# ELECTRONIC

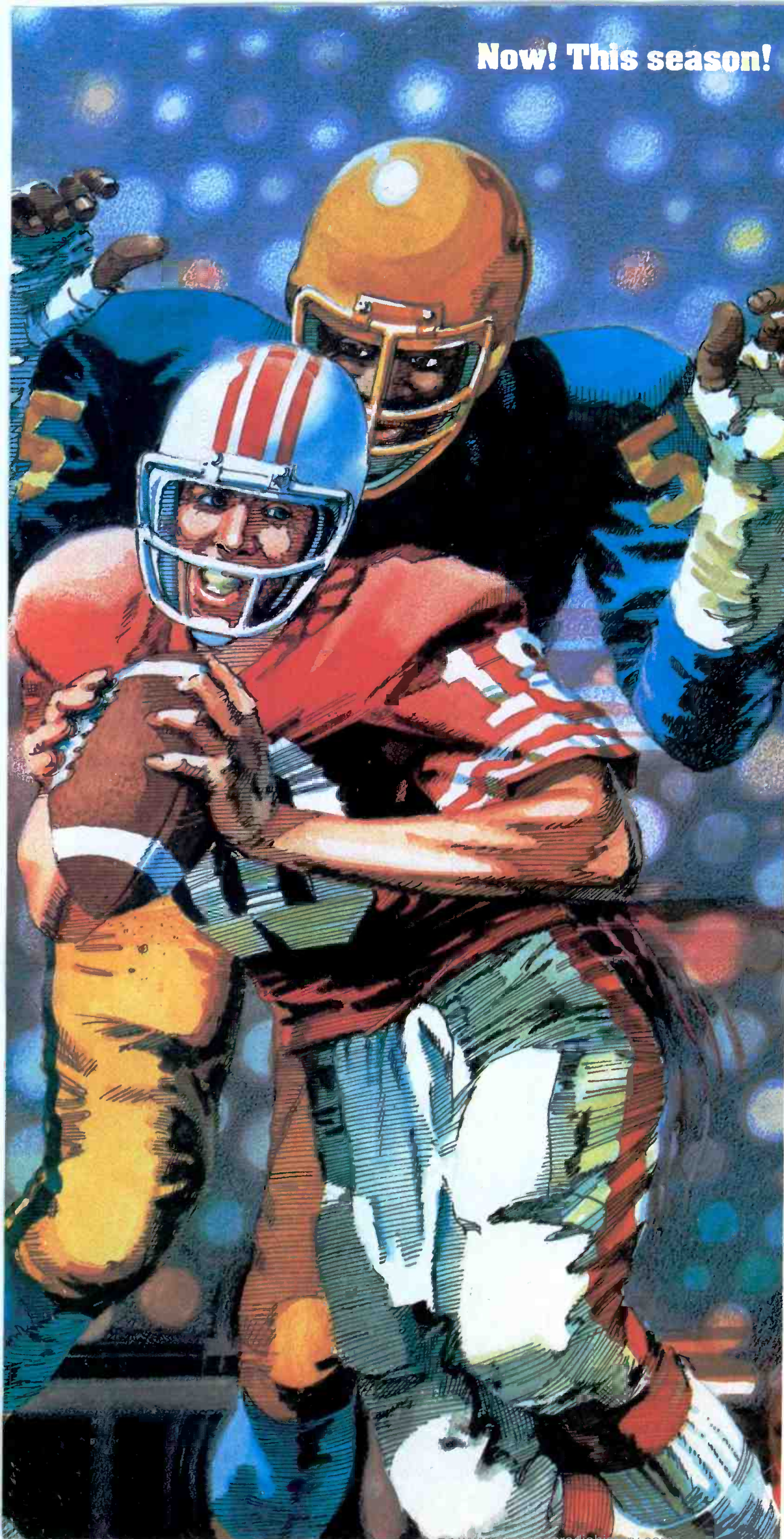
## Servicing & Technology

SEPTEMBER 1984/$2.25

Low-power microwave generators • New PCs

Satellite TV receiving systems • Ten dogs in TV repair


TV via microwaves

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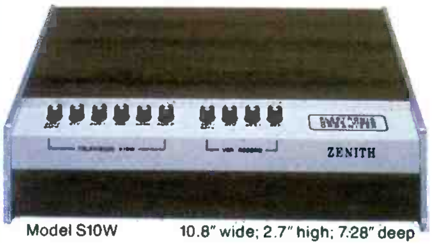


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*The how-to magazine of electronics...*

# ELECTRONIC Servicing & Technology

September 1984
Volume 4, No. 9


An understanding of TVRO, DBS and other advanced TV signal delivery systems requires an understanding of microwave-frequency circuits. The article "Low-power microwave generators" in this issue describes the theory of operation of some solid-state microwave devices. (Cover photo courtesy Comsat, Inc.)

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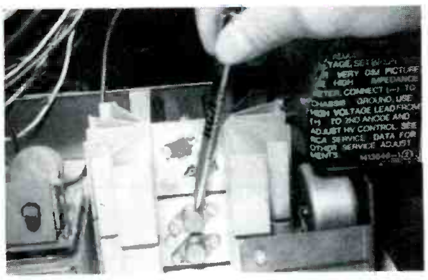

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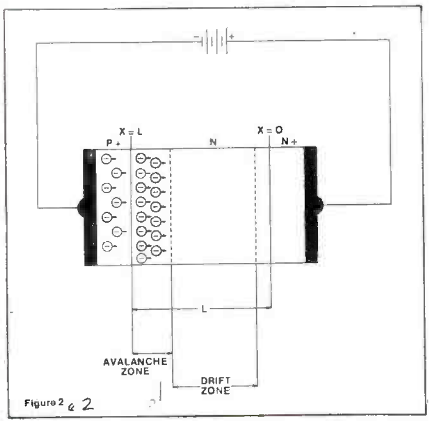


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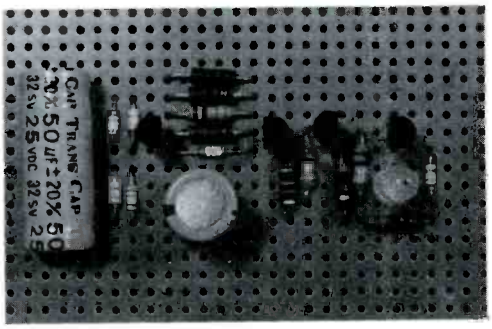
# Departments





**Next month... Build this speaker protector circuit—**

Test bench speakers take a lot of abuse, often being over-driven or fed from sick amplifiers at extremely high levels. The speaker protector circuit detailed in next month's article monitors the speaker lines, watching for a positive or negative dc voltage to appear at the speaker terminals.

# Watch your language

Language is one of humankind's most remarkable achievements. When the grunts and groans of humans turned into words, real communication became possible. Language is the facility that allows our society to function smoothly and harmoniously (more or less). Differences in language across different societies, on the other hand, impede communication. One of the most formidable barriers to foreign travel is to learn enough of the language spoken in the country you're going to visit, enabling you to get by.

It isn't only among the different nationalities that language barriers have been erected, though. Every profession has its own language that effectively keeps outsiders out. The medical profession has been branded with the reputation of discussing patient's problems in medical-book language the patients can't understand. Just look around at some of the other professions: Psychology, politics, accounting, banking, retail sales and manufacturing all have their own jargon that's difficult to penetrate. And, of course, nobody understands lawyers.

The world of electronics is no exception. It requires a fair investment in time and effort to learn the language of electronics. And have you ever noticed how many glossaries of terms have been published in various areas of electronics?

I'm convinced that if you really want to understand a subject, like electronics, you have to be a student of the language, and care enough to dig into the meanings and origins of words. Taking my own advice, I've recently started doing just that. Do you have any idea where the word *electronics* itself comes from? A little trip to any dictionary will reveal that *electronics* can be traced, ultimately, to the Greek word electron, meaning amber. Early experiments with static electricity involved amber, which attracts and then repels small bits of paper or other substances when rubbed.

Many other electronics terms don't yield quite as easily. For example, a look through my American Heritage Dictionary of the English language gives a definition of klystron and goes on to give the origin of the word as from the Greek kluster, syringe, clyster pipe, from kluzein, to wash out. That's interesting, but what does all that have to do with microwave. And, when I looked up the term *aquadag,* that conductive material sprayed on the inside of picture tubes, I struck out completely. I plan to keep looking, however.

Knowing the language won't make anyone an expert in any profession or pursuit, but it does remove one of the barriers and makes learning everything else about that area of study a whole lot easier.

Nils Conrad Persson

**ELECTRONIC Servicing & Technology**

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



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

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# New PCs may be a steel

Augmentative replacement process allows circuits to be printed on almost any surface

Wouldn't it be a shock to open up the back of a TV set to service it, and find a printed circuit board made of steel? Well, it isn't likely to happen any time soon, but through a new printed circuit process developed by the General Electric Company, circuits can be printed not only on steel, but also on plastics, glass or even paper.

Covered by a number of patents, the new technology will enable printed circuit producers to realize cost savings ranging into the millions of dollars a year. The process is simple and low in cost, and it results in printed circuits that, in many applications, can directly replace those produced by conventional techniques.

Fundamental to the new process is a family of special metallic *inks* consisting of a liquid polymer (several different types can be employed) loaded with fine, powdered metals – a mixture of iron and nickel.

To define a circuit pattern, the polymer ink is transferred to an insulating substrate (for example, circuit board) by a process known as *screen printing*. A standard technique for circuit patterning, screen printing makes use of an ultra-fine mesh (resembling window screen, but much finer) in which all areas other than those defining the circuit are blocked out to form a sort of stencil. The ink is then pushed through the openings in the screen – to define the circuit pattern – employing a squeegee.

After the circuit board has been patterned in this manner, it is run through an oven to harden and cure the ink. This process takes about 20 minutes, employing a conventional cross-flow oven, or as little as one minute with an infrared oven. Then the circuit is plated with copper to make it electrically conductive by dunking it in a special copper sulfate bath.

When the circuit board is immersed in this bath, a chemical reaction is initiated because of the dissimilar metals – the iron and nickel in the cured pattern ink and the copper in the plating bath. As a result, some of the metal powder in the cured pattern ink dissolves (going into solution as ferric sulfate), and pure copper from the copper sulfate bath takes its place.

The process is known as *augmentative replacement* because the copper in the plating bath augments and replaces the metal powder in the printed conductor pattern.

The plating process takes about five minutes (vs. as much as eight hours for conventional electroless plating techniques) and produces a contiguous layer of copper along the conductor pattern. This copper film is highly conductive and can be soldered without special preparations. Extensive tests have established that it adheres tightly to the substrate, even under conditions of sustained high temperature and humidity.

With the new process, circuits can be printed on virtually any substrate. As mentioned at the outset, in addition to the standard phenolic insulating board, the list includes all kinds of plastics, glass, paper and even steel.

In many respects, steel is ideal. It is low in cost and strong, and it is a good conductor of heat (to help dissipate that which is produced by electronic devices mounted on it). The fact that it is electrically conductive is its only major drawback.

To overcome this problem, GE Research and Development Center researchers developed a family of special polymer insulations. Applied to the steel by dip- or roll-


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coating techniques, these materials are based on a proprietary catalyst that enables them to be cured under ultraviolet lamps in just three seconds. They are flexible, enabling the steel to be bent if desired, and they have high dielectric strength.

