices; they're plugged into sockets. But you will be called upon to replace controller ports, J200 (cartridge) sockets, switches and, of course, hex buffers on the 2600.

In general, part replacement on a double-sided board requires you to cut the defective component's leads before desoldering. For example, let's say we want to replace a hex buffer, (A203). First, sever the eight pins on one side with a small pair of dikes (diagonal cutters), such as an Xcelite 74CG. (It's a good idea to have a spare, because they're somewhat fragile, and sooner or later, you're going to try to bite off more than they can chew.) Then you can bend the IC body up and down several times until the pins on the other side break.

**Smearing and distortion** in this example was the result of a defective voltage regulator.

The new part can now be soldered directly over the remnants of the old pins. It will stick up above the motherboard a bit, but there is plenty of clearance.

Replacing the J200 cartridge socket is probably the most time-consuming job you'll have. On the 2600, the rivets that secure the socket shroud assembly must be drilled out. Once this is done, sever as many of the pins as you can from the rear of the assembly. Then bend it forward to get at the remaining ones. The socket itself is connected to the shroud with two screws, only accessible when the socket is cut free from the board. Desolder and remove debris from the circuit board holes, and screw the new J200 socket to the shroud assembly and solder. I also recommend using new Pop Rivets to resecure the assembly to the board.

The shroud on the *A* version obstructs access to the pins, so unless you have a soldering device that can heat all the pins at once, you'll probably have to destroy the shroud with a pair of cutters to get to them. Be careful not to stress the actual socket in the process, as this could cause damage to the circuit board. Once you have access to the pins from the top, you can proceed as with the 2600. Because the shroud is usually destroyed in the process, you'll need to order the complete assembly, part CA015796.

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# Recom audio test

By Bud Izen

For someone interested in starting to service audio equipment, it may be difficult to decide on what equipment to buy. There is enough of it around, and in all price ranges. It is also tough, with no previous experience, to decide what is needed right away and what can be put off until later. In order to make these decisions easier, here is a list of equipment that will be needed on day one.

A secondary purpose of this list is to give you some idea of how much money you will need to spend. As you will see, the number of necessary items and their total cost is reasonable. Purchased brand new and at list price, all the 10 required items are obtainable for about $2000. Many of these items are available from discount vendors; many of them you may already own.

Except where specifically noted, brand names and model numbers are provided for comparison purposes only. All specific recommendations represent my own personal experience with certain pieces of equipment.

Some of the advanced pieces of equipment required are available in an alternative package. A few manufacturers produce a combination instrument offering several functions. If you must purchase these items at one time, perhaps you should investigate acquiring such a unit. You may find that it costs less than the total of the items if purchased separately. Manufacturers of these combination instruments include, but are certainly not limited to, Ferrograph, Leader, Nakamichi and Sound Technology. These integrated instruments are often found in shops offering high quality service. If the service bench can be seen by the customer, such instruments present an impressive view.

## 1. Audio generator

High quality, capable of producing low distortion sine and square waves (0.5% distortion, maximum). Example: Leader LAG 26, approximately $165.

## 2. RF generator

High quality, low distortion. Example: Leader LAG 16, approximately $165.

## 3. Test records/tapes

Three types of test records will allow you to test a system with your ear: classical music to test overall listening quality; rock or modern jazz to test for bass response and test records to check overall system response. Shure Brothers makes a good test record, as does CBS Laboratories and a few other companies. An excellent series of test tapes is available from ORA Electronics. Although not actually a tape, a cassette torque meter, housed in a cassette form, is also required, and likewise available from ORA. Total investment should not exceed $200 for these items.

## 4. AC voltmeter

This is a handy item to have for measuring exceedingly low-level audio signals, such as those coming directly off phono cartridges and tape heads. Two reasonably priced and well performing units are the Leader LMV-181 and the Heath SM-5238 (fully assembled) at $235 and $160 respectively. For a little more money, Leader makes a stereo version called the LMV-185 at $390.

## 5. Dual-trace oscilloscope

Most of the items you will test will have two signal channels. It is more efficient to service these products in such a way that the "good" channel can be compared to the "bad" channel. Dual-trace techniques can be applied to TV service as well, so there's no reason not to buy a good scope.

I suggest you buy a scope with a bandwidth of at least 15MHz so that it can be used to look at FM IF signals as well as audio. There are many reputable manufacturers of reasonably priced scopes. These include Gould, Heath, Hitachi, Leader, Lectrotech, Non-Linear Systems (NLS), Telequipment (a subsidiary of Tektronix) and Tektronix.

I have had especially good experience with Lectrotech scopes. Lectrotech is an American company based in Chicago. Besides scopes, they make many other pieces of test equipment. I have been using their scopes in business and in education for more than 10 years and have found them to be reliable, accurate and usually easy to repair in the rare instances of failure. The last time I checked, their dual-trace 15MHz scope was selling for less than $500. If my students can't destroy them, you probably won't be able to either.

A low-cost alternative to the dual-trace scope is to convert your single trace to dual trace by means of an electronic switch. I hadn't recommended this because of the limited bandwidths of most of these devices. However, recently Viz has come out with one that sells for about $100, and has a 4MHz response.

If you plan to buy a decent scope, figure on paying at least $500. If price is no object, then I highly recommend that you buy a scope with features similar to the one I have that can be used for anything from dc to digital. I own the Tektronix 465 dual-channel 100MHz scope with delayed sweep. With optional voltmeter/time-base readout, it costs a little more than $3000 if purchased new.

# mended equipment

### 6. Frequency counter

No shop can afford to be without one of these units in the era of the phase-locked loop. They are also handy for verification of oscillator speed in tape systems. Recent price breakthroughs in IC technology make these units even more affordable. I particularly like one I have been using for a few years.

Ramsey Electronics makes a unit that can count to about 525MHz, displays in seven digits; comes completely assembled, tested and guaranteed; is small, rugged and reliable; and costs $100 with a few handy accessories. You can find their ads regularly in the back pages of electronics magazines. I have been using them in class for a few years. The unit was referred to me by a friend who has been using one in the field service of coin-operated electronic video arcade games. Once you have one for use in audio, you will be surprised how often you use it for TV service.

### 7. Variable ac power supply and current monitor

If you have been working on modern solid-state TV receivers, you probably have one of these units or its equivalent already. The technique of slowly increasing the incoming ac line voltage while monitoring dc power supply output voltage and input current is the only reliable method I know that ensures non-destructive testing when troubleshooting suspected short circuits. This technique has its application in audio service after replacement of shorted output devices and/or power supply components.

I recommend an all-in-one unit for reasons of economy. For example, the unit I use, the Heath IP-5220, costs about $150, and can be assembled in a few hours.

### 8. Dummy load

To help preserve sanity in the shop while testing power amplifiers at high output, and to relieve the financial burden of buying speakers that can handle high power levels, buy yourself a dummy load. Although the ideal dummy load consists of a pure resistance, in fact that type of resistor is expensive, hard to locate and rarely necessary. An actual loudspeaker usually resembles anything but pure resistance electrically. This allows you a few options. If you have time and access to surplus parts, you can do what I did—wind resistance wire on a telephone pole insulator and you'll wind up with a 400W stereo load, which can be tapped at 2, 4, 8 or 16Ω per channel, and cost less than $25! Otherwise you can series/parallel several high-wattage resistors to make up the right load. Finally, if time and/or inclination is not there, you can simply buy a commercial dummy load such as the Leader ID 21, which can handle about 50W/channel and costs around $70. Heath made an excellent 200W dummy load for about $50. Although it has been discontinued, you can get them used. Keep your eyes open.

### 9. Transistor tester

Many audio amplifier circuits are direct-coupled. This means that transistors have to be tested for proper beta range and leakage. A simple go/no-go tester will just not get it. For believable results, including the output capability of matching transistors working in pairs, I strongly suggest that you get a dynamic tester (a curve tracer) as well as a static tester.

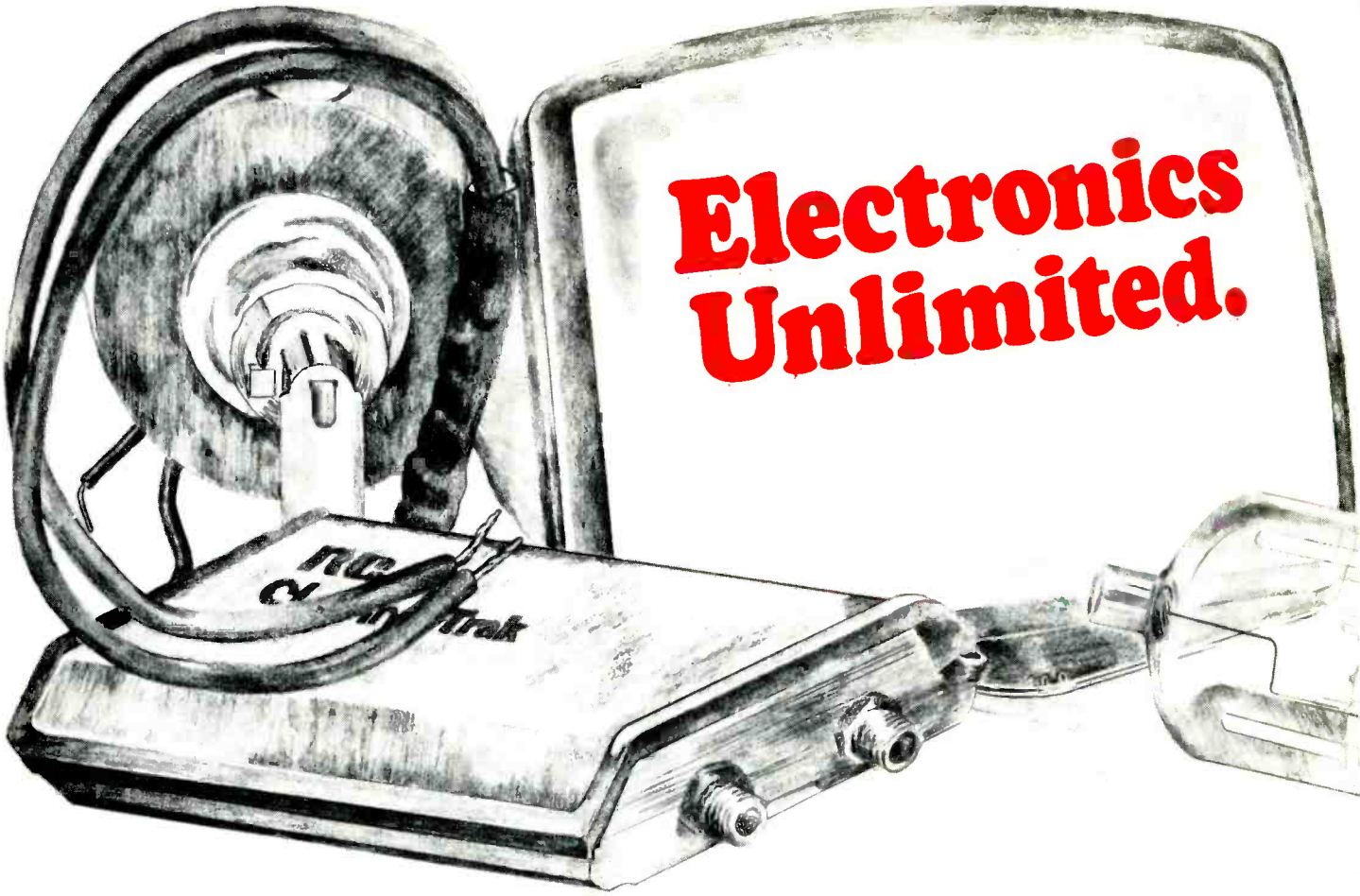
An excellent static tester is the B&K 530. I have been using this device for more than four years. Within its main limitation (it can only apply 100V to a device when testing for breakdown and leakage), it has failed less than 2% of the time to correctly identify a defective device. It can also identify transistor type, beta, high frequency gain, leakage and many other less frequently needed characteristics. It can also identify and check FETS, MOSFETS, SCRS, TRIACS and other devices. It costs about $350 and is well worth it.

As I said, a dynamic tester is also needed, especially for use in device matching and for approximating in-circuit operation. I think the device that gives the most value in this regard is the B&K 501A curve tracer. Although this item is no longer in current production, a lot of them were sold, and you can usually find them on the used market. It has exactly the same limitation as the 530, but is accurate and reliable within that limitation. A curve tracer is indispensable for testing zener diodes for square knee and secondary breakdown, as well as for many other tests. Temperature effects such as thermal runaway are especially easy to simulate on the curve tracer.

### 10. 12V power supply

This device is necessary for the repair and testing of car stereo equipment. Available from many sources, you need one of these supplies that will furnish at least 5A in order to energize 8-track change solenoids and high-power booster amplifiers. The surplus houses and mail-order establishments that advertise in the back of most of the electronics magazines are good sources for these supplies. One such example I saw recently put out 20A and only cost $40. A supply like that will certainly do the job while costing much less than a new precision lab power supply (which probably would not even put out enough current).

So much for the equipment you will need. The total cost of the above items comes to about $2200, if the highest priced item suggested is bought. This is certainly not an excessive cost, and in reality would amount to much less because you may already have some of these items, and could easily buy the remainder either used in good condition or at a discount. ES&T




## Feedback

*An article in the December 1982 issue of* ***ES&T*** *elicited this response from the state of California Department of Consumer Affairs. Bureau of Electronic and Appliance repair:*

"We read the article titled "A Unique Service Shop" in your December issue.

"While the article was interesting, there was a major inaccuracy concerning this bureau that we want to call to your attention for correction in a future issue: California law does not require a safety check on every television serviced in the state. Sections 2734 and 2741 of the Bureau of Electronic and Appliance Repair's regulations delineate the circumstances in which various safety checks must be performed. We invite your attention to these sections in the enclosed copy of the regulations.

"Further, the author's statement that this 'law is enforced by an investigator who walks into a shop with a PR-57 in his hands' is untrue as well as somewhat melodramatic. In fact, while the bureau does own two Sencore PR-57 Powermasters, our field representatives do not descend on service shops with high voltage checkers a-blazin'. They do carry small portable units (not made by Sencore), which are much more convenient for occasional field use.

"By overstating the requirements of the law and by attributing a commercial endorsement for Sencore's unit by this bureau, your author does a disservice to your readers, to Sencore's competitors and to this bureau.

"Thanks for your attention to our constructive criticism. We will look forward to a clarification in an imminent issue of **Electronic Servicing & Technology.**"

Michael V. Abbott
Acting Chief
State of California
Department of Consumer Affairs
Bureau of Electronic and Appliance Repairs

***ES&T*** *informed Abbott that we would publish his letter to make clear the Bureau's position. We also sent a copy of Abbott's letter to Honey. That resulted in a discussion between Honey and Abbott. The following letter from Abbott recaps that discussion:*

"Thank you for your letter of March 3, 1983, and for your attention to our concerns with Mr. C. A. Honey's article. For your information, Mr. Honey and I have talked by phone recently, and I want to share with you some of the clarifying discussion we had.

"As you recall, I objected to two points in the article: (1) the apparent commercial endorsement by the bureau for a particular piece of Sencore equipment; and (2) the

statement that California law requires a safety check on *every* set serviced in the state.

"We had no trouble clearing up the first point. On the second, we concluded that there is considerable room for interpretation of regulation Section 2741(k), the section Mr. Honey was relying on as the basis of his statement.

"Our interpretation of the language in 2741(k) is that 'reassembly of an electronic set' means more than merely installing the back of a TV set after a simple repair procedure, and a safety test would not be required in such instances. The test would be required for more radical repair procedures such as those which involve chassis removal and reinstallation, for example.

"Mr. Honey's point, which is very well-taken, is that the safety check *should* be done for all sets repaired, both for the safety of customers and for the legal protection of the servicer. Though this may be an overstatement of the minimum requirement, it is a reasonable and conscientious interpretation.

"Thanks again for your attention."

Michael V. Abbott

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*For further clarification of the situation, section 2741(k) of the Rules and Regulations of the State of California Department of Consumer Affairs, Bureau of Electronics and Appliance Repair, published in January 1981 is quoted here:*

"After reassembly of an electronic set, except for exclusively dc operated sets, an ac leakage test and a resistance safety test shall be performed.

"The procedures for conducting the ac leakage test and the resistance safety test shall comply with the OEM service data specifications. Where the OEM service data specifications are not readily available, the ac leakage and the resistance safey test shall be performed in accordance with the best available service data specifications."

*We would like to assure readers that neither Honey nor* ***ES&T*** *had any intent to mislead or to imply endorsement of any product by the bureau.*

*All of this brings up an interesting thought for readers who are actively involved in servicing electronic equipment for profit. Are you thoroughly familiar with local, state and federal regulations that bear on your servicing activities? Perhaps you should be!*

---

Feedback letters should be addressed to:

**Conrad Persson, editor**
**Electronic Servicing & Technology**
**P.O. Box 12901**
**Overland Park, KS 66212**

We welcome your comments.

ES&T

# Tips for better cassette recordings

**By Carl Babcoke, CET**

Anyone can make an audio-cassette recording by installing a tape, pressing the *recording* and *playing* push-buttons on an average portable machine, and speaking in the general direction of the internal electret microphone. However, the playback quality ranges from barely acceptable to poor. Some of the shortcomings include limited frequency response, high distortion, excessive noise, speed and pitch variations and a popping noise at each beginning and ending of a taped segment.

At the other extreme are cassette tapes made on high-quality decks. When all conditions are correct, these tapes have excellent frequency response, very low noise and all other characteristics of a professional recording. These desirable results seldom are obtained by accident. They are the result of careful attention to many details; some simple to achieve and several that involve measurements.

Perhaps the most important step is to choose a tape that has the level of quality needed for the type of recording. Practical suggestions and tests were provided in the article "How to Evaluate Cassette Tapes" in the February 1983 issue of **Electronic Servicing & Technology.** Other steps and actions to be performed (or avoided) are described in this article.

### Playback volume

*Adequate loudness of the playback signal is the first consideration.* The best signal-to-noise ratio (S/N) is obtained when the loudest sounds have the highest possible amplitudes, just short of noticeable distortion. This playback volume depends primarily on the recording level, the amount of bias and the capability of the tape to retain sufficient magnetic flux (sensitivity).

The gain of the recording amplifier must be controlled properly for all recordings. Many portable machines now have automatic-level-control (ALC) circuitry that provides satisfactory recording amplitude without serious overloading. Other considerations make ALC unsuitable for better recorders, however.

Cassette decks do not have ALC, so the gain (or gains if the material is stereo) must be adjusted manually. Optimum rotation of the recording-level control depends on the signal-voltage level coming into the deck and on the internal circuitry. No specific gain (or position of the level control) can be stated as best. If a microphone is used, the volume depends on how loudly the person talks, his distance from the microphone, and the exact amount of internal amplifier gain.

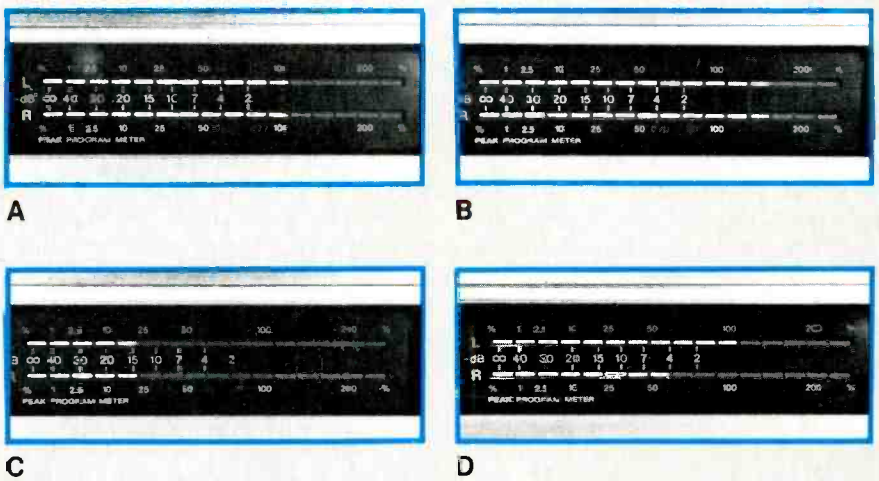



**Figure 1.** Peak-reading digital-readout volume indicators are best for cassette decks. Pictured are readings of a Sony readout using LEDs in green and red. (A) A high quality test tape confirmed the accuracy of the Sony 0dB calibration. The 0dB or 100% LED is red, as are those for higher levels. (B) Levels up to +4dB are recommended for high-bias tapes, but many normal-bias tapes work well at these levels also. (C) A highest level of −15dB will play with some audible tape hiss. Record louder, if possible. (D) Unbalanced left vs. right channel readings could be correct if they occur only occasionally on stereo material. Do not record monaural this way, nor allow stereo programs to show unbalance all the time. Such unbalance is typical of monaural tapes copied by a high-speed duplicator and played on a deck.

