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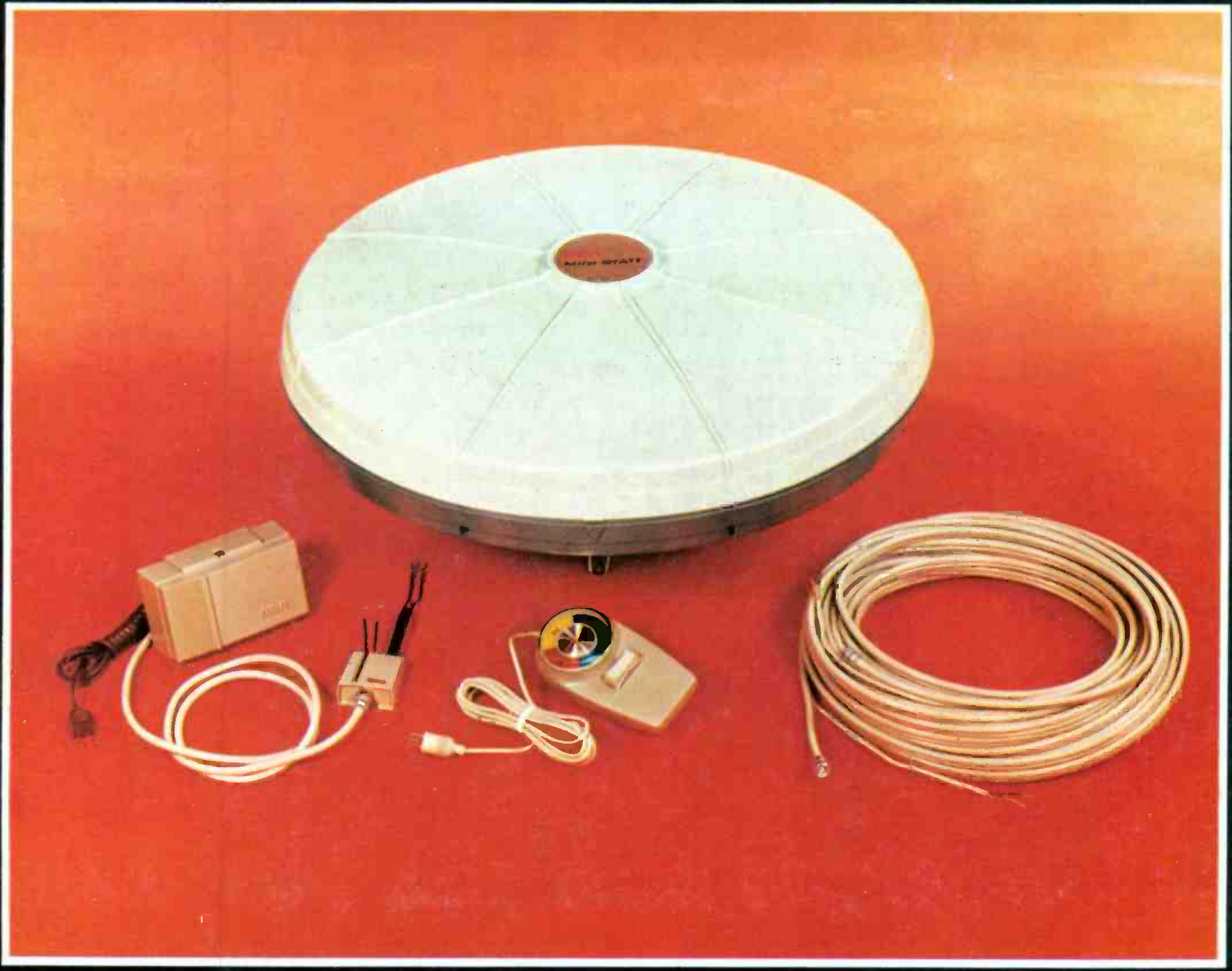
July, 1980 □ $2.25

Electronic Servicing®



Antenna roundup issue

Installing TV antennas

Testing diodes

Biomedical maintenance: Repairing electrocardiographs

Electronic Servicing

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Electronic Servicing

Industrial Maintenance

- MRO shops—maintenance and test equipment
- Semiconductor source guide

Consumer Servicing

- 1981 TV receiver features
- RCA CTC99 vertical sweep

For industrial maintenance and consumer servicing professionals

Electronic Servicing®

August, 1980 □
Volume 30, No. 8

Consumer Servicing

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Photograph courtesy of RCA.

electronicscanner

news of the industry

55,350 attend 1980 International Summer CES

At the close of the 14th annual International Summer Consumer Electronics Show, Jack Wayman, senior vice president of the Electronic Industries Association's Consumer Electronics Group, sponsor and producer of the Show, announced an attendance of 55,350.

While attendance was off from last year, the Summer CES attracted a record 946 exhibitors, using 25% more space than ever before; 550,000 net square feet at McCormick Place, McCormick Inn and the Pick Congress Hotel.

"It was the consensus that some smaller dealers cancelled plans to attend the Show at the last minute, while some of the many large retail organizations seen at the Show had pared down the number of staff attending," Wayman said. "But the major buyers were here and spent more time on the Show floor to get acquainted with the wide array of new merchandise."

"Record-breaking attendance at the Video Conference, and excellent attendance at the other three morning conferences, along with strong interest on the part of the retailers in the afternoon retail workshops were additional signs of the success of the Show in fulfilling the industry's needs for a bi-annual total marketing forum."

William T. Glasgow, vice president of CES, said that exhibitors in general were pleased with the impact of the Show and the activity it generated. He listed dates of the 1981 International Winter CES as Thursday, January 8, through Sunday, January 11, in Las Vegas. The 1981 Summer CES will be held in Chicago, Sunday, May 31 through Wednesday, June 3.

Magnavox relocates

Magnavox Consumer Electronics has moved. The new address is: Interstate and Straw Plains Pike, P.O. Box 6950, Knoxville, TN 37914. Telephone: (615) 521-4311.

GE promotion offers "Tradin' Time Dollars"

General Electric's Tube Products department has announced its new "Tradin' Time" promotion. The program is based on saving GE tube/ProLine semi/tripler flaps and bags. Each tube or semi flap or bag is worth 10 cents, and each tripler flap is worth 50 cents in **"Tradin' Time Dollars."** Flaps and bags are to be sent to GE Tradin' Time Program Headquarters, 5999 Butterfield Rd., Hillside, IL 60162. GE distributors have a supply of pre-addressed labels available for convenient mailing. Dealers receive redeemable "Tradin' Time Dollars" to exchange for premiums and/or a combination of cash toward merchandise at participating GE distributors. In the event that the local GE distributor is not a "Tradin' Time" participant, dealers may redeem their "Tradin' Time Dollars" for S & H Green Stamps. The program is scheduled to run until November 30, 1980.

TRW purchases electron products

TRW Incorporated has purchased the equipment, inventories and certain other assets of Electron Products, a small manufacturer of wound film and paper capacitors based in Monrovia, CA. Under the name TRW Electron Products, it will continue to manufacture the same products as before. It will report to Universal Capacitors, part of the TRW Capacitors Division. The purchase was made from W. K. Industries, a private concern in Laguna Hills, CA., for an undisclosed amount of cash. Manufacturing, testing and engineering will continue at the Monrovia plant. Administration, finance, research and development, and sales will be handled by Universal out of Ogallala, NE.

Microprocessor troubleshooting course schedule announced

Integrated Computer Systems, is offering a course that provides extensive hands-on training in the troubleshooting of microprocessor-based systems. Participants will use a variety of troubleshooting equipment in the class to test and debug hardware and software. Topics covered include: bus, processor, and I/O fundamentals; writing diagnostic software; using logic analyzers; in-circuit emulator techniques; signature analysis techniques and designing for testability.

The course schedule for September, October and November 1980 is: Anaheim, CA, Sept. 23-26; Washington, DC, Sept. 30-Oct. 3; Boston, MA, Oct. 14-17; Houston, TX, Oct. 28-31; and Saddle Brook, NJ, Nov. 18-21.

For more information call: Integrated Computer Systems toll-free outside California: (800) 421-8166 or write Integrated Computer Systems, 3304 Pico Blvd., P.O. Box 5339, Santa Monica, CA 90405.

National Sound and Communications Conference deemed a success; plans underway for 1981

Plans for the second National Sound and Communications Conference, to be held May 5-7, 1981 in Atlanta, are underway, according to William G. Little, Quam-Nichols, and vice president of the sound marketing division for the Electronic Industry Show Corporation.

A committee of sound contractors and sound products manufacturers met in May in Chicago with the management of the Electronic Distribution Show, to discuss the 1981 conference, which again will be held in conjunction with EDS. The planning committee chaired by Ed Miller, Dallas, TX sales representative and vice president of the professional products division of ERA, validated the need in the marketplace for a multi-faceted educational program for sound contractors. This would include sessions on management and finance, markets and market opportunities, installation and technical information, as well as specific product information.

Little said the 1980 logic, logistics, and results all validated the need for the conference and its compatibility with the EDS. The Electronic Representatives Association, professional products division was a co-sponsor of the 1980 Conference, along with the Electronic Industry Show Corporation and Sound Publishing Company.

For information on the 1981 Sound and Communications Conference, which is scheduled for May 5-7, at the Atlanta Hilton Hotel, Atlanta, GA, contact: Electronic Industry Show Corporation, 222 South Riverside Plaza, Chicago, IL 60606. Telephone: (312) 648-1140.

TRW establishes franchise agreement with Arrow Electronics

A national franchise agreement between Arrow Electronics and the TRW Electronics component group was announced by Dom Delorenzis, manager, distributor sales of TRW/ECG.

According to Delorenzis, all 30 Arrow locations will become authorized distributors for TRW Cinch Connectors, TRW IRC Resistors, TRW UTC Transformers, TRW Globe Motors and TRW LSI Products. In addition, a majority of the Arrow operations have been authorized for TRW Optron, TRW Semiconductors and TRW Capacitors.

"Except for TRW's LSI products, inventories are already in place at most Arrow branches and stocks are being built up at the newly franchised locations as quickly as possible. The LSI inventories will not be available until September. LSI circuits are highly technical products and we are conducting extensive training programs of Arrow personnel, to be completed in August, to be certain that our customers can be properly served," Mr. Delorenzis said.

Vance JuDay, executive vice president, director of marketing, Arrow Electronics, said he was pleased with the agreement, and said that it represented "an important step forward for Arrow."

Hitachi announces expansion

Hitachi has opened new offices in Lanham, MD, and Cincinnati, OH. Bill Weston, regional sales manager, and Ken Teroshima, chief engineer, will be working out of the Lanham office. Jerry Brinnacombe, regional sales manager, and Mr. Sakurai, chief engineer, will be working out of the Cincinnati office.

With the addition of these offices, Hitachi now has nine region centers, all with 24-hour parts and field service.

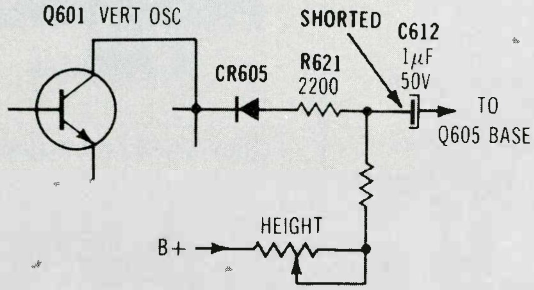
Electronic business communications show postponed

New Concepts— Electronic Business Communications Conference and Exhibition originally scheduled for September 3-5, 1980, at the Las Vegas Convention Center has been postponed for one year. The new dates will be September 9-11, 1981, at the same location. □

symcure

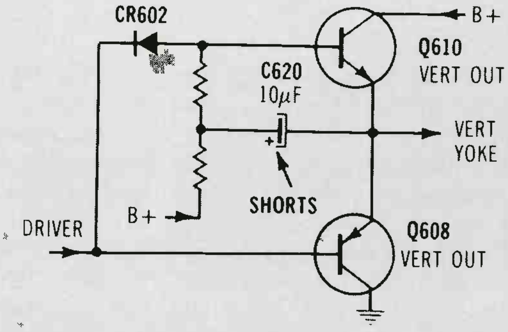
Symptoms and cures compiled from field reports of recurring troubles

Chassis—Zenith 12FB12
PHOTOFACT—1490-2



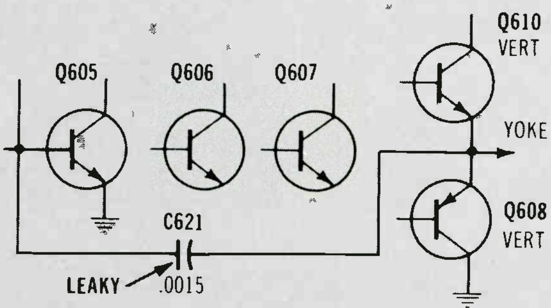
Symptom—Width narrows intermittently with center foldover
Cure—Check B+ resistor RX516 for an open when warm

Chassis—Zenith 19GB1
PHOTOFACT—1543-3



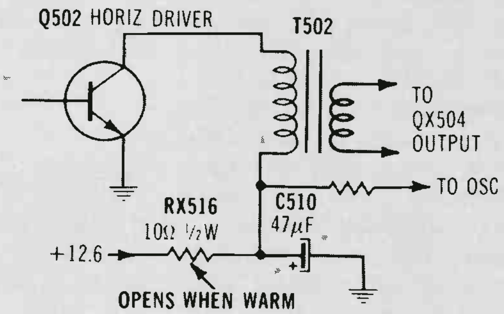
Symptom—Intermittent loss of height
Cure—Check for intermittent short in C620

Chassis—Zenith 19GB1
PHOTOFACT—1543.3



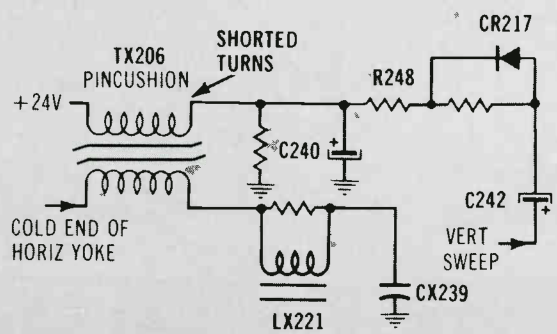
Symptom—Vertical foldover with retrace lines
Cure—Check for leakage in capacitor C621

Chassis—Zenith 19GB1
PHOTOFACT—1543-3



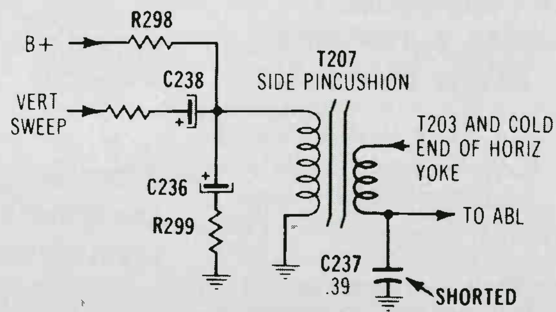
Symptom—Bottom foldover with erratic rolling
Cure—Check for a short in capacitor C612

Chassis—Zenith 13HC10
PHOTOFACT—1634-2



Symptom—Pincushioned picture (right and left edges bowed)
Cure—Replace transformer TX206 as a test for shorted turns

Chassis—Zenith 25EC58
PHOTOFACT—1370-2



Symptom—No picture, no sound, and breaker is tripped. Reset breaker gives loud hum for 5-seconds before trips again.
Cure—Check for shorted yoke-coupling capacitor C237

people in the news

John G. Myers has been named program manager, pressure sensor products, for Micro Switch. Myers was director of the Office of Technology Assessment at the Honeywell Corporate Technology Center in Minneapolis, MN.

Joe Grandolfo has been appointed assistant controller of Quasar. Grandolfo also retains his previous title and responsibilities as manager of accounting and budgets.

Steven T. Klein has been promoted to regional sales manager, Central region, for Klein Tools. Klein was formerly marketing research manager.

Also at Klein Tools, **James A. Mallek** has been named marketing services manager. He was formerly customer service manager.

Robert N. Noyce, vice chairman of Intel Corporation, has been elected to membership in the National Academy of Sciences. Noyce, a semiconductor physicist and businessman, is co-inventor of the integrated circuit and a pioneer of the Bay Area's semiconductor industry, which is based largely on integrated circuit technology.

Noyce is one of 59 scientists and engineers elected to the Academy at its 117th annual meeting. Of these, three others are from industry: **Richard G. Brewer**, IBM Fello, IBM Research Laboratory, San Jose; **William L. Brown**, president, Pioneer Hi-Bred International, Des Moines, IA; and **Theodore H. Maiman**, inventor of the laser, vice president, TRW Electronics, Los Angeles, CA.

Fred E. Scott, Jr. has joined Hitachi as director of VTR engineering. Before joining Hitachi, Scott was senior engineer, 1-inch VTR for Sony Broadcast.

Dennis W. Carroll has been appointed national sales manager of A. W. Sperry Instruments. Formerly, he was assistant sales manager.

Altec Lansing has announced the appointment of three district managers to its professional products division: **Gabriella Engebretson**, Southwest region; **Bill Sparling**, Northwest region; and **Jack Arndt**, Southeast region.

James O. Lawson has been appointed engineering manager for the Sylvania connector products operation. He succeeds **W. L. Griffin**, who has resigned.

Milton A. "Mac" Clement, of Stromberg-Carlson, has been named chairman of EIA's TR 41.1 PABX Engineering Standards Committee. He replaces **O. J. Gusella** of GTE Service Corporation, who continues as chairman of the parent TR-41 Voice Telephone Terminals Committee.

Shure Brothers has appointed **Robert L. Layton** international sales manager.

Patrick R. Wilson has been named to the new position of director of public affairs, GTE entertainment products group. Wilson was manager of public affairs. □

Consumer Servicing

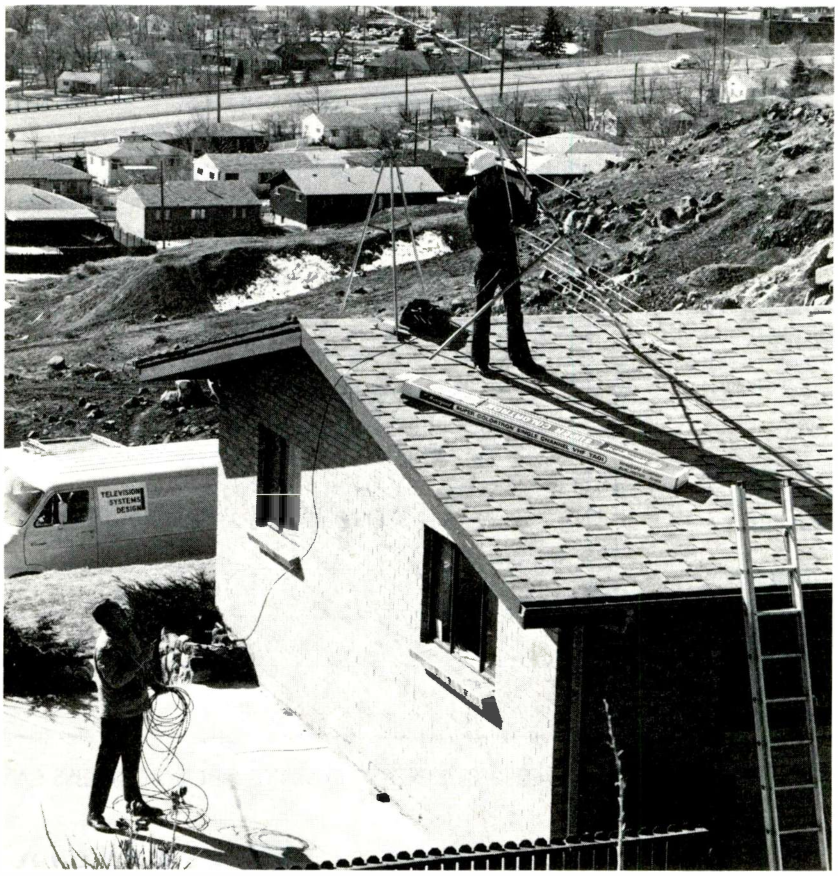
Tips for installing TV antennas

By James E. Kluge
Technical Editor
Winegard Company

Antenna installations are seldom identical. Therefore, it is not possible to list and describe all steps. These tips show things to do and not to do during installations. Better TV reception, longer antenna lifespan and satisfied customers are some of the benefits.

Many present-day installations of outside antennas are replacements for previous systems. Each customer will make comparisons between the performance and lifespan of the old system versus the new one. This adds a strong additional reason to the installer's normal desire to do the best possible job. The new antenna *must* improve the picture.

Before installing a new antenna, a technician should observe the quality of picture on all channels of the television. A new antenna cannot correct erratic reception from corroded contacts in the TV tuner. Also, a television in perfect operating condition cannot provide a good picture from a defective or inferior antenna system. The customer must understand this before work is begun.



A typical home-antenna installation uses a tripod roof mount with 75 Ω coaxial cable downlead.