The same polymer insulations can be employed in the fabrication of multi-layer circuits – complex assemblies consisting of individual printed circuits built up layer upon layer (like the floors of a multi-story house). Because of the almost instantaneous curing, the use of these dielectrics to provide insulation between the various conducting layers greatly speeds the fabrication of such circuits.

Compared to conventional techniques, cost savings in excess of 10 to one can be achieved by fabricating multi-layer circuits using the fast-curing dielectrics in conjunction with the augmentative replacement process. The base-level conductor pattern is screen printed, cured and copper plated (as it would be with a single-layer circuit) and then coated with the dielectric layer – leaving holes in it where layer-to-layer electrical interconnections are desired. This procedure is repeated over and over to create the required number of interconnecting layers.

To complement the new polymer-based conductors and insulating systems, R&D Center researchers also have developed polymer-based resistor inks that, like the conductor inks, are screen printed on a circuit and then cured with heat. These low-cost inks make it possible to lay down hundreds of resistors with one pass of a screen printer – eliminating the need to drill holes for individual resistors and solder them in place.

To avoid the cost of inventorying numerous resistor formulations of different resistivities, the GE researchers came up with two compatible mixes that can do the whole job. Virtually any value of resistance can be obtained by blending the proper proportions of *mix A* and *mix B*.

The patents granted GE cover the broad technology, including the polymer conductors, insulators and resistors, as well as certain specialized applications. ES&T

# News

### GE establishes information service

General Electric has established a computerized customer information network that provides retail and contract customers instant access to important business information.

GE 724 is a toll-free telephone service that helps dealers control inventory and improve their service to consumers by allowing them to place orders and receive immediate confirmation of model mix, product availability and shipping dates. Also, the customer can change the order virtually at any time of day or night and that change will be instantly confirmed.

"GE 724 places finished goods inventory and shipping schedules at the immediate disposal of the customer. For example, a retailer, upon checking the availability of a certain product, can order that product shipped directly to the consumer's home immediately, saving time and expense," says Richard B. Williams, general manager of marketing for GE Video.

Introduced regionally last spring, GE 724 is now available in all GE markets in the United States.

### Satellites target TV interests

Almost 48 million North Americans will be tuning into TV programs broadcast directly from satellites by 1994, says a new study from Frost & Sullivan, New York, NY.

According to *Direct Broadcast Satellite Market,* these *DBS* channels will offer viewers an alternative to lowest common denominator programming by creating shows that appeal to special interests, such as cooking, opera, and sporting events. Pay-per-view (PPV) programming will be offered extensively on DBS. The DBS service provides for the direct reception of video and audio signals through private roof-top antennas from a satellite, rather than over the air from a local broadcasting station or through a cable system.

The long-term business potential of DBS is seen as great: By 1994, revenues from satellite transponder rentals will reach $764 million, programming fees will reach $2.8 billion, and equipment sales will amount to more than $3 billion, predicts the study.

### Color printer market to top $4 billion

The recent widespread adoption of color monitors and color-capable software will drive color printer sales to $4.1 billion in 1993, far beyond the 1984 market of about $750 million. According to a new 190-page report from International Resource Development, a Norwalk, CT, market research firm, this 18 percent annual growth will be fueled mostly by sales of pen plotters to the scientific/engineering and business communities, whose appetite for the generally high-ticket items will drive the market's revenues. Honors in the units shipped category, however, are expected to go to ink jet printers.

The study, *Color Printers,* concludes that new software packages will take advantage of increasingly popular color monitors to accentuate both business graphs and children's home computer "art." At the same time, the report says, the growing demand for color displays will spark a concurrent call for printers capable of reproducing the colorful screens both affordably and with good resolution. These two factors should boost the current installed base of 600,000 color printers to some 22.7 million by the end of 1993, an average annual increase of more than 40 percent.

The IRD study predicts that revenues from pen plotter sales will account for approximately 37 percent of all 1993 color printer business, not surprising considering their usually high price. In unit terms, however, pen plotters are seen as finishing third, behind ink jet (35 percent of all shipments) and thermal transfer (32 percent) printers.

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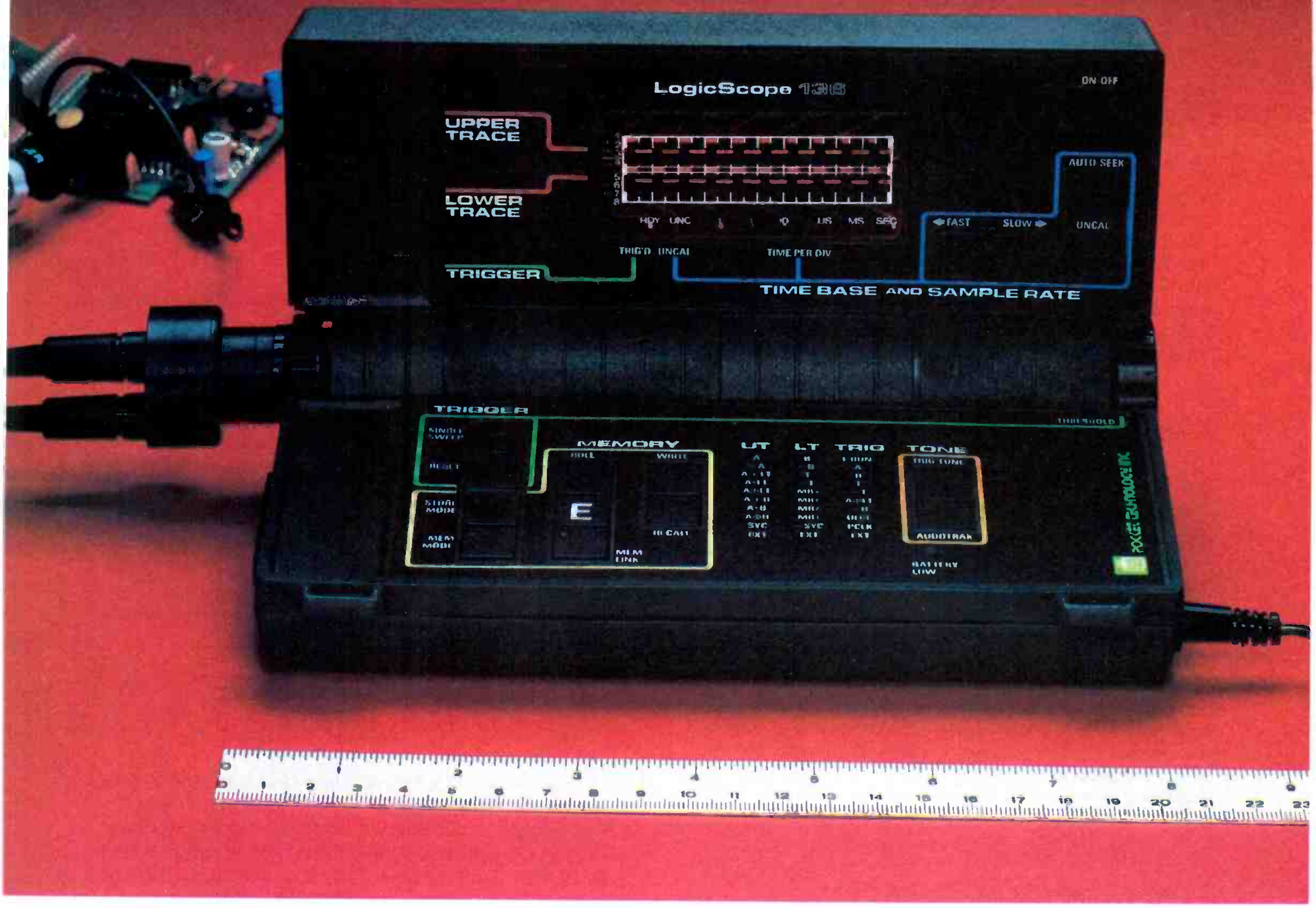


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■ The pocket-sized LogicScope 136 is made possible by a patented breakthrough in display technology. The conventional cathode ray tube has been replaced by a unique array of 400 LED's that permits simultaneous display of two digital waveforms.

■ The 136 can be used for viewing single shot events, or repetitive waveforms. It can be operated in real time mode, or in memory mode which permits acquisition and storage of up to 24 128-bit waveforms. These can be recalled, logically compared (AND, OR, EXCLUSIVE OR) to other stored/input waveforms, or output to an external device via an RS 232 port.

■ Its very low cost, convenience and ease-of-use make the LogicScope the ideal instrument, for designing, troubleshooting or repairing digital systems.

**Consider its Engineering & Field Service Applications:**

■ On microprocessor-based systems, check the timing relationship of various parameters relative to the system clock and other key events. Its storage capability allows visual and logical comparison of non-repetitive waveforms to known reference signals. Output in the start-up of the digital device can be compared to reference signals to determine the operating state of the device. Questionable waveforms can be stored for analysis.

■ Its light weight and small size make the LogicScope convenient to take on every service call. The 136 provides much more information for trouble shooting a digital system or peripheral than a logic probe or digital multimeter, without having to lug an oscilloscope or logic analyzer along.

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Winegard engineers have developed the truest parabolic dish of any of the see-through category. Each petal, rib and outer ring is stretched-formed to a parabolic shape with specs so tight it took months to perfect the process.

Our exclusive extruded rib and locking system has simplified assembly, eliminating the need for hundreds of bolts, nuts, washers and fasteners. Every time you attach a bolt, screw or fastener to a dish you add another stress point, distorting the shape. With Winegard's extruded rib and locking system, the stress is uniform across the dish, maintaining its true parabolic shape and integrity.

## LIGHTWEIGHT BUT RIGID PERFORATED ALUMINUM

Not only is the Winegard perforated aluminum dish lightweight and easy to handle, but it is extremely rugged, durable and well constructed. You can actually see through the perforated petals which are constructed of .040-gauge anodized aluminum. The extruded aluminum main ribs, which provide the basic structural support, are 1/8" thick. The locking ribs are .070" thick and lock the perforated aluminum petals tightly in place. A double-walled outer rim provides an area to insert rim splices at all joints for perfect alignment and additional strength.

Wind-loading capabilities are outstanding with a wind survival rate of 125 mph. And, because the perforation eliminates 36% of the surface area, the dish diffuses solar heat, decreasing amplifier noise.