Music and spoken words have constantly varying amplitudes, so the gain must be adjusted to provide a certain peak amplitude that should not be exceeded. Or the sounds must fluctuate around an average point.

Before suggestions are given about interpreting meters and readouts during recordings, the opposing philosophies of recording gain must be explained.

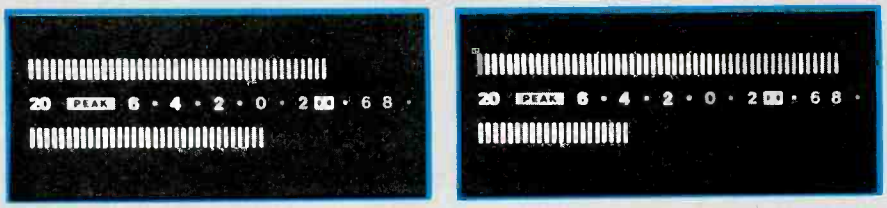
**To compress or not to compress?**

The answer to that important question determines the dynamic range of recordings (the contrast between loud and soft). The two extremes are no volume correction during the entire recording, or repetitive gain adjustments as needed to produce a succession of equal-amplitude peaks. Ideally the method should be selected according to the final use for the recording. Both the type of recorder material and the listening conditions enter into the decision.

Symphony buffs often insist strongly that *none* of the original volume-variation dynamic range should be deleted from these recordings. In this case, the recording gain is adjusted for whatever maximum the recorder will tolerate (without undue distortion) when the orchestra's loudest chord is played. Then the music is recorded from the beginning without any further change of recording gain. This method is excellent for digital-audio recordings that have virtually no background noise. However, the dynamic range of a philharmonic orchestra far exceeds the signal-to-noise ratio of cassette recordings.

With the other approach, all major volume variations are canceled by an operator who manually adjusts the gain control (gain-riding) so the maximum loudness is the same at all times. This gain-riding can be done by manual rotation of gain knobs, electronically by a specialized audio compressor, or by a combination of both methods.

Most symphonic recordings today have some manual gain-riding that raises the softer passages enough to minimize tape or record noise that otherwise might be excessive. Many commercial music records and tapes have maximum levels occurring continually, perhaps in an effort to capture the



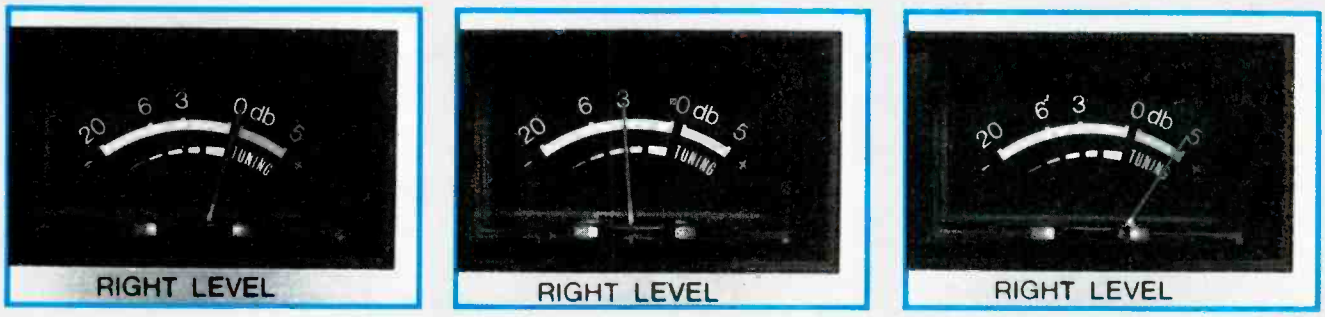

A B

Figure 2. The readout of the Technics M260 3-head deck apparently was calibrated to a different standard. (A) The 0dB test tape should have lighted the trio segments up to 0dB on the lower readout, as shown. It did not. Instead, a reading of approximately +3dB (on the upper readout at the double-square emblem) was obtained. (B) These two readings show the normal range of peaks that will provide good recordings. The actual maximum of about +4dB (+8dB on the fluorescent display) should not normally be exceeded, and peaks should not be allowed to drop below the marked −4dB point often, or tape noise will be heard.

nature of live rock-and-roll performances.

Although there is no definite correct-vs.-incorrect system of level compression, all amateur recordings should be made with the ultimate listener in mind. The needs of a symphony lover who listens with 200W of audio power are totally different (he wants all the dynamic range from whispers of sound to a full orchestra crescendo) from the needs of a hospital patient who must play cassette tapes quietly to avoid disturbing others in the vicinity. If the recorded volume varies wildly, when the playback volume is adjusted for soft reproduction of the loudest sounds, the weaker sounds become inaudible. One partial solution is for the listener to increase the playback gain, but then tape hiss becomes excessive and the next loud sound blares out.

The need for a constant playback level with cassettes is illustrated by some of my experiences in a volunteer job of re-recording master tapes for use in a high-speed duplicator. The sound-system operator who made the original recordings set the gain so the loudest music did not overload the tape, but he did not raise the gain when a speaker spoke at about −20dB to −30dB. When I used a gated compressor to correct these volume changes automatically, all loud and soft sounds were re-recorded at about +2dB to +4dB. Unfortunately, the soft sounds




A B C

**Figure 3.** Recording levels displayed by analog meters frequently require offsetting when recording speech. (A) Zero level peaks usually are satisfactory with music. (B) When the pointer is vibrating rapidly around a lower reading, this might indicate correct gain for certain types of speech patterns. (C) Excessive levels normally should be avoided unless experiments show that this reading provides normal recording levels for certain kinds of human speech.

were accompanied by prominent tape noise that can be corrected only partially by careful adjustments of the graphic equalizer. Mushy distortion from the occasional times the original recording level reached +6dB to +8dB cannot be corrected. This distortion remains after re-recording.

I have made recordings of live performances where a public speaker changed from a bellow to a whisper within seconds. Sudden variations up to 40dB are common in these cases, so attempts to ride gain manually are impractical. My solution was to buy a comparatively expensive broadcast model mixer/compressor (described later).

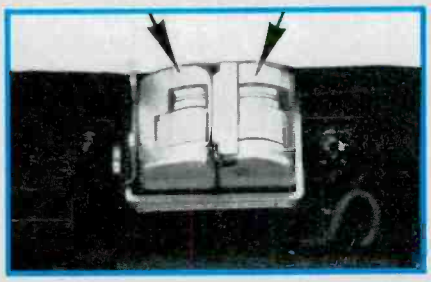


Figure 4. A few cassette decks have a recording head (left arrow) and a playback head (right arrow) in one assembly. This arrangement permits monitoring from the tape a fractional second after the recording is made, and it's highly recommended.

Because the sound levels have been monitored and corrected at the sources, it is easy to adjust proper recording levels when recording radio programs, TV audio and music from phonograph records or other tapes. However, important questions remain about how to interpret speech vs. music readings obtained from various types of level indicators. Serious mistakes can be made if these readings are not evaluated and the gain offset to make up for level-indicator shortcomings.

### Volume indicators

Although many kinds of indicators have been provided in cassette recorders over the years, they can be grouped into two main categories: meters or digital displays. (The few exceptions of a single flashing neon bulb, LED or incandescent bulb can be ignored.)

Digital displays are the most reliable because their indications are consistent, regardless of the waveshapes or speeds of repetition. Figure 1 shows a Sony digital display using rectangular LEDs that indicate 16 levels during both recording and playing. These four levels pictured are excessive, normal, low and unbalanced between stereo channels.

Measurements using a LCT-3003-E test tape (distributed by Ora Electronics) proved my Sony deck digital readout was correctly calibrated at 0dB (Figure 1). However, the Technics readout shown in Figure 2 evidently was calibrated to another standard, for 0dB of the test tape registered at about +3dB on the fluorescent readout. I thought of recalibrating the display, but finally decided to just remember that true 0dB is at the double-square emblem.

This incident illustrates a practical solution for any minor errors in the readout or meter you might encounter. Remember that you can't control anything unless you can measure it. Check your readout's accuracy, and if it is not correct, make mental allowances for the error or recalibrate the

meter.

Moving-pointer analog meters are supplied in many price-leader cassette decks. Sometimes these are called VU (volume unit) meters, although most such meters are poor imitations. Genuine VU meters are used in broadcasting, where they must conform to specific ballistic specifications.

Mechanical inertia of the meter pointer and its driving-coil assembly is the cause of severe reading errors when the sounds are transients. Generally these meters are satisfactory for music that varies slowly in amplitude (for example, an orchestra with vocal that contains sustained chords with no staccato passages). However, gross errors are produced by separate repetitive staccato sounds (which are one kind of transient). A single narrow pulse can be finished before a meter pointer can rise to the correct reading; therefore, a 0dB pulse might reach no higher than −6dB on the meter.

Certain types of speech patterns can produce gross errors in meter readings. A person who speaks rapidly, but with each word separated from those before and after, can transform what should be a 0dB reading to one between −4dB and −9dB, depending on the individual meter. Another meter might have overshoot that would produce an excessive reading – perhaps up to +6dB.

Figure 3 pictures a typical analog level meter with decibel calibrations and three different readings. These readings might all be correct, or all three might be in significant error, depending on the meter's inertial characteristics and the signal's waveform. If you want to know how much "fudge factor" should be added to the meter readings, record several almost unvarying sounds, plus several kinds of percussion or staccato sounds. Then play these test recordings on another machine that has a digital readout of known accuracy. A comparison between the previous recording-meter readings and the more-accurate digital readings will indicate in which direction and by what approximate percentages the meter readings should be offset (by varying the recording gain up or down). When

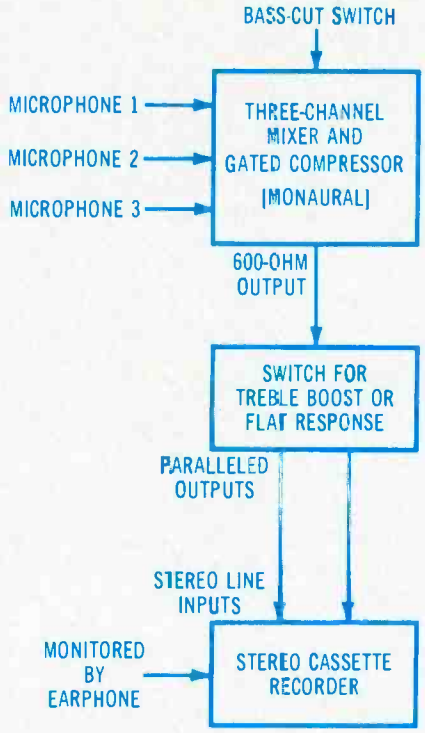



**Figure 5.** Details of connecting the equipment for on-location recordings are shown here. The output of the monaural compressor could be connected through a "Y" plug to both line inputs on the tape deck. However, additional high frequencies are beneficial during later duplication of tapes, and high-frequency boost is performed by a home-built equalizing circuit in a shielded box attached to the compressor's rear panel. A toggle switch selects flat or mid-frequency boost.

recordings are made in the future by higher or lower meter readings, according to the previous tests, the playback volume should be consistently loud, regardless of the types of sounds.

Some time ago, I performed these tests on my large, portable stereo recorder, (the one whose meter is shown in Figure 3), and found most music recordings were acceptable when the meter varied around 0dB. However, recordings of speeches or sermons required that the controls be adjusted so that the meter regularly pinned at about +5dB before the playback amplitude was equal to the music level. This rule of thumb should not be considered as an infallible guide; some meter pointers are over-damped and others are under-damped, requiring some recorders to show apparently low readings for loud playback. On the other hand, others might require apparently excessive readings to produce normally loud sounds.

One excellent feature of many digital readouts is called *peak hold,* and it extends the time the *highest* readout segment remains illuminated after the sound is over. This 2s lighting of one segment in each channel readout allows the operator to be certain of the highest reading. The higher-level segments of displays that do not have the peak-hold feature can flash on and off so rapidly that it is difficult to be certain whether or not they are lighted, particularly when the ambient lighting is bright.

### Louder is better

The dynamic range of cassette recording is limited in maximum volume (the ceiling) by tape and recorder distortion, and in the minimum volume (floor) by tape

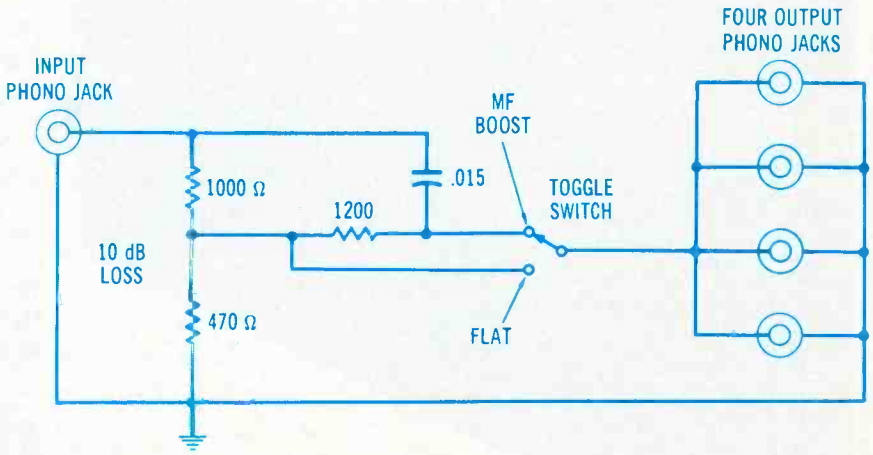



**Figure 6.** A simple loss pad whose loss is cancelled at mid and high frequencies is the only circuitry needed. The compressor output is 600Ω, and the level is more than needed for the deck, so the 10dB loss is left between the two units. (These low values would not be appropriate for an equalizer used between two decks.)

and amplifier noise, including hum. Incidentally tape amplifier noises are pink noise, which sounds much like the hissing noise heard between stations on an FM receiver.

In the tape-recording industry, the word *headroom* is heard often. This term refers to the safety area between the actual recorded level and the higher level at which distortion will occur. Headroom usually is concerned with transient peaks that may be ignored by analog meters or even broadcast VU meters, which tend to integrate or average the consecutive readings.

The amount of headroom needed can be sharply reduced if a peak-reading digital display is used, or if the performance of an analog meter has been analyzed and compensated for the type of peaks encountered. In fact, headroom can approach zero if a compressor is used or the level is monitored carefully on a peak-reading volume digital display. Greatly improved signal-to-noise ratio is the valuable result of these efforts.

**Monitoring from the tape**

Cassette machines with separate recording and playing heads (Figure 4) have numerous advantages over single head units used for recording and playing. The separate heads are stacked snugly side by side so both fit in the space usually occupied by one combination head.

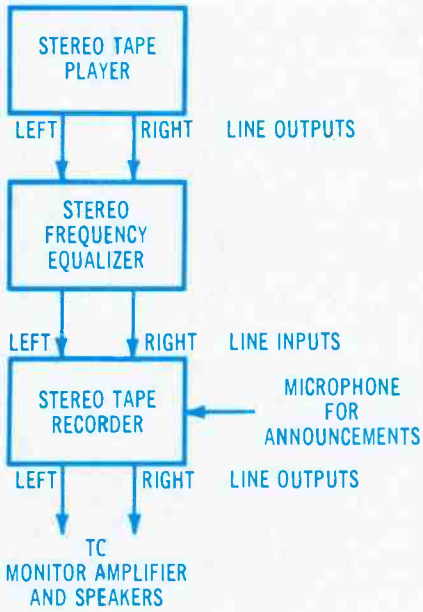



**Figure 7.** Two stereo tape decks should be used for copying cassettes in stereo. Better copies can be made when a graphic equalizer is inserted between the two decks, as shown.

One advantage of three heads is the ability to hear the audio that has been recorded a fraction of a second before. The monitor circuit is supplied through a selector switch with a sample of the audio being sent to the recording head (source audio) or a sample of the pre-amplified audio from the playing head (tape audio). Switching between source and tape positions allows comparison of amplitude and quality between the source and the recording. If the playback audio is more than 1dB weaker than the recording audio, it can be heard by the operator and noticed on the digital display. In the same way, distortion or change of frequency response can be detected instantly.

This instant comparison of input and playback signals can provide an approximate evaluation of tape sensitivity and frequency

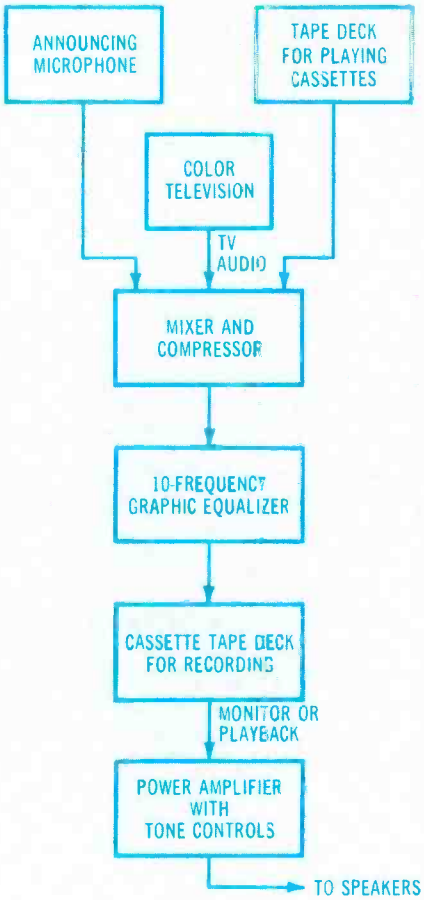
response. When your ears detect a large loss of high frequencies in the playback signal and the digital level display shows an output that is −4dB relative to the source, that tape is vastly inferior.

It has other uses, such as making certain that recording is actually taking place. I have found tapes that had virtually no playback volume, although there was no visible damage. Granted, failure of a tape to accept a recording is no tragedy if you are copying a record; the recording can be done over. But, if you are recording an important person at a public meeting (without a backup deck), a bad tape can be a disaster.

Another advantage of separate recording and playing heads is that the gap and windings of each can be designed for optimum operation. Recording-head gaps need to be relatively wide, while playing-head gaps should be as narrow as possible. No combination head can match the performance of two heads.

All in all, a 3-head cassette deck is worth the hundred or so dollars of extra cost.

A




B

**Figure 8.** A home-built particle-board rack holds the items of equipment on shelves. Wood is preferred over metal because metal shields the AM-radio antenna. (A) Each of the five shelves holds one major unit. Wiring changes can be made easily because there is no back. A master switcher controls the ac power. The equipment is not physically stacked in the order shown by the block diagram. Instead the units are placed where the ones used most often are at eye level when the operator is seated. For that reason, the graphic equalizer is at the bottom of the rack. (B) For monaural recording or editing, this arrangement of equipment is used. Operation has been convenient, and the tapes usually have excellent quality.

### Correcting frequency response

Inadequate frequency response can be corrected by filters or equalizers, but the best results are obtained by correcting the response as early as possible. For example, if you tape an AM radio program, it is certain that the high-frequency response will be degraded by the narrow IF bandwidth, so use a complementary high-frequency boost between the radio and the cassette recorder. Or, if a better copy is to be made from a poor-quality amateur tape recording, correct the response as the better copy is being recorded.

Another important type of frequency correction is performed ahead of the need. Many of my *master* tapes are used in a high-speed duplicator to make dozens of copies. Unfortunately, these duplicators always reduce the high-frequency response. The answer (or at least a workable compromise) is to boost these high frequencies during the original recording.

When I tape away from home, I usually take only a mixer/compressor and one cassette tape deck. (Monitoring is performed with an earphone, usually from the simultaneous tape playback.) Rather than take a graphic equalizer, I permanently mounted a middle-frequency-boost circuit (Figures 5 and 6) on the compressor's back panel. The toggle switch provides relatively flat response or gives a moderate MF boost. Maximum boost is limited to minimize overload (remember, decks are provided with HF boost), but it is sufficient to make the duplicator copies sound better.