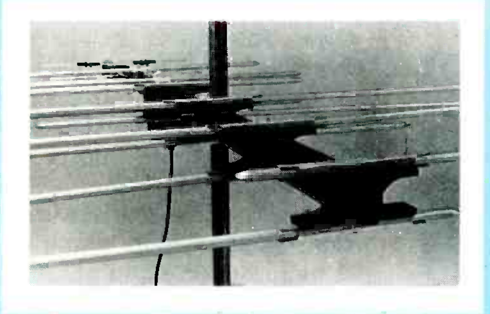
Perhaps the customer remarks that the old antenna lasted only three years. The technician should explain that the nature of outdoor antennas prevents infinite lifespans of both antenna and downlead, and that better protective coatings on metal antenna elements and the use of coaxial cable for downlead can extend the years of acceptable operation. Some types of twin-lead, for example, should be replaced about every two years. Most customers can understand such logic, and they will appreciate the advice later.

Choosing an antenna

One specification of outside antennas describes the TV channels covered. Models are available for high and low VHF channels only, for UHF channels alone, VHF plus UHF, or any combination of these with or without the FM-radio band. The UHF/VHF combination is the most popular.

To correctly answer the question of how much gain an antenna should have, the technician must consider how local conditions may affect TV reception.

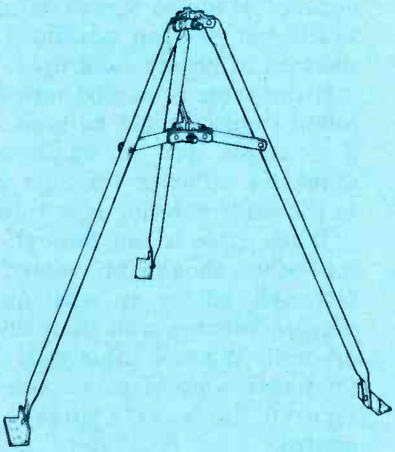
At the TV receiver, snow-free reception requires 1000μV or more at the tuner terminals. Therefore, the antenna must have an output on all active channels of 1000μV *plus an additional amount equal to all losses that occur between antenna and TV.* A preamplifier can be added at the antenna to increase the signal level, but the best a

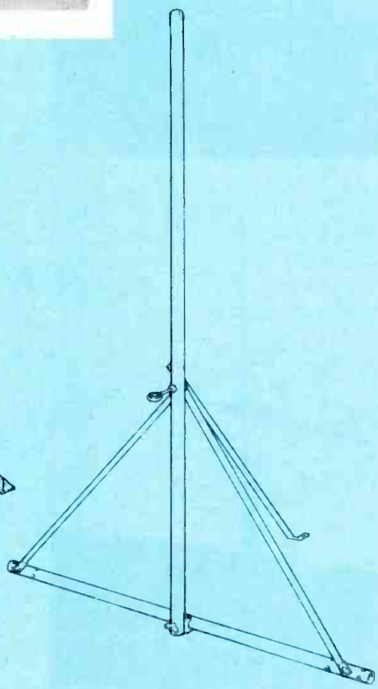


Girder-type construction illustrates the strength and durability of new antennas.

• Rugged construction should include 7/16-inch diameter elements of 0.025-inch-thick aluminum.
• Support insulators should be made of high-impact molded plastic in a girder-type design.
• The elements during unpacking should unfold and be locked into position for strong support and permanent alignment.
• A double boom should be used with longer antennas to provide extra strength and rigidity.
• A weatherproof housing for the preamplifier or balun coils should mount on the boom and provide protection from inclement weather. The same housing should enclose and protect the downlead connections. The preamplifier noise figure is preserved by the elimination of a matching transformer.
• Unwanted rotation of the antenna should be prevented by a 2-part electroplated mast clamp that has 1/4-inch U-bolts.

A thorough study of antenna specifications will save time that otherwise would be required for experimentation. Obtain and analyze these specifications according to the local channels and conditions.





Tripods are very popular for rooftop mounting of antenna masts. Another tripod that includes the mast is designed for installation at the side of a roof peak.

preamplifier can do is retain the antenna's signal-to-noise ratio. It cannot improve it.

Only a higher-gain antenna can increase the signal without also increasing the snow or introducing other drawbacks (such as preamplifier overload on strong signals). When the signal levels and the system losses are known, there are precise methods of calculating the antenna gain needed. But with a simple system for a single TV, select an antenna that appears to have excessive gain for the application. The model rated for the highest gain could be used for all installations, but it might be too large for some, and waste the extra gain in others.

Another factor that is important during antenna selection is the directional amplitude-response pattern, sometimes called polar plot. This includes the shape and width of the forward beam, any rear or side lobes, and the front-to-back ratio. Gain in the forward beam determines the signal level of the desired station. Rear lobes, side lobes and a poor front-to-back ratio can add ghosts to the picture.

Generally, larger antennas have better suppression of ghosts. This alone sometimes is a valid reason for using an antenna of more gain than required. The level can be reduced by a loss pad or traps if it is excessive.

For more information about the electrical characteristics of antennas, refer to *Selecting TV antennas* in the April 1980 issue of **Electronic Servicing.**

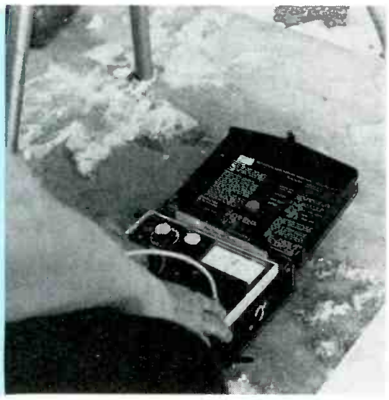
Mechanical features

The following physical features are important for adequate strength and long life of outside antennas:
• Anodized aluminum finish provides the only permanent protection of the metal elements. This can be recognized by the uniform and vivid silver, gold or blue color of the metal (not just a coating or a paint).

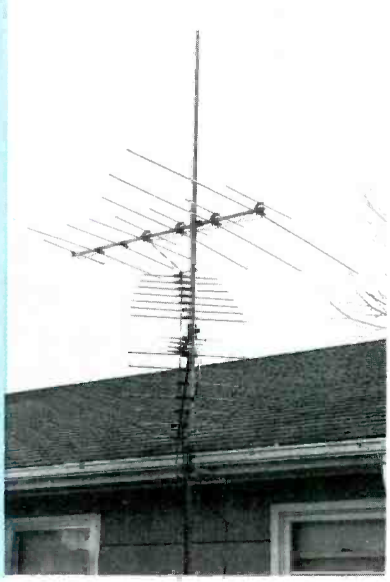
Downlead recommendations

Many problems can originate in the transmission line between antenna and TV receiver. In most cases, this transmission line either is 300Ω twin lead or 75Ω coaxial cable. The majority of full-time installers now prefer MATV-type coaxial cable for these reasons:
• Coaxial cable can be installed faster and easier. Its strength allows the cable to be pushed through some openings and conduit. It can be stapled or taped into place and is not sensitive to nearby metal.
• No standoffs or special hardware items are required, which saves money.
• The PVC jacket is more durable than the twin-lead materials, giving longer life because it is affected little by sunshine or weather.
• Cable is reliable because it does not radiate signals or pick up noise, and it is not affected if the position is changed accidentally.

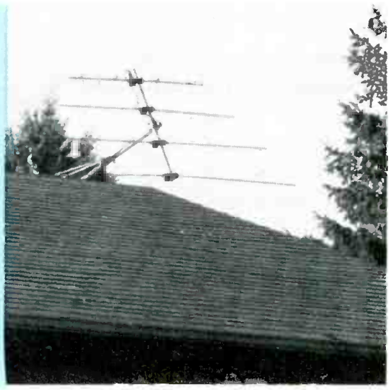
However, there are three things coaxial cable will not tolerate: *sharp bends; piercing* by nails or staples driven into it; and *crushing.*



A signal-lever meter is necessary foı any antenna systems that include a preamplifier or MATV amplifiers. Signal-level meters can be very helpful during preliminary surveying for the antenna location that gives strongest signals. However, the final evaluation of the antenna performance must come from an analysis of the pictures obtained on the customer's color TV.



Although this type of system is somewhat obsolete, it was necessary because the UHF stations were in a different direction from the VHF stations. Special tubular 300 Ω twin lead was used for UHF and standard 300 Ω twin lead was satisfactory for VHF. The color receiver had separate terminals for UHF and VHF. Therefore, no band splitters or impedance-matching baluns were needed. A stronger UHF signal could have been obtained by mounting the UHF antenna above the VHF antenna. But more than enough UHF signal level was obtained in the surburban location. Extra mast length gives a measure of safety to the house.



This tripod roof mount and rotor survived a windstorm safely, but the antenna suffered bent elements and a broken 300 Ω twin lead.

The antenna was undamaged, but the tripod mount pulled loose during a strong storm. Nails were probably used instead of lag screws to anchor the tripod feet.

Sharp bends cause the center conductor to move closer to the shield as the polyethelyne insulation *flows*. This upsets the characteristic impedance of the cable at that point, which can cause reflections that resemble ghosts. Extreme bends may cause shorts between wire and shield.

Staples or nails driven into cable can produce a short circuit or upset the impedance. The impedance also is changed by crushing the cable. Any change of characteristic impedance produces signal reflections which can be seen on the TV as smeared or ghosty pictures.

If the cable is stapled into place, round staples should be used. Also, if a staple gun is employed, it should be adjusted for light power so the cable covering is not dented.

When cable is run through walls the cable should be routed and fastened where it will not be crushed between wall studs and the dry-wall. When a cable loop is left for future connection, be sure it is secured in a safe place until needed.

Twin-lead precautions

If twin-lead is selected, do not coil it (such as where extra length is provided at the end), and don't place it closer than 6 inches from any metal. This includes copper wiring, metal window frames, conducting materials of any kind, or metal ducts used for plumbing, conduits, heating or air-conditioning.

Twist the twin-lead about twice per foot, and use standoffs every 3 feet to space it away from the metal mast or any other vertical surface. Install standoffs every 1 to 2 feet where the twin lead crosses a wood shake roof (do not use standoffs on a composition roof) or on other horizontal runs. Twisting the twin-lead minimizes whipping in a wind and reduces the station signal picked up by the wire acting as an antenna. Such unwanted signal might cause a leading ghost or variable ghosting and erratic reception because of phase cancellations. To further minimize twin-lead pick-up, do not make horizontal runs of more than a foot or so, if possible.

Avoid placing twin-lead where it might collect water or dirt, and route it out of direct sunlight if possible. Add extra standoffs if the area has high winds. Don't bend twin-lead too sharply. And don't use nails, tacks or staples through the twin-lead to secure it. An electrical field exists between (and in the vicinity of) the two conductors. Therefore, any conductor between or near the two wires of twin-lead distorts the electrical field, and this can smear the picture or cause ghost-like reflections.

Twin-lead is made of clear or brown polyethylene that can collect dirt, carbon and corrosion on the surface. Moisture from dew, rain or snow can change the twin-lead corrosion into a conductor that distorts the characteristic impedance, reduces the signal level, and unbalances the line.

Some people believe that the propagation of TV signals is affected by wet weather. Although there is a slight change, it is far less than the performance degradation brought by the change of twin-lead when wet. This susceptibility to weather is one reason why some twin-lead should be replaced every two years.

It should be clear that coaxial cable is often preferred over twin-lead because it is easier and cheaper to install and has better reliability in unfavorable weather. Twin-lead is available with an extra protective jacket. Some types have braided shield around it. These are improvements, but then the cost almost equals coaxial cable.

Installing the antenna

Don't decide the antenna location until the performance is evaluated at all roof areas. Mount the antenna on a 5- or 10-foot mast, attach downlead to it and to a signal-level meter or a TV receiver, and walk around the roof to determine the spot with the strongest and clearest signal.

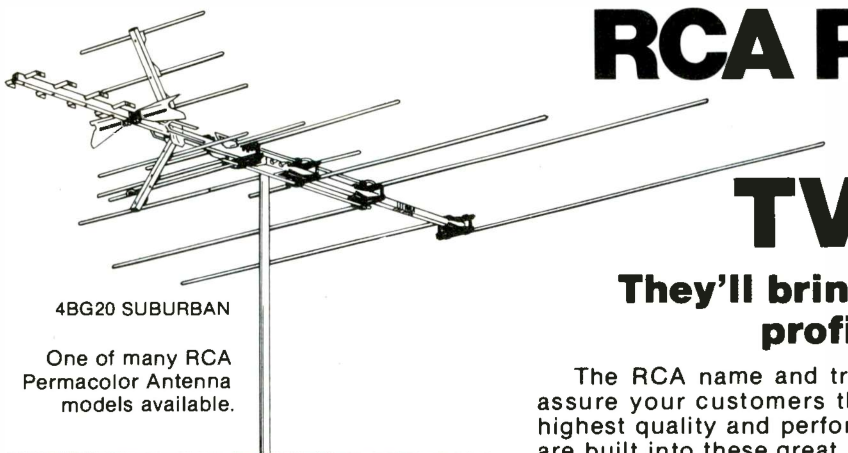
However, the final decision should not be made until the picture quality on all active channels is examined carefully on the TV screen. This shows another advantage of coaxial cable: It can be laid carelessly across the roof, down to the ground, and into the house through any door or window during the walk-the-roof test without degrading the signal quality. The picture quality will not change when the antenna is installed and the cable is fastened permanently. Unlike twin-lead, the length of coax is not critical, and the excess can be coiled if desired without degrading the picture.

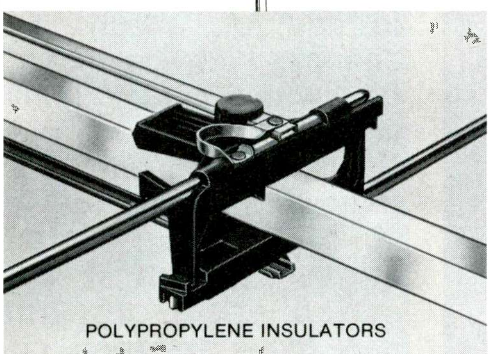
After the best location is found, the antenna should be mounted securely by chimney mount, a tripod at the roof peak, or on an outside wall near a peak. A strongly mounted tripod will safely sustain an antenna with 5- to 10-feet of mast. Of course, smaller mounts can be used if adequate guy wires are attached properly to the mast.

Antenna elements should be extended and locked into place and the downlead and/or preamplifier should be attached before the antenna assembly is mounted to the mast. If standoffs are used, they should be mounted before the mast with antenna is secured to the mounting device.

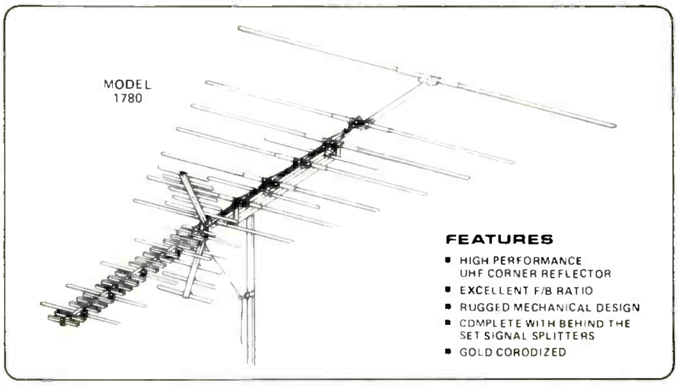
If possible, don't penetrate composition roof shingles with nails, lag screws or standoffs. Seal the roofing carefully if penetration is necessary. For example, both the bottoms and

Continued on page 17

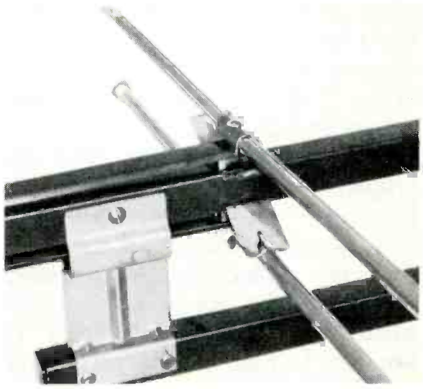




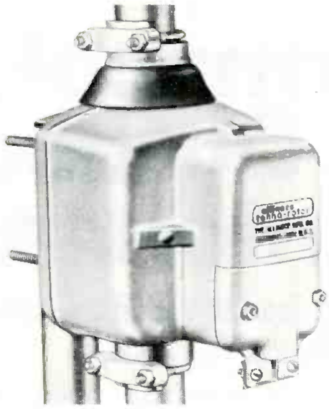
Antenna



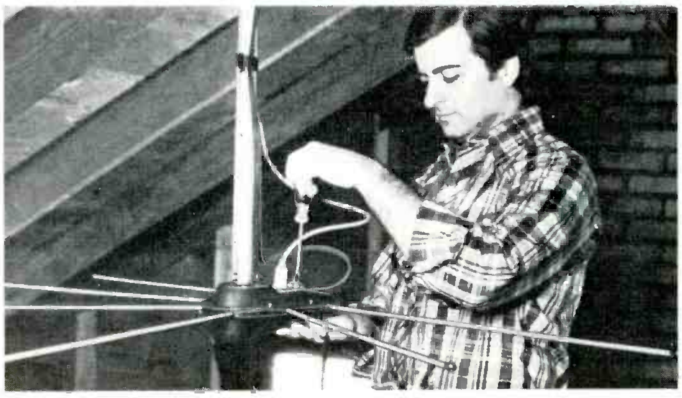
Finco model 1780 covers UHF, FM and both VHF TV bands. A corner reflector increases the UHF gain. The metal elements are protected by a gold corodized finish. *Courtesy of the Finney Company.*



No tools are needed to assemble most new antennas. During shipping, the elements are placed parallel to the boom. Then each is rotated perpendicular to the boom where it is held by flat springs. This reduces the time required for installation. *Courtesy of the Winegard Company.*



Rotators for large TV, CB and amateur antennas are available. *Courtesy of Alliance.*

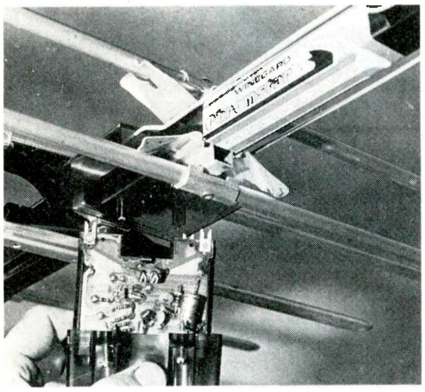


Pictured here is a Winegard 20-20 model. These small antennas are available with or without internal preamplifiers. A combination power supply and rotation control is included. The 20-20 can be mounted indoors or outdoors. The impedance is 75 , and a two-wire cable is needed for the power. *Courtesy of Winegard.*

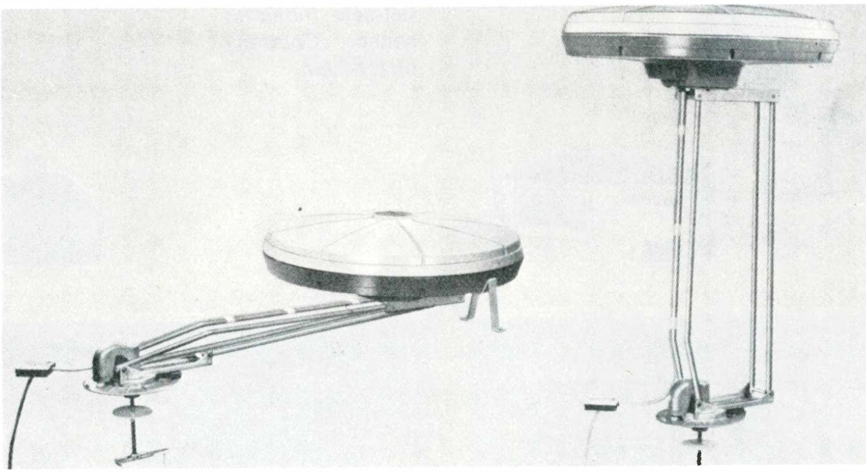
Antenna improvements are being made constantly. Improvements of electrical performance include higher gain, wider bandwidth and higher front-to-back signal ratio. In addition, mechanical changes provide longer life with more durable construction and metal finishes that resist corrosion.