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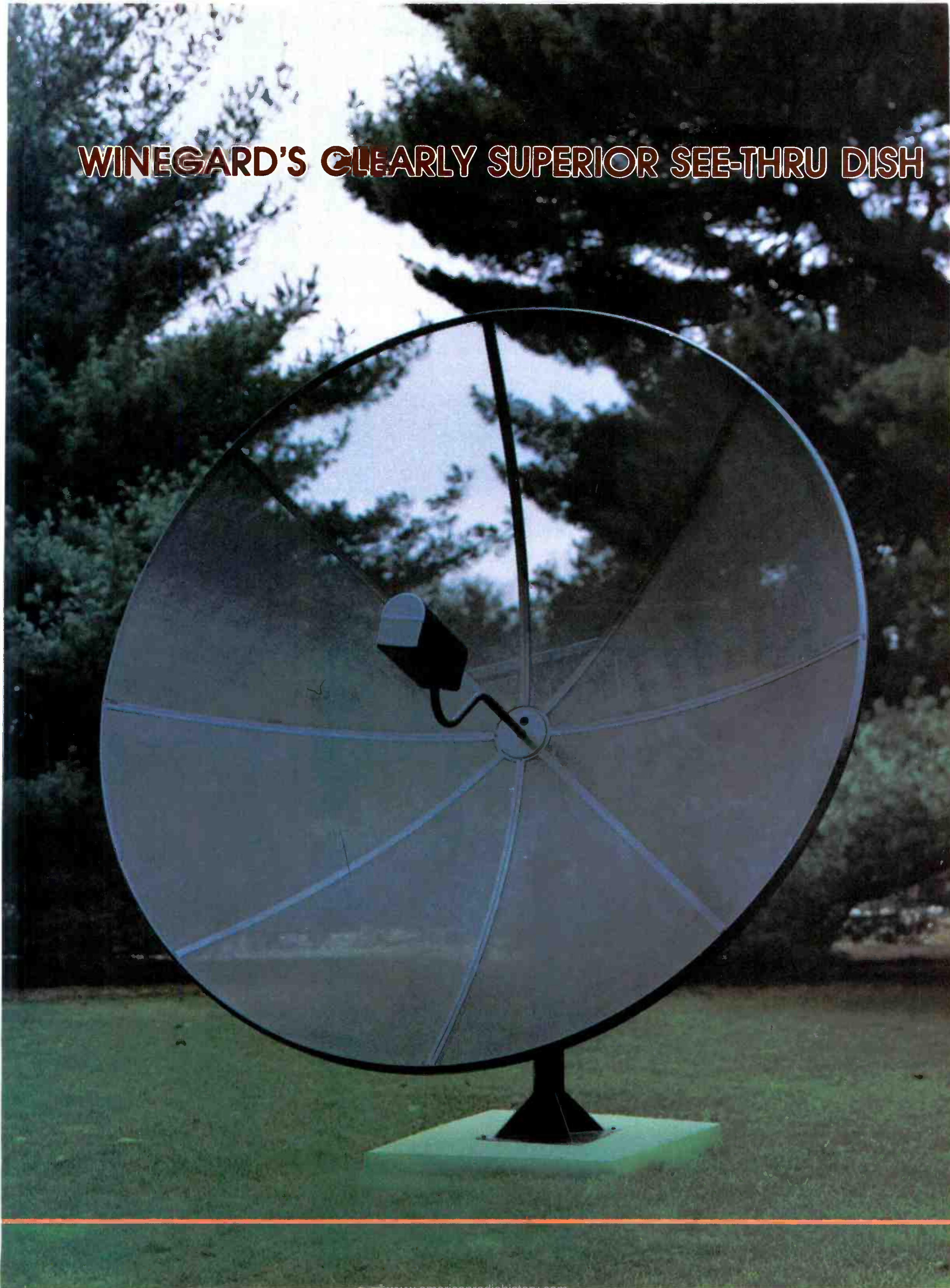

WINEGARD'S CLEARLY SUPERIOR SEE-THRU DISH

# Ten Dogs in TV Repair

By Homer L. Davidson

Anyone who has spent hours trying to diagnose a TV problem understands the term *tough-dog repairs,* although they know the term has nothing to do with damages inflicted by teeth and claws of living canines. Instead, the term describes TV receivers that stubbornly resist conventional tests and techniques. These dogs are universally detested.

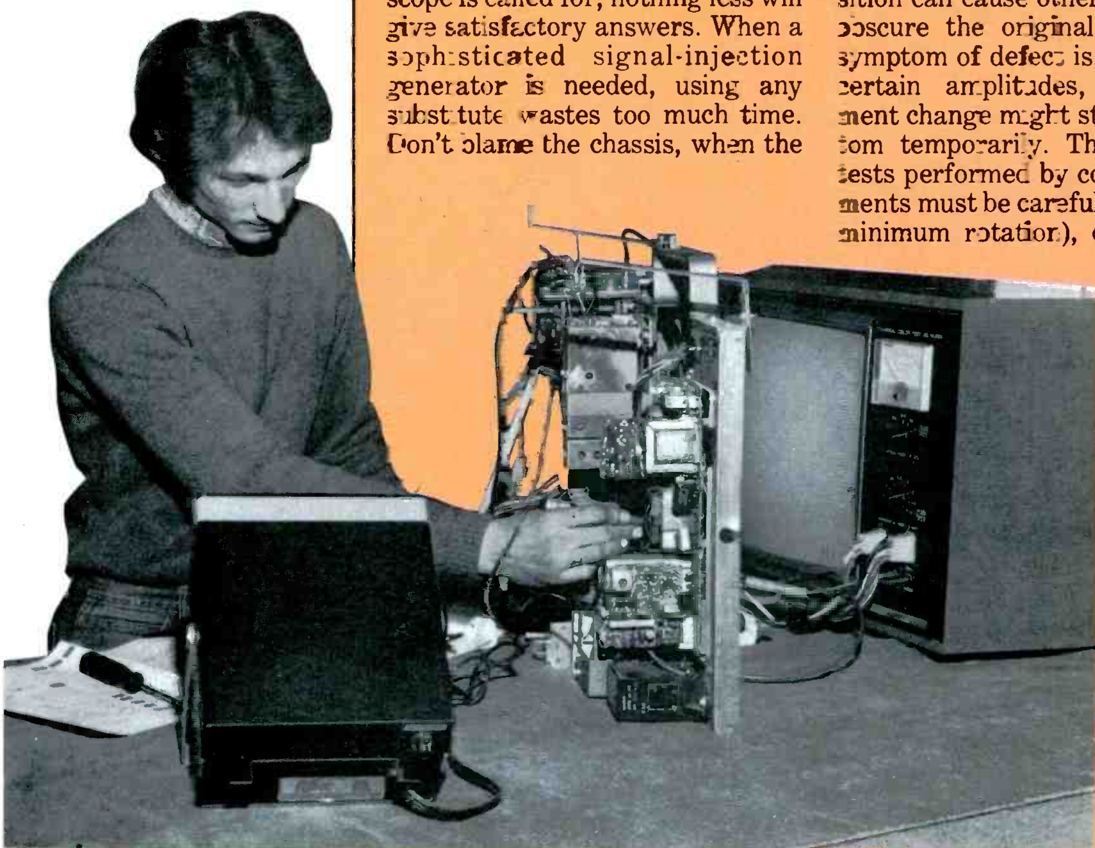
It is no coincidence that most difficult problems have intermittent symptoms, because erratic operation multiplies the difficulties while you attempt to obtain dependable, repeatable and easily interpreted test results.

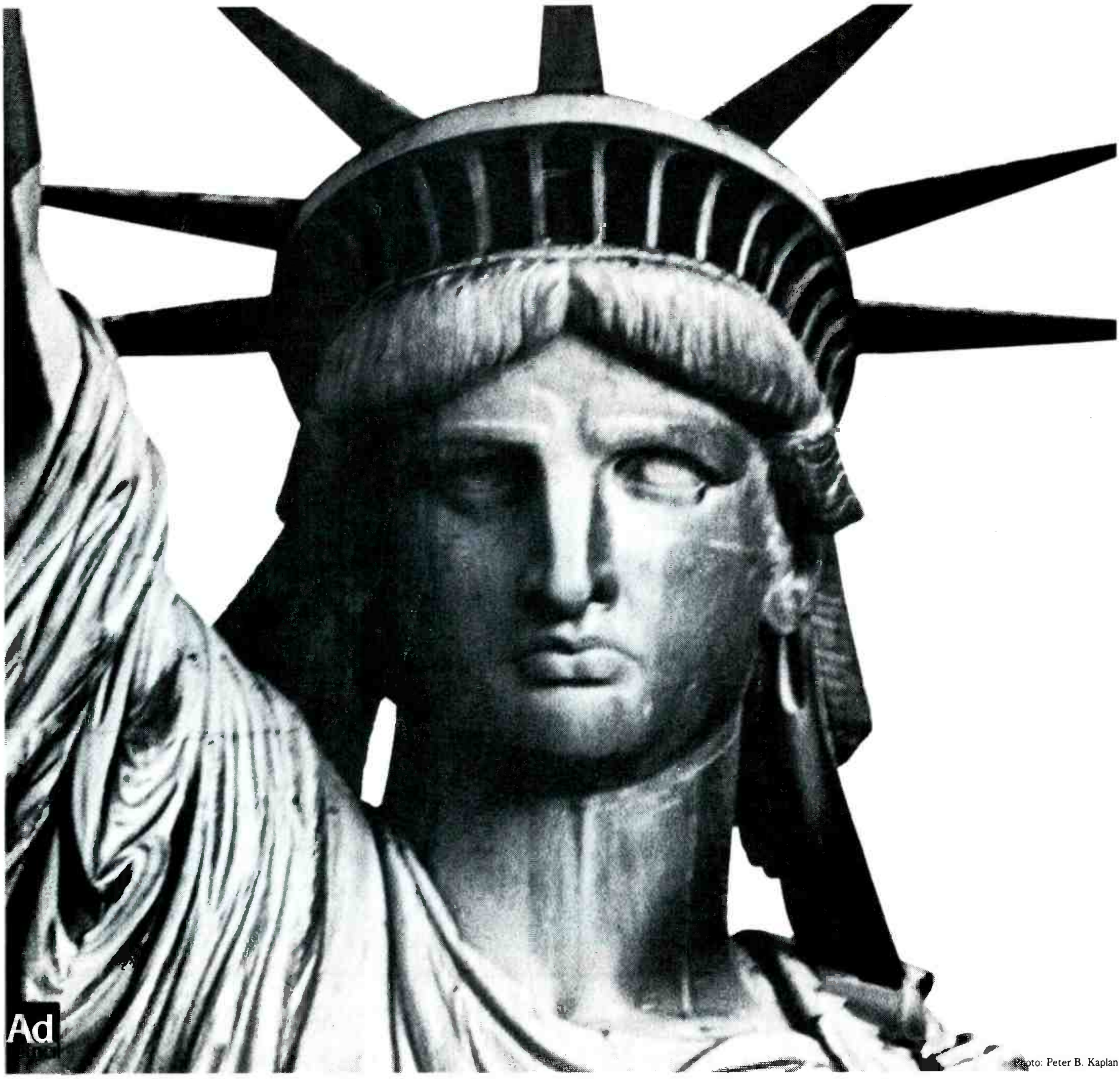
The use of correct and complete service data (that includes a schematic with waveforms and dc voltages) can prevent many moderately difficult troubleshooting jobs from becoming tough dogs. Therefore, if you value your time, always have good service data handy.

Lack of essential test equipment also changes routine repairs into tough dogs. If a good triggered scope is called for, nothing less will give satisfactory answers. When a sophisticated signal-injection generator is needed, using any substitute wastes too much time. Don't blame the chassis, when the shortcoming is with your equipment.

Of course, it's possible to produce dogs by employing any of several methods that are inappropriate for the specific problem. Simple tests, such as visual examinations of picture quality and chassis conditions, can have great value at times *when they are successful.* However, they are not adequate for the more-serious defects. *Therefore, the time for simple tests should be limited to just a few minutes.* Change quickly to DMM, scope or generator before too much time is wasted.