### Recording stereo copies

A stereo cassette copy of a stereo music tape is very easy to make, if two machines are used with the line-output signal of one deck cabled to the line-input jacks of a second. I use a Technics 3-head model as the recorder, so it can monitor from the tape.

The audible results of this method often are disappointing. Music cassette tapes are factory-made, high-speed copies and some are badly deficient in high frequencies (perhaps because they use low-quality tape). Or, perhaps the bass guitar is not loud enough for your taste. The answer to all frequency response problems is to add a stereo graphic equalizer between the two decks (Figure 7). Without recording, play the tape through the equalizer and listen as you adjust the equalizer controls. After settings that produce pleasing sounds are found, rewind the original tape and record the copy, being careful to start them at the proper points. It is an excellent idea to add slightly more high frequencies during the listening-without-recording test, because some loss of high frequencies usually occurs during the recording (mainly because of the tape used).

Recording stereo music copies requires a premium-quality blank tape. If you enjoy music, invest in

a normal bias, a chrome high-bias or even a metal tape that will provide full frequency response. It is futile to use a low-performance tape and expect to correct the deficient high-frequency resonse with the equalizer. Good high-frequency response cannot be *forced* onto such tapes, regardless of the high-frequency boosting (refer to the waveforms on page 54 of the February 1983 **ES&T**). Recording at levels above the MOL of the tape results in compression. The suggestion to use a premium tape for recording music cannot be stated too strongly.

### A tape-editing system

Editing tapes by the old system of cutting the tape and splicing together various segments is not practical for cassette tapes. Slow tape travel does not permit location of specific sections with any accuracy. But more important, cassette tapes usually have forward and reverse tracks, preventing any successful splicing of more than one direction. Also the tape is so narrow that it is difficult to splice without disturbing the azimuth.

Instead, cassette tapes should be edited by a re-recording process, which can be totally acceptable if the original tapes have at least average volume and frequency response. In fact, when all possible corrections have been made, *a re-recorded copy can sound better than the source tapes did.*

Figure 8 shows my own editing system. I usually keep the various units cabled together for monaural operation (Figure 8B), although it takes just a few minutes to change it for stereo operation. Of course, the monaural compressor must be disconnected from the signal path.

Simplified operation and flexibility are two advantages of the system, while the quality of the individual units are adequate for limited commercial operation.

Each of the mixer/compressor inputs has its own gain control, so it is not necessary to change the wiring when selecting another signal source. Also, two or more can be mixed together in any balance.

An identification or a description of recorded material can be placed at the beginning of a tape by using the announcing microphone, then immediately the recording deck is placed in the pause function while the next material is made ready. Segments of any length from any number of cassettes can be inserted on the master tape. With patience and practice, it is possible to edit down to one word. And the editing points do *not* have loud popping noises.

The Shure compressor can hold the recording level to no more than about 3dB variation, even without attention or careful adjustments. If the operator sets the

**Figure 9.** These are examples of the many adapter plugs that are available.

compressor controls carefully according to the compression meter, the recording peaks can be held to about 1dB. When the response rate and gating are adjusted carefully, the compressor action cannot be discerned in the sound.

Most program material can be improved by careful operation of the graphic equalizer. By the way, the word *graphic* here refers to the approximate frequency-response curve portrayed by positions of the vertical-traveling knobs that admit amplitudes of 10 octave frequencies (per stereo channel).

Loud popping noises at the beginning and ending of each recorded segment are most common with portable machines, because the complicated record/play switch must change between those two functions each time, and the switching involves dc voltages. Neither of my cassette decks adds any dc-voltage pops to a recording. Of course, a transient that sounds similar to a pop is formed from a sinewave or low-frequency signal that started or ended abruptly by a switch. The resulting vertical leading or falling edge is heard by human ears as a popping noise. This type of noise usually is eliminated from good decks with a pause function that moves the capstan and head slightly back from the tape without switching out of the playing or recording mode (whichever is in operation).

If you exercise moderate care not to operate the pause control in the middle of a word or note, the tape editing (achieved by changing from one tape to another) cannot be heard, unless there is a major difference of the two background noises, such as crowd, fan or air-conditioner noises). Even if the level and frequency response of two adjacent program segments are vastly different, adjustments to the compressor and equalizer can make them sound alike. Just remember to make all adjustments while in the pause mode.

The compressor also makes possible a production operation that the broadcast industry calls *ducking*. For example, music comes into the compressor with a low gain setting, and the compressor action produces normal output loudness. When an announcer talks into a microphone having a much higher gain setting, the louder microphone level forces the compressor to reduce both microphone and music volumes so the compressor output remains the same as before, but now the microphone sound is dominant. The effect is as though the microphone had normal gain while the music gain was reduced smoothly. This is a good feature, when needed.

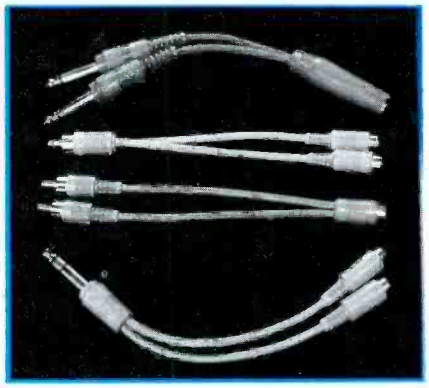


**Figure 10.** When a stereo cassette deck is connected for monaural operation, some of these "Y" connectors might be needed to activate both channels.

After weak volume and poor frequency response have been corrected, many edited tapes produced on this equipment have far better quality than that of any of the source tapes. Of course, other brands and models of equipment can be used with comparable results. If you do not now need all the features and units found in this cassette-editing system, these can be added or others deleted later to form a system that is best for your needs. Just consider these features as source ideas.

### Cables and adapter plugs

When anyone attempts to connect two or more items of sound equipment, the first discovery is that few plugs, sockets and cables are compatible without adapters.

There is good news and bad news in this necessity for cables and adapters. The good news is that many companies have recognized the need for these small items and have manufactured them in a bewildering abundance. But the bad news is that you can spend a small fortune acquiring all the cables and adapters you need.

These items come in several general categories. One group includes metal adapters from phone plug to miniature phone plug, ⅛in phone plug to phono jack, female phono jack to female phone jack, and many others (Figure 9).

Another helpful basic group includes the various *Y* adapters that connect one thing to two others. One adapter connects a single ¼in microphone connector to two ¼in shielded plugs. It is used to connect one microphone to both stereo channels of a tape deck (Figure 10).

### Accessories and black boxes

Additional gadgets can make a recording system more flexible while saving time or allowing better control of levels or frequency response. Figure 11 shows the schematic for a simple shielded box containing only a 2-position rotary switch, six phono jacks and several inches of hookup wire. The switch allows the use of two tape

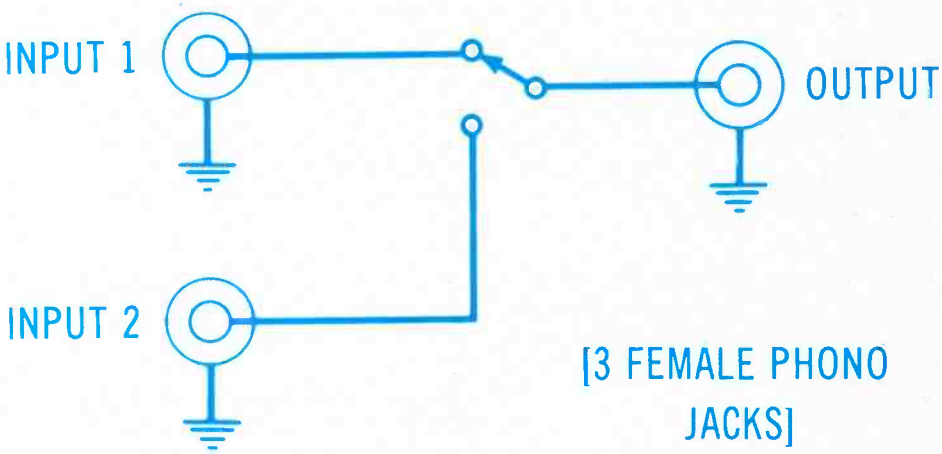



**Figure 11.** Occasionally, it might be convenient to have a tape deck or a phonograph switched to another item of equipment such as a deck or an amplifier. The circuit for a home-made switch box could not be more simple, consisting of a switch and the associated hardware.

decks alternately, or it can switch the stereo output of a deck to an amplifier or another deck. Of course, a switch with more positions can be substituted and more phono jacks added, if additional units are to be switched in and out.

A more sophisticated commercial switching unit is the Radio Shack Tape-Control Center (Figure 12). This unit can switch up to three tape decks and one amplifier. Although it appears to be a good unit, it did not operate as I wanted at the time. When plugged one way with tape inputs on one line and tape outputs on another line, an ultrasonic oscillation occurred. Follow the Radio Shack instructions for best results.

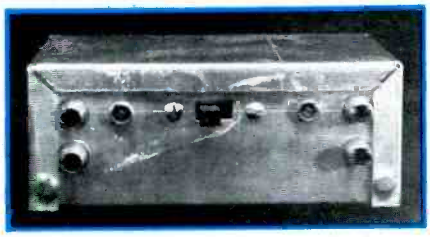
Before I acquired a good AM/FM/amplifier unit with tone controls, I used the home-built box of Figure 13 to control bass and treble. This passive circuit produced a loss at all frequencies and canceled the loss at marked frequencies to yield the effect of a boost. Equalization circuits, either fixed or variable, can be built in a metal box for use where needed.

Another commercial unit I recommend without reservations to those who appreciate loud but natural bass response is the Radio Shack Bass Enhancer with subsonic filter. It is ac-power operated and has a combination on-off and bypass switch that feeds the audio through without any change when pushed to off. Two sliding controls determine the frequency of maximum gain and the amount of boost at that frequency. The *frequency* control selects the frequency between 40Hz and 160Hz where the boost will occur, while the *boost* control regulates the selected frequency increase between 0dB and +12dB. Part of the internal active circuitry also provides a sharp rolloff below 40Hz (subsonic filter). The Bass Enhancer is excellent for use with smaller speaker systems because it can boost the lowest usable frequencies and not waste power on lower frequencies that would not be heard anyway. My speakers have 12in woofers plus midrange and tweeter speakers, so the bass normally is flat to about 55Hz. Therefore, I use +12dB at 40hz and obtain good response down to almost 40Hz (a welcome extension of bandwidth).

An unsuccessful home-built audio compressor and the good Shure compressor mentioned earlier are pictured in Figure 14. In the simple one, rectified audio caused an LED to light, and it illuminated a cadmium-sulfide cell that reduced resistance to reduce the output-signal level. Although the unit compressed steady audio very efficiently, it had excessive choppiness when compressing spoken voices because the return to maximum gain was too fast.

**Figure 12.** A commercial signal-routing box is the Radio Shack Tape Control Center. It can be very useful when several tape decks are used with one system.

**Figure 13.** One example of a custom-built equalizer. It gave five degrees of bass boost, two treble decreases and three treble boosts. These passive circuits impart a loss of about 20dB.



A

B

**Figure 14.** Two audio compressors, one unsuccessful (A) and one very successful (B) are pictured. Details are given in the text.

The Shure model SE-30 mixer/compressor was my final choice, and it has proved to be very satisfactory. The analog meter shows either the output signal in decibels or the amount of compression up to 30dB. Adjustable gating is employed to provide smooth and unobtrusive compression without the steady buildup of background noise between slow words or sounds, as most others do. A loud sound produces immediate compression and normal output level, then the gain stays low constantly until another loud sound arrives (or a succession of weaker ones that bring the gain up in small steps). Model SE-30 has three inputs, each with its own level control, so it functions also as a 3-channel mixer.

### Comments

Over the past two years, I have tried to probe the limits of cassette tape recording, including what recording levels the tapes can stand without excessive compression or distortion. Most normal-bias tapes can be satisfactorily recorded up to +4dB above industry standard 0dB, if the high frequencies are not too prominent. When a tape is driven near its saturation point, excessive treble can change the normal lisp of human voices into a loud rasp. With a 3-head machine, it is interesting to listen to the tape playback as the recording level is steadily increased and notice the high frequency rasp that finally degrades the speech.

Similar tests have been made on two brands of high-speed monaural duplicators. One of the unexpected results was the discovery that the tape characteristics measured at normal 1⅛in/s speed bear little relationship to the results obtained by the same tape after it is used as a duplicator bulk copy tape. Two brands of tapes can have nearly identical real-time measurements, but after they are recorded in a duplicator, one might have 4dB higher level than the other. These details and other findings will be reported in a future article.

If you have any questions about audiotape recording, please address them to the editor. ES&T

# Photofact

**These Photofact folders for TV receivers have been released by Howard W. Sams & Co. since the last report in ES&T.**

**CITEK/TEKNIKA**
2213/2252 ..... 2160-2

**JC PENNEY**
685-2065-00 ..... 2165-1

**QUASAR**
Chassis AD/GTS-981 ..... 2161-1

**SAMSUNG**
BT-239TK, TR ..... 2161-2
CT-339FB, ZB ..... 2164-1

**SEARS**
564.40260250 ..... 2159-1
564.41812250 ..... 2160-1
564.43700250/3700251/3800250/
3800251/3900250/3900251 ..... 2162-1
685-2030A-00 ..... 2163-1
401.51060150 ..... 2163-2
564.42101250/01251/02250/02251 ..... 2164-2

**WARDS**
GNB-17632A,B ..... 2159-2
GGV-17622A,B/642A,B ..... 2162-2
GNB-12914A,B ..... 2165-2

# Quick-facts

**These Quickfacts volumes for TV receivers have been released by Howard W. Sams & Company.**

**JC PENNEY**
Models 685-2001 through 685-2124 ... Vol. 1, April 1983
Models 685-2129 through 685-4946 ... Vol. 2, May 1983

**Coming in ES&T...**

**The magnetron: a key to microwave oven servicing.** Servicing microwave ovens is not as complicated as it might seem. Determining when to replace the expensive magnetron tube, an important part of servicing these appliances, will be discussed in this article.

# Readers' Exchange

**Needed:** Manual or copy of manual for Solar Exameter capacitor analyzer. *Frank J. Fligel, 1338 S. Wesley Ave., Berwyn, IL 60402; 1-312-484-6761.*

**Needed:** Sams Photofacts 900 on up, tubes and TV parts, and isolation transformer. Must be reasonably priced. *Arnold Schaefer, 125 Diggs Ave., Milbank, SD 57252.*

**Needed:** Schematic, operating instructions and service manual for Precision Apparatus Company series E-200-C signal generator. *Rustan R. Crespo, 440 59th St., West New York, NY 07093.*

**Needed:** Wiring diagram for an Eico tube tester model #625 and a tube chart for a Philco tube tester, model #050. *Murl D. Carver, P.O. Box 11, Paintsville, KY 41240.*

**Needed:** Operating manual and schematic for RCA model WA-44C audio signal generator. Will pay expenses. *Ardan Electronics, 33 Surrey Lane, East Northport, NY 11731.*

**Needed:** Operator's manual for a Western analyzer, model #980 Mark II. Will pay for cost of sending copy. *Howard Koch, 7 Shore Road, Edgewater, NJ 07020.*

**Needed:** Supremes volumes R-7 and R-17 and service/parts manual for Bohsei T-500 b/w television. *C. T. Huth, 146 Schonhardt St., Tiffin, OH 44883.*

**Needed:** Circuit diagram of any video tape recorders commonly used in homes. *Joe Homaidan, 50 Oba Akran Ave., P.O. Box 349, Ikeja, Lagos State, Nigeria.*

**Needed:** Sencore VA-48 video analyzer and LC-53 inductance/capacitance meter. *R. M. Query, Box 23717, L'Enfant Plaza Station, Washington, DC 20024-0717.*

**Needed:** March 1973 issue of *Electronic Technician/Dealer;* also a source that explains the art of ringing coils and transformers to check for shorts. *John Augustine, 530 N. 9th St., Reading, PA 19604.*

**Needed:** Schematic or service information for Electrostatic Sound Systems of Sacramento, CA, model 500 audio power amp. Company is now out of business. *Robert Bargenquast, 2612 N. Buffum, Milwaukee, WI 53212.*

**Needed:** Used Sencore Z-meter. *J. Konney, Linear Audio, 3155 North Long, Chicago, IL 60641; 1-312-777-5538, days.*

**Needed:** Sencore model PR57 Powerite and Sencore model TF46 transistor tester. *Paul Capito, 637 W. 21st St., Erie, PA 16502.*

**Needed:** Zenith flyback S-89846 at reasonable price and schematic and technical data for Realistic QTA-753 4-channel Stereomax receiver, model 31-4015. *Lawrence T. Anderson, 3453 Balsam NE, Grand Rapids, MI 49505.*

**Needed:** Service manuals for Bohsei T-500 TV and Sansui SR-2020BC changer. *Charles T. Huth, 146 Schonhardt St., Tiffin, OH 44883.*

**Needed:** Updated tube information for a Knight K660B tube tester. *Bob Hade, 2107 Bell Ave., Rockford, IL 61103.*

**Needed:** Will pay $1000 for a pre-1942 television. Also need RCA model G2000 CTC47 1969 console color receiver. *Jeff Lendaro, c/o Morris TV, 1 Padanaram Road, Danbury, CT 06810.*

**Needed:** Drug-store tube tester. Must be in good condition, reasonable and check latest tubes. *Don Maurer, 20 S. 4th St., Lebanon, PA 17042.*

**Needed:** Deflection yoke for a 21-inch Motorola b/w television (part #24D68523A05). Also need Sams Photofact for Motorola G-21TS-593-C00. *Bill's Radio & TV Repair, RR#1, Box 5, McNabb, IL 61335.*

**Needed:** Schematics for German-built Loewe Opta Nordkap stereo, type 32255 t/w. Willing to pay cost and shipping. *Joseph Spencer, 315 S. Prospect, Colorado Springs, CO 80903.*

**Needed:** Conar model 250 oscilloscope with service manual and leads. *Daniel Ruiz, 336 W. Alverdez, Clewiston, FL 33440; or call 1-813-983-8483 after 7 p.m.*

**Needed:** Service manual for any or all Advent projection TV sets. Will buy or copy and return. *Atlas TV Service, 4201 Oak Circle, Boca Raton, FL 33431; 1-305-391-5888.*

**Needed:** Sprague model TO-5 capacitor analyzer for parts source; need not be working, must have good dial potentiometer. Operating manuals and schematics for Clough-Brengle 126 oscilloscope, Precision E490 multiplex generator (Dynascan can't supply) and RCA 150 signal generator. *G. J. Kulp, 1115 Lilac Lane, West Lawn, PA 19609.*

**Needed:** Power transformer for Teac model 1000 reel-to-reel recorder, part #56118. *W. G. Parker, 4621 Jasper St., Metairie, LA 70002; 1-504-888-3917.*

**Needed:** Sencore VA48; call or write stating price and condition. *Leonard's TV & Radio Inc., 1431 Colorado Ave., Lorain, OH 44052; 1-216-288-3252.*

**Needed:** Picture tubes #510HJB22 and 490BLB22A, and yoke for Sears set, part

#80-77-4D. *Richard Salazar, 10940 Sunnyslope Drive, Riverside, CA 92505.*

**Needed:** Model #T12 Heathkit signal tracer. *Johnny R. Mon, Box 182, Logan, WV 25601; 1-304-752-8821.*

**Needed:** Schematic for AM/FM radio, Magnavox model FM13, NBC 1474 692225-2, serial #62940, style R-197-23. Will buy or copy and return. *Gordon Wilcox, 42143 Loganberry Ridge South, Novi, MI 48050; 1-313-349-9034.*

**Needed:** Sams Service Guides CB 1-198, MHF 1-197 and SD 1-15. Will buy partial or complete set. Send list and asking price. *Michael Ames, 7 Hyatt St., Cortland, NY 13405.*

**Needed:** Back issues of *Electronic Technician/Dealer*, from June 1977 to March 1982, and Tekfax books after 112. *Ken Rector, Ken's TV, 12813 Ranchero Way, Grass Valley, CA 95945; 1-916-268-0156.*

**Needed:** Schematic for Benjamin Electronic Sound Corporation stereo, model R2X40, or address for the company. *Thomas Lutz, Consumer Electronics, 614 Edward St., Aurora, IL 60505.*

**Needed:** Power transformer for Dumont 901 Enginscope #20009861. *Jeff Longman, 512 H Drive South, East Leroy, MI 49051.*



**For sale:** NRI 1% signal generator, like new, best offer; Heath VTVM, model V-7, excellent condition, best offer; model 960 Sencore transistor radio analyst, like new, best offer. *R.J. Horsley, 67 Theodore St., Buffalo, NY 14211.*