To obtain up-to-date information and specification sheets for the new models shown, circle the appropriate reader service number.

roundup



A mast-mounted or antenna-mounted preamplifier produces the best signal-to-noise ratio. This preamplification should occur *before* the downlead attenuates the signal. Either a preamplifier or a balun is necessary at the antenna when it is to be connected with coaxial cable downlead. *Courtesy of the Winegard Company.*



The RCA line of antennas has several small, rotatable, amplified Mini-State antennas that can be operated indoors and outdoors. The Mini-State pictured is for use in a motor home, van or boat. The antenna assembly rotates inside the housing under command of the remote control, which also indicates the forward direction. *Courtesy of RCA.*

ANTENNA MANUFACTURERS

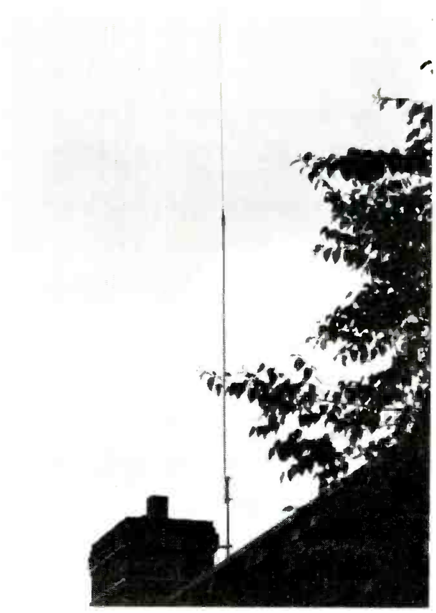
	TV OUTDOOR	TV INDOOR	CB RADIO	BUSINESS RADIO	ROTATORS	MATV	HARDWARE	TOWERS
Alliance Mfg.(11)					X			
Antenna, Inc. (12)			X	X				
Antenna Craft (13)		X						
Antenna Specialists (14)			X	X				
BP Electronics (15)		X	X					
Channel Master Ellenville, NY 12428	X							
Finney Co. (16)	X							
GC Electronics (17)	X	X	X				X	
RCA Distributor (18)	X	X			X*	X	X	
Shakespeare (19)			X	X				
Sinclair Radio Labs (20)			X	X				
Telex/Hy-Gain (21)								X
Winegard (22)	X	X			X*	X		

*THESE ROTATORS ARE PART OF AN INDOOR/OUTDOOR SYSTEM

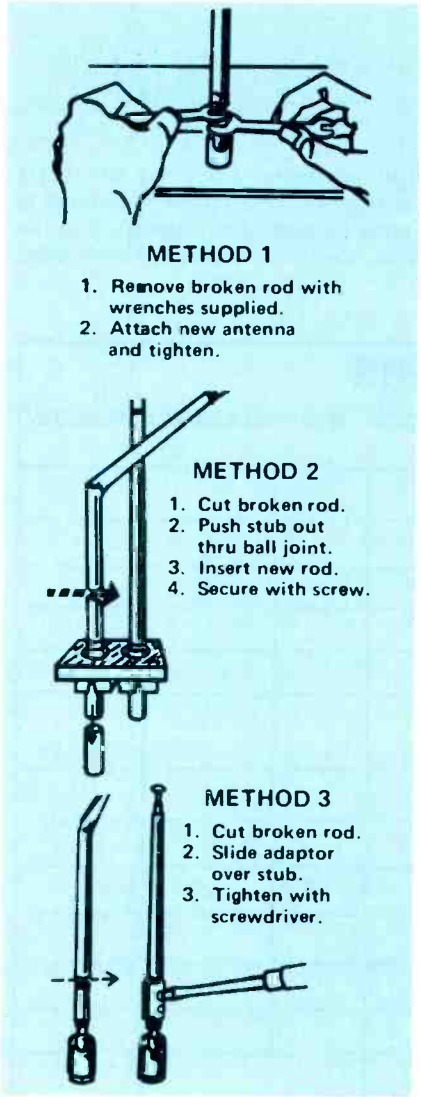
TO RECEIVE MANUFACTURER'S INFORMATION, CIRCLE NUMBERS ON THE REPLY CARD

Antenna Roundup

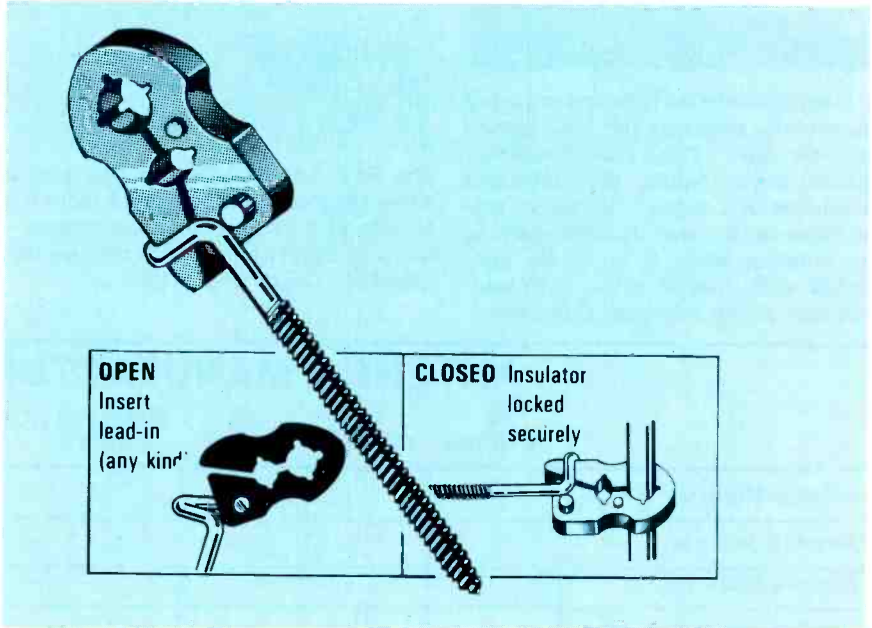
The Hy-Gain division of Telex offers a 70-foot crank-up heavy-duty tower. An electric winch system with limit switch allows power extending, and an optional remote control system displays the limit positions and has a fail-safe indicator sensor. *Courtesy of Hy-Gain.*



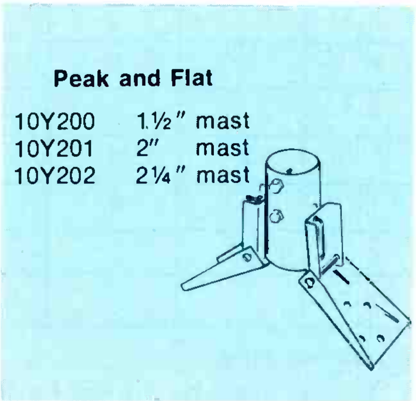
Super Big Stick fiberglass-insulated CB base antenna, by Shakespeare, is 18-foot long and has an ethylene/propylene/rubber insulating boot that insulates the antenna for voltages up to 13kV. Shakespeare is the manufacturer. *Courtesy of Shakespeare.*



Three methods of repairing the antennas of portable TVs are illustrated in the GC catalog. *Courtesy of GC.*



GC Electronics lists many items of hardware for TV-antenna installations. One unique product is E-Z Swing-In standoffs which swing open for insertion of the downlead and then can be locked in the closed position. *Courtesy of GC Electronics.*



RCA's TV Antennas and Accessories catalog lists many matching baluns and hardware for antenna installation, such as this mounting bracket. *Courtesy of RCA.*

Antenna installations

Continued from page 13

tops of tripod feet should be sealed, including the screw heads. Lag screws should be installed (instead of nails) in tripod feet. In areas where strong wind gusts sometimes occur, the tripod feet should be positioned over the roof-support beams, and the lag bolts screwed tightly into these beams.

Signal levels

If signal-level tests show less than 1000μV at the television for each picture carrier, there are three choices for improvement. The antenna can be moved to a different or higher location. A larger antenna with more gain can be substituted, or a low-noise preamplifier can be added to the antenna. (Other remedies, such as vertical or horizontal stacking of multiple identical antennas, sometimes are necessary in specific locations.)

Remember that the visible snow (signal-to-noise ratio) can never be better than it is at the antenna. All other parts of the system either retain the S/N ratio or make it worse. A good preamplifier can overcome the downlead losses that follow, and thus maintain the approximate S/N ratio coming from the antenna. No other amplification can reduce the snow.

Importance of matching

All antennas, transmission lines and TV tuner signal-inputs have characteristic impedances. If these three have identical impedances, no matching is needed. Usually, however, matching is required. Mismatching produces smeared pictures, ghosts and possibly snow from insufficient signal.

Most antennas now have 75Ω balanced impedances. To match a coaxial cable, a 75Ω balanced to 75Ω unbalanced matching transformer is required. These transformers are called baluns from *bal*anced to *un*balanced. For folded dipoles having 300Ω balanced impedance, a 4-to-1-ratio balun is necessary to match 75Ω unbalanced coaxial cable.

The usual input impedance of a TV tuner is 75Ω unbalanced. Older televisions included a 4-to-1-ratio balun that matched the common 300Ω balanced twin-lead to the tuner. Now the trend is toward supplying a 75Ω connector that connects directly to the tuner input. (Of course, hot chassis, televisions must have series capacitors for safety.) Therefore, coaxial cable from MATV or CATV system can be connected without a balun.

Unfortunately, many 300Ω transmission-line systems still are in use. Indoor dipole (rabbit ear) antennas are one example. Consequently, most TV manufacturers provide both 75Ω unbalanced and 300Ω balanced inputs that can be selected by switches or by proper connections of wires and lugs.

When 75Ω cable connects directly to the TV-tuner 75Ω input, the only balun is between antenna and cable. Elimination of unnecessary baluns minimizes signal losses and impedance mismatches, since baluns are not perfect devices.

Protection

Because of the location and materials, outside antennas and metal masts function as a type of lightning rod, giving some protection when grounded. Of course, nothing can protect totally against a direct strike of lightning, and more than an antenna would be destroyed in that case. However, partial protection is provided by a grounded mast that prevents a gradual buildup of static charges. It also grounds the energy induced by nearby lightning strikes.

Use number 6 AWG aluminum or number 8 AWG copper wire to connect the mast to a metal stake driven several feet into damp ground. The stake should have a diameter between 1/2-inch and 5/8-inch. Connections at both ends of the ground wire should be tight and of heavy-duty materials.

Don't clamp the antenna at the extreme top of the mast. Instead, mount it about 1 foot below the mast top so any minor electrical discharges can strike the mast directly instead of the antenna.

Finally, check the entire installation for secure mounting of the downlead, correct impedance matching, tight connections at the TV receiver, and the performance of the television on all active channels.

No two antenna installations are identical. Therefore, it is difficult to suggest precise step-by-step procedures. These general tips should prevent most serious mistakes while providing the best possible reception. □

AGC problems in tube TVs

PART 2

By Homer L. Davidson and Carl Babcoke

Additional AGC troubleshooting methods for older TVs are explained. Case histories illustrate practical servicing.

Figure 1 Picture snow can be produced on moderate-to-strong TV signals when the RF AGC negative voltage is too high.

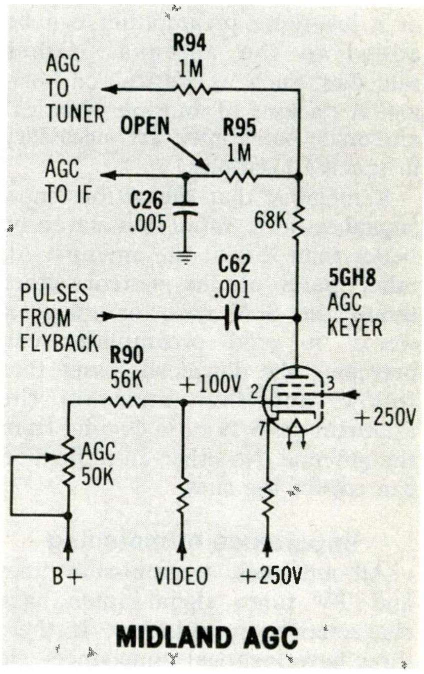


Figure 2 An open R95 in Midland model 15-214 eliminated the IF AGC. Therefore, the AGC keyer plate voltage became more negative. This applied excessive negative AGC to the RF tube and caused snow.

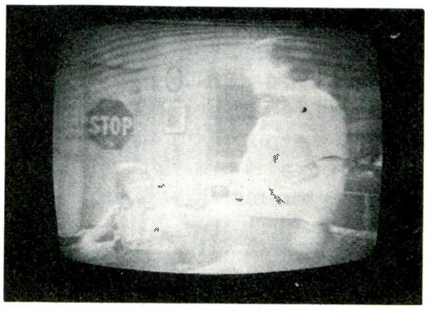


Figure 3 An intermittent tube socket of the AGC keyer in a Sylvania caused erratic losses of contrast. Any moderate increase of *both* RF and IF AGC voltages reduces the contrast.

The diagnosis of AGC problems in tube-type color receivers should be divided into two parts. Included in the first simple tests are these steps: observation of reception on all active channels, and of the snow on one channel that does not have a signal; exploratory adjustments of the AGC control; tube testing; and temporary use of a test tuner. Only a short time should be devoted to these first tests. They often are valuable, but not sufficiently complete to serve as the *only* testing techniques.

After the short-cut tests have failed to locate the AGC defect, the more logical methods (analysis of waveforms, resistances, and dc voltages) should be started immediately.

In the case histories that follow, these troubleshooting principles are applied to several typical AGC failures.

Snowy pictures

Only the strongest TV signals could be seen—and they had excessive snow—on the Midland model 15-214 (Photofact 994-2). New tuner/IF tubes and tuner substitute did not improve the snowy picture (Figure 1). The outside antenna was suspected of being defective, until a loaner portable TV was connected to the same antenna. The snow was normal on the second TV.

The Midland TV was brought to the shop for additional tests. New tuner and IF tubes were installed again (since some tubes become defective from rough treatment in the caddies), but without improvement.

Snow in the picture can be caused by these problems:

- Tuner defects, such as open balun coils or insufficient gain in the RF stage (a substitute tuner did not work any better).
- A gassy first-IF tube (RF and IF tubes had been changed).
- An open or other defect in antenna or downlead (the same antenna gave a snow-free picture on another TV).
- A component failure in the AGC circuit that increases the negative AGC voltage at the RF-tube grid.

The last possibility was the only one not tested, so it was the logical one to explore next.

Dc voltage tests revealed -9V at the RF-tube grid (much too high) and an IF AGC of -1V (too low).

Logic pointed to a defect in the IF AGC circuit. Insufficient AGC voltage to the IF tube forces the AGC keyer to supply too much negative AGC to the RF tube, and the resulting zero gain of the RF tube allows the normal mixer noise (snow) to seem more prominent.

Ohmmeter measurements of the AGC circuit (Figure 2) proved that R95 was open, and a new one stopped the abnormal snow. This repair required only a minimum time, since the symptoms and preliminary diagnosis identified the probable defect.

Intermittent contrast

The Sylvania D06-3 occasionally would lose contrast (Figure 3). During these times—which were not related to elapsed time or chassis heat—the AGC control adjustments had no effect on the picture. Connection of a substitute tuner didn't affect the intermittent condition.

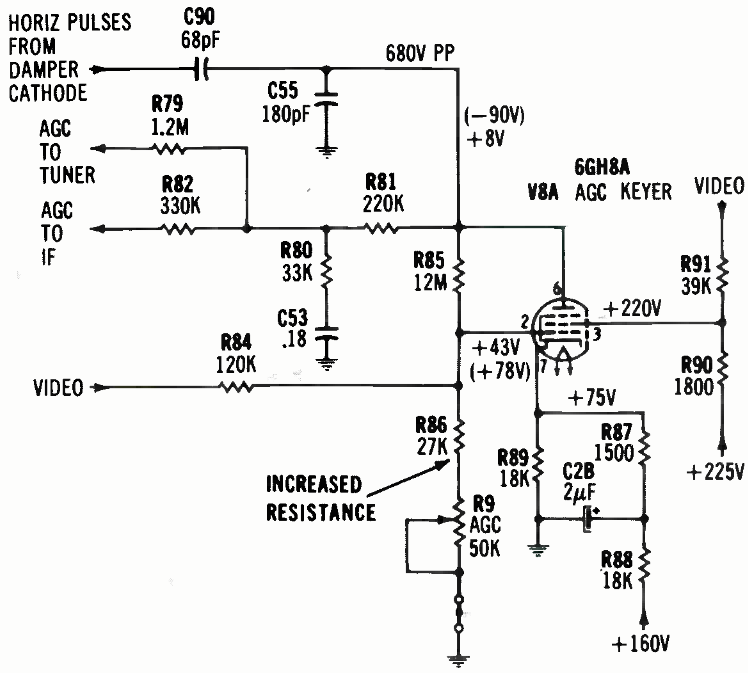
Horizontal pulses at pin 1 of the 6GH8 AGC-keyer tube were normal, but the video at grid pin 9 was weak. Insufficient video at pin 9 is not likely to be the only problem, since this would force the AGC keyer to increase the RF and IF gain, thus raising the video level to the required point. Therefore, the preliminary diagnosis was changed from *AGC problem* to *video problem.*

When a scope probe was touched to the pin-6 plate of first-video amplifier 6MB8, the picture suddenly regained its contrast. Moving and twisting the components around the socket proved the socket was intermittent. Installation of a new 6MB8 socket solved the intermittent contrast.

Either video defects or excessive AGC gain-reduction can reduce the contrast. The test methods must be able to identify the one cause.

Multiple problems

Three separate troubles were found in one RCA CTC31A chassis. It is common for older color receivers to have more than one problem, since customers often wait until the TV fails completely before having these secondary defects repaired.



RCA CTC31A AGC

Figure 4 In an RCA CTC31, an open limiting resistor increased the control-grid voltage of the AGC keyer. The keyer became more active and produced additional negative voltage at the plate. This supplied more AGC to RF and IF tubes and decreased the contrast.

The raster was bright green. Usually, leakage or a short circuit in a dc-restoration diode (one at each -Y plate) causes raster-color changes in this model. A quick ohmmeter test found low-resistance leakage in the G-Y diode. Installation of a new diode allowed the gray scale to be adjusted.

The other symptoms were low contrast and a lack of response to AGC-control adjustments. Sometimes both symptoms are caused by one defect, but that was not the case here.

All dc voltages at the 6GH8 AGC-keyer tube were far out of tolerance. About -90V (too high) was measured at the pin-6 plate, but the pulses there had normal waveshape and amplitude. The high keyer voltage applied more than -20V to the grid of first-IF 6KT6, thus eliminating all gain.

An overactive AGC keyer evidently was the problem. Usually, a wrong dc voltage at keyer grid or cathode is responsible, and most wrong voltages are produced by burned or increased-value resistors.

In-circuit ohmmeter checks appeared to show an increased value of resistor R86 (27K Ω in Figure 4). One lead of R86 was disconnected to permit an accurate test, which showed more than 70KΩ. The increased resistance raised the positive grid voltage, causing excessive rectification and high AGC voltages. A new 27K Ω resistor restored operation of the AGC control and provided good video at the plate of the first video amplifier tube. However, the visible picture still lacked contrast.

Open peaking coils or delay lines can reduce contrast, but all these had continuity. Signal-tracing with the scope revealed a low video amplitude at the delay line. At the input of R49, the video level was normal, but the amplitude was small where R49 connected to the delay line. R49 had increased to

AGC problems

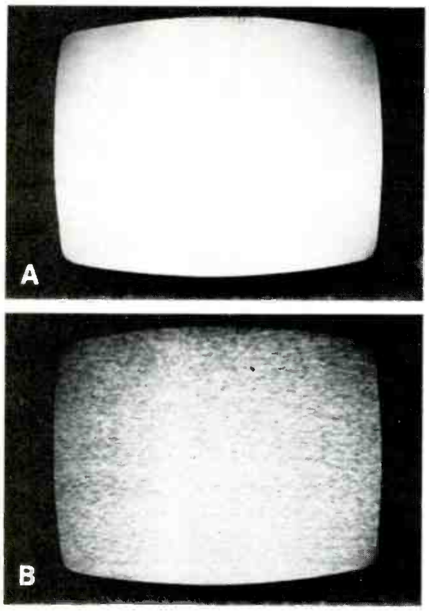


Figure 5 (A) A blank raster can be caused by three basic problems: a loss of video not connected with AGC functions; an overactive AGC keyer that biases RF and IF stages to cut-off; or a combination of strong signal with a complete loss of AGC action. The resulting high-negative video-detector voltage biases the first video amplifier to cut-off, thus eliminating all video beyond the detector. (B) If the blank raster was caused by overload from AGC failure, normal heavy snow should be seen when the TV is tuned to a channel without a signal. These are important symptoms.

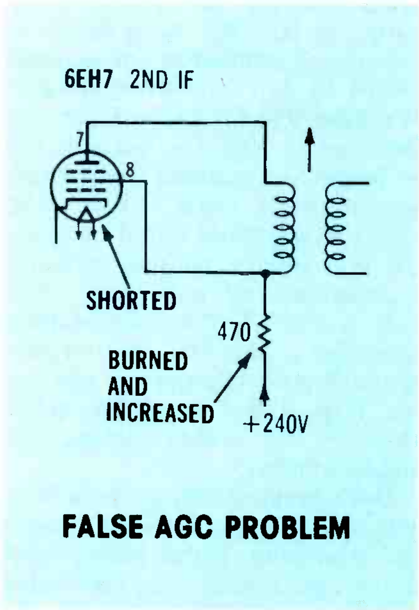


Figure 6 Defects in tuner or IF stages can imitate AGC symptoms. Low gain in the second IF stage of a Zenith caused a low contrast picture and noisy sound.

about 20K Ω from the original 750 Ω. A new resistor brought back the contrast.

Tuner or AGC?

Two AGC conditions of opposite action can eliminate the sound and produce a white raster without a picture (Figure 5A). First, excessive negative voltage from an overactive AGC keyer can bias the RF and IF tubes to cut-off, removing the picture. (With most keyer defects, this overvoltage condition probably will continue for no-signal and strong-signal alike.)