Another simple test that has inherent hazards is the common practice of rotating many adjustment controls (such as horizontal hold, vertical hold, vertical height, AGC, focus, centering and screen color tracking) just to "see what happens." Granted, these easy adjustments sometimes reveal an erratic control or an allied defect. Unfortunately, excessive rotation that ends with the control at a different point than the beginning position can cause other problems or obscure the original one. If the symptom of defect is triggered by certain amplitudes, the adjustment change might stop the symptom temporarily. Therefore, any tests performed by control adjustments must be carefully done (with minimum rotation), or the draw-



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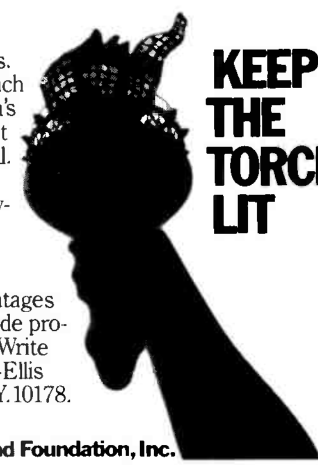


backs can exceed the advantages.

If a part is unsoldered during a test, or a new component installed, care must be used so the part is placed in the correct board holes and soldered with skill. Double and triple troubles multiply the difficulties of troubleshooting a tough dog, particularly if careless or improper servicing has created some of the multiple troubles. A word to the wise should be sufficient!

After all the tough dogs that have been produced by lack of proper test equipment, schematic or test methods are accounted for, there are many other dogs that exist for no known reasons. *Electronic repairs are frequently not easy.*

The 10 case histories that follow are presented to help you repair tough dogs more easily.

### Repair #1

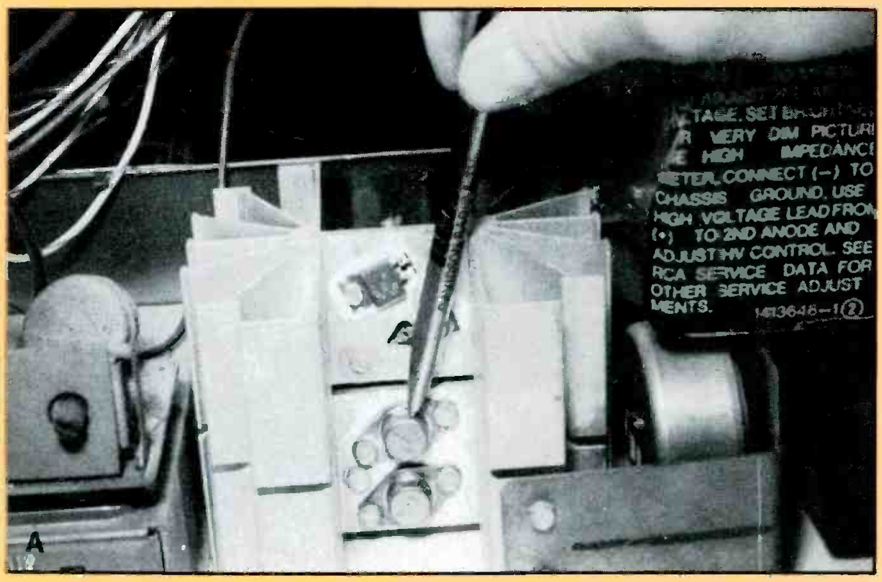
An RCA color receiver equipped with a CTC68 chassis (Photofact 1517-1) occasionally blew the F101 line fuse or tripped the CB101 circuit breaker. After the fuse was replaced or the breaker was reset, it would operate for times varying between three hours and three days before the problem occurred again.

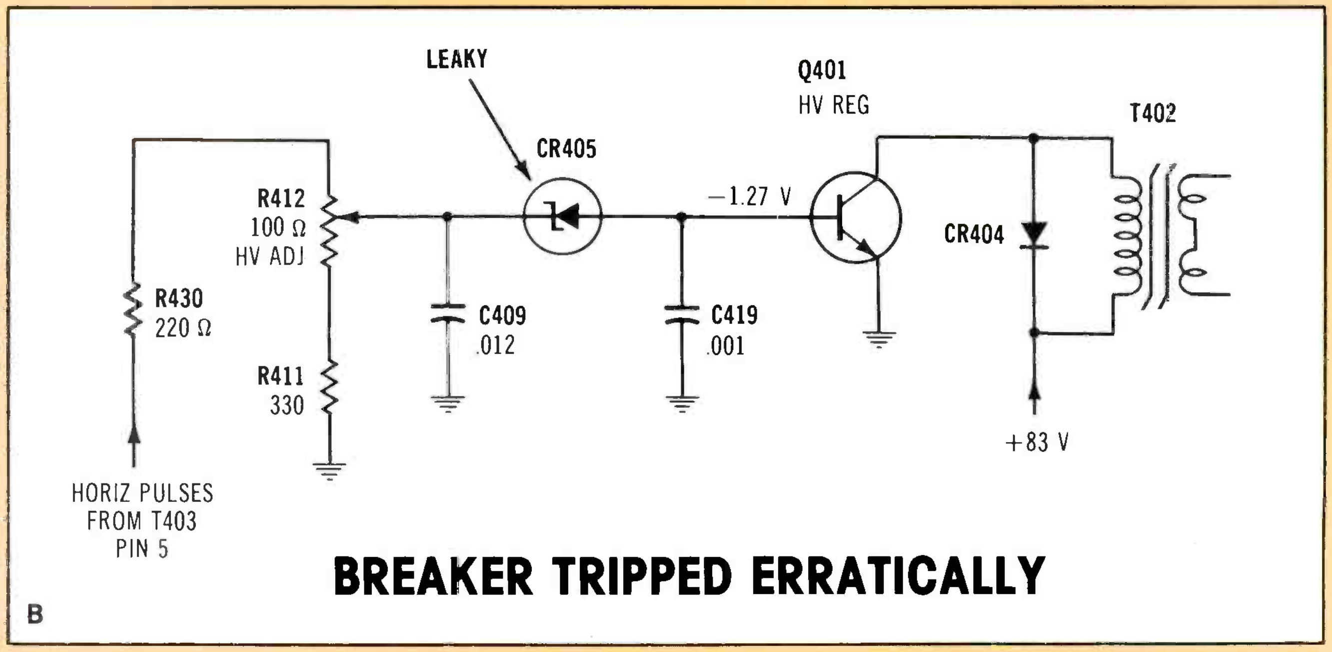
No improvement was noted after replacement of the MAB003B power-supply and MAH001A horizontal-oscillator modules. After the SCR101 trace and SCR102 retrace SCR's were replaced (Figure 1A), the receiver operated longer, but eventually the fuse blew again.

A 100W incandescent light bulb was connected by clip leads across the open fuse to indicate when the overload occurred (the bulb became brighter) and to limit the maximum current. The ac power was obtained from a variable-voltage transformer.

Lower-than-normal voltages from the transformer prevented onset of the overload, while higher line voltages produced overload current after a few hours. *A warm T401 regulator transformer hinted at a horizontal problem;* otherwise, there was no indication of the defect's nature or location.

To isolate all high-voltage circuits from the horizontal-deflection system, the input terminal of tripler unit STM101 was disconnected, and a scope added to




**Repair #1** (A) Replacement of SCR101 and SCR102 appeared to stop the fuse blowing and breaker tripping for a time in the RCA chassis. (B) Later, leakage in CR405 was found to be causing the problem, requiring installation of a new zener diode.

# START UP
## AND
# SHUT DOWN
## CIRCUITS

## *Do You Really Understand Them ? ?*

From a functional standpoint, **every** hi-voltage circuit that employs a start up and shut down feature will have the same "pre conditions" of operation. That is; the following series of events must take place in **exactly the following sequence** . . . if the overall circuit is to function.

(1) **The primary LV power supply** must power up and produce something over +135 volts for the LV regulator, as well as sufficient B+ for the start up circuit to run the horiz osc/driver circuits for at least a brief second.

(2)**The LV regulator circuit** must now provide the collector of the horiz output (via the primary of the flyback) with B+ voltage of approx. +110/120v.

(3)**The horiz osc/driver/output** must now "pulse" the **primary** winding of the flyback, which will then **produce** a magnetic field around the core of the transformer. The **secondary** windings will then **capture** their respective portions of this magnetic field based on the number of turns in that particular secondary winding. Each time the primary winding is pulsed, each secondary winding will emit either a positive or a negative pulse depending on which end of **that** winding is grounded. During the **off** portion of each cycle, the magnetic field will collapse producing an opposite polarity pulse.

**Important Note:** If one winding, or the circuit that is **connected to** that winding becomes **shorted,** the magnetic field will saturate the core of the transformer and the **primary** winding will then act as though it were a short piece of solid wire (a dead short). In this event, the output of **all other** secondary windings will now be zero. **Conversly,** if you **remove the load** from any **one** secondary winding (I.E. an **open** video or vertical circuit) the output of **all other** secondary windings will **increase.**

**Moral:** An open or shorted circuit that is connected to **one** secondary winding will not only effect the output of **that** secondary winding, it will effect the output voltage of **all other** secondary windings.

Once the primary is pulsed, the secondary winding(s) will provide B+ voltage to run the horiz osc and driver circuits. **Every single shut down circuit in todays industry relies on the above concept.** (No other concepts are involved.)

(4)**Every shut down circuit** relies on one or more secondary windings of the flyback, regardless of whether it is a "high end" or a "low end" shut down circuit.

A **"high end"** shut down circuit will "kill" either the horiz osc or driver, or the LV regulator should the output of its respective flyback secondary winding **increase** (because a load has been **removed** from **any one** of the **other** secondary windings of the flyback ...I.E. an open vertical or video circuit). **High end** shut down "lines" are almost invariably connected to the **base** of either the osc or driver stage via a zener diode whose other end will be connected to a secondary winding of the flyback via a resistor. If the secondary output becomes "high", the excessive voltage exceeds the rating of the zener. The resulting output of the zener then turns either the osc or the driver on, **and keeps it on** until the overall circuit dies.

A **"low end"** shut down circuit will "kill" either the horiz osc or driver, or the LV regulator should the output voltage of its respective flyback secondary winding **decrease** because an additional "load" has been placed on **any one** of the other secondary windings. **Low end** shut down circuits are almost invariable connected to the "bottom end" of the hi-voltage winding of the flyback (the **A B L** source). The other end of the **low end** shut down circuit will usually be connected to the **emitter** of one of the transistors in the shut down circuit.

**A 60HZ pulse from the VERTICAL circuit** is often required to keep the LV regulator circuit operating. This is neither a start up nor a shut down circuit. It is instead a **"sustaining"** circuit. Without this "sustaining" pulse, the LV regulator will cease to function. In the absence of a "sustaining" pulse, the collector voltage of the horiz output will fall from its normal +108/+125 volts to something that is approaching only +90 volts. Insufficient primary B+ will cause **low secondary output** and low secondary output will cause **"low end"** shut down!!

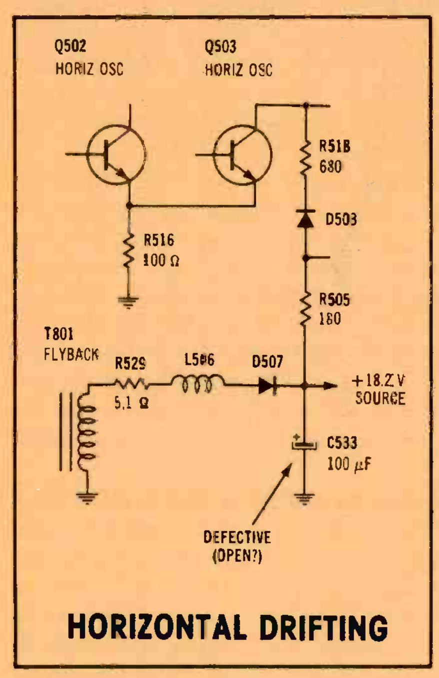
Needless to say, if any aspect of the hi-voltage circuit should fail, the overall circuit will die, leaving you victim to the proverbial "chicken and egg" syndrome, with few (if any) voltages to work with.