**For sale:** B&K TV analyst, model 1077B; includes leads, manuals and two sets of slides; $400 or best offer. Sencore TV-video analyzer, model VA48; includes leads and manuals; $950 or best offer. Also have other equipoment, Sams, parts, etc. Send for list. *Joseph D. Carey, 9617 Deneen St., Noblesville, IN 46060.*

**For sale:** Sencore VA-48 video analyzer, new condition, $800; TF-46 Super Cricket, $200; B&K 467 CRT restorer/analyzer, $200. All in mint condition. *Emigdio M. Perez, 298 Montgomery St. A5J, Jersey City, NJ 07302; 1-201-332-6403.*

**For sale:** Almost-new Sencore VA48 TV and VCR tester, $849 (lists for $1395). *Herbert Silver, 516 Lowell St., Wakefield, MA 01880; 1-617-246-2280.*

**For sale:** Eico 950K bridge and comparator, $50; Heathkit 10-103 triggered scope, $200; Sencore 161 picture tube checker and rejuvenator, $150. All complete with leads and manuals, in good condition. *Arts TV, 1650 Airport Road, Montrose, CO 81401; 1-303-249-4995.*

**For sale:** B&K scope, $149; Beltron picture restorer-checker, $195; 13-in. color television, $249. *Worldwide Service Electronics & Products, 318 S. K St., Sparta, WI 54656; 1-608-269-2392.*

**For sale:** Retiring TV technician wishes to sell Beitman schematics from 1950-1970. Complete set. *Jack Mandik, 3852 N. Bell, Chicago, IL 60618.*

**For sale:** Sams 66-899; $800 shipping. Branson 3-quart ultrasonic cleaner, model 220, $180. *Terrick TV, 809 Amity St., Homestead, PA 15120; 1-412-462-8720.*

**For sale:** Sencore UPS164 power supply, $300, and Sencore TR193 transistor tester, $75. *All-Tronix & TV Svc., 1364 S. 33 St., Lincoln, NE 63510; 1-402-476-8164.*

**For sale:** KM-394 Nordemende AF-mVmeter/distortion analyzer. Sensitive ranges: 0.1mV/0.03%. Like new, $495. *Bob Cresci, Room 1016, 250 W. 57th St., New York, NY 10107; 1-212-265-5709.*

**For sale:** Schematics and service information for old radios and televisions, 1930 to 1950; also many old tubes. *Chris Shanahan, Box C-15224, CTF-N SA352, Soledad, CA 93960.*

**For sale:** TV Sams Photofacts from 200 to 1690, plus five cabinets. *Call Pete at 1-518-295-7202, Schoharie, NY.*

**For sale:** Precision model E-200-C, signal

generator, $75; Lectrolech V-7, $75; B&K scope 1450, $100. *R. F. Nister, Globe Radio & TV Service, 3407 Arlington Ave., Riverside, CA 92506.*

**For sale:** Heathkit 5in oscilloscope, model IP-102, like new with demodulator and low capacitor probes, $140. Also Heathkit IG-57A TV post marker/sweep generator, like new with attenuator, $95. Both for $225 plus shipping. *Goetsch Electronics, 12698 Shorewood Drive, SW, Seattle, WA 98146; 1-206-241-0507.*

**For sale:** New Heathkit scope kit, #4530, 5MHz, triggered, $190; Heathkit signal generator #IG-102, $65; Geiger counter #CDV-700, $65. All with leads and manuals; free shipping in United States. *Rich Bednarcik, 28 Steele Ave., Lincoln Park, NJ 07035; 1-201-694-6374 in the evening.*

**For sale:** Fairchild dual-trace scope, model 702, Genometer model 156 signal generator, and Heathkit capacitor checker, model C-3; all for $75 plus freight, in good condition, with manuals. *T. T. Walton, 8209 Lynnhaven Ave., Lubbock, TX 79423.*

**For sale:** Conar model 682 pattern generator, $50; REM model CRU II CRT tester & restorer, $75. Certified check or money order. *John R. Nelson, 169 S. Airlite St., Elgin, IL 60120.*

**For sale:** RCA VTVM model WV 98-C Senior Voltohmist; Heathkit IG-57-A post marker/sweep generator. Both in excellent condition; make offer. *William J. Maida, 341 Isabella Drive, Longwood, FL 32750.*

**For sale:** Yaesu FR-101, FL-101, like new, $600. Also have many items of test equipment for sale; call or send for list. *E. A. Sjolander Jr., Chequamegon Electronics, 917 MacArthur Ave., Ashland, WI 54806; 1-715-682-9494.*

**For sale:** CK 3000 test jig with adapters, nearly new, $250 plus shipping; Photofacts 600-1293 with files, $500 plus shipping; Telematic UHF/VHF subtuner, never used, $35. *Gerald Fitzgerald, 39 Robin Hood Drive, DeLand, FL 32720; 1-904-736-3808.*

**For sale:** Picture tube rebuilding equipment, one oven, one vertical lathe, accessories. Any reasonable offer. Also old Sams Photofacts 14-171; 116 folders in all, $300 plus postage. *Kenneth Rafuse, Bauer Ave., Manorville, NY 11949; 1-516-87-6677.*

**For sale:** Schematics for auto radios from the 1940s to 1960s (Delco, Motorola, Stromberg Carlson, Phillips, Bendix, United Motors Service (GM), Philco and Sylvania). Also have schematics and service literature for televisions from the 1940s and 1960s (Admiral, Arvin, Crosley, Dumont, Emerson, General Electric, Motorola, Philco, Quasar, RCA and Spartan). Most are in good shape and complete. Will not split up. All for $175 or best offer; postage extra. *Ed Day, RFD #2, Box 184, Ox-Brook Road, Claremont, NH 03743; 1-603-542-8191.*

*(Continued on page 45)*

# 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.*

**101 Ways to Use Your VOM, TVM and DVM, by Bob Middleton; Howard W. Sams & Co.; 144 pages; $10.95.**

Due to the nature of their work, TV servicers and electronic technicians are required to be familiar with a large variety of test equipment. However, they often develop a certain routine so that only a limited number of tasks are performed with each piece of test equipment. Although the procedures used may not be the most efficient, the familiar routine is used as long as the results are satisfactory.

This book encourages technicians to explore the possibilities of their equipment by describing the many ways these pieces can be used – from simple voltage and resistance checks to alignment applications.

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

**Servicing Home Video Cassette Recorders, by Marvin Hobbs; Hayden Book Company; 237 pages, $11.95.**

This 10-chapter book includes a glossary of videocassette terms and two appendices explaining the automatic assembly recording system and special consideration for cable television.

Various chapters cover the video signal circuitry, servo circuit operation and system control operation of the VHS system in detail, with the difference found in Betamax explained in a separate chapter. A comparison is also made between the mechanical aspects of these formats. Several chapters explain the adjustment tools and electronic test equipment used for VTR servicing, mechanical adjustments and replacements, and electrical alignment and adjustment. A final chapter covers personal video camera theory and servicing.

Published by Hayden Book Company, 50 Essex St., Rochelle Park, NJ 07662.

**Troubleshooting With the Oscilloscope, by Bob Middleton; Howard W. Sams & Co.; 256 pages; $10.95.**

One of the quickest and least costly ways to troubleshoot most electronic equipment is to use an oscilloscope. This book provides step-by-step procedures on the use of an oscilloscope and combines these with specific facts of TV receiver troubleshooting.

The first chapter introduces the scope, Chapter 2 covers the operation of both free-running and triggered-sweep oscilloscopes, and Chapter 3 discusses probes. The remaining chapters are devoted to troubleshooting black-and-white, color, solid-state and tube-type televisions, and to troubleshooting digital-logic circuits.

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

**Basic Electronic Switching for Telephone Systems, Second Edition, by David Talley; Hayden Book Company; 312 pages; $10.95.**

This revised edition includes major advancements in electronic switching technology and equipment. The book has been written to furnish executives, engineers, technicians and advanced students with a broad, in-depth knowledge of electronic switching precepts and the operations of contemporary electronic telephone offices.

The book initially reviews the fundamentals of electromechanical switching systems from the original, direct-control, step-by-step method to the common control panel, rotary and crossbar types. The book also covers the essential principles of stored program control, central processing units and the distributing processing means utilized in modern electronic switching systems.

Published by Hayden Book Company, 50 Essex St., Rochelle Park, NJ 07662. ES&T

*(Continued from page 43.)*

**For sale:** B&K Precision signal generator, series #E-200 (about 1960 model) with instruction manual and cables; Sencore tube leakage checker and capacitor tester, model #LC3, with manual, $20; Sams Photofacts (32 sets from #151 to #1009), $1 per set. Write for complete list. *John Brouzakis, RD 3, Box 602B, Charleroi, PA 15022; 1-412-483-3072.*

**For sale:** Sencore VA48 in excellent condition with all cables and manuals, $800. *David Briscoe, 1432 Briarwood, Memphis, TN 38111; 1-901-744-2278.*

**For sale:** Heath IG-28 color bar/dot pattern generator, $80, in like-new condition. Assembly and use manual included; will ship UPS collect. *C. A. Caputo, 7 Donna St., Peabody, MA 01960; 1-617-535-1091.*

**For sale:** Sencore VA48 video TV and VIR analyzer; B&K model 1472B scope; B&K 1077 TV analyst, all in excellent condition with manuals. *Joseph Bednarz, Box 760, Ojai, CA 93023.*

**For sale:** Sencore VA48, like new, with cables and manuals, $750. Also approximately 750 receiving tubes in original boxes (about 400 for older model equipment); best offer. *J. C. Conley, Box 187, Sherrill, IA 52073; 1-319-552-1600.*

**For sale:** Sencore CB servicing system (CB-41 tester, CB-42 analyzer, NL-204 noise pulse simulator and PS-43 power supply; all complete with tech data), $750; Sencore SG-165 AM/FM stereo analyzer, complete with tech data, $500; more than 250 Sams CB and audio radio manuals and more than 30 TAB CB and stereo repair manuals, $400. *David Skyberg, Sky's Electronics, P.O. Box 89, Glenns Ferry, ID 83623; 1-208-366-7909 (shop) or 1-208-366-2345 (home).*

**For sale:** Sencore SG-165 AM/FM stereo analyzer, $400. *Angelo Alessi, 29 Cross St., New Windsor, NY 12550; 1-914-562-9152.*

**For sale:** RCA WR-52A stereo FM signal simulator; RCA WR-69A TV-FM sweep generator, RCA WR-99A crystal calibrated marker generator. *John Schaedler, 3239 NE Chippewa, Kansas City, MO 64116.*

**For sale:** Sencore FC-45 frequency counter, $400; Sencore DVM-56 microranger, $550; B&K E200D RF generator. New condition; plus shipping. *Bill Bechtold, 7429 Frederick St., Omaha, NE 68124; 1-402-397-2461.*

**For sale:** In excess of 400 brand new, unopened TV Photofacts, #600-1100; $2 each for entire batch or will trade for ARs, TSMs, TRs or CBs in like-new condition. *J. L. Wingfield, P.O. Box 685, Cedaredge, CO; 1-303-856-6341.*

Many brightness and color-tracking symptoms can be caused either by the color picture tube or the circuitry around the picture tube.

# CRT problems or circuit defects?

By Homer L. Davidson

All visual symptoms of a defective color picture tube can be placed in four broad categories: brightness problems, incorrect colors, arcs and focus problems. Of course, a multitude of variations is possible within each group (a black raster certainly is the ultimate example of insufficient brightness), and some cases involve more than one category. For example, incorrect brightness might be too low, too high or erratic. One cause of low brightness can be weak gun emissions, and this often blurs the visual focus.

Circuit defects can exhibit the same symptoms as those caused by most picture-tube deficiencies. Therefore, a technician must first determine whether the defect is in the picture tube or in the circuits that control it. Incidentally, all examples given here are about 3-gun color picture tubes (often called cathode-ray tubes or CRTs).

CRT defects seldom cause changes in the incoming signals or the dc-voltage supplies for the CRT. Therefore, *incorrect signals or dc voltages at the picture tube usually indicate circuit defects.* One of the first testing steps should be the measurement of dc voltages at all active contacts of the CRT socket.

Another first step checks the ability of the CRT's three guns to provide sufficient electron current and brightness. The *service/normal switch* (Figure 1) is pulled out to the *service* position (which eliminates the height, applies a fixed bias to the CRT guns and disconnects the luminance signals). Each of the three screen-grid (or G2) controls is rotated in turn to obtain a bright red, blue or green horizontal line on the CRT screen. Failure to obtain one bright line indicates a weak CRT gun or a defect in the chroma demodulators. For the RCA model of Figure 1, a defect in one of the kine-driver modules also can prevent a line from appearing on the screen. Measure the CRT-cathode dc voltages at a single wire coming from each module to the CRT socket. With other brands and models, measure the CRT-cathode voltages at the CRT socket.

### Insufficient brightness

Weak CRT gun current in a b&w TV receiver can be identified usually by *white compression* in the visual picture. Because weak CRTs often develop stronger electron current and screen brightness after several minutes of operation,

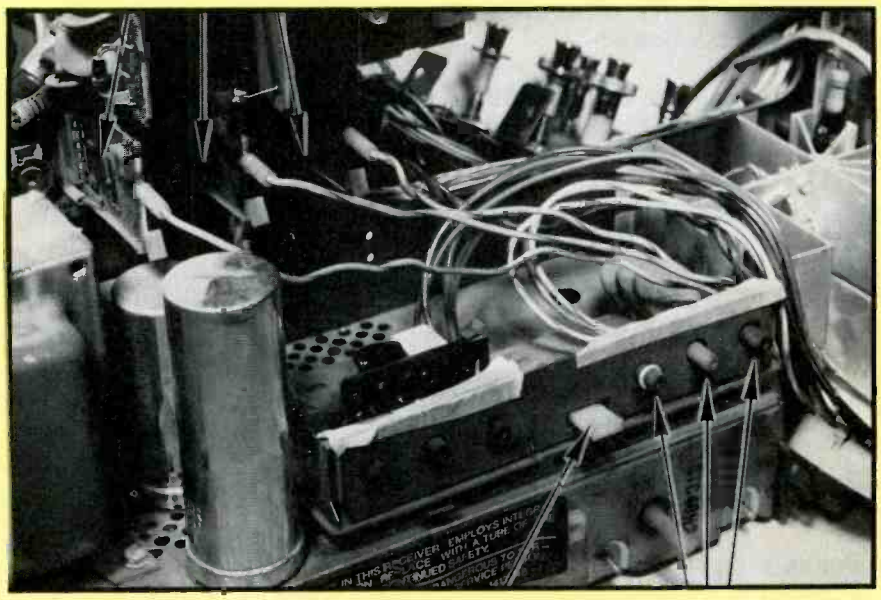


**Figure 1.** Arrows point to the components and adjustments that are most important for picture-tube tests in this RCA CTC48. Three arrows at the top indicate the kine-driver modules that matrix luminance and chrominance signals, amplify them and feed them to the three CRT cathodes. Wrong dc voltages here can affect the brightness of all colors or each color separately. The *service/normal* switch is located by the single arrow at the bottom. At the lower right, pointed out by arrows, are three screen-grid (or G2) controls that determine the maximum gun current (maximum color brightness) of each CRT gun.

the picture should be examined shortly after turn-on. White compression darkens what should be brilliant white into a gray shade. Further, the effect changes radically as the *brightness* control is adjusted. This is a revealing symptom because clipping in the video amplifier can also clip the white tips in the waveform, but the effect does not change when the brightness is varied. White compression from a weak CRT gun is easy to identify visually after you have examined a few examples carefully.

White compression occurs in color receivers, as well, but the effect is not as unmistakable as with b&w CRTs. One reason is that a single weak color is obscured by the brighter ones. When all three color guns are operating, a slow warmup of one gun produces a major shift of screen color (called gray-scale) as the CRT becomes warmer internally.

Check this gray-scale drift by turning down the color control to eliminate all color, and watch for a slowly changing screen color on the b&w picture. *The picture will be deficient in the color provided by the weak gun.* For example, a weak red gun results in a cyan screen, a weak green gun produces a magenta screen, and a weak blue gun causes a greenish-yellow screen for the first few minutes (or longer, if the gun never achieves normal current).

A CRT tester can verify warmup drift, but the CRT should be allowed to cool for an hour or so before the test. Measure and write down the readings of each gun after about 30 seconds, one minute, three minutes and six minutes (or longer if the readings continue to change). Some mistracking is indicated by gun currents that differ by more than ±20%, while major differences of more than 100% usually prevent adjusting for satisfactory gray-scale trackings.

If your CRT tester has the feature, rejuvenation of a weak gun can be attempted, but it is wise to ask the customer's permission because a violent rejuvenation (or a moderate one repeated too many times) can reduce the gun current below the original value.

Of course, a drifting screen-grid voltage or grid-to-cathode bias of a gun can simulate a slow-warmup gun. If the emission tests show no drift, but the brightness continues to vary slowly on the screen, these screen-grid and bias voltages should be measured for each gun. Also, a weak gun often produces blurred line focus on the screen (a good secondary symptom); therefore, pictures in each of the three colors should be viewed separately when identifying soft focus. Otherwise, the brighter colors with good focus will obscure any deficiencies of the weak color.

Erratic or insufficient CRT-heater voltage also can reduce the maximum picture brightness, simulate weak guns and exaggerate any unbalance between the gun currents.

Remember that many newer color receivers take CRT-heater power from a winding on the horizontal-output transformer (flyback). Therefore, the heater waveform is not a 60Hz sinewave but instead shows 15,734Hz pulses. These pulse amplitudes should be measured by a scope because most meters will give incorrect readings.

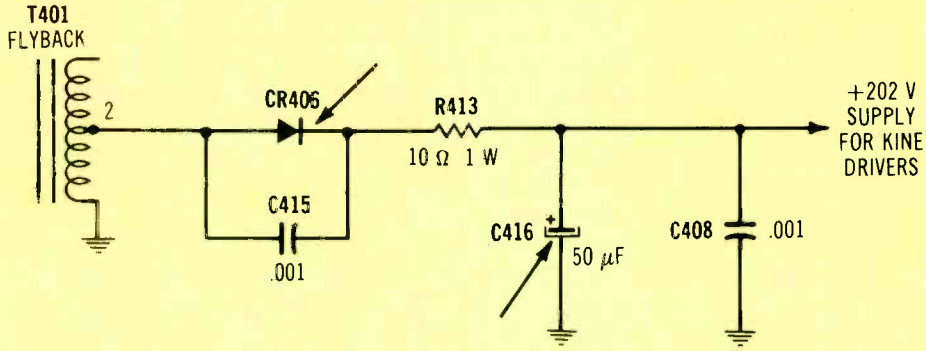



**Figure 2.** Loss of the +202V supply in an RCA CTC85H receiver (Photofact 1800-1) removed all B+ from the kine-driver modules, thus reducing the CRT-cathode voltages to almost zero. Insufficient CRT-cathode voltages produce maximum brightness.

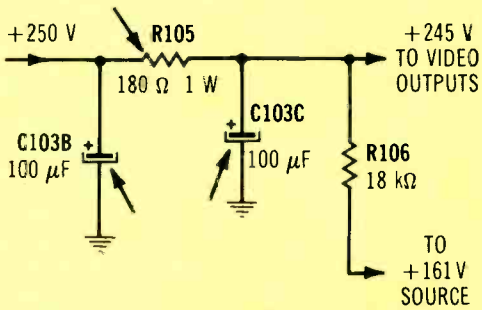



**Figure 3.** An RCA CTC58N (Photofact 1428-2) developed excessive brightness when these components became defective and eliminated the +245V supply that powered the luminance/color power output transistors, which feed the CRT cathodes.