Also, total failure of the AGC keyer to produce negative voltage can prevent a picture from reaching the TV screen because the video detector is driven hard, producing a large negative voltage that applies cut-off bias to the first video tube. Sound can be heard (perhaps with buzz or distortion) because the sound-IF signal is recovered from the third IF stage, not the video detector. Notice, however, that the raster has no picture or snow *only when a strong signal is received.* If the TV is tuned to a channel without a signal, normal snow (Figure 5B) should be seen. AGC is needed only for strong signals.

A dead tuner or inoperative IF stage also can produce a raster without a picture (and usually without sound). Therefore, the no-picture symptom can apply to three entirely different malfunctions. These procedures must determine which is the problem.

With a Penncrest model 4867A, the *no-sound and no-picture* symptoms could result from a dead tuner; a no-gain IF stage; or AGC failure (either lack of operation or an overactive keyer).

The Penncrest showed no picture or snow (and had no sound) on all VHF channels. Therefore, a loss of negative AGC voltage was not possible. Dc-voltage tests revealed RF and IF AGC voltages that were typical of no-signal conditions. This suggested the AGC was good, but the tuner or IFs were dead.

A substitute tuner was connected

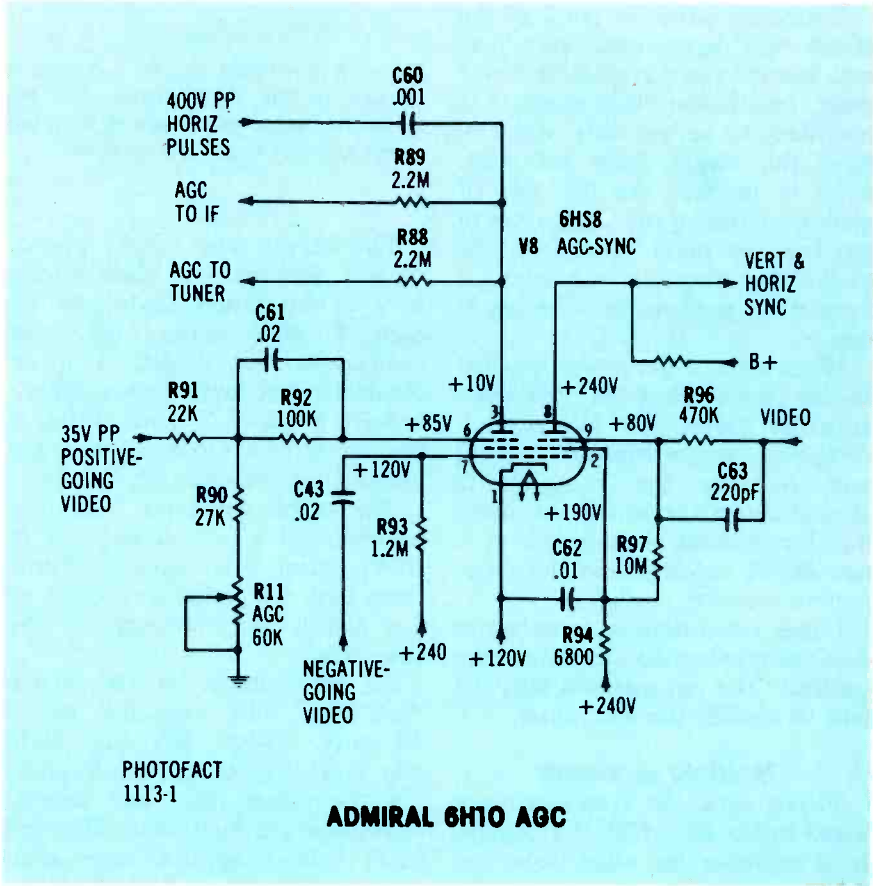


Figure 7 Many variations of this combination AGC, sync separator, and noise canceller were used in older TVs. The clipped negative-going video at the pin 7 grid allowed strong noise pulses to cancel the positive noise pulses at pin 6. The pin 6 suppressor grid operates similarly to the control grid in a triode AGC keyer; it controls the plate rectification.

to antenna and IF cable, providing a normal picture. This proved that the tuner was defective, or some tuner voltages were incorrect.

Before the old tuner was removed for shipment to a tuner-repair company, the B+ voltages on top of the tuner were measured. Supply voltage was present at the chassis end of the 1200 Ω isolation resistor but none at the tuner end. Replacement of the resistor and readjustment of the AGC control restored the original performance.

IF imitates AGC problem

The 25MC33 Zenith had garbled noisy sound and a picture of low contrast. Adjustment of the fine tuning and AGC control did nothing to improve the picture. Clamping the IF AGC voltage and trying a test tuner also failed to provide a better contrast.

These symptoms hinted at problems in the IF section. Measurements of the B+ at plates and screens revealed only +120V at the 6EH7 second-IF plate (Figure 6) instead of the proper +240V. The 470 Ω decoupling resistor had increased to about 15K Ω. Contrast and sound became normal after replacement of the resistor and a touchup of the AGC adjustment.

Notice that suspicion first was directed to the IFs because the tuner and AGC circuits tested alright. Then measurements in the IF section proved the defect was there.

Several AGC problems

Figure 7 shows one variation of the popular old combination AGC, sync separator and noise-cancellation system. This circuit is in chassis 6H10 Admiral color TVs.

Essentially, the tube has two pentodes, but the cathode, control grid and screen grid are common to both pentodes. Notice that the suppressor grids perform the functions of control grids. Pin 6 is the effective control grid for the AGC function, and pin 9 is the control grid for the sync separator half. Dc voltages at the cathode, control grid pin 7, and screen grid pin 2 affect the amount of plate current in each pentode, affecting the amount of AGC negative voltage at pin 3 and the clipping point of the sync at pin 8.

Except for the incidental effect on plate current, the only function for the pin 7 control grid is to receive negative-going noise pulses that might enter with the video. R93 brings B+ to this grid, and the grid current through the grid/cathode diode action stabilizes the grid voltage a volt or so above the cathode. Therefore, the positive part of the video that comes in through C43 is clipped (removed) by the same grid current. The negative-going noise pulses are not clipped, and they serve to reduce the plate current in both pentodes.

These negative-going noise pulses at the grid have the effect of stopping the AGC action (pentode on the left) and the sync separation (pentode on the right) during the time of the noise pulse. Therefore, the noise pulses do not give false triggering of the AGC, which (without the noise cancellation action) would momentarily decrease

AGC problems

the contrast following strong noise pulses. The clipped video at pin 7 is not needed unless noise pulses are mixed with the video. Except for loss of noise immunity, an open C43 will not affect the AGC operation or the sync separation.

The critical dc voltages are those at pin-1 cathode and pin-6 suppressor grid; however, the pin-7 and pin-2 voltages have some effect on the AGC operation.

Leakage in C62 (that bypasses the common screen grid) reduces the AGC, giving a dark picture. It also may degrade the sync and affect the vertical and horizontal locking.

When an open C61 blocks the positive-going video from reaching the suppressor grid (which acts as a control grid for AGC keying), the symptoms are the same as if the positive pin-6 voltage has been reduced. The picture is dark, and overload causes picture-pulling or flagwaving (Figure 8).

One hard-to-locate problem produced excessive AGC and a blank raster. The R11 AGC control developed an open at the center-lug wiping contact. This increased the resistance to ground, and the more active AGC reduced the contrast (similar to the symptoms of a larger value of R90 in Figure 2).

Summary of tips

The following series of tests can locate the general area of most AGC defects in tube-type color TVs:

- Turn the AGC control a small distance clockwise and then the same amount counterclockwise from the original position. Notice any effects on the picture. Return the control to the original position if these adjustments do not help.
- Check the TV operation on strong and weak signals, noticing any tendency toward overload. Look for normal snow on a channel that has no signal. A loss of AGC action will allow proper weak-signal operation, but stronger carriers will show dark unstable pictures or a white raster (depending on the carrier strength).
- A white raster without picture might indicate a loss of signal in the tuner, IFs, or video amplifiers. But AGC that does nothing *or too much* can do the same.
- If a bad tuner is suspected because of snow, insufficient contrast or loss of picture, connect a test tuner to the same antenna and IF cable and compare its performance with the set's tuner. Keep in mind that any improvement could occur because of improper voltages applied to the old tuner, and not because the tuner is defective.
- If the symptoms point to a lack of sufficient negative AGC control voltages, substitute the RF or IF AGC voltage by connecting an external bias supply. Warning: make certain the external voltage that brings good operation is within the range of *normal* voltages for that model. A clamping voltage that is higher or lower than the average is not a good test, for it might obscure another problem.
- If the previous tests have not identified the general problem, begin tests of dc voltage, resistances, and waveforms. Examine everything about the AGC-keyer circuit.
- Excessive AGC voltage to the RF tube can cause snow, even when the tuner is perfect. Test this by momentarily grounding the tuner AGC wire, if the signal level is not extremely high (which might cause overload). Any reduction of snow proves the RF AGC is too negative. A common defect is an open resistor between RF AGC and B+.
- A shorted or leaky video-detector diode can imitate AGC overload or weak IFs. Remember that the detector and first-video amplifier are part of the closed AGC loop. Check all resistors, RF chokes and traps in the video-detector circuit.
- Three items about each AGC keyer are especially important. They are the dcV between control grid (or other grid that does the same function) and cathode; the video amplitude at the keyer grid; and the amplitude and waveshape of positive-going horizontal pulses at the keyer plate. Measure these early in the testing.
- Each TV model is designed for certain ratios between dc voltages: *video-detector output; IF AGC; and RF AGC*. When correct, these voltages give good contrast while preventing snow and overload. A very accurate analysis of AGC troubles can be made by comparing these voltages, when the optimum voltages are known for the model under repair. For example, one old model had these voltages during *normal* operation on a local TV station: detector -2.6V; IF -5V; and RF 0V (at the RF grid). The snow on Figure 1 was caused by: detector -3V; IF-0.4V; and RF -5V. The Figure 3 low contrast was produced by: detector -0.5V; IF -9V; and RF -2V. In Figure 5A, the white raster was caused by: detector -19V; IF -0.5V; and RF 0V (the video tube was biased to cut-off, so no picture was seen). The Figure 8B picture bending was produced by a lower strength and: detector -7V; IF -3V; and RF 0V (at grid). Generally, normal IF AGC plus insufficient RF AGC causes overload *only* when the signal is very strong. Contrast is reduced by simultaneous application of too much RF and IF negative AGC voltage. A total loss of RF and IF AGC causes overloads on strong signals, producing either a dark bending picture or a white raster without a picture. □

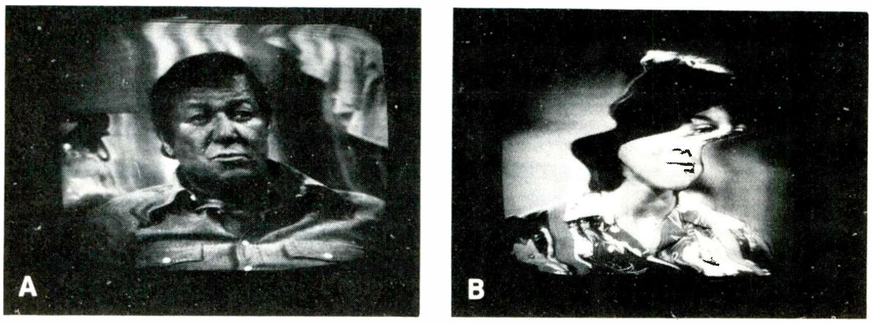


Figure 8 Insufficient AGC action can produce unstable pictures. (A) A darker picture with "flag-waving" at the top is the symptom of moderate overload. (B) A stronger signal causes increased overload which affects the horizontal sync, so large sections of the picture can bend erratically to the right. A quick test is to observe the results of signal reduction. If the problem is AGC overload, a decrease of antenna signal into the snow threshold should stop the bending. A video generator with a variable RF-output control can be very helpful for testing any problems that change with signal level.

RCA...chroma... circuits and servicing

By Gill Grieshaber, CET, and Carl Babcoke, CET

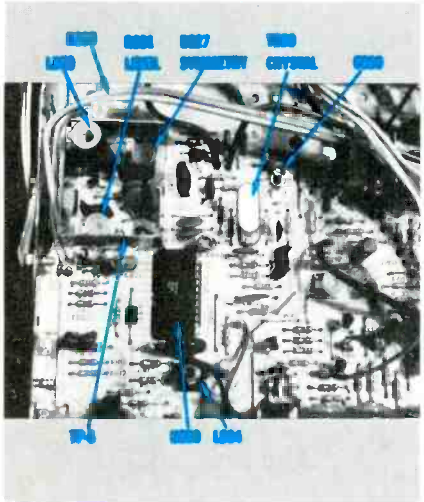


Figure 1 Most of the chroma components of the RCA CTC99 are grouped in this area.

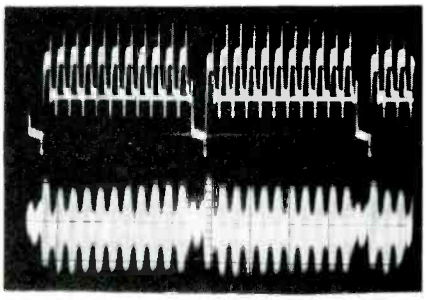
Components of the RCA CTC 99 chroma section are grouped on the circuit board behind the IF enclosure. Several major components are identified in Figure 1. One integrated circuit (U800) performs most chroma functions, including amplification, color-subcarrier generation, burst separation, and demodulation. The luminance and chrominance -Y signals are matrixed inside discrete transistors before these signals are amplified by power transistors that drive the picture-tube cathodes.

Chroma-bandpass

Chroma buffer transistor Q801 is a PNP emitter-follower that drives the chroma-bandpass stages through R800. C800 and adjustable L800 (Figure 2) comprise a series-tuned circuit that is aligned for maximum gain around 4MHz. R828 and variable-control R827 (called the symmetry control) determine the "Q" of the 4MHz peak.

This stage is not followed by a transistor or IC amplifier (as was common practice previously). Instead, the two tuned stages are coupled by C801.

C802 and nonadjustable L801 make up the parallel-tuned 3.6MHz bandpass filter. The frequency response is broadened by R801 and R819 in parallel. R801 functions also as an auxiliary preset chroma-level control. From R801 and TP-6 the filtered chroma signal (minus the luminance) is sent to pin 1 of U800, the chroma IC. All bandpass components (including both con-



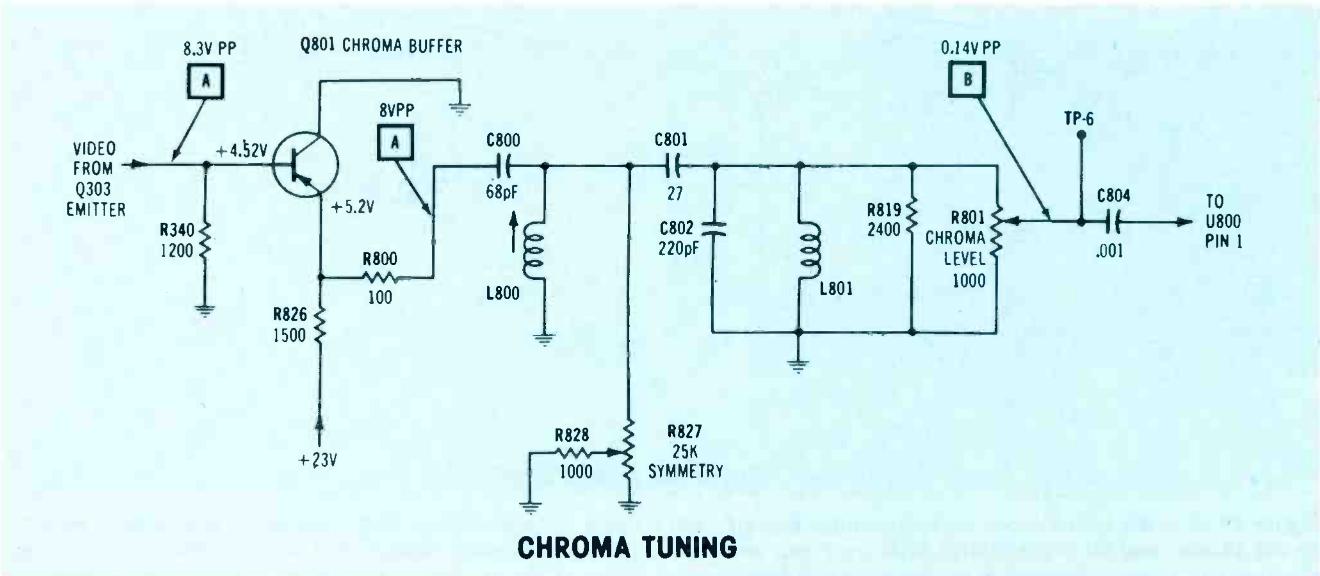


Figure 2 Q801 isolates the chroma bandpass-tuning circuits from the luminance signal. The waveform-A composite video has 3.58MHz color bars plus sync pulses and "black" bars. Following the bandpass tuned circuits, all luminance is removed, leaving only the pulses of color bars (see waveform B). Series-tuned circuit C800/L800 is peaked at 4MHz. R828 varies the "Q" and L800 is adjustable. C801 couples this signal to the C802/L801 parallel-tuned circuit. Notice that no amplification is supplied between the two tuned circuits; they are coupled through C801. A passive chroma-level control (R801) determines the chroma amplitude applied to U800 pin 1. The waveform-B signal at TP-6 has pulses made of 3.58MHz for 10 color bars after demodulation and one color burst.

trols) are inside a topless partition shield.

U800 functions

U800 is a 24-pin IC that performs these functions:

- Two stages of chroma amplification.
- Burst separation.
- AFPC detector for color locking.
- ACC amplification and killer detection.
- Generation of a 3.58MHz crystal-controlled carrier for demodulation.
- Switch-controlled automatic color phase.
- Adjustable flesh-tint detector.
- I and Q demodulation with matrixing for R-Y, G-Y and B-Y outputs.
- Voltage - controlled color - saturation adjustments.
- Voltage-controlled hue adjustments.

For effective troubleshooting, it is important to know which IC pins are used for these functions. Figure 3 lists many of these, along with important waveforms.

Burst-separation pulses

In composite video, color burst is placed on the back porch of the blanking pulse following the horizontal-sync pulse. Older receivers obtained the turn-on pulses for burst-separator operation from the

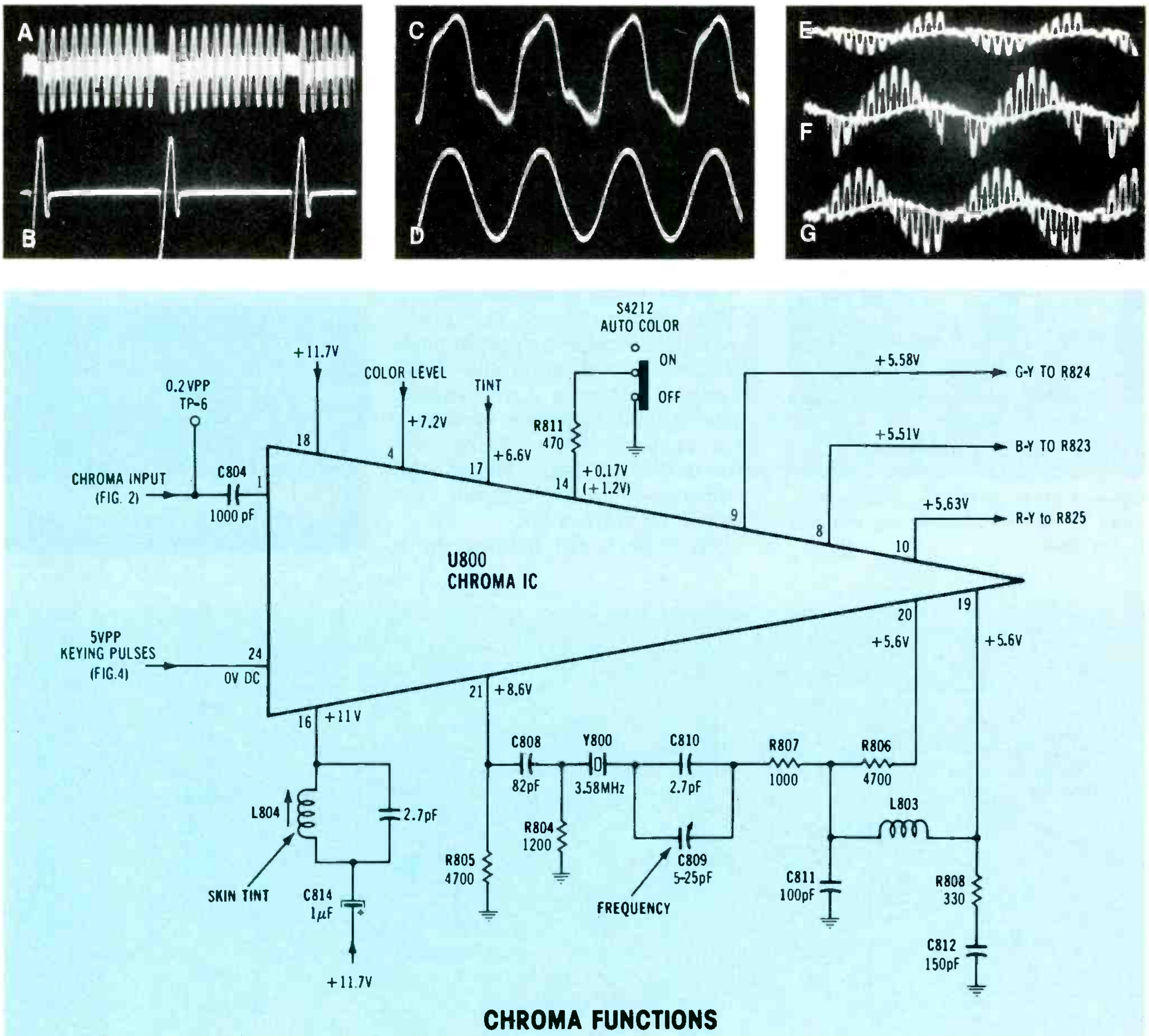


Figure 3 Functions of the input signals, output signals, and control voltages of the U800 chroma IC are shown. Pins 21, 20 and 19 are used for the 3.58MHz color oscillator and demodulator phase shift. Waveform A is the 0.2VPP input chroma signal at pin 1, and waveform B shows the 5VPP burst-keying signal at pin 24. Notice the phase relationship between the burst in the chroma and the positive ringing pulse of the keying waveform. The waveform-C 1.4VPP rounded square wave at pin 21 is the color-oscillator feedback signal. Waveform D shows the 3.58MHz sine wave that is found at pin 19 (0.43VPP) and pin 20 (0.4VPP). Waveforms C and D were scoped at 0.1μs/div sweep time; all others at horizontal-sweep rate. Waveform E is the 0.68VPP G-Y signal at pin 9, the pin 8 2.2VPP B-Y signal is waveform F; and waveform G shows the 1.9VPP R-Y demodulated signal at pin 10. Frequency of the color oscillator can be adjusted by grounding the U800 pin 24 burst-keying signal, connecting together U800 pins 2 and 3, then adjusting trimmer C809 until the color bars float by.

horizontal-sweep circuit. However, these sweep pulses required a time delay (by a low-pass R/C filter) to prevent them from arriving before the burst.