**How then do you troubleshoot it?** First remove the horiz output transistor and plug in your **Super Tech** diagnostic computer. Make one additional connection to ground then, press four buttons (one at a time). The display lights on your **Super Tech** will tell you **exactly** where the problem is with **100% accuracy** in every instance. In addition, your **Super Tech** computer will allow you to "power up" the TV set, in spite of the present hi-voltage problem so that you can verify the operation of **all other** circuits I.E. tuner, IF, video, chroma, audio, vertical, etc.

During the above process, **Super Tech** will automatically check the flyback, tripler, video, chroma, IF, tuner, vertical, horiz osc/driver circuits for shorts, opens or defects with **100%** accuracy.

The amazing part is, your **Super Tech** will do all of the above in something **less than** 30 seconds, most of which is spent waiting for the CRT filaments to warm up! Any technician who basically understands the contents of this article can learn to operate a **Super Tech** Diagnostic Computer in about two hours. Since there is no programming involved, with just two hours of practice, you too can diagnose **any** start up, shut down, hi-voltage, osc/driver or LV regulator problem in **less than** 30 seconds. Phone (806) 359-1824 and we will give you names, addresses and phone numbers of others (just like yourself) who did not believe it but, are now diagnosing start up and shut down problems ---in less than 30 seconds.

Or circle (10) for a free brochure.




**Repair #2** An open C533 caused drifting horizontal frequency in a Sony receiver.

monitor the horizontal pulses for overload. Operation for a whole day without overload indicated the tripler might be the intermittent component, so a new one was installed. Operation with the new tripler was without overload for a week under normal line voltage and with high line voltage for several hours intermittently. We now hoped the receiver was repaired, and released it to the customer.

However, three weeks later, the customer brought it back. Tests this time showed the CB101 breaker would not hold. After several tests, we found a shorted CR405 regulator zener diode (Figure 1B).

CR405 was replaced and the high voltage adjusted to specifications. Several years have passed since then and the horizontal-sweep circuit continues to operate correctly.

But several questions remain. Was CR405 the only component that was defective originally? Or were the tripler unit and the diode both intermittent? These questions probably never will be answered.

### Repair #2

Sometimes, only diagonal out-of-lock horizontal stripes could be seen on the screen of the Sony KV1500 (Photofact 1322-2). At first, a small readjustment of the preset horizontal-frequency control (there is no customer-operated hold control) locked the picture solidly. However, the picture would drift out of lock after 30 minutes or more of operation. The vertical locking was not affected.

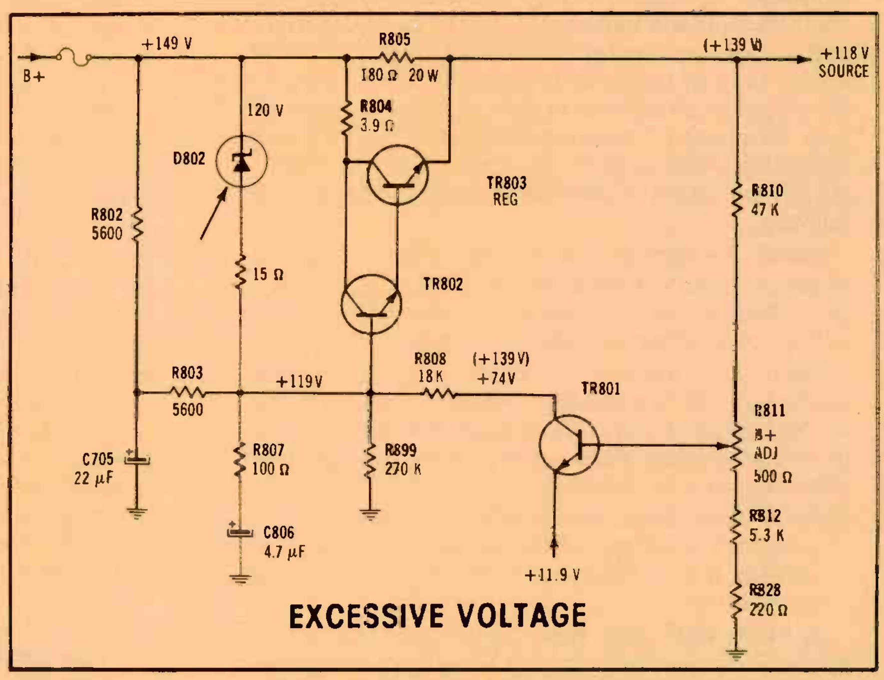
Because this appeared to be horizontal-oscillator drift, we tested the oscillator circuit first. Dc voltages of the Q503 horizontal-multivibrator oscillator transistor were slightly incorrect. The collector reading showed +5V instead of the schematic's +4.1V, while the emitter measured +1.7V instead of the desired +1.9V. These readings indicated the Q503 transistor was drawing less current than it should. However, the scope waveforms appeared normal. We changed Q503, but the voltages were not improved and the locking was no better.

After several frustrating hours without any success, we measured the +18.2V supply for Q503 (Figure 2) and found it was only +10.5V. The rectifier diode (D507) had satisfactory leakage and the usual voltage drop (when tested by the constant-current method), but *paralleling a new 100µF filter capacitor across C553* increased the source voltage to normal and *stopped the drifting horizontal frequency.*

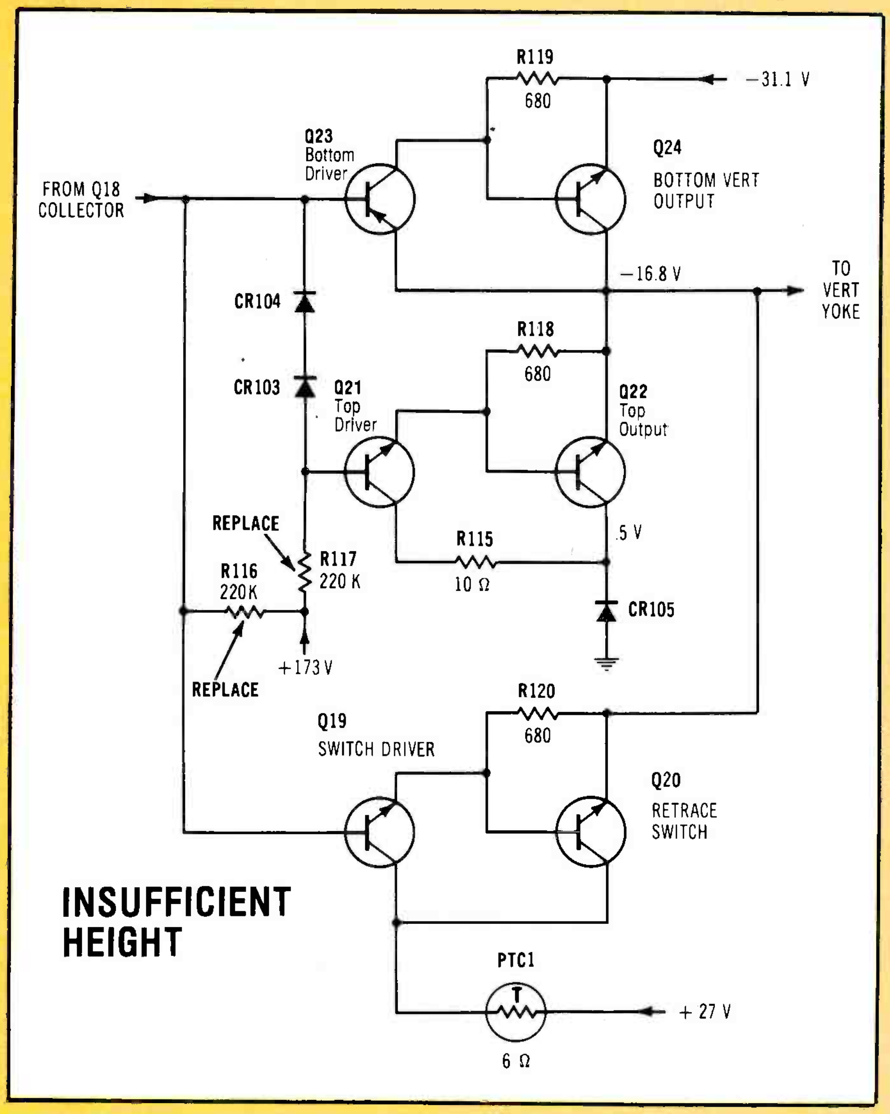
### Repair #3

Intermittent horizontal stripes after a few minutes of operation were the symptoms of a Panasonic CT716 (Photofact 1679-2). Although the correct schematic was not available at that time, a comparable one was used for troubleshooting. During one episode of out-of-lock stripes, excessive high voltage was measured at the picture tube, indicating that the safety circuit was producing the stripes as a warning not to use the set.

Supply voltage for the horizontal-output transistor should be one of the first measurements made when the high voltage is excessive. At the output-transistor collector, this supply checked +139V rather than the normal +118V. The reading did not vary with rotation of B+ adjust control R811, which meant that the regulator was defective.




**Repair #3** Leakage in zener D802 eliminated the +118V regulation, changing the output voltage to an excessive +139V that activated the safety circuit, causing out-of-lock horizontal.




**Repair #6** Replacement of open R117 restored full height to the picture. Replacement of R116 also is recommended.

circuit before tests of them can be considered trustworthy.

As a test, top-driver Q21 and top-output Q22 transistors were replaced. But Q20 continued to operate very hot. Next, one lead of each vertical resistor was disconnected from the circuit and the value checked before the resistor was resoldered. Although R117 (220kΩ) had checked approximately the correct resistance in the circuit, it was found to be completely open, when removed from the circuit. *Installation of a new* 220kΩ R117 restored full height with good linearity and stopped the Q20 excessive heating.

Incidentally, the 220kΩ resistors in this circuit have a history of failures. Therefore, we recommend that both should be replaced in each vertical circuit you work on.

## Repair #7

A dark but otherwise normal picture was the customer's complaint for the RCA CTC46 (Photofact 1278-3). After the CRT-bias control was rotated fully CW, the picture remained too dark. The three CRT screen grids did not have low dc voltage, but measured about average. Substitution of the MAL001A video module did not increase the brightness. Width and high voltage were within tolerance.

The picture was too dark with the chassis connected to a test jig, eliminating the picture tube from suspicion. All dc voltages appeared to be within limits in the video stages and picture-tube circuits. The R4202 brightness control measured the correct 1500Ω across the terminals. All wires to the brightness were checked and found connected properly. No defects were found in the brightness-limiter circuit. Temporarily, the tests were stopped while much thought was given to the problem.

A fellow technician suggested substituting another tuner-mounting assembly (TMA) from another receiver that had the same chassis. With the other TMA connected, the brightness range was restored to normal. Evidently, the problem was in the brightness-control circuits (the control is on the front panel where it can be adjusted by viewers) or the cables. Double checking the brightness control solved the problem. The total resistance was correct (1500Ω). But with the control fully clockwise, a reading of more than 300Ω was obtained between those two control lugs where no more than a few ohms should be found (Figure 7).

*Installation of a new brightness control restored proper brightness and brightness control.* Complex problems sometimes have simple answers.