### Intermittent brightness

When color-picture brightness changes suddenly at unpredictable intervals (but without variation of gray-scale tracking or color hues),

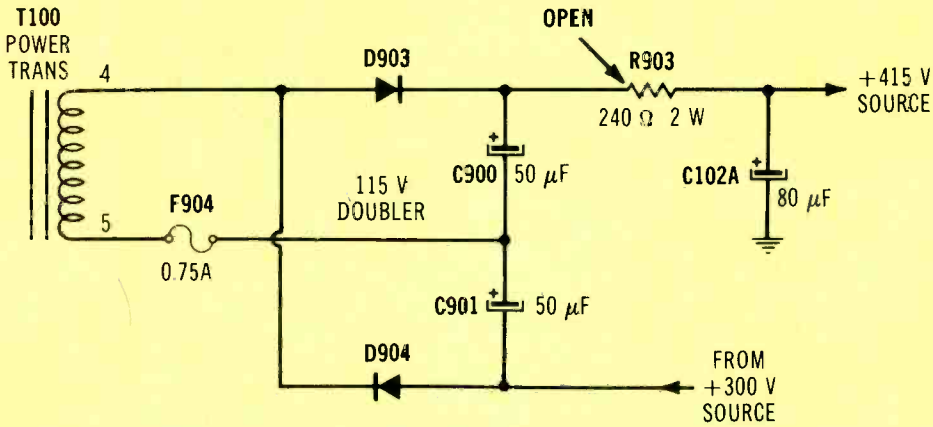



**Figure 4.** One open resistor in one 3M20 Admiral color receiver (Photofact 1434-1) eliminated the +415V supply, which powered the −Y color stages and the Y luminance amplifier.

the problem usually is in the circuitry, and not in the picture tube. If one of the three colors erratically becomes much brighter or disappears, the defect might be in the picture tube or in the circuitry.

A picture-tube defect that suddenly changes the brightness of one color in raster and color picture usually is caused by particles of gun-cathode coating that lodge between CRT gun elements, producing shorts. Sometimes these particles can be dislodged by placing the receiver with its CRT face down and tapping gently on the CRT neck near the base. In extreme cases, a capacitor-discharge rejuvenation can be performed while the CRT neck is tapped.

Erratic brightness can also be produced by intermittent CRT-heater power, but the brightness changes slowly. Turn off the ac power, unplug the CRT socket and measure heater-pin continuity at the base as slight pressure is applied to the pins. Use the same ohmmeter to check continuity through the heater source (power-transformer or flyback winding). Examine the socket for loose wires or corroded connectors. Keep testing until the open circuit is located.

Often the heaters are visible through the glass CRT neck, and you can see by the glow when the heater has power, or by blackness when it does not. This is more convenient than measuring the voltage when the connections are stressed, in an effort to start or stop the heater power during tests.

**Uncontrollable brightness**

Uncontrollable brightness can have either of two causes. One is a failure in the video circuit that prevents normal operation of the brightness-control function. The second produces brightness so excessive that the screen-grid and brightness controls cannot reduce it to normal.

Excessive brightness that cannot be adjusted to approximately the correct value *is seldom caused by a picture tube.* Defects in the video stages are usually responsible. Often the cause is CRT screen-grid or control-grid dc voltages that are too positive or CRT cathode voltages that are not sufficiently positive. Test these voltages first to find which is incorrect, and then check the circuits associated with the incorrect voltages.

With an RCA CTC85H, for example, the CRT cathodes measured almost 0Vdc, causing brightness so intense it could not be reduced to normal by the screen-grid controls or the brightness control. A few dc-voltage tests located a leaky C416 filter capacitor and a shorted CR406 diode rectifier (Figure 2). A sample of the horizontal-deflection signal is rectified by CR406 and filtered by C416 to produce +202V (which supplies the kine-driver transistors), and the transistor collectors were direct coupled to the CRT cathodes. With loss of this supply voltage, the CRT had a positive grid-to-cathode bias at each gun so they were drawing saturation current and producing maximum brightness.

Another RCA CTC58N had a similar problem (loss of color-amplifier supply voltage), but the power supply is produced by rectified 60Hz power (Figure 3).

Excessive brightness with an Admiral 3M20 also came from a loss of a video dc-voltage supply, but the reason was different. The +415V supply is formed by a +115V doubler circuit (Figure 4), which is in series with a +300V supply. Two circuits receive power

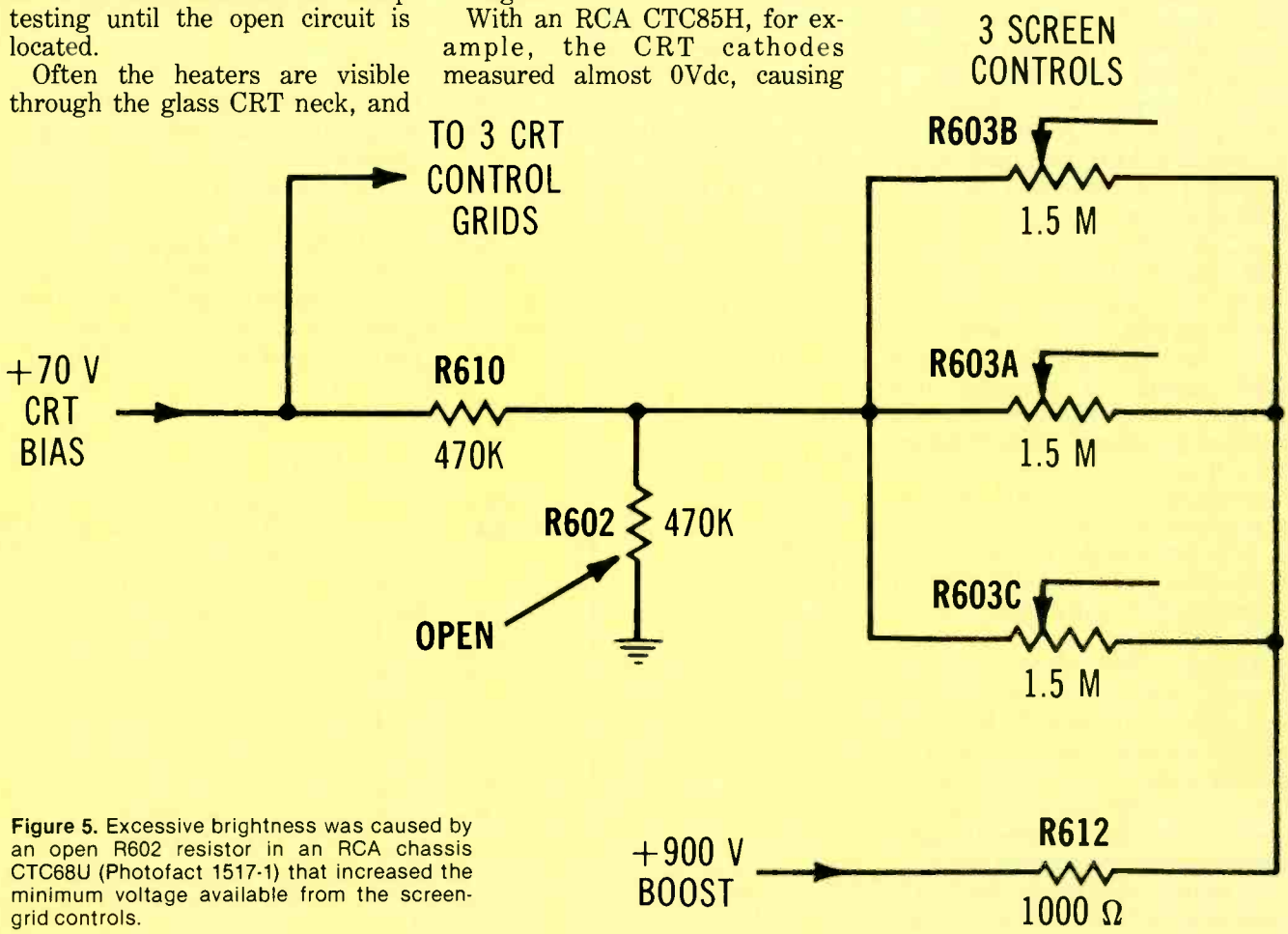



**Figure 5.** Excessive brightness was caused by an open R602 resistor in an RCA chassis CTC68U (Photofact 1517-1) that increased the minimum voltage available from the screen-grid controls.

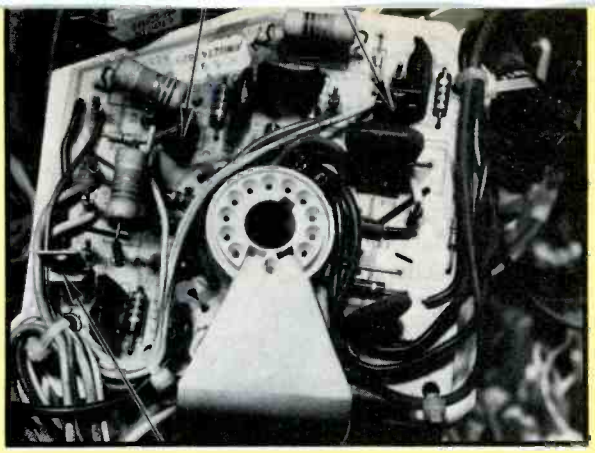


Figure 7. The luminance/chroma output transistors often are mounted on the small circuit board that contains the CRT socket. Arrows point to the three transistors. Their metal-tab heatsinks are connected to the collectors, so they can be used as convenient test points.

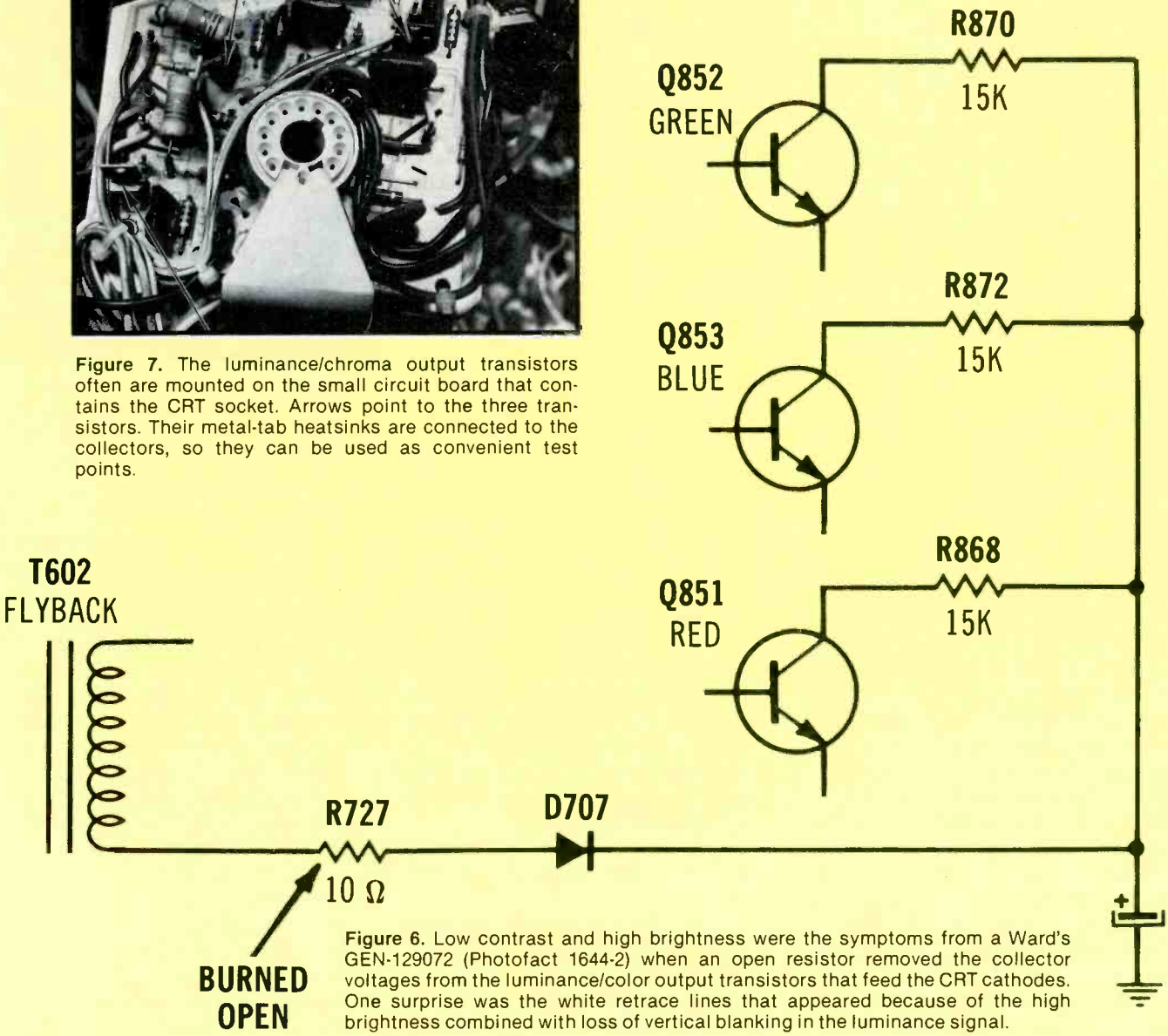



Figure 6. Low contrast and high brightness were the symptoms from a Ward's GEN-129072 (Photofact 1644-2) when an open resistor removed the collector voltages from the luminance/color output transistors that feed the CRT cathodes. One surprise was the white retrace lines that appeared because of the high brightness combined with loss of vertical blanking in the luminance signal.

from the +415 supply. One includes the three −Y color amplifiers, which feed color signals to the CRT grids. Without a B+ supply, the CRT grid voltages (which are direct connected to the −Y plates) dropped almost to zero. Also, the video output-tube plate circuit (and the associated video-drive controls for the CRT cathode signals) are powered from the +415V supply. Without this supply, the video plate and the three CRT cathodes were operated at zero volts. This is zero grid bias, which in turn produces maximum electron gun current that causes maximum brightness on the CRT screen.

Another reason for excessive brightness that could not be reduced by adjustments of the three screen-grid controls was illustrated by a CTC68 RCA color receiver. Tests proved all three CRT screen-grid dc voltages were little changed by rotation of the screen-grid controls. The voltages could only be adjusted as low as +650V. Resistance tests of all controls and fixed resistors in the screen-grid circuits proved resistor R602 had increased from the marked 470KΩ to more than 5MΩ (Figure 5). When R602 was replaced by one of the specified value, the screen voltages could be adjusted over the usual ranges, and the brightness-control function was restored to normal.

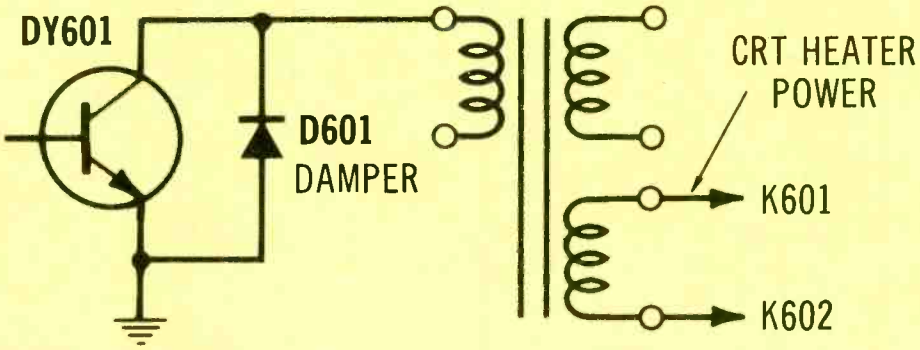



Figure 8. This Sharp CRT-heater wiring is typical of many newer color receivers that apply horizontal-sweep pulses to the CRT heaters.

### Retrace lines

Excessive brightness often allows vertical-retrace lines to be seen clearly on the CRT screen, although all modern color receivers have some type of vertical and horizontal blanking that supplements the blanking in all NTSC video signals. Usually this blanking is accomplished by adding clipped samples of vertical and horizontal deflection pulses to the video waveform, where it is amplified along with the video signal.

However, defects in the video circuit (before it is matrixed with the three −Y chroma signals) can weaken the video and the blanking pulses so the retrace lines are not blanked out, but appear on the CRT screen. In other words, certain kinds of low contrast usually cause retrace lines to appear (Figure 6).

If, because of a defect, one of the three color-output power transistors (which drive the CRT cathodes with luminance and color signals) loses much of its gain and has a reduced collector voltage, that color will be brighter in the raster, but without video or chroma signals. Because the video is missing, the blanking pulses also are missing. Lack of blanking from both signals allows the normal retrace lines to be seen on the screen, but only in the affected color. In other words, the retrace lines are red, blue or green, depending on the defect's location.

Proof of these video problems usually can be easily obtained by measuring dc voltages at the collectors (metal tabs) of the three video/chroma power amplifier transistors, which often are mounted on a small circuit board along with the CRT socket (Figure 7). These collector voltages range between approximately +120V and +180V, depending on the brand and model. Usually, in a normal receiver, these three collector voltages will measure within 10V to 15V of each other, until a defect changes one collector voltage. For example, if one collector tests +132V, a second reads +128V and the third measures +200V, the circuit showing the +200V reading has the defect.

### No raster

The following are the only known causes of a no-raster symptom.

- absence of high voltage at the CRT
- absence of focus voltage at the picture tube
- a defective picture tube (open heater, shorted elements, open internal wiring or extremely weak electron-gun currents)
- excessive negative CRT control-grid voltage relative to the cathode voltages
- insufficient positive CRT screen-grid dc voltages relative to the cathodes
- loss of CRT heater-supply power
- sufficient dc current in the yoke to deflect the raster away from the phosphorus screen coating

Notice that the control-grid and screen-grid voltages relative to the cathodes are very important. If the control-grid voltage (to ground) is normal, but the cathode's positive voltage (to ground) is higher than normal, the gun has excessive bias and the *effect* of reduced screen voltage. Both conditions reduce the gun current, and the lower current decreases the brightness of that color.

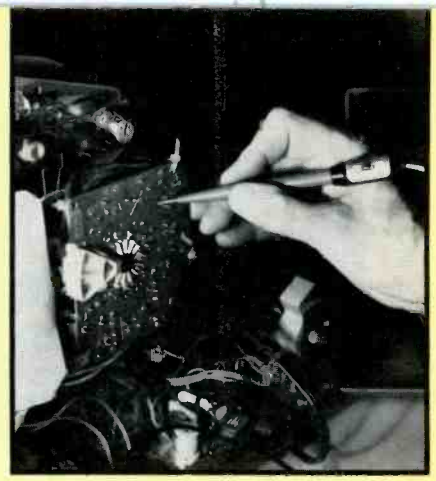


**Figure 10.** Always check the focus voltage (and other important voltages) when there is the slightest suspicion these voltages might be incorrect.

Always use a CRT tester to determine the CRT's condition before you waste too much time checking other things. If no glow can be seen from any heaters or cathodes in the CRT neck, either the heaters are open internally, or the heater supply is missing (perhaps from a bad solder joint or socket connection).

Remember that many newer receivers obtain the CRT heater power from a separate winding on the horizontal flyback transformer (Figure 8), so a loss of horizontal sweep removes the CRT heater power. Check the continuity of CRT heaters and their flyback winding by the same methods as used for CRTs that obtain heater

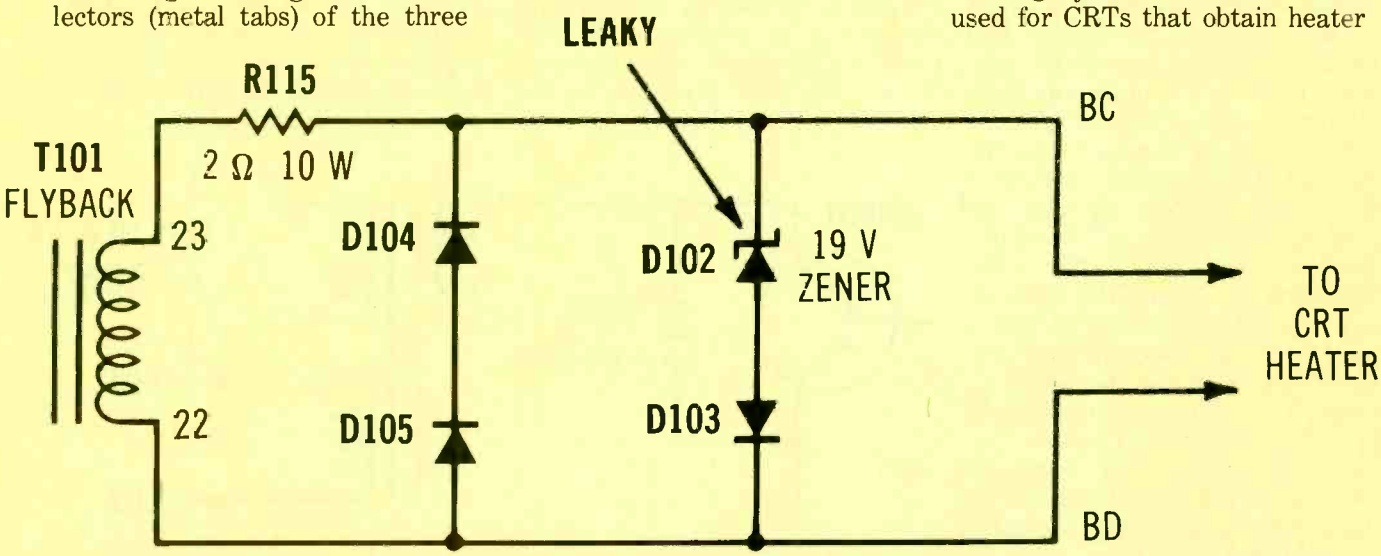



**Figure 9.** A leaky zener (D102) in an Admiral 4M46-2B chassis (Photofact 1825-1) reduced the CRT-heater voltge, causing symptoms of a weak picture-tube.

power from a winding of a 60Hz power transformer.