Videocassette tape recorders do not have horizontal sweep. Therefore, they process horizontal-sync pulses to serve as burst-separator pulses. Some color televisions also process sync pulses for this purpose.

Figure 4 shows the RCA CTC99 and CTC101 circuit and waveforms used to generate burst-separator pulses. Positive-going horizontal sync pulses are filtered and reduced in amplitude before they reach the Q800 base. Negative-going rounded pulses are produced at the Q800 collector, and they drive the series-tuned circuit C803/L802. The tuned circuit rings weakly, showing the original negative-going pulse and one cycle of ringing. The burst separator in U800 can be enabled only by a positive voltage. Therefore, the single positive peak of the Figure 4E ringing waveform keys the burst separation when it reaches U800 pin 24.

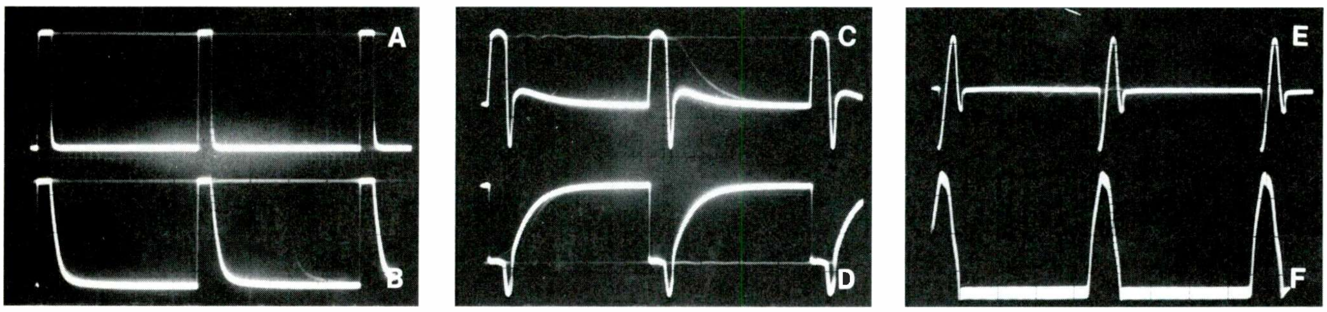
For proper burst separation and solid color locking, the values of C803 and L802 are very critical. A longer time constant (larger capacitance or inductance) will move the positive peak farther to the right (excessive time delay). A shorter time constant moves the positive peak to the left in a scope waveform (shorter time delay). Either condition could destroy the coincidence between keying pulse and color burst. Correct conditions are shown by the A and B Figure 3 waveforms.

Dc control circuits

Many sources supply the dc voltages (Figure 5) that regulate brightness, contrast and color saturation according to manual adjustments of variable controls and to automatic operation of the room-illumination sensor and the brightness-limiter circuits. The interconnections between these circuits become rather complex. For example, the contrast and brightness should be regulated simultaneously (when necessary) by the brightness-limiter circuit and by the cabinet-mounted light-dependent resistor (LDR) that monitors room illumination. This is done by connecting a resistor between LDR1 light sensor (which partially controls the contrast) to collector voltage of Q702 the brightness-limiter transistor.

Brightness-limiter action—Origin of the control voltage for brightness limiting is the low end of the flyback winding that supplies the high-voltage rectifiers. R411, R715 and R730 form a resistive path from the HV winding to +23V (and through the supply voltage to ground). Therefore, any increase of picture-tube current generates more negative voltage at the F/F1 end of the HV winding. This negative voltage subtracts from the fixed positive voltage. Therefore, all dc voltages in the ABL circuit change with picture-tube current that produces brightness.

Voltage at the junction of R730 and R715 is limited by two types of diode action. The cathode of diode CR702 is connected from the



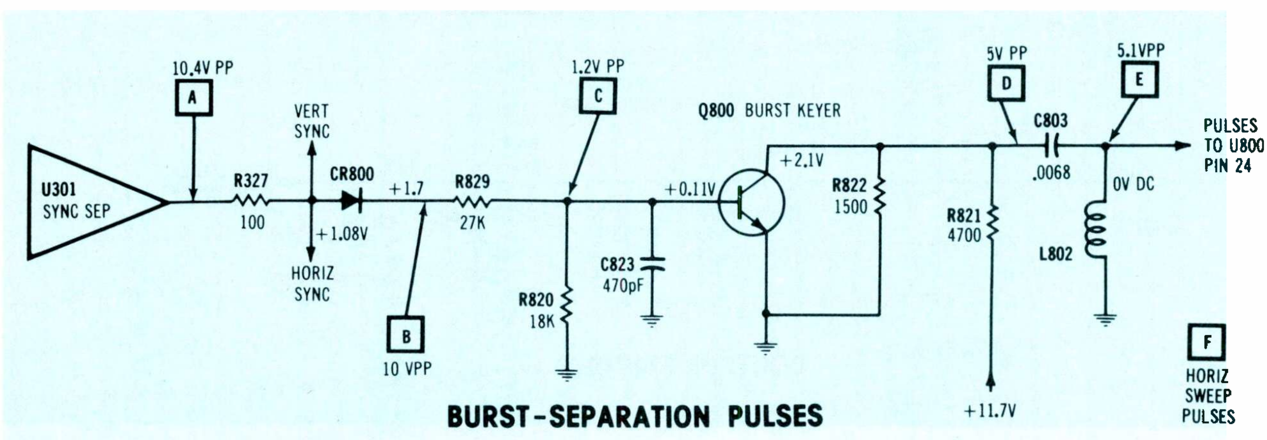


Figure 4 Horizontal-sweep pulses are not used for burst keying. Instead, horizontal sync pulses are processed and used to ring the C803/L802 series-tuned circuit. The important waveforms are shown in the pictures. Waveform D is the driving signal for the C803/L802 ringing circuit. The positive peak of waveform E ringing signal at U800 pin 24 keys-on the burst separation. Figures E and F are dual-trace waveforms that show the ringing-pulse delay (E) relative to horizontal-sweep pulses (F).

RCA chroma

junction to ground. If excessive CRT current attempts to drive the junction highly negative, CR702 conduction limits the voltage to -0.7V.

Also, the base of Q702 brightness-limiter transistor is connected to the same junction and CR702 cathode. Q702 is a NPN type; therefore, the positive voltage at the base is clamped by the B/E diode action and cannot exceed +0.76V. (The sample television measured +0.68V at maximum brightness and +0.75V with no brightness.)

Collector current for Q702 comes through R712 and R731 in parallel. At normal brightness, the Q702 B/E bias is sufficient to saturate the C/E path, which then has slightly more than +0.1V. The Q702 collector is connected to R722 (and Q707's base where the dcV determines the brightness) through switching diode CR701. With normal brightness, CR701 has about +4V at the cathode and +0.1V at the anode; CR701 is reverse biased and cannot conduct. CR701 does not pass the Q702 collector voltage to the brightness circuit until the Q702 collector voltage exceeds about +4.7V (+4V plus 0.7V for the diode drop). This condition occurs when the Q702 forward bias drops to about +0.70V (near saturation, small bias changes produce large collector-current changes).

An increase of the dc voltage at the Q707 base reduces the picture brightness. Therefore, excessive brightness (or a component defect)

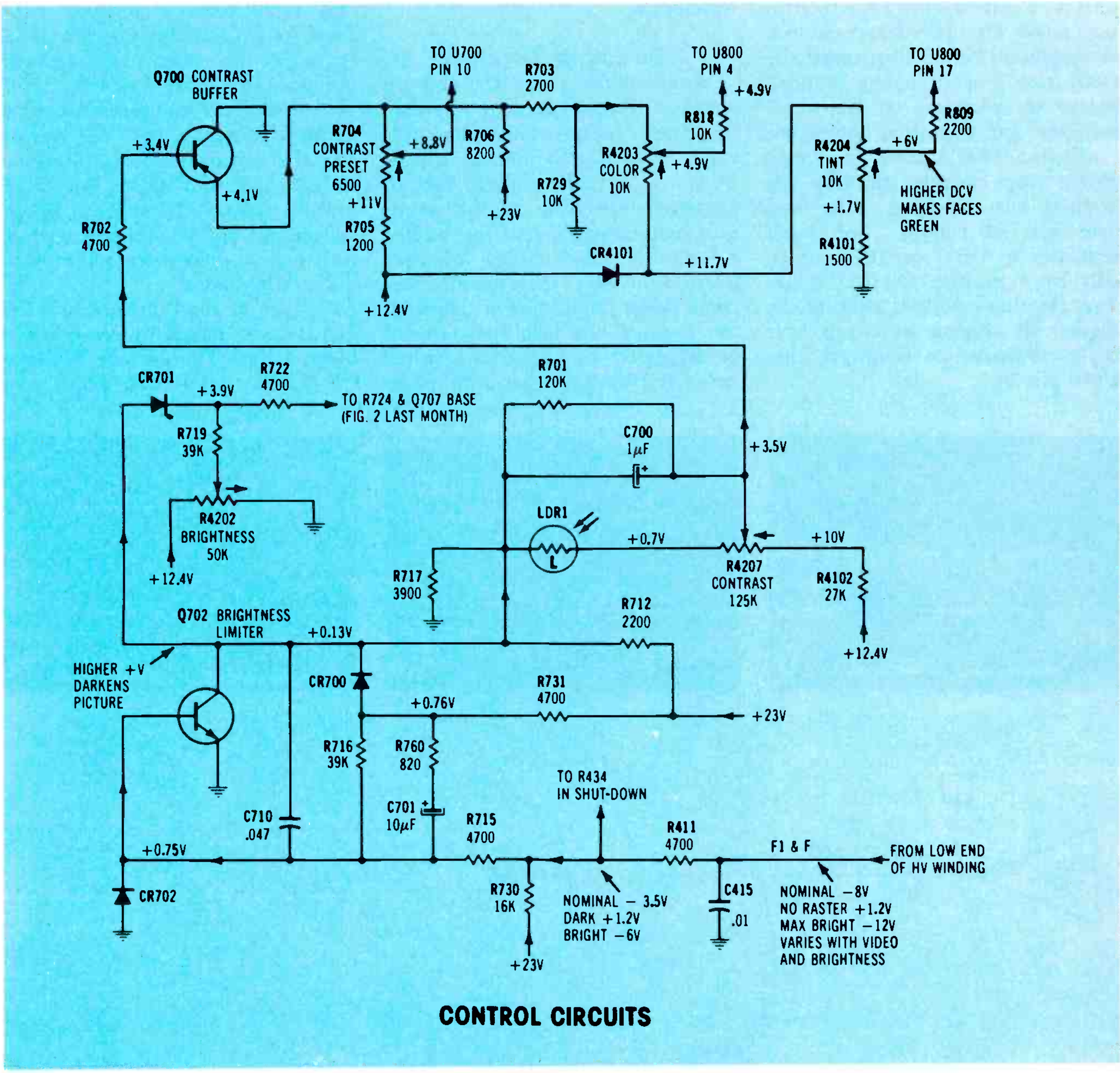


Figure 5 Brightness, contrast, color saturation and tint are controlled by dc voltages in the CTC99. Front-cabinet-mounted LDR1 varies the contrast voltage, and the contrast voltage affects the color voltage. Brightness-limiter Q702 is operated saturated until the HV current exceeds the maximum allowable, then the higher Q702 collector voltage switches on CR701 and reduces the brightness-control voltage at Q707. Also, the higher Q702 collector voltage increases the contrast voltage (through R701 and LDR1), which decreases both contrast and color. Notice that a lower control voltage increases color, brightness or contrast.

that increases the Q702 dc voltage above about +4.7V produces this counter action, which reduces the brightness. For example, an open Q702 probably would cause a black raster. But a shorted CR701 increases the brightness to maximum just short of blooming.

For troubleshooting brightness problems, it is important to know that a more-positive dc voltage at the Q707 base (also base and emitter of Q703 video buffer) darkens the picture, while a less-positive voltage brightens the picture.

The Q702 higher collector voltage during excessive brightness also reduces the color level and the contrast. Dc voltage at the center lug of R4207 contrast control is isolated and increased slightly by Q700 emitter follower that drives the preset contrast control and finally reaches U700 luminance-IC pin 10. Increased positive voltage at pin 10 decreases the picture contrast, and a decreased voltage increases the contrast.

Additionally, the LDR resistance and the Q702 collector voltage together determine the dc voltage at the low-voltage end of the R4207 contrast control. Stronger light falling on the LDR reduces the resistance. Therefore, higher room illumination increases the contrast by decreasing the dc voltage at the junction of LDR1 and R4207. Notice that this contrast voltage does not affect the Q702 collector voltage and the brightness, but the higher Q702 collector voltage during times of excessive picture brightness does come through R701 and LDR1 to the contrast control where it decreases the contrast.

Variation of the contrast dc voltage also changes the color saturation level. Q700 emitter dc voltage is reduced by voltage divider R703/R729 and then is applied to the low-voltage end of color-control R4203. A lower dc voltage from the center lug of R4203 increases the color level, and a higher voltage decreases the amount of color. The reason for diode CR4101 is not known from these tests. Perhaps it minimizes start-up transients in the color circuit.

Color-output stages

Matrixing G-Y with Y luminance was illustrated last month, including luminance waveforms of color bars with the TV color control turned down. Only the three color-output transistors (called drivers) are located on the small circuit board (Figure 6) that contains a few components, spark gaps and the picture-tube socket. The drive controls, bias controls and matrixing transistors are all on the main circuit board.

The CRT-socket board has a separate plug-in focus socket with a large spark gap (Figure 6B). Evidently, this is required because of the high 8kV focus voltage.

Output waveforms—Figure 7 shows four waveforms for each of the three color power-output stages. The top trace is the matrix transistor base waveform. Matrix collector waveform is the second trace. This is a composite of chroma and video since the luminance was added at the emitter. The many narrow pulses that mark the bar's edges are in the luminance signal. Third trace is the driver transistor emitter waveform. The fourth trace shows the driver collector waveform that is supplied to the proper CRT cathode.

Notice in the Figure 5 schematic last month that the only component between the second and third waveforms is a 270Ω resistor. Therefore,

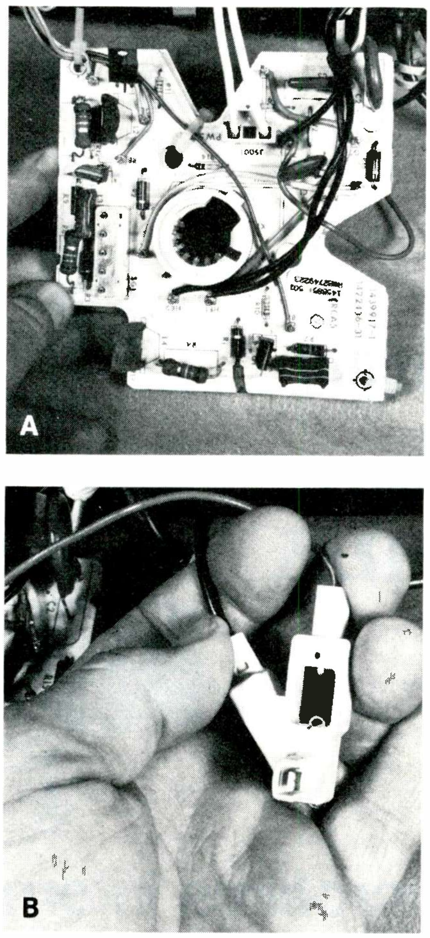


Figure 6 (A) A back-side view of the circuit board that contains the CRT socket shows three power transistors and a few components. Matrixing transistors, drive controls and bias controls are on the main circuit board. (B) The CRT focus pin is a separate assembly that has a large spark gap.

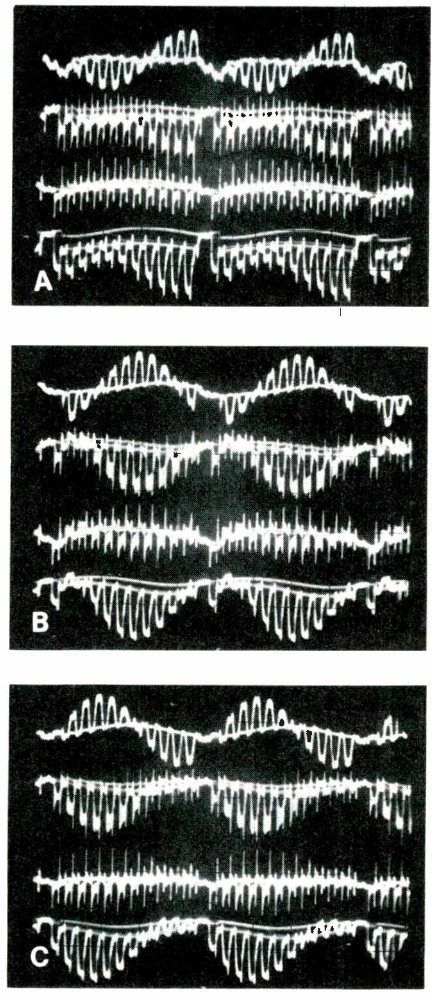


Figure 7 (A) Top trace is the 0.62VPP G-Y signal at the Q705 base; second trace is the 4.5VPP Q705 collector signal; third trace is the 1.05VPP emitter signal of Q2; and fourth trace is the 90VPP collector signal that drives the green CRT cathode. (B) Top trace is the 2.3VPP B-Y signal at the Q704 base; second trace is the 5VPP Q704 collector signal; third trace is the 1.1VPP drive signal at the Q1 emitter; fourth trace is the 120VPP Q1 collector signal that drives the blue CRT cathode. (C) Top trace is the 1.9VPP R-Y signal at the base of Q706; second trace is the 7.6VPP Q706 collector signal; third trace is the 1.3VPP emitter input signal at Q3; fourth trace is the 145VPP Q3 collector signal that drives the red CRT cathode. Refer to page 38, June **Electronic Servicing** for the complete matrixing schematic.

both waveforms should be identical except for amplitude. They are not.

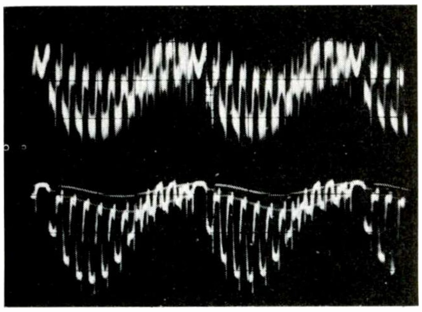


Figure 8 These scope traces help clarify the reason for the waveshape change between the matrix collector and the driver emitter. The base is not bypassed, but it has a 1000Ω resistor. Therefore, the base/emitter constant current transfers some emitter waveform to the base. Of course, the only true input waveform is between base and emitter (not base or emitter to ground). *The top waveform was obtained by floating the scope between emitter and base* of Q3 red driver. This waveform is quite different from either base or emitter waveforms in Figure 7. A small hum from floating the scope broadened the horizontal lines of the waveform.