## Repair #8

After the JC Penney model 2009A (Photofact 1699-1) was operated for about an hour, the raster disappeared. However, the picture-tube heater was glowing and the high voltage was normal. With these symptoms, the defect usually is in a video stage.

One time when the raster was missing, the video stages were scoped. Very low amplitude of video was found at the Q203 base (Figure 8) along with a higher dc voltage. However, video was present at the Q202 collector. Between those two points is a X201 delay line, which measured more than 3000Ω (normal resistance is about 46Ω). *Installation of a new delay line eliminated the previous intermittent operation.*

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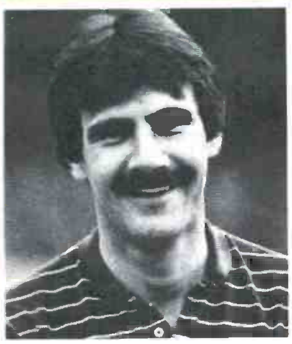

**Wayne Marong**
Owner — Harbour Audio/Video
Camden, Maine

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*IS THE CONIFER ANTENNA EASY TO INSTALL?*

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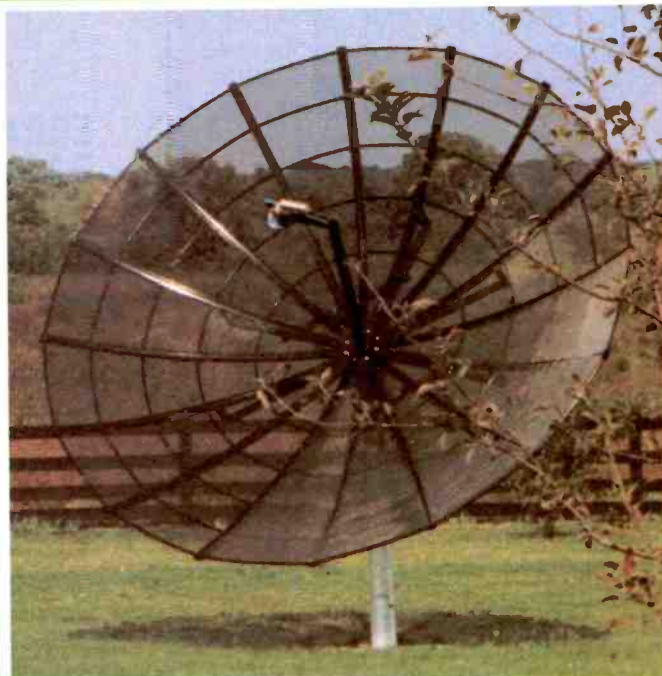

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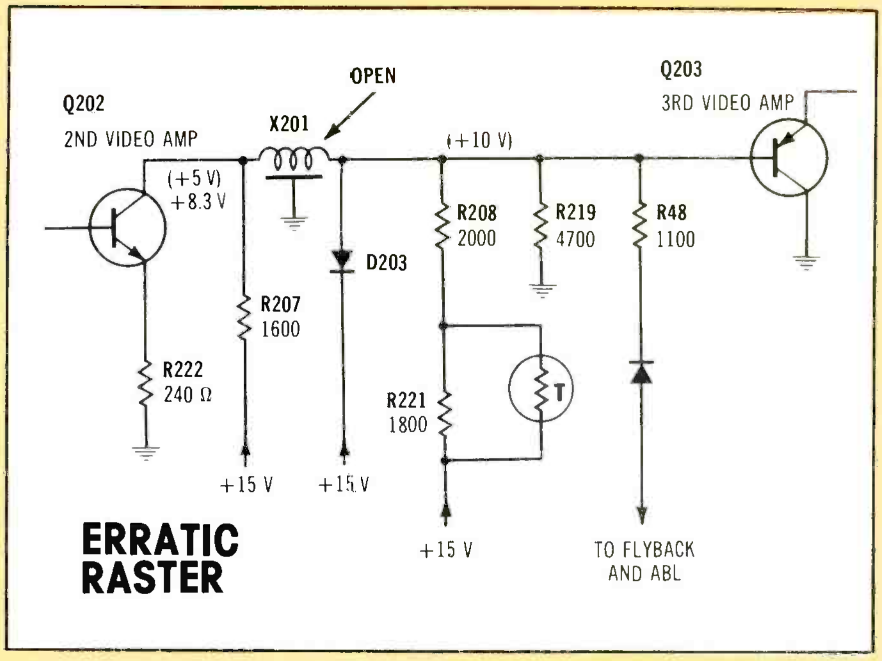
Dual-trace scopes can be used to great advantage for finding the point where a signal ceases erratically. Place the probes at input and output of a suspected stage. Or, as in this case, place the probes one or two stages apart. Then keep moving the probes until one is connected to the last point of the signal path *that has a signal,* while the other scope channel shows a loss of signal at the *next* point of the signal path, although only one or two components separate the two test points. The problem will be found in the receiver circuitry between the two scope probes, thus narrowing the number of possible suspects.



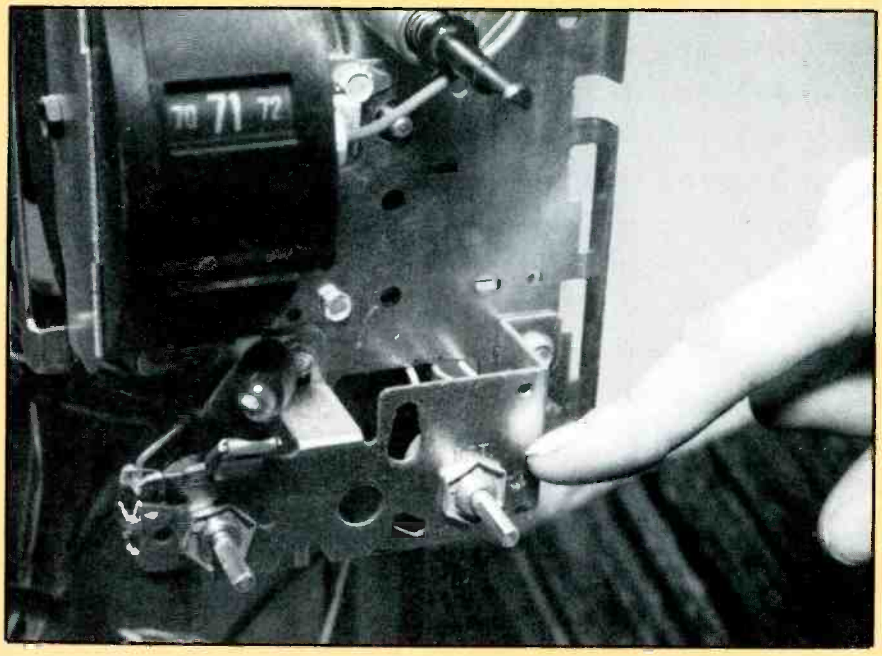

**Repair #7** Internal series resistance of the brightness control produced a dark picture on this RCA's screen.

### Repair #9

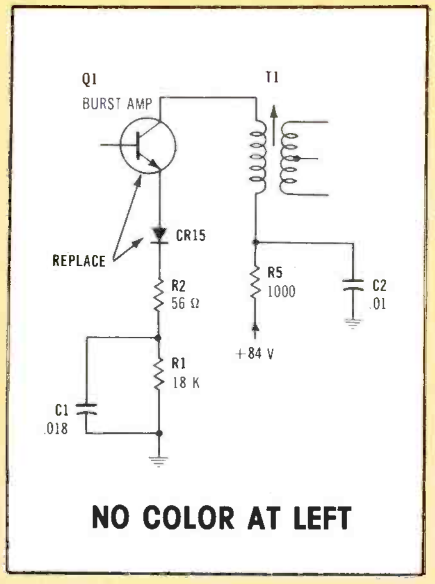
An unusual color problem was observed with one RCA CTC44 (Photofact 1191-1). The picture had good color except the last four inches at the left edge of the screen was missing; the picture there was in black-and-white. Given those symptoms, it is difficult to know what to suspect or where to begin testing.

All color-circuit transistors were tested in-circuit, and accurate dc-voltage measurements were taken on all these transistors. Nothing unusual was found.

All chroma stages were inspected visually and fresh soldering flux was noticed around CR15 (Figure 9). Someone had replaced the original CR15 diode and the Q1 burst-amplifier transistor, probably in a vain attempt to restore color to the left edge. Both the transistor and the diode were good when tested. Perhaps an incorrect type had been used. The universal transistor was replaced by an original-part transistor, but the symptom did not change. Another inspection showed that CR15 had been replaced using a GE number 504A diode, which is a 60Hz power-supply type that is not suitable for high-frequency operation, even at horizontal-deflection frequency. *A new RCA part number 125828 diode was installed and color was restored across the entire width of*




**Repair #8** An open delay line removed the raster from the JC Penney receiver.




**Repair #9** An ordinary 60Hz power-supply-type diode had been used to replace CR15 in an RCA CTC44 causing loss of color at the left edge.

*the screen.* This was a problem created by a technician.

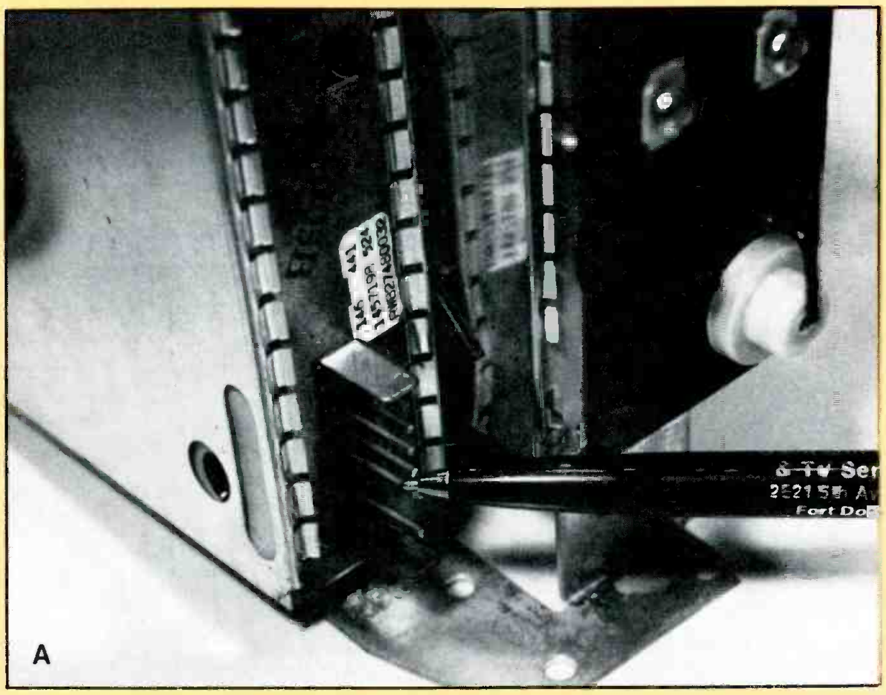
### Repair #10

Sometimes the picture disappeared from the screen of the RCA CTC109A (Photofact 1952-1), but the high voltage always was present. A bad picture tube or a dead video stage can give those symptoms. However, when the raster and picture disappeared, the digital channel numbers went black, indicating a tuner problem.

With many newer RCA color receivers, the raster is dark (or nearly dark) when a channel is not tuned in or when no antenna is connected. Therefore, we temporarily replaced the tuner and memory modules. The picture came on normally for a few minutes and then blacked out. Moving the chassis sometimes brought back the picture. Measurements of dc voltages in the tuner assembly appeared to be normal.