Serious problems arise, however, if a standard meter is used to measure a CRT heater that is supplied with horizontal-sweep power. Only true-RMS and thermocouple types of meters provide correct readings of 6.3Vac. For example, my DMM usually reads around 2.94V when measuring such CRT heaters. If the schematic gives a pulse waveform and an amplitude in peak-to-peak voltage, use your scope and compare its reading with the schematic figure. Typical causes of CRT-heater power losses include corroded tube pins, bent springs that make contact with the tube pins inside the CRT socket, opens at circuit-board rivets, and other physical defects. Use ohmmeter readings to locate these open circuits.

Figure 9 shows a rare example of reduced CRT-heater voltage. Clipping and zener diodes are used to stabilize the heater supply. When D102 shorted in a 4M46-2B Admiral chassis, R115 operated very hot, and the CRT voltage measured about 25% of the usual reading. A shorted D102 produced a low-brightness, low-contrast picture, but proper operation was restored when a new D102 zener diode was installed.

Incidentally, a quick test for adequate CRT heater power is to parallel a number-47 dial-lamp bulb across the CRT heater pins. When the voltage is sufficient, the 47 bulb will light at normal brightness. Lower bulb brightness indicates insufficient voltage for the CRT.

Measure all dc voltages at the CRT socket (Figure 10) plus the focus and high voltages. Compare the readings obtained with those on the schematic (or against your memory of typical voltages, if a schematic cannot be obtained). Remember the previous comments about the relationships between the various voltages.

### One color missing

A color that is missing from both b&w and color pictures might be caused by the picture tube or the dc voltages applied to that gun. Check the CRT on a tester, or connect the chassis to a test jig for operation with its known-good CRT. If all colors are present when the test jig is used, the picture tube is bad and must be replaced.

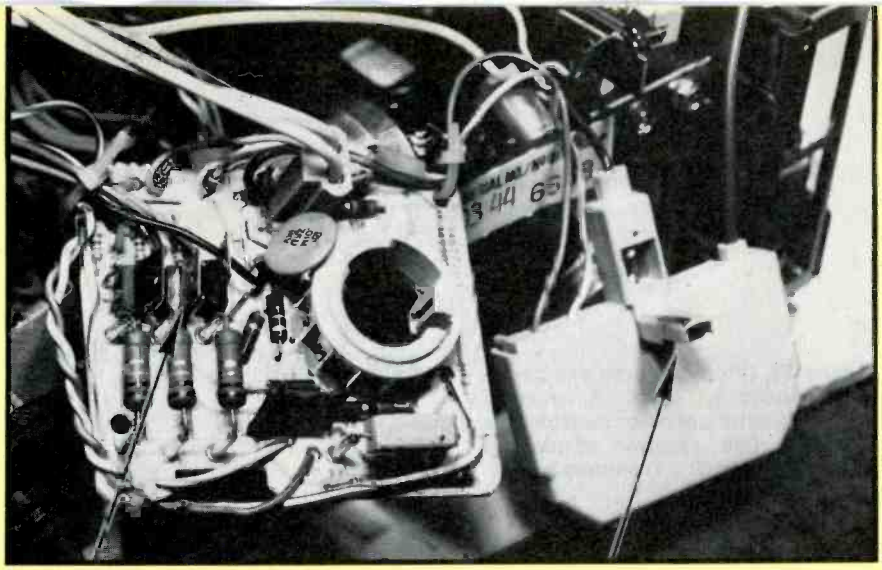


**Figure 11.** The arrow at left points to three luminance/chroma output transistors (bunched together in this model). Use the metal heatsinks to measure collector voltages. The right arrow indicates the focus-voltage plug, which can be removed from the CRT socket during tests.

If these tests show the CRT is not defective, check collector voltages of the three video/color power transistors that are often mounted on the CRT-socket circuit board. A high collector voltage will reduce the intensity of one color, because the collector is directly connected to one CRT cathode (a more positive cathode is increased grid bias, which reduces the CRT gun current).

The tint of the missing color points to the circuits and transistors that should be tested. Heating or cooling each power transistor (Figure 11) often starts or stops the symptoms, identifying the heat-sensitive transistor. When the trouble is nearer the video detector, use a scope to trace each stage back to the one that eliminates the color.

A Sylvania tube-equipped model D16 had normal green and blue tints with weak red tints in color pictures, although the raster had proper amounts of all three. Therefore, the problem was identified as a defect in the chroma circuit, and not a bad picture tube. Voltage and resistance tests located a burned R678 demodulator-collector resistor that had decreased from its 47KΩ value to about 4KΩ (Figure 12). This stopped all the X-demodulator output signal, which eliminated the red tints and degraded the blue and green tints in color pictures.

Replacement of resistor R678 restored all the correct color tints.

### Focus problems

Poor focusing of the bright dot (that is deflected to form a raster) can originate in a color picture tube. The slightest leakage between the focus electrode or the focus wiring and the internal aquadag CRT-coating (which is connected to the high voltage inside the CRT) will raise the focus voltage far above the amount needed for best focus. At the other extreme, resistive leakage between the focus electrode or its wiring and other CRT internal parts (having lesser voltage) will reduce the focus voltage below the amount needed for correct focusing.

CRT testers usually do not check the focus action or the focus-anode current, but the chassis can be connected to a test jig where the focusing ability can be checked on the test tube.

Of course, improper voltage from the chassis to the focus electrode can produce poor focus on the CRT screen. Remember that CRTs (excluding the Sony sets with two high voltages) require a focus voltage of approximately 20% of the high voltage. Check both voltages, using the same probe and meter, to determine if the focus voltage is in accordance with the formula.

Focus divider resistors inside some tripler rectifier units can change resistances with age, preventing proper focusing. If the focusing voltage is lower than the value required for good focusing, replace the tripler.

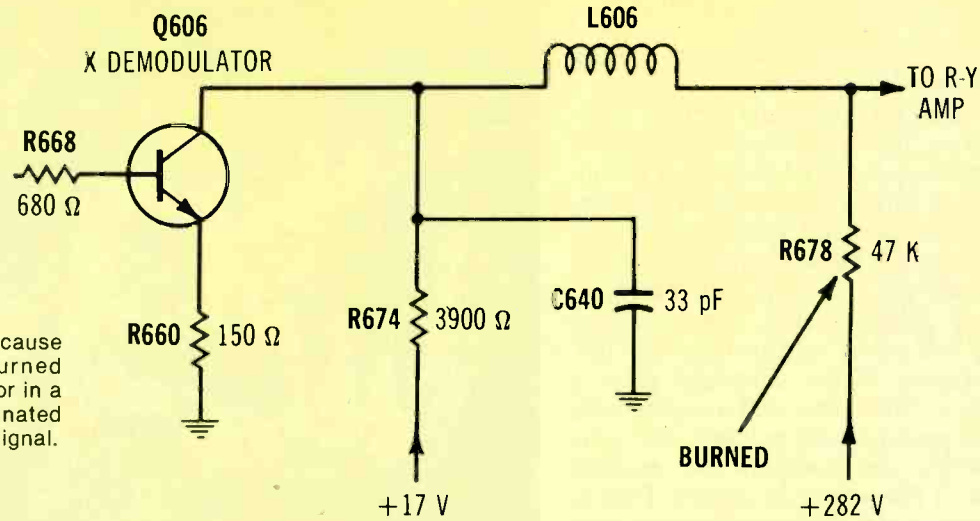



**Figure 12.** Circuit defects can cause weak colors, also. A burned X-demodulator collector resistor in a Sylvania D16 receiver eliminated most of the red (R – Y) chroma signal.

Most adjustable focus controls can be rotated manually to provide any voltage between about 4.5kV and 5.5kV. Therefore, the focus voltage should be monitored with probe and meter while the control is rotated from one end to the other. If the proper voltage range cannot be obtained, first visually check the focusing control and its connecting circuits. Look for cracks or arcing paths. Replace all defective components. Clean the CRT socket contacts to remove any soldering flux or other substances that might leak voltage.

Spark gaps that are a part of the CRT socket are a common source of unwanted leakage. Do not overlook them as potential troublemakers.

### Arcs inside or around the CRT

High-voltage arcs can occur at many locations. Arcs inside the CRT guns only usually indicate excessive high voltage or a gassy picture tube (if the arcs appear to produce a blue haze). Check the high voltage, reduce it to normal by adjustments or component replacement if the high voltage is excessive, and then check for arcs again. Some picture tubes tend to have audible arcs that occur rarely. These arcs are more of a nuisance than a problem and seldom do any damage. Minor impurities may cause such arcs.

Frying sounds from small arcs often originate around the anode button of a color picture tube, especially in humid weather or in humid areas of the country. If they are allowed to continue, these small arcs can become larger and might destroy the rubber anode cover.

To clean around the anode cavity, turn off the receiver, discharge the high voltage at the anode button (do this long and thoroughly; it tends to rebuild a charge), remove the anode plug with its rubber cover, clean the glass thoroughly around the anode button using alcohol, and then replace button and cover. If the arcs continue, try insulating with one of the arc-inhibiting products. In severe cases, nothing stops the CRT arcs but a new picture tube and high-voltage lead.

A rare type of arc is sometimes seen between the outside aquadag coating of the CRT and the metal springs that ground the aquadag. It is difficult to imagine an arc between a ground and the material that is supposed to be grounded. In most cases, these arcs are secondary because they are triggered by other arcs inside the CRT. An appreciable amount of high-voltage power is stored by the glass-dielectric capacitance formed by the aquadag inside and outside the CRT glass. When an arc occurs inside the CRT, the inside aquadag is temporarily grounded (during the arc), and the short-circuit total charge attempts to move from the outer aquadag to ground through the grounding springs. The aquadag has appreciable resistance, and the contact between aquadag and springs is not very good, so the high current builds up a large voltage drop, causing an arc between the aquadag and the grounding springs.

A partial solution for such secondary arcs is to increase the spring tension against the aquadag. However, elimination of the CRT's internal arc provides the only total cure.

### Radiated noise

Small round dots were flashing on the screen of an RCA CTC59XA color receiver. Also, another receiver operating nearby showed weaker identical dots operating in perfect synchronism. The noise dots were coming from the RCA, and could be picked up on other receivers.

This reception (by another television) of noise from arcs can be very helpful, because components can be disconnected (even when this eliminates the visible picture). Then the noise dots, or their absence on the *other* receiver's screen, reveal whether or not the removal of the component stopped the arcs.

When the lead from the flyback to the tripler input was disconnected, all arc dots disappeared from the other TV screen. Although a defective tripler was suspected, the grounds between chassis, tuner and picture tube were checked and retightened. Also, the anode-button area and other CRT connections were cleaned. However, the noise dots were unchanged until the focus control was rotated slightly. During focus-control adjustments, the arcing became worse or disappeared entirely, depending on the position. Obviously, the control was arcing internally. After the control was replaced, all the arcs and the radiated noise were eliminated.

### Comments

These facts about testing methods should enable technicians to determine rapidly whether a color picture tube or the associated circuitry is responsible for the observed symptoms. EST

# Reception problems? Take a look at the coaxial cable

By Carl Bentz

Many of the TV reception problems encountered by servicing technicians can be traced to problems outside the TV set: interference, poor atmospheric conditions, antenna problems and cable problems, to name a few. This article provides an in-depth look at coaxial cable, including its construction and installation, as well as advantages and disadvantages of cable as a transmission medium.

A thorough knowledge of coax cable and the kinds of problems that may arise when a TV receives its signal via cable, can save time and frustration in making a diagnosis.

### Coaxial cable construction

Coax cable is a specialized form of 2-conductor wiring. A look at the end of a piece of coax explains its name (Figure 1). In a concentric structure, a *center conductor* is covered by a layer of insulating spacer material called the *dielectric*. An outer conductor, the shield, surrounds and encloses the center structure. For some applications, a protective plastic jacket covers the shield.

For FM and TV broadcast (VHF and most UHF), a rigid tubular coax carries the transmitted signals from the transmitter to the antenna. Both the center conductor and the shield are generally made of copper or copper alloy. The dielectric often found in such broadcast applications may be dry air, but nitrogen or sulfur hexafluoride gas are preferred. Nonconductive spacers of plastic, ceramic or glass materials are used within the structure to maintain the concentric placement of the center conductor relative to the shield. Sections of the rigid coax bolt together with flange fixtures attached to the ends of each section. Special fittings allow the transmission line to be routed around corners and provide for expansion and contraction. Hanging brackets are needed to hold the coaxial line in place and to support it, often including some form of springing so that vibrations of a tower being shaken in a high wind are not transferred directly to the line, yet the line is held secure.

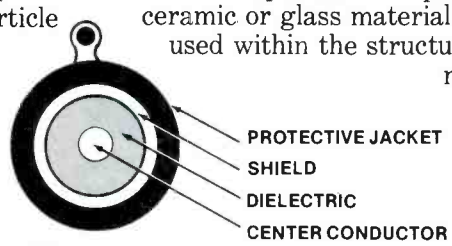



**Figure 1.** The coaxial structure of cable.

A semiflexible coax is common in CATV distribution plants. An aluminum shield, with or without a jacket of a plastic (often PVC or polyethylene), may contain materials to discourage rodents from chewing into the aluminum outer covering. Within certain limits, this type of cable may be bent or formed into curves needed to bypass obstructions or to negotiate changes in direction. More than two or three attempts to reshape the aluminum shield, however, will probably require the cable to be replaced, because the flexing will cause the tubing to fracture. Because the outer conductor can be readily shaped, a more substantial dielectric material than air must be used. Various schemes have been devised to keep the center conductor properly located as the outer tube is formed into curves.

The third kind of coaxial cable is highly flexible. RG59-type cable is often used for equipment rack wiring, video signal carrying within a TV studio and as house-drop or in-house wiring applications for CATV. Because this cable must be very flexible, the dielectric is generally a solid or a foam material that will allow the cable to be bent sharply while maintaining the relative conductor placement. The shield may be of foil or wire braid, or a combination of the two, providing the required flexibility and high shielding effectiveness. For some applications where the cable is likely to span long distances without support, a *messenger wire,* generally of steel, is molded into the outer plastic protective jacket to provide additional strength. The weight of a long span of cable could be sufficient to cause the center conductor or the shield to break without this extra support.

### Characteristic impedance

Two conductors in space with current moving through them create interacting energy fields. The closer the conductors are placed relative to one another, the greater the interaction of the fields. If the two wires form a circuit, we may represent them in terms of a continuing series of inductors (coils) and capacitors. We refer to these components, as shown in Figure 2, as *lumped constants* of inductance (L) and capacitance (C).

If we were to measure the L in henries (actually microhenries, $\mu$H) and the C in farads (or microfar-

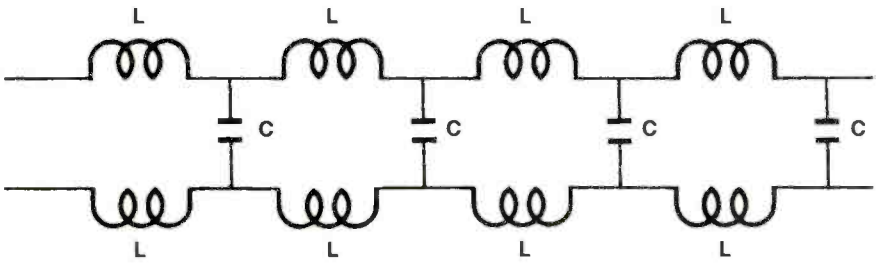



**Figure 2.** Inductance (L) and capacitance (C) of coaxial cable may be shown as *lumped constants*. Cable specifications may list a capacitance/foot (pF/ft), but an inductance value is generally not given.

ads, $\mu$F, are more practical), we could calculate a characteristic impedance $Z_0$ of the cable by use of the formula

$$(1) \quad Z_0 = \sqrt{L/C}\,\Omega.$$

The characteristic impedance of a coaxial cable may also be determined from physical dimensions. In fact, cable is manufactured to exacting specifications, based upon dimensions. If, in Figure 3, *a* is the outside diameter of the inner conductor, and *b* is the inside diameter of the outer conductor, then $Z_0$ is given by the formula

$$(2) \quad Z_0 = 138 \log_{10}(b/a)\Omega$$

where *a* and *b* must be in the same measurement units.

Experiments have shown that the ratio of b/a should be 3.6 in order to achieve the lowest losses in the cable. If $Z_0$ is calculated for the 3.6 figure, the result is 76.77Ω, which is very close to the 75Ω usually discussed in video and CATV use. The characteristic impedance of a cable depends upon its intended application, however. Although cable TV and video studios generally use the 75Ω type, most RF transmitters operate with 50Ω lines. Higher values, to 150Ω, are available for applications that may include data and instrumentation.

It should be noted that these impedance values are not something easily measured with a VOM or other metering equipment generally available around the technician's workshop. A familiarity with different coaxial cables will allow a technician to look at a cable and probably tell the difference. Overall diameter of a cable is not the clue to cable impedance, however, because 75Ω cable may be obtained in RG59 type, 0.24in diameter; RG11 type, 0.405in diameter; and RG187 type, 0.105in. Similarly, 50Ω flexible cable also comes in various sizes. On the other hand, the semiflexible type cable used for CATV distribution, in diameters of 0.45, 0.5, 0.57, 0.66, 0.75 and 1-inch, is strictly 75Ω.

### Coaxial specifics

If a coaxial line is connected to a load, amplifier input circuit or antenna of equal $Z_0$, then the values of L and C should be of no major consequence: The coax line appears to be purely resistive and signal loss may be theoretically related to the resistance of the conductors. The total resistance of a length of conductor may be calculated from this formula:

$$(3) \quad R_0 = P_0 l/s\Omega$$

where $P_0$ is the resistance coefficient of the conductor material (for copper, 1.694$\mu\Omega$/cm; for aluminum, 2.67$\mu\Omega$/cm), *l* is the length of the line in meters and *s* is the cross-sectional area of the conductor in meters$^2$. The value calculated with formula 3 is valid for dc and low-frequency ac power signals, such as 60Hz.

If signal frequencies over 1MHz are used, the signals travel along the surface of the center conductor, the result of the *skin effect*. A new resistance comes into play relating the signal frequency and cable dimensions:

$$(4) \quad R_s = 4.16\times10^{-8}\sqrt{f}\left(\frac{1}{a}+\frac{1}{b}\right).$$

In formula 4, *f* is the signal frequency, and *a* and *b* are the cable dimensions shown in Figure 3. This value has the dimensions of ohms per meter (Ω/m). Because the signal travels only within the "skin" of the cable, it is also helpful to have some idea of exactly how deep the RF signal penetrates the center conductor. Just as other characteristics are material dependent, the depth of penetration of the RF signal in copper differs from that in aluminum. For copper, penetration is calculated with this formula, where *m* is in meters.

$$(5) \quad P_s = 0.0664m/\sqrt{f}$$

While these calculations are in the realm of cable manufacturers' design engineers, they allow us to see why some coax cable uses a center conductor of aluminum with a copper coating. If a center conductor and shield of aluminum will carry the required ac current for powering CATV units along the line, then only a thin layer of copper on the center conductor will be necessary to handle the RF TV signals. A layer four times the depth of penetration exhibited by a 1MHz signal is 0.01 inch. From the penetration formula (5), it can be concluded that for TV channel carrier frequencies, the layer could be even thinner.

One way to reduce the skin-effect resistance is to increase the overall surface area of the conductor. If the center conductor were stranded (i.e., several conductors of a smaller size are grouped to create the original overall gauge, see Figure 4), a greater surface area results. One advantage of a stranded-center conductor is that if one of the seven conductors in Figure 4 broke, six others could still carry most of the signal. The skin effect resistance would be increased because of the break, but there is an increased reliability caused by the redundancy.