The unbypassed base has an unwanted signal that subtracts from the emitter signal to form the correct input.

This is made clear by the waveforms of Figure 8. For the top trace, *the scope was connected between base and emitter* (not to ground). The bottom trace was made normally between driver collector and ground. Notice that the two waveshapes are identical (except for some hum and noise that broadened the horizontal lines).

Practical servicing

Because of the many interconnections between luminance and chrominance circuits, it is best to troubleshoot them as one section.

A good wide-bandwidth triggered scope and an accurate digital multimeter are the two essential test instruments. In most cases, the scope should be used to locate a stage that might have a defect. Then the DMM functions of voltage and resistance measurements should be employed to pinpoint the trouble area. The accurate but simplified schematics used during this series have been especially prepared to show input and output signals and all important waveforms.

The extreme density of components on the few circuit boards in new models of most brands bring problems of locating the parts that require testing. Compounding the customary hazards (of ruining a good component while making tests) are the closeness of lead wires. Insulated hook types of probes should be used. It is dangerous to use large test probes that can slip between two conductors and possibly ruin some solid-state device or other component. Remember, a diode, IC or transistor can blow before a fuse can protect it.

In-circuit tests are essential

Each RCA CTC99 has approximately five ICs, 33 transistors, and SCRs, and more than 50 diodes, not including the devices in tuners and tuner-control circuits. All but one or two are soldered to boards.

Such large numbers can bring serious problems.

These solid-state devices *should not* be removed for testing or replacement unless absolutely necessary. Access to the bottom of the circuit board is difficult unless all connecting wires are unplugged and the chassis removed from the cabinet. Even with good accessibility, much valuable time can be wasted by unsoldering and soldering components that are not defective. Therefore, these removal or disconnecting operations must be kept to a minimum.

The best solution to these problems is for each technician to perform all possible tests before disconnecting or removing any components.

Integrated circuits can be tested partially by examining the input and output signals and verifying that all essential dc voltages are reaching the IC. If no breaks can be found in the wiring, and the dc voltages are correct but the output signal is missing, then possibly the IC needs to be tested by replacement.

Many transistors can be tested in-circuit by instruments designed for that function. A few transistors are paralleled by low circuit resistances that make in-circuit tests unreliable. These should be removed for out-of-circuit tests.

Testing diodes

In-circuit testing of diodes has been of questionable value in the past. The internal resistance of any diode varies with the applied voltage. In ohmmeters, the applied voltage depends on the current drawn. Low ohmmeter current, therefore, increases diode resistance so much that it sometimes equals other resistances in the circuit. Identification of the various resistances is difficult.

During research on CTC99 troubleshooting, it became evident that a fast and dependable method of testing diodes in-circuit was needed. Several experiments led to the construction of an adapter to be used with a digital multimeter (or other voltmeter) as a readout.

The diode-test adapter does not measure diodes by their resistances. Instead, a substantial current is drawn through each diode and *the voltage drop across the diode is measured.*

Test results—Very good results were obtained when more than 24 of the CTC99 main-board diodes were tested for forward-bias and reverse-biase voltages.

Almost all diodes measured between 0.67V and 0.69V. CR421 gave a reading of 0.628V. Two showed readings of less than 0.60V. CR403 (which rectifies the +215V source) measured 0.599V, possibly because of collector-to-base current in the color-output power transistors. The CR105 damper diode measured 0.542V, which increased to 0.600V when the Q100 horizontal-output transistor was unplugged. The four bridge rectifiers gave dependable and consistent readings.

Only two diodes were loaded so heavily by the circuit that the readings were of no value. One of the horizontal-centering diodes measured 0.126V for both polarities, while the other had the centering jumper across it and thus had OV.

Reversed readings—When the adapter test leads were connected to nothing (infinite resistance), the full 19V (with new batteries) was sent to the readout meter. DMMs can endure this overload on the 2V readout range without damage. However, for reverse-bias readings, the 20V range should be used.

Reverse-bias voltage readings made out-of-circuit indicate only internal diode leakage. However, in-circuit readings show diode leakage in parallel with circuit resistances. Therefore, low-voltage readings might indicate either diode leakage or a low-value circuit resistance. Study the schematic to verify or disprove the possibility of excessive circuit loading.

The same 24 CTC99 in-circuit diodes were tested also for reverse-bias readings. Two did not overrange on the 2V range. CR402 measured 1.8V and CR401 showed 1.7V with reversed test leads. The CR423 measurement was 4.04V. Four main bridge diodes showed reverse voltages of about 16V. Those diodes without low-value shunting resistances gave readings of 18V to 19V.

These readings make it safe to state: *When measured in-circuit, any diode that activates the overrange on the 2V range (when reverse bias is applied from the diode-test adapter) should be considered normal.*

Transistor junctions, high-voltage diodes, phase-detector diodes, and LEDs also can be tested for forward voltage and leakage by the diode-test adapter and a readout meter.

Comments

Luminance and chrominance problems should be tested with a scope. All the signals (including the 3.58MHz color carrier) can be scoped easily. However, if the problem involves either excessive brightness or a dark picture, all diodes in luminance and chrominance circuits should be tested by the voltage-drop method. Diodes usually fail (if they fail) by becoming shorted. Therefore, *shorted diodes should be suspected first.*

When these tests fail to find the problem, a multimeter should be used for dc-voltage analysis. For brightness problems, measure the focus and screen voltages at the picture tube and make certain the heater has the proper amplitude of horizontal pulses. Then measure the dc voltages beginning with those in the three color power transistors and working upstream to the matrixing transistors. Remember, the luminance and chrominance signals join there, so identify whether the luminance or chroma voltage is incorrect. Continue to move back upstream until the problem stage is located.

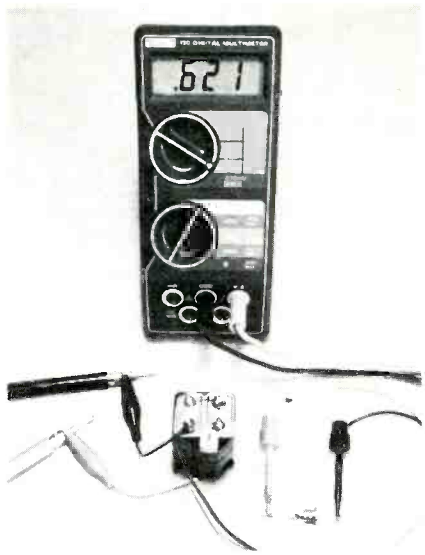
Use the following table to help locate the shorted diode causing a black raster or a bright picture:

SHORTED DIODE	SYMPTOM
CR703	bright picture
CR709	very bright
CR708	slightly brighter
CR715	no change
CR713	no change
CR712	no raster
CR700	no change
CR701	very bright
CR702	no raster
CR700	no change
CR706	bad vertical
CR707	bad vertical
CR711	no raster
CR800	no change
CR710	extremely bright with horiz noise

Next month

Vertical sweep and servicing problems will be the subjects next month. □

Industrial MRO



The experimental adapter for testing diode junctions by the constant-current voltage-drop method is shown connected to a diode and with a Keithley model 130 DMM as readout.

Testing diodes by voltage drop

By Carl Babcoke, CET

Seldom are diodes operated for the resistance they can provide. Therefore, testing the *resistance* of a diode (as a method of determining the good or bad condition) is a roundabout measurement that often brings mistakes or ambiguous results. A technique for measuring the characteristic voltage drop of diodes is explained, and a simple adapter to supplement a dc voltmeter is described.

During electronic troubleshooting in the field, most suspected diodes are checked for their resistances during alternate applications of forward-bias and reverse-bias polarities of voltage. The reverse-biased resistance of a good diode should be much higher than the forward-biased resistance.

Although thousands of bad diodes have been correctly identified by this method, it has several limitations and disadvantages.

Ohmmeter operation

An analog ohmmeter connects a known-value meter resistor in series with the unknown resistance that is to be measured, and applies a stable and known dc voltage (usually from an internal battery) across both series resistances. An internal

LINEAR VERSUS DIODE RESISTANCES

OHMMETER RANGE	1.12KΩ RESISTOR		9.4Ω RESISTOR		POWER SUPPLY DIODE	
	RESISTANCE	VOLTAGE	RESISTANCE	VOLTAGE	RESISTANCE	VOLTAGE
RX1	1500*	1.531V	8.9	0.718V	9.5	0.750V
RX10	1100	1.417V	10	0.132V	71	0.648V
RX100	1150	0.814V	50*	0.0143V	530	0.542V
RX1K	1K	0.155V	00*	0.0014V	4.2K	0.442V
RX10K	00K*	0.016V	00	0.000V	31K	0.365V
RX100K	00K	0.0016V	00	0.000V	240K	0.297V
RX1M	00K	0.0016V	00	0.000V	1M	0.110V

RESISTANCES MEASURED ON RCA WV-98B VTVM
VOLTAGES MEASURED ON A DIGITAL MULTIMETER
* INDICATES ACCUMULATED ERRORS

Table 1 These results were obtained when the resistance of two linear resistors and a power-supply diode were measured by the ohmmeter function of a VTVM.

dc voltmeter then measures the voltage drop that is formed across the unknown resistance. The resistance-versus-meter-current operation is nonlinear, thus a special nonlinear scale must be provided on the meter face.

A digital multimeter applies a constant known current to the unknown resistance and measures the voltage drop across the resistance. The advantage for digital readouts is the linearity, which is as good as the accuracy of the constant current. In other words, doubling the resistance also doubles the voltage that is developed across the resistance. This voltage drop then is measured by the dc voltage function of the DMM.

Unfortunately, both analog and digital meters have the same shortcoming when measuring diodes.

A diode's resistance changes each time a different ohmmeter range is selected. This is not a defect of ohmmeters, but a result of combining ohmmeter and diode characteristics.

An increase of diode current increases the voltage drop across it, but not at a linear rate. Diode voltage tends to flatten and stabilize near the characteristic voltage. Its curve resembles a voltage regulator.

Table 1 illustrates resistance linearity versus diode linearity, and gives the dc voltages across them for seven VTVM ohmmeter ranges. Notice that the voltage across the 9.4Ω resistor almost equals the diode voltage on the RX1 range. However, the resistor voltage decreases at the proper X10 rate for all ranges above RX10, while the diode voltages decrease slowly.

A convenient range for testing many circuits with a VTVM or FET meter is the RX1K range that has 10KΩ at the center of the scale. A diode measured on that range has about 4Ω of resistance (or higher, if other circuit resistances reduce the meter voltage). This high diode resistance is about the same as other resistances in many circuits, and the usual forward and reversed tests are not very accurate or informative when made in-circuit. The problem is similar for digital meters, even those with high-powered ranges.

One solution

One solution is to establish a single range that measures with higher current. A current between 5mA and 10mA provides dependable readings without danger of damaging low-power solid-state devices.

A few digital multimeters (such as the Beckman TECH-310) test the forward-bias voltage drop across a diode when 5mA of current is flowing. Power for the test comes from a constant-current source, so variations of diode conduction do not affect the accuracy. Although the range is marked by a diode symbol without numbers, the voltage-drop reading is displayed from 0.001V to 1.999V.

This method has been tested extensively and has proven to give helpful and correct readings in almost all cases, including in-circuit tests.

Building a diode-test adapter

During consideration of servicing methods for the CTC99 and other new receivers, it seemed a good idea to have a small adapter that would permit this type of diode voltage-drop measurements with meters not originally equipped for such tests. Designing and constructing a true constant-current source can become complicated. However, it is easy to make an *almost-constant source* of current by starting with excessive voltage and limiting the current by adding a large-value resistor in series with the diode. The diode that's under test needs only a fraction of the total voltage, so normal variations of diode voltage produce only small current changes.

The Figure 1 photograph shows the simple adapter. The only components are two 9V batteries, a 3300 wire-wound or metal-film resistor, plus wire and clips or insulated hooks (Figure 1B).

With the test leads shorted together, the current measured 5.56mA, which dropped to about 5mA when a diode was connected. Of course, the battery *current* is zero unless a conductor is connected to the test leads.

A digital multimeter having a 1.999V (so-called 2V) range is an

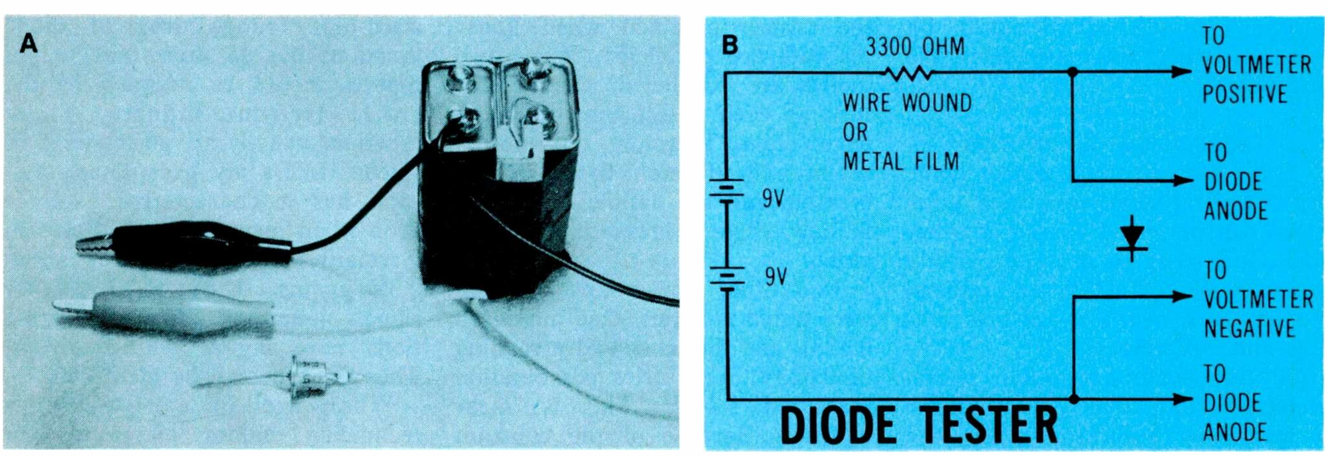


Figure 1 (A) All components are visible in this photograph of the constant-current voltage-drop diode test adapter. A large wire-wound resistor was used for stability, not because high wattage is required. (B) The schematic is equally simple. Convenience features could be added. An on-off switch and an LED power indicator would remind technicians to shut off the power. A spring-return polarity-reversing switch would save time if many diode junctions are to be tested quickly.

Testing diodes

excellent readout. The high input resistance does not load the diode under test.

An accuracy of about 0.1V can be obtained by using the 1.5V range of a VTVM. The off-scale reading between measurement will not damage the meter. Volt-ohm-meters (VOMs) with a 2.5Vdc range provide readouts of moderate accuracy. However, the open-probe voltage of about 19V is 7.6 times the full-scale reading. It is not advisable to permit the full voltage to be applied to the VOM for very long. The testing sequence can be done safely by starting with the VOM on the 50V range, connecting the diode, and then switching to the 2.5V range (if the reading drops sufficiently to indicate diode current) for the forward-voltage reading. After the reading, the 50V range should be selected before the diode is disconnected.

The diode-test adapter has proven to give very accurate readings both in-circuit and out-of-circuit. Most silicon diodes measure between 0.65V to 0.69V.

Testing transistor junctions

Base-to-emitter and base-to-collector junctions of several in-circuit transistors were measured by the volt-drop adapter. Most silicon junctions gave readings between 0.73V and 0.79V. Notice that the transistor readings were higher than the diode average of about 0.66V.

Inaccurate low readings were obtained only with those in-circuit transistors that had 330Ω or lower shunting resistances. In fact, a slight 1-to-1.5 ratio could be obtained when 100Ω paralleled the junction.

Tests of special diodes

Some higher-voltage diodes made up of several series-connected junctions can be tested by the adapter. One old plug-in damper diode (used in RCA CTC36 and others) tested 3.61V with forward-bias voltage and 19V reversed.

A three-lead horizontal phase-detector dual diode of unknown origin was believed to be the common-cathode type. A few tests with the adapter, however, proved it contained two diodes of the same polarity in series, with the center lead connecting to the anode of one and the cathode of the other diode. One diode checked 3V (18V reversed), and the other measured about 4V (19V reversed).

These diodes were tested by several ohmmeters of different types, but none of the ohmmeters gave any indication of diode operation. The damper diode tested as if open. The phase detector diode reading was 140KΩ for both ohmmeter polarities.

Another advantage of the test adapter is the dependable measurements it gives for light-emitting diodes (LEDs). Each of two small LEDs lighted properly when forward bias from the adapter was applied. One tested 2.99V and the other had 3.29V. With reverse bias, neither was lighted and the readings were 16V and 17V.

A larger LED showed a moderate amount of light and measured 1.59V with forward bias, while reversing the bias gave an 18V reading without any light. The low range of many ohmmeters can cause some LEDs to light, but there is no indication of the voltage rating of the LED. Higher-voltage LEDs (such as the two 3V types) cannot be tested on conventional ohmmeters, except for the leakage resistances that do not change with applied voltage.

An experiment was performed by testing paralleled diodes. One diode mesured 0.643V, and the second read 0.598V. When paralleled across the adapter leads, the reading was 0.580V. This proves that other diodes or transistor junctions in the circuit can reduce the voltage drop.

Notice, however, that this is not the answer obtained when linear resistors are paralleled. When two diodes are paralleled, the current through each is less than if one is tested alone. Therefore, the internal resistance of each diode is increased, and the parallel resistance is only slightly lower than either alone.

Two other power-supply diodes were tested in series. One measured 0.623V and the other had a reading of 0.623V. The series combination measured 1.245V. This is linear addition. Because of the constant current, the individual voltage drops were not changed. Not so with VOM tests. The same diodes tested 10Ω and 11Ω on a VOM, but in series the resistance reading was 80Ω. This demonstrates another superiority of the voltage-drop test over ohmmeter readings.

Leakage readings

In another experiment, a substitution box was used to parallel various resistors across the adapter test leads to determine the voltages produced by different leakage resistances during reversed-bias tests of diodes and transistors.

The following voltage drops versus resistances were measured:

VOLTAGE DROP	RESISTANCE
19.3V	INFINITE
18V	50K
16V	17K
14V	10K
12V	6K
10V	3300
7V	2000
6V	1500
5V	1100
3.5V	775
2.3V	470
1.9V	400
1V	200
0.9V	170
0.62V	120
0.4V	75
0.3V	60
0.2V	35

Interpolation from these figures can provide approximate resistance values during tests of diode leakage, or for determining the amount of in-circuit paralleling resistances.

Conclusion

This method of testing the forward-bias voltage drop of diode junctions has so many advantages that it should be adopted by the entire electronic industry. These junctions usually are germanium or silicon (LEDs are exceptions), and each has a characteristic voltage drop when measured out-of-circuit. Germanium junctions check about 0.3V against 0.58V to 0.70V for silicon junctions. Selenium junctions have higher voltage drops. Thus the type can be identified.

When used properly—with a technician making allowances for specific circuits—the constant-current voltage-drop method of evaluating diodes is almost foolproof. □

Servicing electrocardiographs

Even well-made medical electronic equipment occasionally develops defects. The writer—an experienced medical-electronics technician—explains typical repairs of electrocardiographs.

By Joseph J. Carr, CET

An electrocardiograph (ECG) provides amplitude-versus-time continuous recordings of waveforms produced by human hearts. Interpretations of these waveforms can reveal the medical condition of a heart. Electrocardiograph waveforms are recorded in permanent form on strips of special paper (Figure 1). When similar heart waveforms are displayed on a CRT screen for temporary viewing, the instrument is called an electrocardioscope (ECS).

Heart-produced voltages and waveshapes

A small voltage is generated by each contraction of any muscle in the body. The heartbeat signal, monitored at various points of the skin, consists of these muscle-contraction voltages plus the signals that trigger the contractions (when they occur at a different time). The resulting composite waveform is rather complex. A typical 2-lead waveform is shown in the drawing of Figure 2.

Amplitudes of these heartbeat signals range between a fraction of a millivolt to perhaps 3mV between two points on the skin. But the average is about 1mV peak-to-peak. The repetition rate varies with the individual and other factors from 15 beats-per-minute (BPM) to 200 BPM; however, most are between 50BPMs and 80BPMs. At 60BPM, the repetition rate is one per second or 1Hz. The bandwidth required for good reproduction, therefore, is from barely above dc to slightly over 100Hz. Frequencies above 100Hz show undesired muscle jitters and other artifacts. Total response to dc would present problems from electrode-to-skin battery-like voltages.