After several fruitless hours of checking voltages and signals, we remembered the negative-going 60VPP horizontal-rate pulses that should be found at J2 (see photograph in Figure 10A). A scope showed no pulses, when the receiver was dead.

A resistance test from the J2 pin to ground should show a very low resistance. This measurement was very high; nearly infinity. There was continuity from J2 to coil L103 (Figure 10B), but L103 tested open. A visual inspection showed bad connections at the coil's ends; the winding was not open. *We cleaned the wire ends, tinned them and resoldered them correctly. This eliminated the erratic loss of picture* and completed the repair.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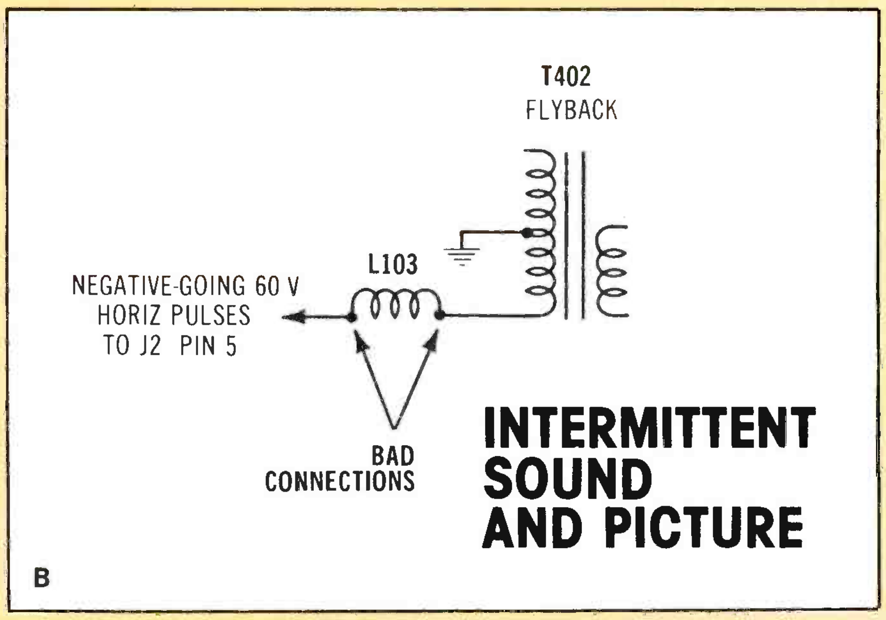


B

**Repair #10** (A) A pen shows where the negative-going horizontal pulses should be found at the tuner-control circuit. (B) Bad soldered connections at L103 removed the pulses from the tuner circuit causing loss of picture and sound.

### Comments

Six of the 10 examples given here involved intermittent operation. This corroborates the statement made earlier that intermittent or erratic components multiply the problems in troubleshooting color-TV receivers.

One of the first (and most important) steps is determining what conditions start (or stop) the malfunction. A defect that can be started by something you do to the receiver is much easier to troubleshoot than one that starts and stops itself and ignores all outside efforts.

Heating and cooling suspected areas alternately often triggers intermittent conditions, particularly those inside solid-state devices. Applying pressure, bending, tapping or pushing against boards, solder joints or capacitors are other effective mechanical methods. Visual examinations can locate some erratic conditions, but the other methods are better.

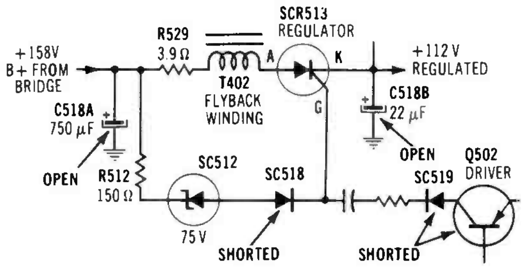
If these simple mechanical, thermal and visual tests are not effective against certain kinds of intermittent conditions, they should be stopped quickly in favor of scopes, generators and other instruments that permit greater precision.

ES&T

# Symcure

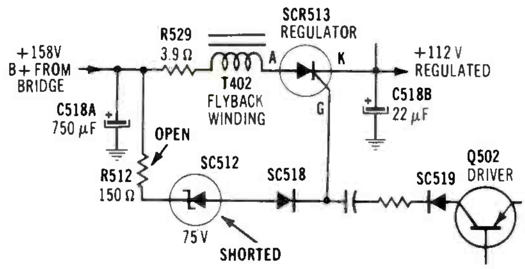
Symptoms and cures compiled from field reports of recurring troubles

**Chassis** – NAP (Magnavox, Sylvania, etc) E32-4 1
**PHOTOFACT** – 2034-1



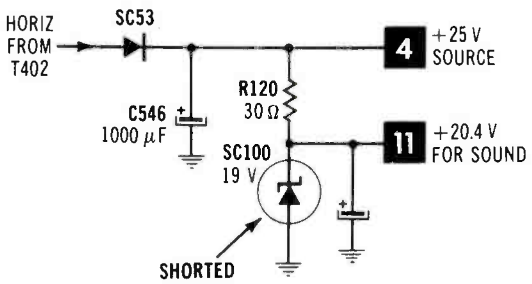

**Symptom** – No sound or picture; SC518, SC519 and Q502 shorted
**Cure** – Test filter capacitors C518A and C518B, and replace if open

**Chassis** – NAP E32-4 2
**PHOTOFACT** – 2034-1



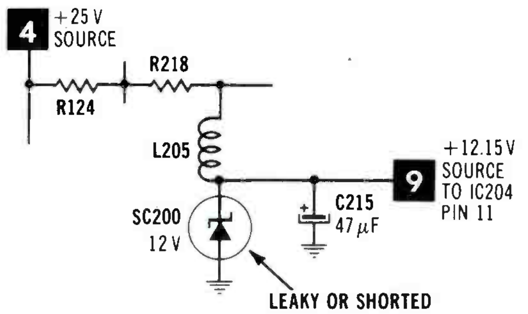

**Symptom** – No sound or picture; possible "tic-tic" from flyback
**Cure** – Check zener diode SC512 and resistor R512, and replace them if shorted and open respectively

**Chassis** – NAP E32-4 3
**PHOTOFACT** – 2034-1



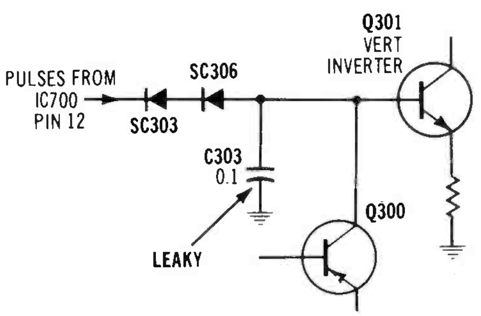

**Symptom** – No sound; no +20V at IC102 pin 14
**Cure** – Check zener diode SC100 and resistor R120, and replace them if shorted and burned respectively

**Chassis** – NAP E32-4 4
**PHOTOFACT** – 2034-1



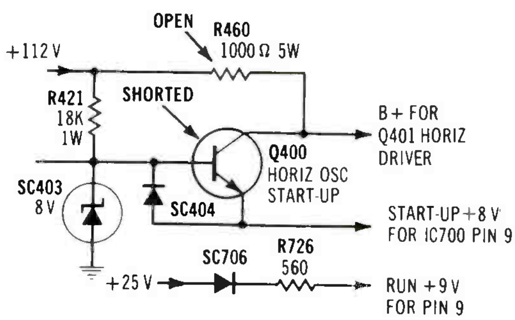

**Symptom** – No video; snowy picture; or erratic horizontal locking
**Cure** – Check zener diode SC200, and replace it if leaky or shorted

**Chassis** – NAP E32-4 5
**PHOTOFACT** – 2034-1




**Symptom** – Poor linearity and insufficient height
**Cure** – Check capacitor C303, and replace it if leaky

**Chassis** – NAP E32-4 6
**PHOTOFACT** – 2034-4




**Symptom** – No sound or picture
**Cure** – Check Q400 and R460; replace them if defective

# Photofact

**AOC**
Chassis M3C2-5B9 .......... 2265-1

**ATARI**
5200 .......... 2265-3

**CAPEHART/SPECTRICON**
9950AR/5950AR .......... 2269-1

**HITACHI**
CT2530/31/32/33 .......... 2264-1

**JC PENNEY**
685-1020J,-30 .......... 2266-1
685-2042J,-30/044J,-30/078J,-30 .......... 2267-1

**MAGNAVOX**
Chassis T809-08/09 .......... 2266-5

**QUASAR**
Chassis ALDC105 .......... 2270-1

**RCA**
Chassis CTC120A .......... 2267-3
Chassis CTC117A .......... 2267-3
FGC444F/46S .......... 2266-4

**SANYO**
Chassis A2F-60000 .......... 2266-2
Chassis A2F-615A00, A2V-61500 .......... 2270-2
M9830K .......... 2270-3

**SHARP**
19H74 .......... 2266-3
FF19633 .......... 2267-2
19H94 .......... 2268-1

**SONY**
Chassis SCC-266K-A,SCC-453D-A .......... 2268-2

**ZENITH**
S1983W/87W,W88/89W .......... 2264-2
Z1310A,PT/382W,W3 .......... 2265-2
Z2512K,K3/514M,M3/514PN,PN3/
516NK,NK3/518P,P3,584P,P3 .......... 2269-2

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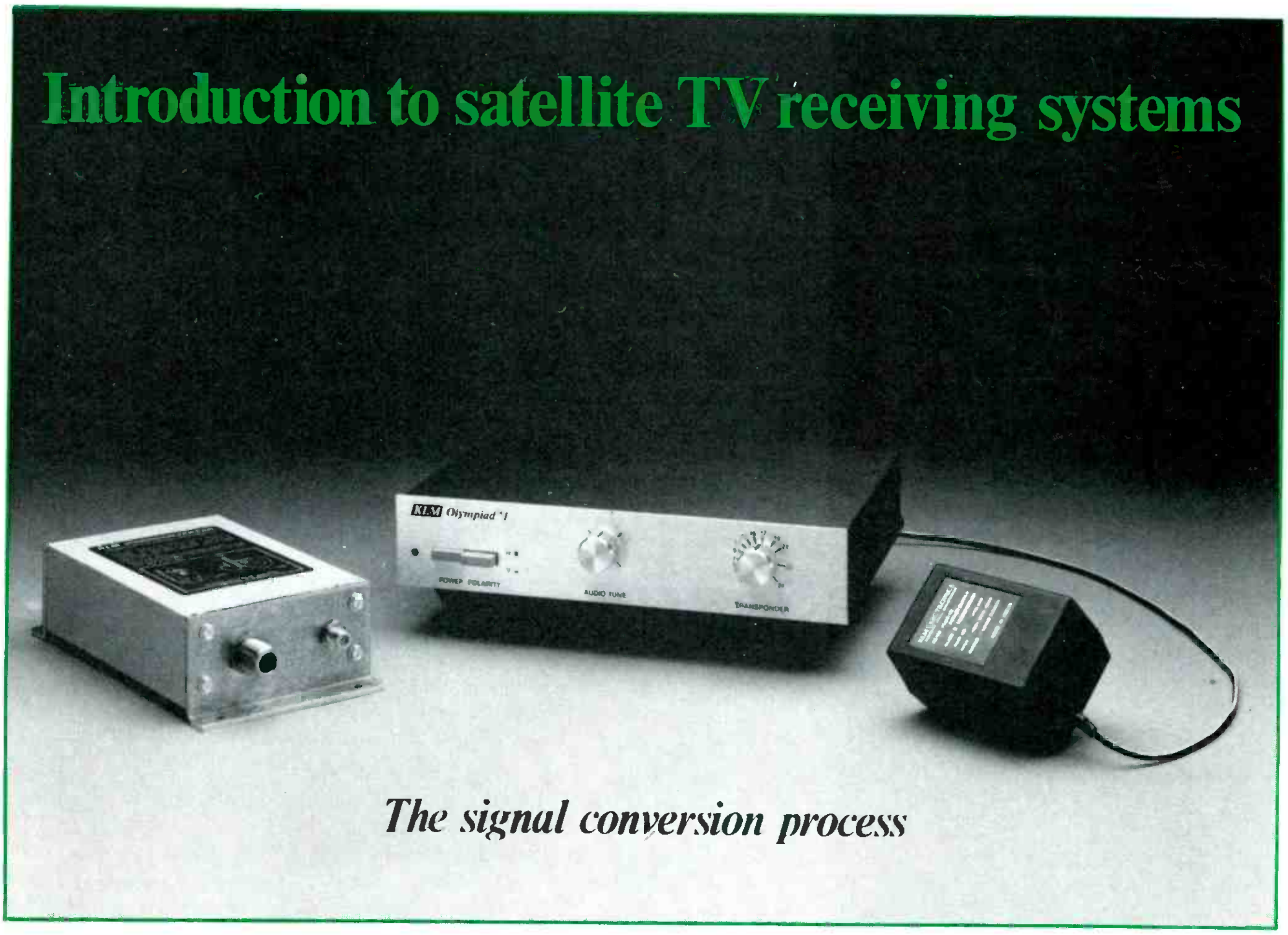
# Introduction to satellite TV receiving systems