### Real cable

So far we have considered the cable to be ideal. The loading $R_L$ has been in terms of perfect terminations ($R_L = Z_0$). The dimensions *a* and *b* have not varied along

**Figure 4.** A solid conductor may be replaced with a stranded conductor of the same gauge size. If the conductor at the left is 22Ga, the stranded one at the right might be listed as 7x30Ga.

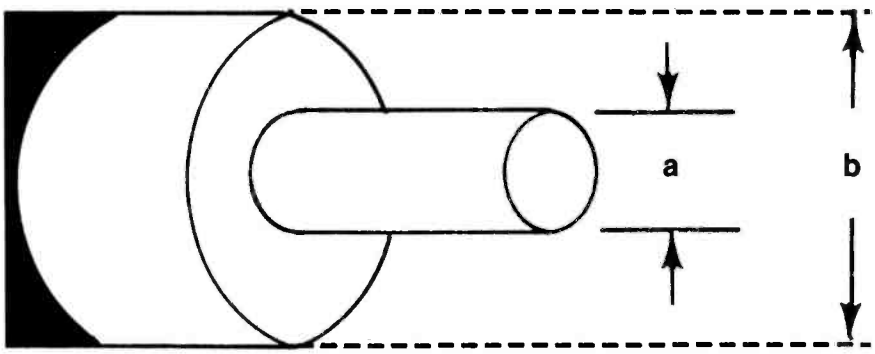



**Figure 3.** The *a* and *b* dimensions determine the characteristic impedance of the cable.

the length of the cable. The center conductor is exactly equidistant from the shield at all points along the cable. All connections are firmly made onto clean, untarnished metallic surfaces. The dimensions within the connectors used for splices and entries into amplifiers and cable devices maintain the $a$ and $b$ values. The world maintains a constant temperature at all times. The dielectric material within the cable is homogeneous (the same density) along the length of the cable. Obviously, no such ideal cable exists.

Perhaps the least controllable factor affecting coaxial cable is the environmental ambient temperature. In many areas of the United States, temperatures may vary from over 100°F to well below zero. Cable dimensions vary with temperature, unfortunately by differing amounts. Every metal, alloy and even foam dielectrics have specific coefficients of expansion and contraction. Changes in cable dimensions are generally related by the formula

$$(6) \quad l = l_0(1 + \alpha_L(T - T_0)).$$

where $l$ is the resulting length from an original length $l_0$, $T - T_0$ is the change in temperature in Kelvin° (Celsius° + 273°) and $\alpha_L$ is a constant for the particular material. For 99.9% copper, the coefficient of thermal expansion $\alpha_L$ is 17.71 x $10^{-6}$/°C. One form of aluminum exhibits a factor of 23.94 x $10^{-6}$/°C. It is obvious from these values that aluminum expands more than copper. It is conceivable, then, that the shield expands more than the center conductor. The $b/a$ ratio increases slightly, so the characteristic impedance must also increase.

For their GID-3 series coax, Scientific Atlanta specifies an attenuation increase ($Z_0$ increase is related) of approximately 2.16%/10C° increase in temperature over 20°C (68°F). As the temperature decreases below 20°C, so does cables loss, by a factor of 1.8%/10C°. On very hot days, CATV signals will decrease because attenuation increases, while on cold days, signal levels will increase (attenuation decreases). Fortunately AGC circuitry in the CATV line amplifiers will compensate the majority of these changes.

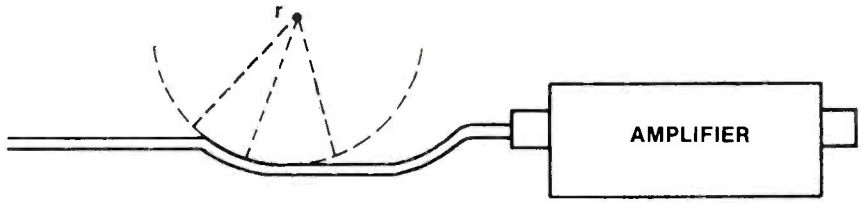



**Figure 5.** The dimension $r$, the radius of the curve in a drip or expansion loop, should be at least 10 to 15 times the radius of the cable. For 1-inch cable, $r$ should be at least 5in, preferable up to 7.5in.

The changes in cable length, however, require some consideration by the installers when the cable is originally installed from pole to pole, particularly. If one were to measure the lowest point above ground in a span of cable on a very cold day, and compare that point above ground on a hot day, the difference would be significant. In fact, if a span crossing a street were strung too slack on a cold day, when the temperature warmed up, the cable might hang too low and interfere with traffic. On the other hand, if a cable were installed with too much tension on a warm day, when the ambient temperature drops, the extra tension created by material contraction could pull the cable shield out of a connector, particulary if it were improperly installed. Even a center conductor could pull out, or, if scored during the installation process, break. Technicians should be aware of the resulting problems and headaches of trying to find why a customer with cable service suddenly began having TV reception problems on a cold day, or why interfering signals are suddenly present in many received CATV channels.

One controllable factor is the manner in which connections are made. If the connection involves a well designed connector, changes in the $a$ and $b$ dimensions will be small. Yet, every time a connector is introduced into the cable, some loss occurs. At amplifiers, the connectors cannot be avoided. Splices between amplifiers or passive devices, however, should be avoided if at all possible. A properly installed splice connector could contribute as much as 0.6dB loss to the signal. A poorly installed splice could develop into total attenuation of the signal.

Dielectric materials used in CATV offer a certain amount of variation to real cable. Ideally the best dielectric would be a vacuum. However, because the center conductor must be maintained concentric to the shield, a variety of schemes have been devised. Each attempts to approximate the next best dielectric that is practical – dry air. The closer the dielectric approximates dry air, the lower the loss. At RF frequencies, there is some small attenuation factor attributable to the dielectric. The more solid the dielectric material, the greater the loss. Regularly spaced discs, spiralling spacers, foams and solids have all been used.

Theoretically, spaced discs, such as are used in General Cable's fused disc cable, or a spiralling spacer, such as the Andrew Corporation's Heliax cable, should provide the best practical dielectric. In both, the percentage of air within the cable is 95% or greater relative to the solid material that creates the spacers. Care in handling during installation and maintenance should be followed with these types of cables, because there is a slightly greater chance for shield deformation between the spacers and the center conductor. Short of actual kinking, however, both types should work well. A poor connection with these cable types could lead to more problems with moisture, however, due to their more open structure.

Another answer to dielectric materials has been foam. During the manufacturing process, gas (air) is mixed with the plastic-type compound that makes up the foam. The smaller (and more numerous) the bubbles of gas, the greater is the percentage of gas, relative to solid in the foam. Small, numerous bubbles also allow a greater homogeniety of the foam. The interlinking network of the solid material surrounding the bubbles provides sufficient support for holding the center conductor to its concentric position, even during reasonable forming.

# What's new in video?

By Conrad Persson, editor


The Sony SL 5200 Beta HI-FI

Video certainly has changed since the early days. Back in the '40s and '50s, the screen was small, the picture was monochrome, you had to darken the room to watch a TV program, and programs were available for only a limited part of the day (remember test patterns?).

Today, you can watch your favorite program in full color on a 40in projection TV screen in a brightly lighted room. If your choice happens to be standard broadcast television, most likely you can find something to watch for at least 18 or so hours a day. If your choice is cable, you'll definitely find something being broadcast at all hours. A VTR or videodisc player, of course, gives you the ultimate in viewing flexibility.

### So what's new?

There's still room for improvement. Today, if you go to a movie, you can experience full-fidelity surround sound, and the finest home audio systems can give you near-perfect sound reproduction. Additionally, as we all know, the video portion of television is inherently far from perfect because of the NTSC conventions used in its design.

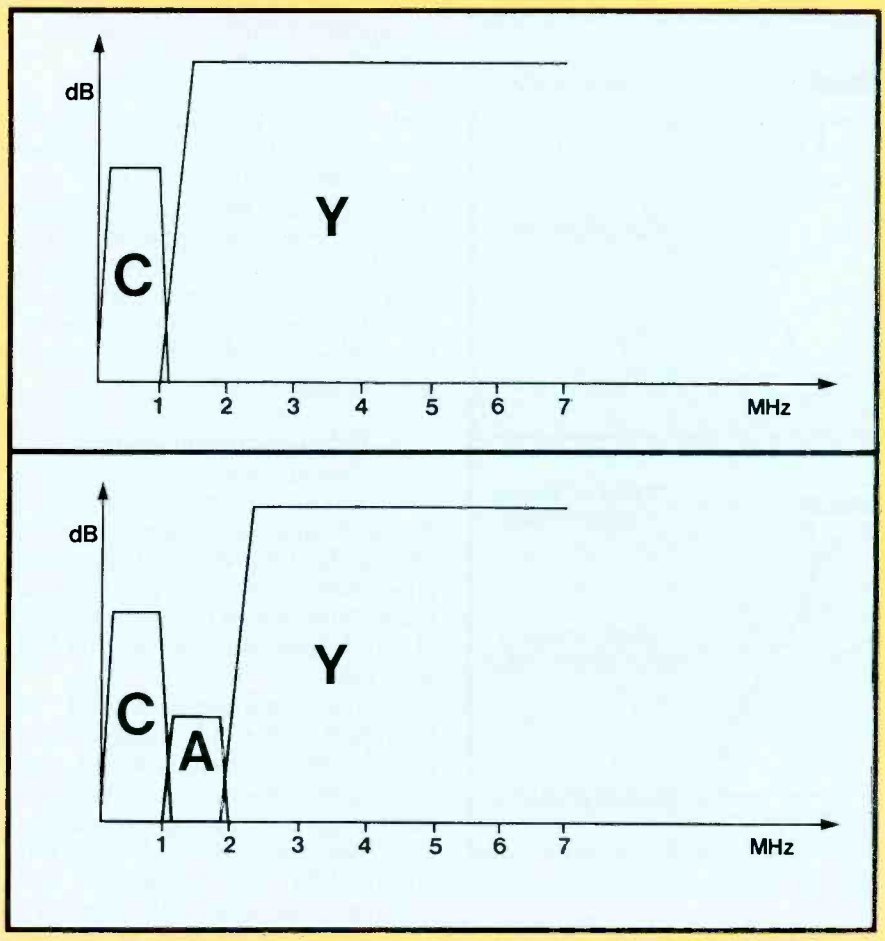
Several exciting developments hold the promise of making TV viewing just about as impressive as going to a wide-screen, surround-sound movie.

### High-fidelity audio VTRs

By introducing a new method of recording sound on videocassette

| | S/N | FREQUENCY RESPONSE | WOW AND FLUTTER | DISTORTION |
|---|---|---|---|---|
| BII | MORE THAN 40dB | 50Hz-11KHz | 0.3% (WRMS) | 3.0% |
| BIII | MORE THAN 40dB | 50Hz-8KHz | 0.4% (WRMS) | 3.5% |
| | DYNAMIC RANGE | FREQUENCY RESPONSE | WOW AND FLUTTER | DISTORTION |
| BII AND BIII | MORE THAN 80dB | 20Hz-20KHz | LESS THAN 0.005% (WRMS) | LESS THAN 0.3% |

A comparison chart of audio specifications shows conventional audio characteristics (top) and Beta Hi-Fi audio characteristics (bottom).




**Graphs of video head** frequency spectrums compare conventional video heads (top) to Beta Hi-Fi (bottom).

tape, Beta-format VCR manufacturers have achieved video sound performance that approaches the sound available from the latest digital audio systems.

Originally designed to record monaural TV programs for playback at a later time, the Beta format has always delivered high-quality pictures along with audio performance on a par with TV sound. However, the rise of prerecorded videocassettes has stimulated consumer demand for playback media that can recreate the entire experience of today's movies: superb pictures and superb stereo sound. In addition, "video music" is attracting young people to the experience of stereo music accompanied by video images. Beta Hi-Fi, scheduled for introduction in mid-1983, responds to these demands with a combination of high-quality picture and high-fidelity sound.

While hi-fi VCRs can be connected to televisions with stereo audio inputs, the full benefit of the system can best be appreciated with the use of a stereo system. Used in this way, hi-fi VCR systems embody the eagerly anticipated integration of audio and video, as well as making a suitable companion for projection and component TV systems.

### The technology

Beta Hi-Fi delivers audio performance superior to LP records, audio cassettes and FM broadcasts. In fact, the sound quality of Beta Hi-Fi approaches that of digital audio.

Previous methods of recording videocassette audio – whether monaural or stereo – have used a fixed audio head recording a *longitudinal* audio track. The slow tape speed and narrow track yield limited sound quality, and quality is further degraded at slower tape speeds.

In contrast, Beta Hi-Fi takes advantage of the high writing speed of the rotating video heads. In the new system, stereo sound is frequency modulated and recorded together with video chrominance and video luminance by the video heads, with an improvement in sound quality.

The best index of the new system's performance is dynamic range (the ratio from the softest to the loudest sounds an audio medium can handle). Dynamic range for the typical home VCR is about 40dB, the incorporation of conventional noise reduction improves this figure to about 46dB, and the finest analog high-fidelity media deliver more than 60dB. Beta Hi-Fi achieves more than 80dB. The system's other audio specifications are comparable:

- Frequency response from 20Hz to 20kHz
- Wow & flutter less than 0.005% (WRMS)
- Harmonic distortion less than 0.3% at 400Hz
- Channel separation more than 60dB

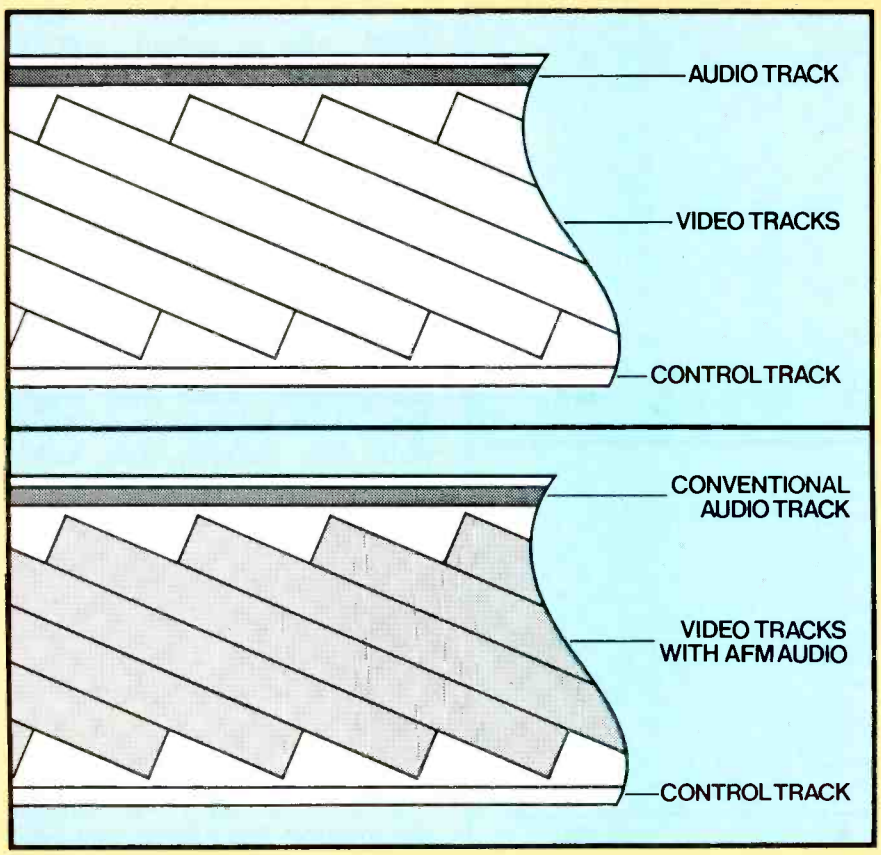
### Total compatibility

With stereo sound recorded by the rotating video heads, the conventional longitudinal audio track is still available for monaural recording by the fixed audio head. The Beta Hi-Fi system retains this head to achieve total compatibility with existing Beta VCRs and tapes. In this way, tapes recorded on the new Beta Hi-Fi machines will play back (with monaural sound) on conventional Beta VCRs. Tapes made on the conventional Beta VCRs will play back in monaural on the new Beta Hi-Fi decks.

### Digital television

Semiconductor circuitry that could result in fundamental changes in TV manufacturing and servicing, as well as in the performance capabilities of TV sets, is currently under development. The Intermetall Semiconductors Division of International Telephone and Telegraph is working on a set of large-scale IC (VLSI) chips that will result in TV sets with a number of advantages over existing televisions.

The following edited remarks by Manny Hunter, general manager of engineering of the Video Products Division of GE were presented at the Consumer Electronics Show in Las Vegas last January. They describe the benefits that GE foresees from the




**The track formats** of conventional (top) and Beta Hi-Fi audio (bottom) are shown.

incorporation of digital techniques into their TV products.

*"Color by the numbers*—GE's digital video processing—means replacing bulky analog components with microelectronic technology, resulting in a new family of high-performance TV products. By replacing the several hundred analog signal components with new silicon digital chips, we can achieve higher quality performance over the life of the television without increasing product cost.

"These new products will inherently have the following consumer benefits:

- built-in digital audio (both stereo and bilingual),
- higher reliability through 2:1 reduction in parts count,
- computer compensation for aging and transmission signal variations over the life of the set
- and, if servicing is required, the computer aided diagnostics make repair rapid and simple.

"Once the television is digitized, additional features can easily be added through software and memory modification. Such examples include:

- improved picture sharpness and resolution through additional digital signal processing,
- picture freeze, including a picture zoom capability,
- a picture within a picture—two pictures viewed simultaneously,
- elimination of ghosts,
- teletext and videotex, which are already digital can be added at lower cost,
- and high-performance digital sound, such as PCM, when direct digital audio is finally broadcast.

"Of course, all of these features can now be achieved with existing TV analog circuits—but not even close to what consumers could afford.

"The benefits of digital television over analog are self evident when you consider that only seven integrated digital circuits are required, as compared to more than 400 parts in the analog television, and the digital circuits not only do the same job but they do the job better."

All of these features are achieved through a TV system in which the signal is demodulated using conventional analog circuitry and then digitized. This digitized signal can then be manipulated to achieve the improvements cited.

Another important benefit is that digital TV eliminates television's currently existing international incompatibility. There are three distinct methods of broadcasting a color TV signal, and a TV set of today is designed to operate with only one of these signals. A digital set will be able to receive any of the three signals with equally acceptable results.

### Video Surround Sound

An exciting new home entertainment product concept—Video Surround Sound, was demonstrated during the 1983 Winter Consumer Electronics Show, by Jensen Home Electronics of Schiller Park, IL, and Tate Audio of Marina Del Rey, CA.

"Video Surround Sound is technology for the home that represents an extension of the total home-entertainment concept offered by the marriage of quality audio plus superb video," said Fred Hackendahl, vice president and general manager of Jensen's Home Electronics Division. "Eventually products will be available to the consumer that will allow him to bring into his home surround sound technology that can produce effects similar to what he experiences in the theatre.

Tate Audio's proprietary technology, the Tate System, was developed under an agreement with CBS as a companion standard to the CBS SQ 4-2-4 channel matrix. SQ is an encoding/decoding process for audio that achieves a 360° soundfield. When the SQ process is coupled to the Tate System of surround-sound decoding, high separation, virtually like a multi-channel discrete tape, is attainable. The Tate encoding/decoding system is completely monophonic and stereophonic compatible, and has the inherent simplicity of only requiring 2-channel software for its delivery. Therefore, encoded material, whether broadcast or recorded, behaves exactly like mono or stereo when heard on home systems. The same encoded signal provides a surround-sound sensation when a Tate System decoder is added in the playback chain of a multi-channel audio system.

# Products

### Magnameter

A compact, multi-purpose magnameter (Cat. no. 20-226) from *GC Electronics,* is designed to help speed servicing of all makes of commercial and residential microwave ovens.

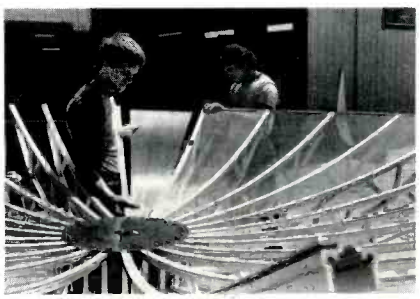
Featuring a taut-band meter, the GC magnameter analyzes magnetron and voltage diode operation, measures secondary transformer voltage and plate current, and signals dangerous voltage levels. To reduce testing time, the meter's circuit includes a rectifier that assures correct readings on either polarity without reversing the leads. A built-in safe-

ty device enables servicemen to "dump" dangerous high voltage from an oven's capacitor before working on the unit's current-carrying components.