Connecting leads

The heart signal changes waveshape when the ECG connecting leads are attached to different points of the body. Leads with electrodes can be connected to left leg (LL), right leg (RL), left arm (LA), right arm (RA) and six or

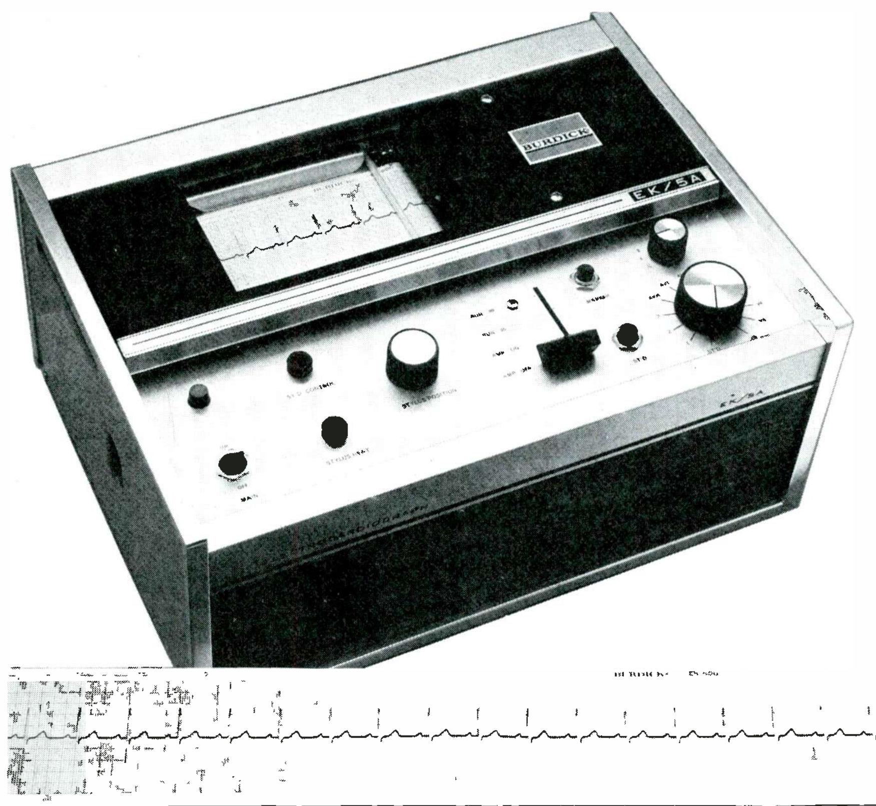


Figure 1 Electrocardiographs produce a scope-type waveform on moving paper tape for diagnostic tests of human hearts. *Courtesy of Burdick.*

seven points on the chest. Seldom are all leads attached to a patient at any one time. All 10 or 11 leads might be attached in an automated lab where the ECG selects its own leads while recording automatically. Most other ECGs have five leads (both arms, both legs and one chest lead) and a switch to select the most common combinations. The chest lead then can be moved manually when necessary.

Each combination of leads gives the cardiologist a different "view" of heart condition or operation. And the analysis of several waveforms by a skilled doctor can reveal the type and extent of any damage, and its location in the heart. Technicians are not required to study or understand these interpretations, but they must keep the ECGs and leads in perfect operating condition so the waveforms are trustworthy and not distorted.

The multiconductor shielded cable that connects the patient to the ECG machine usually has a five-pin size-14 AN/MS military-style connector at the machine end, although a special connector sometimes is provided. At the patient end of the cable are five wires which have either regular banana plugs or a special type of pin tip. These wires are color coded to help the staff connect them quickly and accurately.

Not all metallic contacts provide a good ECG connection. Several special electrodes are used. For

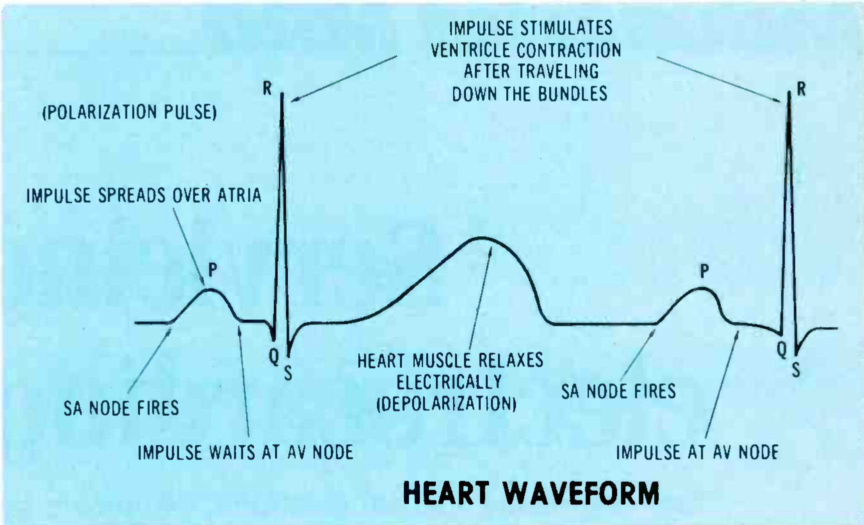


Figure 2 Several heart actions that contribute to the typical lead-two waveform have been identified in this drawing. Amplitudes of the depolarization and atria pulses have been exaggerated.

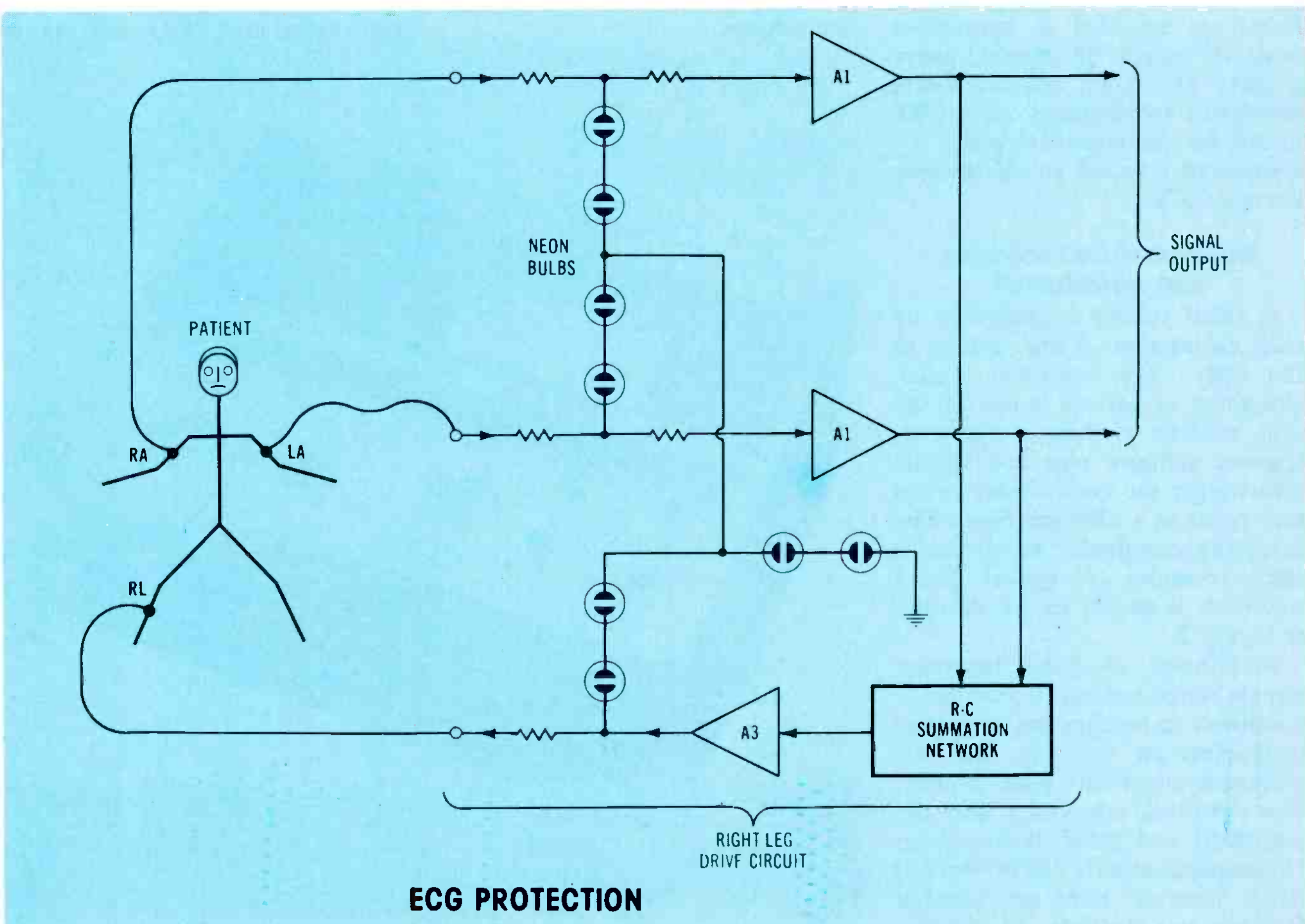


Figure 3 Neon-bulb protection of the ECG preamplifiers and a hum-cancelling drive to the right leg are two features shown by the block diagram.

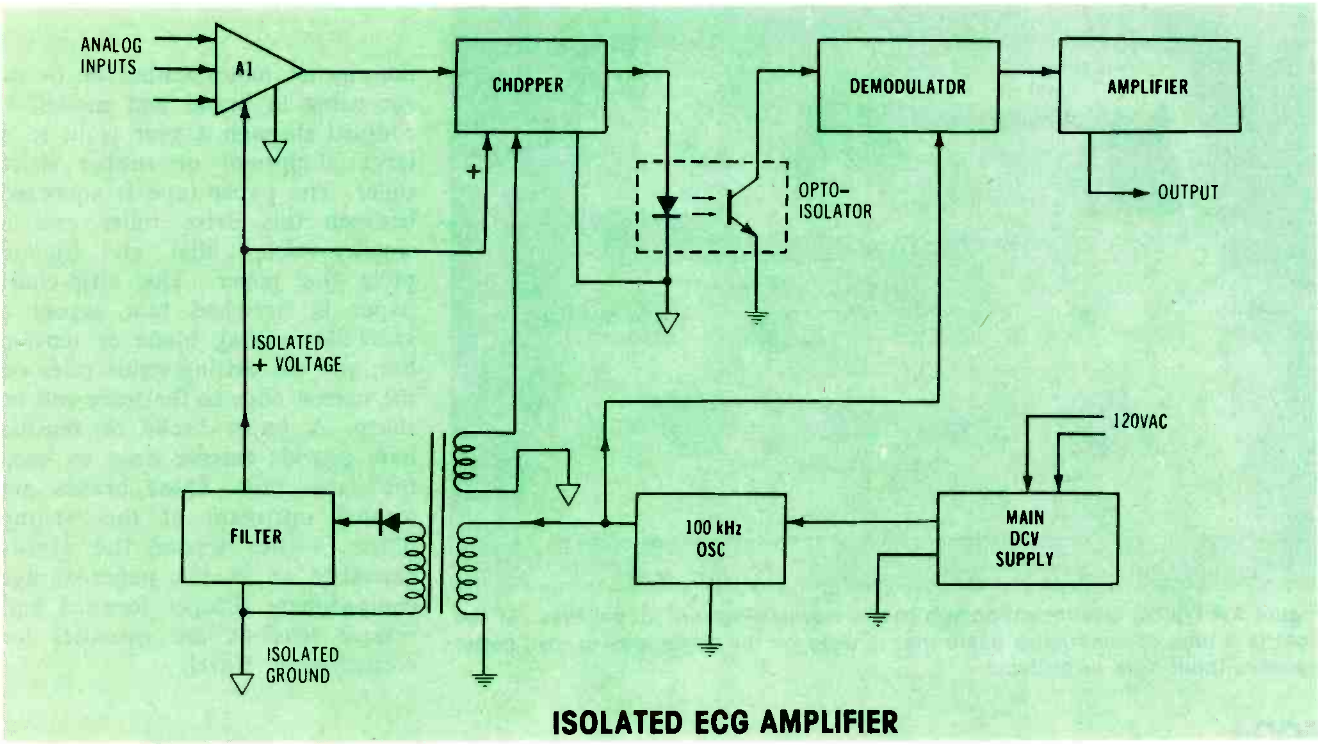


Figure 4 An opto-isolator transmits ac signals while providing very high isolation between its inputs and outputs. A 100kHz oscillator has isolated windings that furnish ac power for a separate isolated power supply, the isolation chopper, and the demodulator that recreates the original waveform from the pulses sent across the opto-isolator. Therefore, the input preamplifiers and the patient-connecting leads are isolated completely from everything. This is necessary for patient safety.

short-term recordings, a flat metal electrode is applied to limbs while a suction-cup-equipped electrode is attached to the chest.

For the limbs, the metal electrode measures about one 1"x2" and has a binding post on one surface. It is held to the patient's limbs by rubber straps. The chest electrode is a small metal suction cup with a rubber squeeze ball to generate the suction that holds it to the skin. However, long-term monitoring for ICU or CCU usually requires disposable foam-rubber or paper-backed "paste-on" electrodes.

A more secure electrical connection between electrode and skin is provided by a conductive paste or jelly which is smeared on the electrode before use. The paste also reduces artifacts (spurious signals) and minimizes the small dc offset voltage that is generated by the interface between electrode and skin. A typical tube of conductive past is shown beside the ECG in Figure 5.

Differential input

A typical ECG input stage is shown in Figure 3. The resistors and neon bulbs are there to protect the ECG when a defibrillator is discharged on a patient who is being monitored. Peaks up to 3000V can appear at the ECG inputs during defibrillator discharges.

Differential inputs are necessary to cancel or phase-out any signals that are common to both inputs. This includes 60Hz hum that comes by capacitance effect from surrounding power wiring. Because hum has a faster repetition rate than heartbeats have, it appears as a broad base line.

In older ECG machines, the patient's right leg was grounded directly to the ECG chassis, and the chassis in turn was grounded (through the power-cable third wire) to ac-power ground. However, this is a significant safety hazard, which has been solved by two changes. One is the use of isolated input amplifiers (described later). The other improvement uses the right-leg lead for another purpose.

In Figure 3, the differential inputs come (for the lead-two connection shown) from right arm and left arm which furnish the signal. *The right leg receives a signal, rather than supplying one.* Outputs from the two A1 input amplifiers are sent to a resistor-capacitor summing network that cancels the differential signal and passes the common signal. Therefore, the output of amplifier A3 contains only 60Hz hum and other undesirable signals. These common-mode signals are applied out-of-phase to the right leg, where they partially cancel the in-phase hum and noise at the arms.

Isolated amplifiers

Figure 4 shows a block diagram of an isolated-amplifier system. A 100kHz oscillator receives dc power from the main ECG supply. One winding of the 100kHz output transformer feeds a rectifier and filter system that is isolated from the ECG ground—and *all* other grounds, also. Notice the triangular ground symbol. The preamplifiers are operated from this isolated dc power.

Output from the preamplifier is a low-frequency analog signal that cannot efficiently pass through an isolation transformer. Therefore, it is changed to high-frequency slices of varying amplitude by the chopper circuit. The chopping is accomplished by another isolated signal from the 100kHz transformer.

The chopped signal is applied to

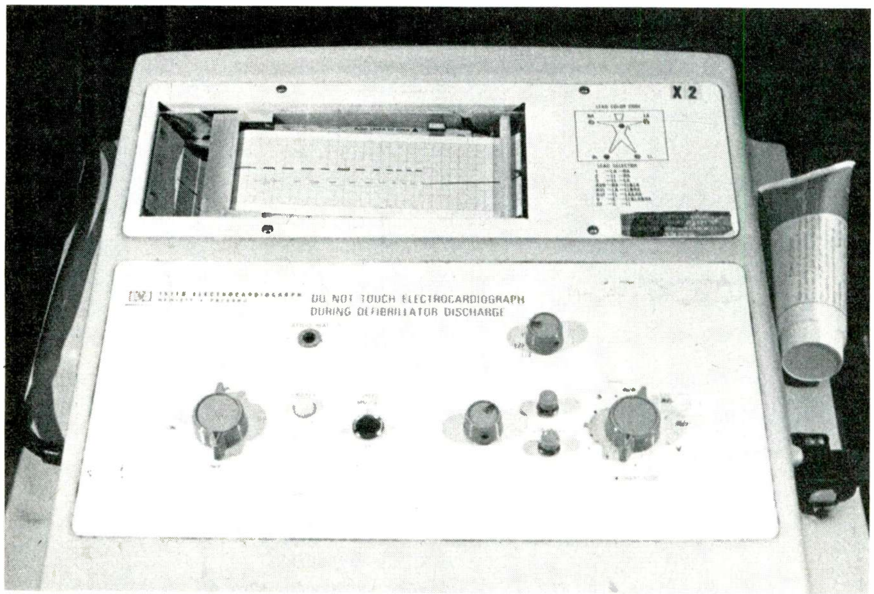


Figure 5 A typical electrocardiograph is this Hewlett-Packard model 1511. At the right is a tube of conductive paste that is used on the electrodes to give better traces without hum or artifacts.

the LED end of a photo opto-isolator, where the pulses produce rapid LED blinks that vary in brightness. A photo-transistor in the opto-isolator assembly receives the pulses of LED light, changes them to electrical pulses that are then passed to the demodulator where synchronous demodulation restores the original low-frequency analog waveform. This waveform is amplified in conventional fashion.

Notice that the ac signals (as well as the dc power) of the opto-isolator transistor, the demodulator and all following amplifier stages are referenced to ECG ground. Also, notice that the link between isolated and non-isolated circuits is the light beam between LED and photo transistor in the opto-isolator.

With isolated preamplifier, almost perfect isolation (and patient protection) can be obtained between the patient leads and all other grounds, including ac-power ground. The measured resistance can approach 1,000,000,000,000 Ω.

A typical ECG

Typically, an ECG has a rotary lead-selector switch, a 1mV standard level switch, a sensitivity switch, stylus-heat control, a trace-centering control, tape-speed selector and an on/off switch. The readout is made on moving paper tape. A Hewlett-Packard is shown in Figure 5.

Two types of writing stylus are employed, depending on the specific machine. One kind is an ink pen that operates by the fountain-pen principle. Ink pens are used now only in research machines or those ECGs used with central-monitoring systems in operating rooms or catheterization laboratories.

Almost all clinical ECGs have *thermal* tips that mark the paper tape. The tip of the stylus either is a resistance element (older models) or it contains a resistance wire. In both types, the resistance is heated by low-voltage electricity, which can be ac or dc according to the model The strip chart paper for thermal tips is treated with paraffin so it turns black when the hot stylus tip touches it.

A permanent-magnet moving-coil galvanometer moves the pen or stylus writing tips. This galvanometer is merely a stronger version of the familiar D'Arsonval meter movement with a pen or stylus instead of a meter pointer attached to the winding bobbin. The galvanometer is operated from amplifier power.

A second smaller stylus marks the edge of the strip paper, and it is moved by a relay armature or electromagnet that is energized through the mark control. Pressure on the *mark* button places a mark indicating a change of leads or the start of some other event, such as the injection of a drug.

The paper-drive system is simple. An electric motor (either ac or dc according to brand and model) is coupled through a gear train to a large aluminum or rubber drive roller. The paper tape is squeezed between this drive roller and a smaller rubber idler, and friction pulls the paper. The strip-chart paper is stretched taut across a knife-like writing blade or tension bar, and the writing stylus rides on the narrow edge so the trace will be sharp. A paper brake or tension bars provide reverse drag to keep the paper taut. These brakes are located upstream of the writing blade, either under the stylus assembly or in the paper-storage compartment. Proper forward and reverse tensions are essential for correct paper travel.

Typical ECG problems

The problems of servicing ECG machines tend to fall into two basic groups. One group consists of actual defects. These defects call for troubleshooting and repairing the machines. The other complaints are caused by operator errors, and the technician should enlighten the customer tactfully. Diplomacy is essential for success when dealing with medical personnel.

60Hz hum—It is possible, but very rare, for ECG machine faults to cause 60Hz signals on the waveform. An open power-supply filter, a broken connection at the lead switch or input connector, or a corroded lead-selection switch can produce 60Hz that rides on the waveform base line.

In almost every case, however, the source of hum is external to the ECG machine. The hum is seen if a patient cable is open, the connector is broken, the electrode is defective, or the electrode paste has dried.

An open in the power-line grounding circuit, a high-resistance ground through a defective third pin of the power plug, or a loss of ground-pin tension in a wall ac outlet also can produce 60Hz hum. In the latter case, a nurse or ECG technician might report that the machine malfunctions only in a certain room.

The patient cable leads can be tested by shorting together all wires at the patient end and noticing whether or not the hum disappears from the trace. Use an ohmmeter to trace the continuity of individual leads. Most leads are made from conventional wire and test almost zero resistance. Some older solid-state ECGs have lead wires that measure 10K Ω (for better protection from defibrillator damage).

Handling problems of 60Hz interference requires much diplomacy. Probably the nurses and ECG technicians have been warned that 60Hz interference *might* indicate a life-threatening situation. Although the probability is very low, the threat of malpractice suits can make hospital personnel overly careful. Therefore, it is best to make a call and check out the problem, even when a nurse or ECG technician could "repair" the machine by cleaning an electrode.

Also, there will be cases where the nurse has enough time to check the electrodes and cables, but reports that the problem still is there or that it is worse. Usually the continuation of symptoms is caused by substitution of another cable that was previously defective, but was not thrown away after it was found to be bad. Therefore, it is good practice for a technician to take diagonal cutters and operate on the bad cable so it will not be used with another ECG machine.