Circle (87) on Reply Card

### Satellite antenna

The *KLM Electronics'* new 11-inch parabolic antenna has an all-aluminum modular design that cuts installation time by 60-70%,



according to the manufacturer.

The X-11 delivers 40.5dB gain at 55% efficiency, has a focal length of 61 inches, and an f/D ratio of 0.47. It weighs 125 pounds, yet its windload area of 72 square feet will survive winds up to 100mph.

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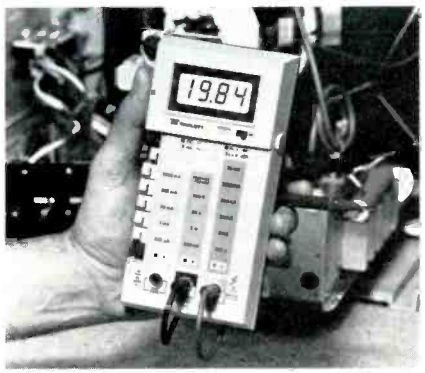
### Hand-held DMM

The new model 3550 32-range, 7-function DMM from *Triplett* is

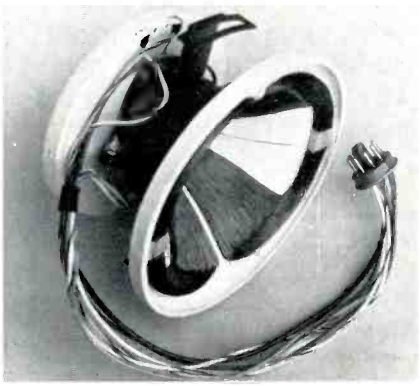



human-engineered with in-line push-button range and with function switches and color coded panels for fast, convenient operations. The 200$\mu$A ac/dc range, hi/lo ohms for in-circuit resistance checks or diode checks on all ranges, and overload protection on all ranges makes it practical for laboratory, design and field-maintenance.

Circle (83) on Reply Card

### Color deflection yoke

The newest deflection yoke from *Thordarson Meissner* is the Y268. This standard color yoke is an ex-



act replacement for Sears' Silvertone model 80-77-4 A to H.

Circle (76) on Reply Card

### Sweep function generator

The new models 502D and 502DA sweep function generators from *Exact Electronics* make


function generators accurate, versatile and easy to use.

The model 502D is a 0.001Hz to 5MHz, 1000:1 LIN/10,000:1 LOG sweep function generator with digital readout of the frequency of the main generator and the ramp (sweep) generator. Model 502D outputs include high and low main outputs, ramp (sweep) output, TTL sync output, voltage proportional to frequency output and ramp sync output.

Circle (92) on Reply Card

### PCB repair system

The *Pace* PEP-220 gold-plating system is a portable system for quick and safe replating of edge

connectors or any gold-plated surface.

The Pace Gold Plating System includes everything needed for plating: non-contaminating electrode assemblies, gold-plating solution, electro-clean solution, nickel-plating solution, conductive and platers tape, power cord, case, stand and tray.

Circle (84) on Reply Card

### Volt-ohm meter

The new model 50, 12-range VOM, just introduced by *Triplett Corporation,* features single-range switch simplicity for convenient industrial maintenance, vocational tech school, commercial electronic/electrical measurement use and automotive circuits maintenance. Overload-protected with a special 3/8A, 250V and 3A, 600V fuse arrangement, the hand-held tester also features snap-off

battery compartment access and built-in tester stand.

Circle (93) on Reply Card

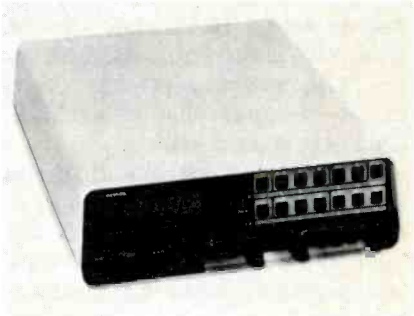
## Marketplace

Use ES&T classified ads



### 4½-digit DMM

*Weston Instruments* has announced the new distributor-stocked model 7145 DMM. With five functions, 26 ranges and 4½-digit resolution, the 7145 offers the measurement flexibility combined with laboratory-grade performance that is designed for demanding field-service applica-



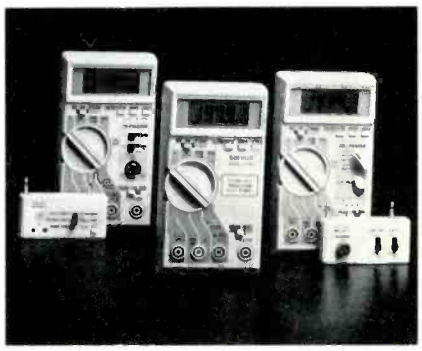
tions, as well as for production, testing and design laboratory use.

Circle (81) on Reply Card

### Hand-held DMMs

*Soltec* is introducing the LD series of hand-held DMMs, which includes three new auto-ranging 3½-digit meters.

The auto-ranging multimeter series consists of the LD-510, LD-520H and LD-530F, and features large LCD display (14mm



high) and reliable LSI circuitry. The LD-510 also has a range-holding switch for quick and repetitive measurements as well as a tone for over-range indication and rapid continuity checks.

Circle (85) on Reply Card

### 2-way FM radios

A new line of frequency-synthesized, 2-way FM radios priced for the general industrial user has been introduced by *Midland LMR,* a division of Midland International Corporation. These new frequency-synthesized radios use a tiny microcomputer instead

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of crystals to control channel frequencies and most of the radio's other functions.

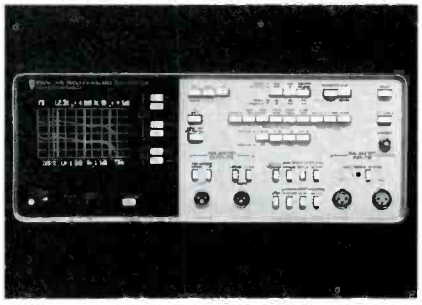
Called Midland Syn-Tech, the units are available in 60 models, all of which can be programmed to transmit and receive from one to 36 channels.

Circle (86) on Reply Card

### Tape recorder/audio test system

With the introduction of the *Sound Technology* 1510A tape recorder/audio test instrument, the audio engineer has the capability of performing all of the necessary tests for maintenance, troubleshooting and general check-out of any professional audio device, whether it is a tape recorder, film machine, mixing board, reference turntable, parametic equalizer or any other outboard device.

The 1510A will measure and display: ac volts, azimuth/phase error, second or third harmonic distortion, frequency response,



channel separation, noise, wow and flutter, speed, drift, maximum operating level and dropouts.

Circle (121) on Reply Card

### Satellite TV receiver

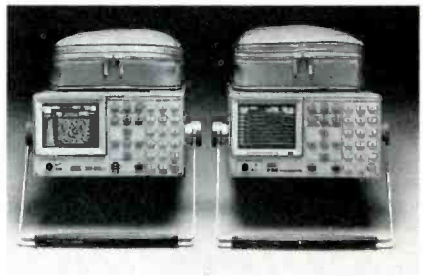
The *Winegard* SC-7032 receiver with a consumer-designed housing, has a full range of features to fill the requirements of the home satellite TV reception system. Included are channel scan, polarity reversal button, signal strength meter, audio tune, channel select with LED readout, built-in satellite selector control with LED

read-out for optional actuator and built-in polarotor that automatically changes polarization. In addition, an optional channel-select remote control with fine-tune button and up/down transponder switch is available.

Circle (122) on Reply Card

### Logic analyzer family

The Design Automation Division of *Tektronix* has announced the



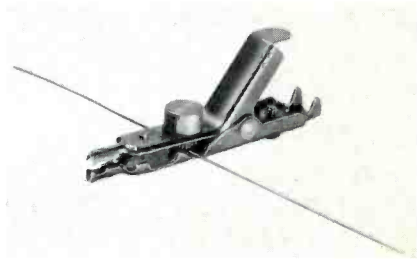
addition of the Sony/Tektronix 318/338 logic analyzers to its 300 series of "ultra-portable" logic analyzers. Both analyzers offer state and timing with serial state and character analysis as an option.

The 318 provides 16 parallel channels of data acquisition at up to 50MHz, and the 338 delivers 32 channels at up to 20MHz.

Circle (123) on Reply Card

### Test clip

This test clip, from *J.S. Popper,* has a bed of hardened needles for penetrating the insulation in 20-22 gauge conductors, without a need to go to the terminals. A notch in

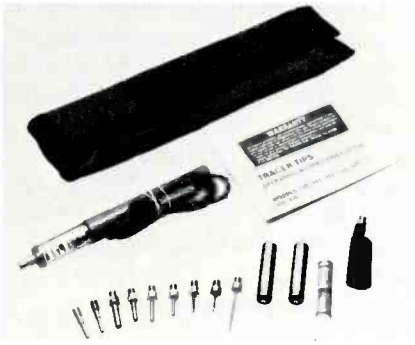


the nose grips screw heads without wiggling off, and opposed "U" jaws securely grip various shape terminals. The single penetrator reaches the conductor on stranded wire.

Circle (124) on Reply Card

### Probe kit

The model 121 Master Test Kit from *Desco Industries* has a set of



probes for almost any test need. It includes a Desco Circuitracer, which will check continuity or voltages of live or dead circuits from 0-600V, and comes with high-voltage and low-voltage test lamps, batteries and a set of probes that includes standard aircraft connector pins and sockets in 12, 16 and 20 gauge.

Circle (129) on Reply Card

### Automatic transistor checker

*Leader Instruments* has introduced a new automatic transistor checker, the LTC-906A, which has identical performance features to the Leader portable LTC-906 model, in a larger bench-top design. Because of its size, front-panel controls are less crowded and easier to operate.

In the automatic mode, activating a single switch initiates a programmed test that automatically identifies emitter, base and collector, and type-of-device (NPN, PNP, FET, diode or other) with audible and visual good-or-bad indication, for both in-circuit and out-of-circuit testing. In the dc parameter mode, out-of-circuit measurement can be made of leakage current, hfe, Vbe and Vd.

Circle (131) on Reply Card

### Thermistor and RTD thermometers

*Keithley Instruments* has introduced four new digital thermometers that offer increased accuracy over thermocouple meters and have 0.1° sensitivity.


Models 865(°F) and 866 (°C) are thermistor thermometers, and have high accuracy over the environmental temperature range. Models 868(°F) and 869(°C), with platinum RTD (Resistance Temperature Detector) sensors, offer high accuracy, equivalent to thermistors, over a wider range and with greater stability over time.

Circle (132) on Reply Card

# Literature

**Leader Instruments** has produced a new color brochure describing Leader's full line of video test instruments. Leader's half-rack mounted vectorscope and waveform monitor, with Leader's full-rack sync/test generator, are illustrated with the controls captioned so that every function can be clearly understood.

Circle (110) on Reply Card

The full line of **Ungar** soldering and desoldering equipment for production, service, hobby and do-it-yourself use is described in a new catalog. The 24-page catalog includes specifications for soldering systems, irons, heaters, tips, desoldering systems, heat guns, kits and soldering and desoldering aids. The newest temperature-controlled systems and "Thermo-Duric" heaters are included for the first time.

Circle (111) on Reply Card

A new 40-page catalog from **Electronic Specialists** presents their line of computer interference control products. Protective devices for smooth software operation include equipment isolators, ac power-line filter/suppressors, line voltage regulators and ac power interrupters.

Descriptive sections are included, outlining particular computer problems and suggested solutions, and typical applications and uses are highlighted.

Circle (100) on Reply Card

Catalog 83-36R from **OK Industries** features 118 pages of tools and equipment for electronics and telecommunications manufacturing, field service and labs, and schools and hobbyists. The full-color catalog is divided into nine sections, covering a complete line of wire-wrapping tools, testing and troubleshooting tools, wire and cable, assembly products and aids of various types, and N/C wire wrapping machines and support systems. The catalog also

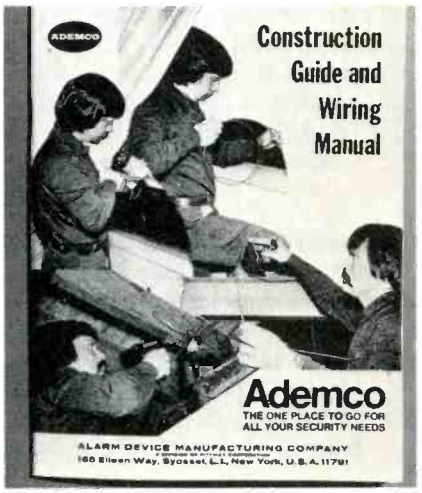

features a unique product line of low-cost tools and products especially for educational and home use.

Circle (101) on Reply Card

A new 24-page publication cross-references **RCA** SK-series replacement semiconductors with generic components and manufacturer's stock numbers in video arcade games. The manufacturers include Atari, Bally, Cinematronics, Exidy, Gottlieb, Gremlin, Midway, Stern and Williams. Types are listed in both generic component sequence and in manufacturers sequence.

Circle (103) on Reply Card

*Construction and Wiring Guide Manual*, a how-to reference manual, is available from **Ademco.** The guide contains 60 pages of in-




formation showing basic residential building construction, wiring techniques, conduit bending procedures, soldering and wiring splicing. Photographs and drawings are used to depict step-by-step snaking methods and short cuts used in most alarm installations.

Circle (102) on Reply Card

The Engineering Department of the **Electronic Industries Association** has announced the availability of RS-324-A, "Registered Screen Dimensions for Color Picture Tubes." The EIA-recommended standard RS-324 "Registered Screen Dimensions for Color Shadow Mask Picture Tubes" was revised (now RS-324-A) to simplify the standard and make it more useful to the user. Obsolete examples were eliminated and replaced by current panel size, 25V.

Copies of RS-324-A are available for $4 each.

Circle (108) on Reply Card

# 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

**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

**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

**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

**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

**"SELL:** Vintage radios, tubes, and parts – S.A.S.E. Tom Wright, 4933 Yakima, Pocatello, Idaho 83204" 5-83-2t

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

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

**SATELLITE TELEVISION SYSTEMS.** Starting at $1,750. 100°K LNA's $389. FREE Wholesale Catalog. Call or write. 313-361-5146. SIGNALS Box 8836, Detroit, MI 48224. 4-83-3t

**COMPLETE JERROLD WIRELESS REMOTE/DE-SCRAMBLER** – 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

**SAMS FOTOFACTS to 1650** – AR – TSM – Manuals, B&K color dot generator – $89.00 – Precision oscilloscope $69.00. Maurer TV, 29 South 4th St., Lebanon, PA 17042; 717-272-2481. 6-83-1t

**NEW PHILCO** color TV modules, $9.95 plus $1.50 postage, 3 or more $7.95 each. Maurer TV, 29 South 4th St., Lebanon, PA 17042; 717-272-2481. 6-83-1t

**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

## FOR SALE (CONT.)

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

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

**SENCORE VA48 ANALYZER,** BK1472B scope, BK1077 analyzer, all with accessories and manuals and in fine condition except BK1077 needs calibration. $1350.00 the lot shipped UPS. Joseph Bednarz, Box 760, Ojai, CA 93023. 6-83-1t

## 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

**ELECTRONIC RAPAIR SERVICE** Radio, TV, VCR, 5 Technicians. Prime Utah County location near shopping mall. Gross $300,000 & up. Call Century 21 Harman Realty 801-224-2010 Dave 801-225-7539. 6-83-1t

**TELEVISION REPAIR SHOP** in beautiful suburban Los Angeles. Established 14 years. $75,000 total, $30,000 down. Nets $33,000. Pat. broker, 805-495-8118. 6-83-1t

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

**RAMPART SECURITY SYSTEMS DEALERS'** sales are booming. The Rampart Franchise Program offers ENORMOUS PROFIT POTENTIAL PLUS EXCITING RESIDUAL INCOME. Our success and reputation are a result of a total business format approach for the EXPLODING alarm market. Product, marketing and management training with complete backup has made success a reality for over 70 dealers. No experience necessary just a strong desire to succeed. Investment only $15,000 backed by inventory. Call Bob Pollack (800) 523-8002 or write RAMPART INDUSTRIES, INC., 1 Oxford Valley, Suite 317, Langhorne, PA 19047. 4-83-3t

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**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

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# Advertisers' Index

New from Zenith!

# Two-way protection from high voltage surges for the appliances and electronics you sell or service!

A brief, high voltage surge – or spike – can occur in any electrical system and, at amplitudes lower than 600V, cause little or no damage.

But at greater amplitudes, a spike can do real damage. And the greater the high voltage surge – resulting from nearby lightning, for example – the greater the risk of harm, especially to solid-state devices.

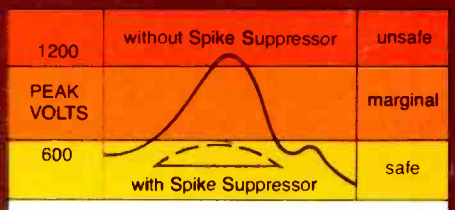
That's why Zenith now introduces the Spike Suppressor: to protect the susceptible TV receivers and household appliances you sell or service from damaging high voltage surges!

And the Zenith Spike Suppressor protects not one, but two ways.

First, the new Zenith Spike Suppressor absorbs most line voltage spikes so only a safe voltage level reaches the protected equipment.

Second, heavy or prolonged voltage surges cause the Zenith Spike Suppressor to cut off power completely for added protection and to signal the need for a replacement.

That's double-duty protection against spikes and reason enough for you to stock and sell the Zenith Spike Suppressor. Your bottom line's another. So call your Zenith distributor now!




In this graph, the solid curve represents the excess voltage or "spike" imposed on an electric system and, represented by the dotted line, the protection provided household appliances as the Zenith Spike Suppressor absorbs the excess voltage and prevents it from surging thru the system.

ZENITH®

*The quality goes in before the name goes on.®*

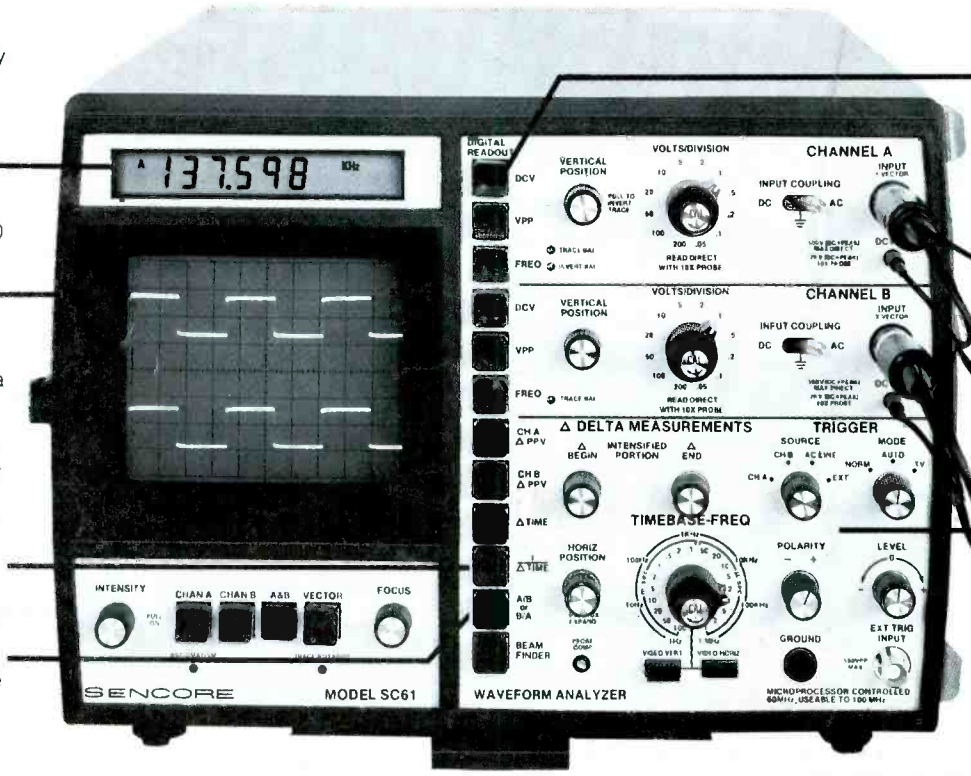
# Double Your Troubleshooting and Testing Productivity . . . Or Your Money Back!

**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.

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