Incidentally, an open lead wire often can be identified by operating the lead-selection switch and noticing which positions work correctly and which ones have hum. Compare this information with the chart on the machine to determine which lead is open.

Wandering baseline—When a monitored patient moves, the ECG trace slowly moves up and down. But the trace can wander continually if the paste has dried on an electrode, Cleaning the electrodes with alcohol pads (or even warm water) sometimes cures wandering baselines.

Smeared traces—The nurse or ECG technician probably will tell you over the phone that the machine needs a new stylus. Sometimes the snap diagnosis is correct. The side of the stylus that contacts the paper might be worn, or a piece of charred paper or other debris might be trapped under the stylus. Such cases require stylus replacement or cleaning.

However, many times the blurred trace is caused by insufficient back tension on the paper tape. This allows the paper to make a large bend around the tension bar, and the stylus contacts too large an area of paper. Misalignment of tension rods or the paper brake can thus produce blurred traces.

The possibility that the strip-chart paper has been loaded incorrectly is even more likely. This type of complaint often reaches epidemic proportions with new students or staff members.

Incidentally, it is far more difficult to load the tape incorrectly than to load it correctly. Generally, it is necessary only to make certain the tape moves *over* the tension bar but *under* everything else.

No trace or a light trace—Only two general problems can cause a light trace or loss of the trace. One is insufficient stylus pressure against the paper. Figure 6 shows the stylus and galvanometer after the access cover is removed.

To test for insufficient stylus pressure, gently press down on the tip with pencil or small screwdriver while the paper is moving (Figure 7). If a wide dark trace is formed while pressure is on the stylus tip, this proves the pressure had been too weak.

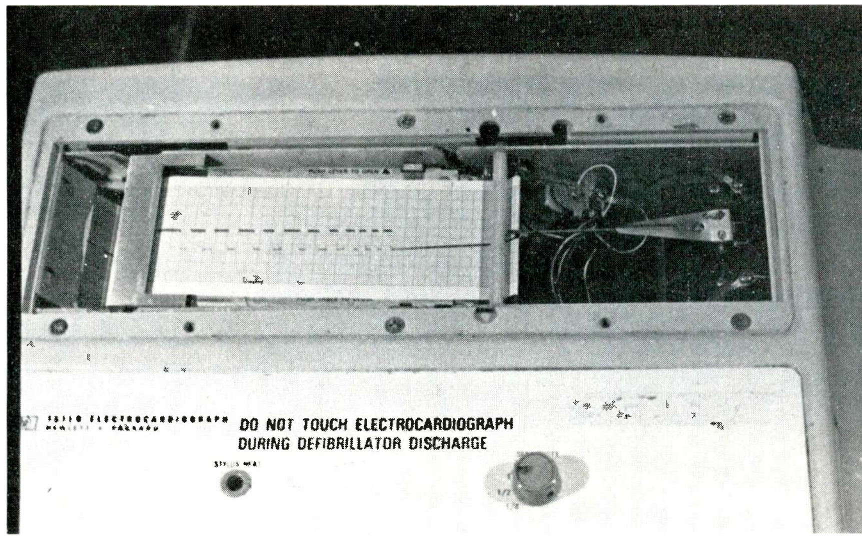


Figure 6 The stylus and galvanometer are exposed for convenient voltage tests and stylus-pressure adjustments after the access cover is removed.

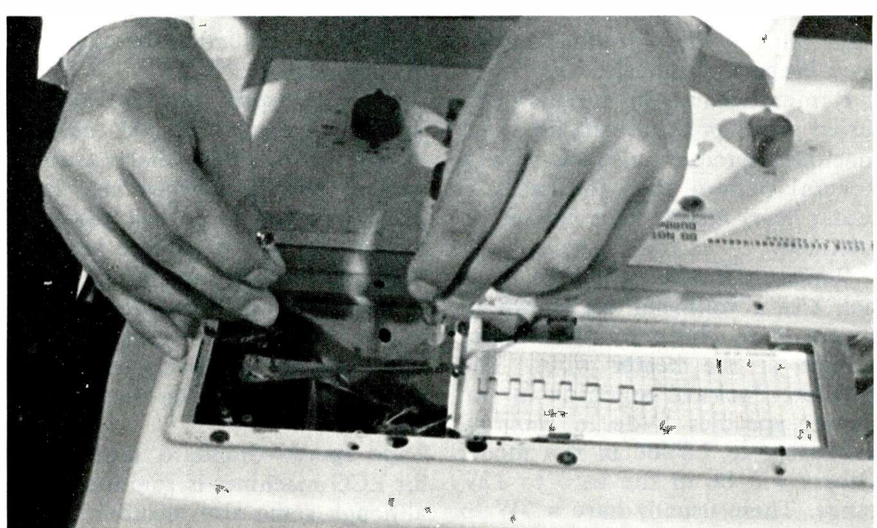


Figure 7 The technician is adjusting the stylus pressure with a screwdriver (at left) and a pressure gauge.

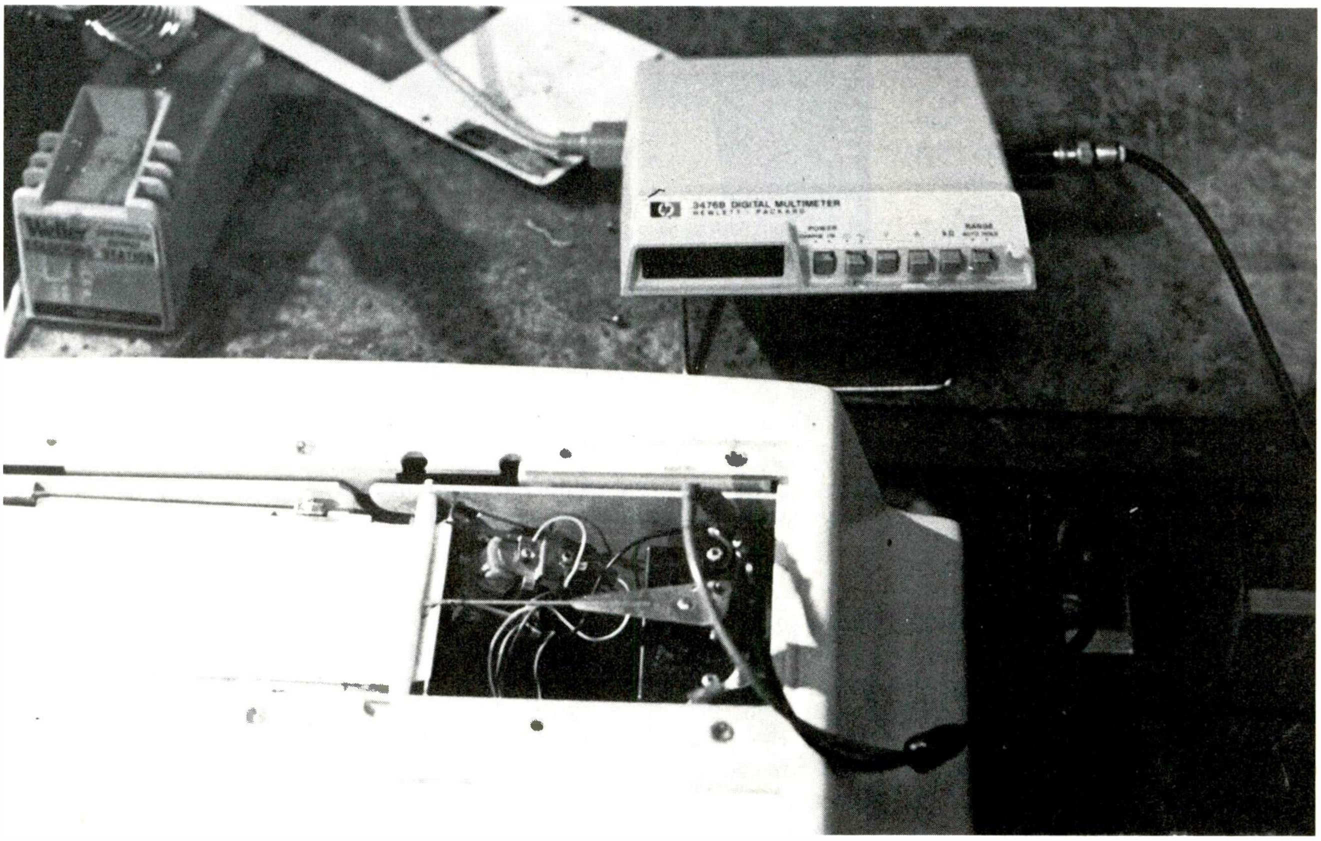


Figure 8 Galvanometer voltage can be measured without removing anything except the access cover. Use an accurate meter, such as a digital multimeter.

Do not adjust the stylus pressure with guesswork. Instead, it is imperative the pressure is adjusted to the manufacturer's specification, which requires a small screwdriver and a stylus-pressure gauge. The correct adjustment has been reached when the stylus barely lifts off the paper—suddenly producing a light trace—at the gram weight specified by the manufacturer. Always refer to the specification for each brand and model.

Remember, an incorrectly adjusted stylus pressure can (in some machines) produce a trace with a normal person that indicates a recent heart attack. This cannot be tolerated.

Replace the stylus when the tip is hot. Use a voltmeter (as shown in Figure 8) to check for the correct voltage at the heater wires. The Hewlett-Packard machine in the picture specifies 5Vdc in *standby*, increasing to 7.5Vdc in *run* mode. Others will be in the zero to 12V range. These usually have a 3W to 5W wirewound rheostat in series with the heater element to function as an adjustable-heat control.

Zero voltage across the heater might indicate a defective power supply, open heat control or a heat control turned all the way to zero.

Damping problems—Incorrect mechanical or electronic damping can distort ECG waveforms. Excessive damping rounds the corners of pulses and square waves about the same as a reduction of high-frequency response.

Both electronic and mechanical damping controls should be adjusted for the best sharp corners without overshoot when the standardize button is pushed regularly to apply a type of square wave to the tape. Most manufacturers specify that the overshoot and undershoot should not exceed 0.5mm when a 1mV pulse covers 10mm (two major division) on the paper.

Tape speed—Standard tape speed for ECG machines is 25mm/second, although some also include 50mm/second for fast-beating baby hearts.

Speed can be checked easily by using the marker stylus and a stopwatch. Mark the paper when the watch is started and again when the watch is stopped. Ten seconds is a convenient test time because exactly 250mm of tape should be measured between the marks.

Most speed problems are caused by slipping idler rollers or worn drive rollers, although worn gears and bad drive chains cause some troubles. The motors never seem to go bad.

Tools and equipment

Few special tools are required for ECG repairs. The usual hand tools and an accurate multimeter are sufficient. A good selection of spline and hex Allen drivers are time-savers, and a stylus gauge of the proper range is essential. A signal generator of the type that emits a simulated ECG waveform can be very valuable for testing repaired machines. In the trade, this kind of generator is called a *chicken heart*. One source of medical generators is Med-Search Systems, 5480 Wisconsin Ave., Chevy Chase, MD. □

reader's exchange

There is no charge for a listing in *Readers Exchange* for items "Needed," but we reserve the right to select and edit all copy. Due to the limited amount of space for this department, "Needed" listings must contain no more than *three* items. If you can help with a request write directly to the reader, not to **Electronic Servicing.** "For Sale" listings will be charged for and included in the regular classified section of **Electronic Servicing.** Please consult that section for price and ordering instructions.

Needed: Vectorscope, Sencore ringer yoke and flyback tester, and B&K-Precision 1077B Analyst. *Ken Miller, 10027 Calvin St., Pittsburgh, PA 15235.*

Needed: Old radio service literature. Old tube types, *WD11's, 71, 112's 26, 45, 47, Dallas Swindal, 1112 San Jose Ln., Hanahan, SC 29406.*

Needed: 6AAJ8/ECH81 and 6DA6/EF89 tubes. *James L. Bolich, 460 Doris Circle, Aberdeen, MD 21001.*

Needed: Servicing information on Dressen Barnes dc-regulated power supply model 1K500B; Dynamic Instrumentation microcomputer model 4132; TEK 291. *J. Allen Call, 1876 E. 2990 So., Salt Lake City, UT 84106.*

Needed: Schematic for Seeburg AM/FM stereo model SS40. *A. Volovcin, 24 Mason St., Metuchen, NJ 08840.*

Needed: Schematics for National Leisure Corporation of Anaheim, CA, video games. PC modules made by Six Pac (World Wide Video). *E. Farker, 305 Main St., Huntington Beach, CA 92468.*

Needed: Schematic for Concord camera MTC12. Quote price. *Ernest Jones, 810 W. Vernon Ave., Kingston, NC 28501.*

Needed: Schematic for an old Westinghouse radio model WRK-275. *Dan Grim, 9912 Mesa Arriba N.E., Albuquerque, NM 87111.*

Needed: Schematic and service data for Lowe—Opta Fonovox Senator-Stereo type 532224 console stereo system. Will buy, or copy and return. *Jasper Baker, 700 Lenox Ave., Apt. 21A, New York, NY 10039.*

Needed: Schematic for Knight model KG-687 sweep marker generator. Will buy or copy and return. *Mike Larinoff, 5403 Cedar Creek, Houston, TX 77056.*

Needed: Schematic for a Concord AM/FM stereo receiver model MK-12. Will copy and return, or pay for copying. *James E. Higley, 1460 Cypress Ave., Hanover Park, IL 60103.*

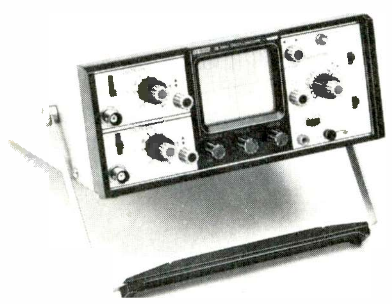
Needed: Sencore SG165 stereo Analyst, dual-trace scope, and other TV-stereo test equipment. Must be in good working order with probes and manuals. *Electronic Specialists, 1685 Edna Pl., Macon, GA 31204.*

Needed: A scope diagnostic unit and exhaust gas analyzer for automobile engines. *George Epstein, 200-27 46th Ave., Bayside, NY 11361.* □

test equipment report

15MHz mini-scope

The **B&K-Precision** model 1420 portable mini-scope features bandwidth rated at 15MHz, vertical sensitivity rating of 10mV per division, usable response beyond 20MHz, and an optional battery pack. The 1420 can be powered by 117Vac, 234Vac, 10-16 Vdc or optional internal battery. Both high- and low-voltage power supplies are fully regulated, maintaining time



base and amplitude accuracy over a wide range of input voltages.

The 1420 is priced at $825, and comes complete with two lightweight slim-body 10:1/reference/direct probes (includes accessory tips for each probe), ac power pack and detailed instruction manual. Options include a rechargeable battery, 234 Vac power pack, carrying case, dc power cable and demodulator probes.

Circle (23) on Reply Card

Ac voltmeter/ammeter kit

The model 30-K ac voltmeter/ammeter kit by **Triplett** includes a drop-resistant clamp-on model 30 volt/ammeter, the model 101 line separator for in-circuit ammeter readings, the new model 32 Ohms (0-1000 Ω) probe for extended VOM capability, and a carrying case.

The kit is priced at $95.

Circle (24) on Reply Card

Frequency standard

The model 4401 frequency standard from **Global Specialties** incorporates a crystal oven oscillator developed by the model 6001 650MHz frequency counter. Twenty-five output frequencies are available. In addition to a full-time output at 10MHz, one of 24 secondary outputs may be selected between 0.1Hz and 5MHz through the combined action of a pushbutton 8-decade output scanner and a x1/x2/x5 multiplier selector switch. Both the 10MHz output and the selected output are buffered 50 Ω TTL-compatible-square waves, short-circuit-

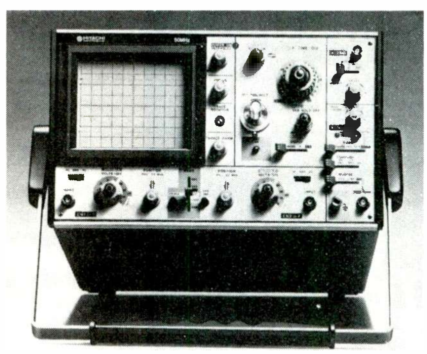
proof, and are available at front panel BNC connectors.

The model 4401 is factory calibrated to the National Bureau of Standards via WWVB, and the calibration control inside the case is user accessible.

Circle (25) on Reply Card

50MHz scope

Hitachi has introduced the model V-550B 50MHz dual-trace delayed sweep scope. The V-550B features 6-inch square CRT with an internal graticule, trigger view, (external and internal triggering signals can



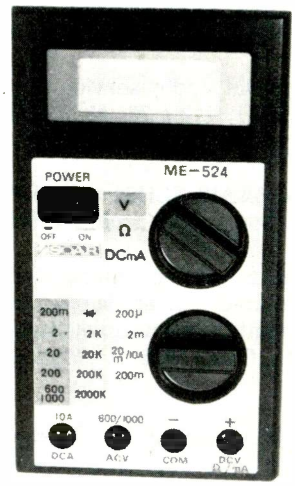
be displayed as a third trace), variable trigger hold-off, full TV triggering and single sweep capability. An automatic focus whenever intensity or sweep range control settings are altered.

The price of the V-550B and two probes is $1745.

Circle (26) on Reply Card

3½-digit LCD multimeter

The model ME-524 from **Soar**, is a 3½-digit LCD multimeter that has a built-in buzzer for making continuity checks. It also features four function modes, automatic polarity indication, and automatic zero adjustment. All modes appear on the LCD display. The battery-operated ME-524 can measure dc voltages



from 200mV to 600V, ac voltages from 200 to 1000V, dc current from 200mA to 10A and resistance from 2k Ω to 2 Ω.

The price of the ME-524 is $90.

Circle (27) on Reply Card

Multitester

Universal's M75 multitester features 17 ranges, a fuse protected OHM circuit, color-coded scale plate and front panel, diode protected movement, sensitivity of 20,000 Ω /Vdc and 10,000 Ω /Vac and a one year warranty. The M75 comes complete with carrying case, test leads, batteries and instructions.

Circle (28) on Reply Card

Rugged VOM

The WV-590 VOM from VIZ features a ring-core taut-band meter movement and ABS plastic case, that can endure dropping, banging and shaking without damage. The meter movement has been ruggedized and is sealed against dust and moisture. A varistor protects the movement from overload while a snap-in fuse protects the electrical circuits. The unit can measure dc and ac voltage, dc current, resistance, decibels and audio-frequency voltage levels, a total of five functions with 20 ranges.

The WV-590 is available for $69.

Circle (29) on Reply Card □

product report

Storage Cabinets

A-M modular cabinets by **Akro-Mills** are available in 14 cabinet models with 10 sizes of drawers. Six models feature transparent drawers, and eight models have heavy-duty gray drawers. All cabinet frames are made of welded steel and are 18-inches wide. The cabinets are designed to stand independently, stack together, hang from walls or fit into standard shelving.

Circle (30) on Reply Card

Soldering iron

An industrial grade precision soldering iron with a rapid heat-up time is available from **M. M. Newman.** The Antex model G/3U is a lightweight, miniature soldering iron that reaches operating temperatures in 45 seconds. Featuring a

balanced, proportioned handle, it has replaceable 3/32-inch diameter tips that slide directly over the heating element for efficient power usage.

The Antex model G/3U is priced at $14.95.

Circle (31) on Reply Card

Personnel lift

A powered personnel lift has been introduced by **Genie Industries** for overhead maintenance and installation work. The PL24P is an aluminum lift with a platform height at full extension of 23'8" that yields a working height of 31 feet. The unit is powered by an ac motor and hydraulic pump system. An optional 12 volt dc battery pack and recharging unit is also available.

Circle (32) on Reply Card

Workbenches

The BFC Workbench Component System, a line of workbench components that can be made up into a wide variety of benching combinations, heights and sizes is now available from the **Bernard Franklin Company.** The system is based on the use of two central components: bench legs, leg adaptor and workbench tops. Interchangeable drawers; adjustable shelves; modesty panels; steel, plastic, or wooden tops; and electrical outlets can be added to the benches.

Standard finish is gray baked enamel with a rust-resistant phosphatized pre-paint treatment. Optional colors are available. Prices start at $84.95.

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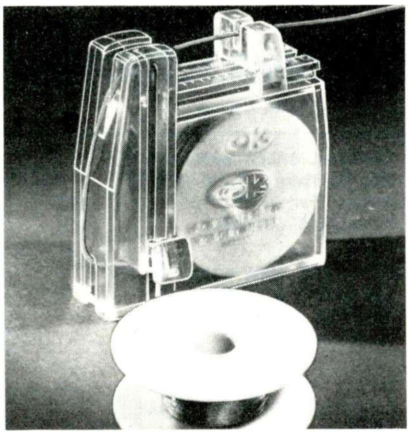

Wire dispenser

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Each AD dispenser, complete with wire, is $11.95; refills are $3.98; and replacement blades are $1.98.

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