Downconverter (at left in photo) uses superheterodyne technique to convert satellite microwave frequencies to lower frequencies for transmission to receiver.

## *The signal conversion process*

By MARTIN CLIFFORD
Technical Consultant
KLM Electronics

The output of the low-noise amplifier (LNA) generally mounted on or near the TVRO dish is the downlink signal, consisting of audio and video, both frequency modulated. If the objectives of the LNA have been met, the signals are now not only about 100,000 times stronger than they were at the input, but the signal-to-noise ratio is also better.

The LNA output can consist of the signals of as many as 24 transponders of a selected satellite, with all of those signals in the downlink frequency range of 3.7 to 4.2GHz. These could be delivered just as they are to a satellite receiver in the home, and in the early days of satellite TV that is exactly what was done. However, ordinary coaxial cable, even for relatively short lengths, has excessive signal attenuation for signals in the GHz range. There are some cables specifically designed to handle these frequencies, but they are quite expensive.

The technical solution is relatively simple, and that is to have the output signals of the LNA drive a downconverter. A downconverter, as its name indicates, is a circuit for changing the downlink signals to a much lower frequency, one that can supply closed wire signal transfer with losses that can be tolerated.

Downconversion is not a new concept but is a technique that forms the basis of all superheterodyne receivers, whether they are AM or FM. In such receivers, a mixer/local oscillator arrangement downconverts the received signal by mixing that signal with one generated by a local oscillator. The local oscillator is an electronic signal generator built into the receiver.

The resulting downconverted frequency is generally known more as an intermediate frequency or IF. The mixing or heterodyning process results in an output that consists of the two original frequencies, the signal and local oscillator frequencies, plus a number of sum and difference frequencies. However, a number of tuned circuits, or possibly a SAW filter can select one out of all the frequencies available.

In superheterodyne receivers, the downconversion process can be handled by separate local oscillator and mixer circuits, or these two can be combined into one, with the joint circuitry then known as a converter. But no matter how this is done, the result is one of downconversion. Essentially what has happened is that the original broadcast carrier frequency has been replaced by one having a much lower frequency. For TVRO systems, that intermediate frequency is generally 70mHz, replacing the original 3.7 to 4.2GHz signals.

The downconversion process does not affect the original audio and video baseband signals. These are carried along in the downconversion process, and so the intermediate frequency can be regarded as the new carrier.

Starting with the LNA, the TVRO system also makes use of the superheterodyne principle, except that a component instead of an integrated approach is used. Superheterodyne receivers, such as those used for AM and/or FM broadcast reception, are integrated units consisting of an RF amplifier, a mixer or converter, a number of IF stages, followed by a demodulator and then audio voltage and power amplifiers, with all of these component sections mounted on a single chassis and housed in a single enclosure.

However, it does not follow that all superheterodynes must be integrated. For satellite TV, the superhet can be separated into several basic units: an RF amplifier, a mixer or converter, followed by an IF section plus a demodulator. Some of these sections have been given new names. The RF amplifier is now the LNA. The mixer/local oscillator has become the downconverter. And the remainder has become the satellite TV receiver. Although the LNA and the downconverter are separate units, and are generally mounted at some position from the rest of the components, circuitwise what we still have, overall, is a superheterodyne. The act of separation and the use of new names haven't changed the functions.

While the basic purpose of the downconverter is to change the very high frequency of the downlink signals to some much lower frequency, it is also part of the signal selectivity process. At the input to the downconverter, with the signals received from the LNA, there can be as many as 24 different channels, assuming all the transponders of a selected satellite are simultaneously active, and that all of these are transmitting TV signals, the frequencies of all these channels will beat with that supplied by the local oscillator with a large number of resultant frequencies at the output of the downconverter.

By its very nature, the circuits following the downconverter are intermediate frequency circuits

(IFs) tuned to just a single band of frequencies. What we have, then, is the process of signal selectivity, a process that started with the antenna probe immediately preceding the LNA.

The LNA and the downconverter can be immediately adjacent, positioned on some dish support. They can be connected by a short length of ordinary flexible coaxial cable or by hardline, a section of cable having a rigid outer shield. Ideally, to minimize signal losses, the LNA and downconverter should be as close to each other as possible.

Just like the mixer-oscillator in a superheterodyne receiver, the downconverter must be tuned, but because the downconverter is not in the home but is positioned outdoors, some engineering ingenuity was required. The downconverter contains a voltage tuned oscillator (VTO) and is able to change its frequency through the application of a dc voltage. This is typically less than 8V dc, and is delivered via a connecting line from a power supply in the in-home satellite receiver. The amount of current delivered is measured in mA and the voltage is low, so lines from the home to the downconverter don't present a shock hazard.

To change channels, all that is required is the use of a push-button or rotary detent-type control positioned on the front panel of the in-home satellite receiver. This control is often marked to indicate the number of the selected channel. Operating this control changes the level of voltage delivered to the VTO, resulting in a change in the frequency of the local oscillator, and is the channel selection process.

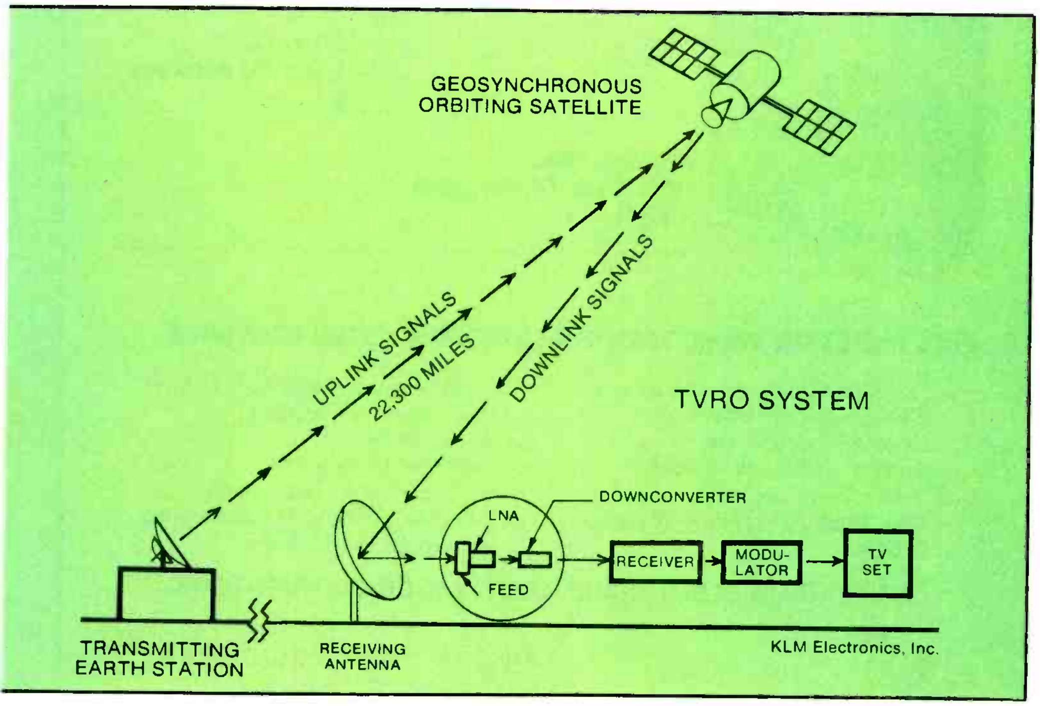
In a sense, then, the LNA and downconverter, although often separate units, represent the front end of a superheterodyne receiver. The output of the downconverter can be supplied to any number of IF stages, and, as in any superhet, selectivity is based on the number of such stages and their design. The output of the IF is usually 70mHz with both the audio and video signals frequency modulated.

Economically, and from an electronics efficiency point of view, these two components, the LNA and the downconverter, need not be separated but can be integrated into one unit, then becoming known as an LNC or low noise converter. Integrating the two units makes a lot of electronic sense, because these components should be as close as possible. However, with separate units it is easier to upgrade one component or the other.

Since the output of the downconverter is at a fairly low frequency, what is required at this point is a transmission line for carrying that signal from the outdoor downconverter to the in-home satellite receiver, something that is handled by coaxial cable. A power line is also needed to supply voltage and current to the LNA and to the downconverter.

A separate coaxial line can be used for the signals and suitable wiring for the dc, but these can be separate or housed together under a single protective covering, a combination sometimes called siamese cable. Generally, the cable, whether siamese or separate coax and dc lines, is put into suitable lengths of PVC pipe and buried underground (¾-inch ID PVC is generally used, in 10 foot lengths, joined at each end by a threaded coupler). The joints and the ends of the pipe, representing the entrance and exits ends, should be carefully sealed against water. Special sealants are available for this purpose. There is also some siamese cable available whose outer covering is such that it does not require the use of PVC pipe. The pipe, plus its enclosed wiring, must then be buried in a trench. The run from the downconverter to the home should be as direct and as short as possible. If possible, the satellite receiver should be positioned as close to the entry point of the wiring as feasible.

If the output of the downconverter has a signal level that is high enough, that signal can be used to drive more than one TV receiver, after first having been processed by the satellite receiver. However, in such an arrangement all of the TV sets so connected will show only the display of the selected channel. But in an in-home arrangement in which TV set users want independence of choice, or in a com-




Transmission of satellite microwave frequencies via cable would result in the high loss. The downconverter is mounted at the receiving dish location, usually in the same enclosure as the LNA.

mercial setup such as a hotel or a motel, or possibly a high rise apartment house, a different approach is needed.

This different approach is supplied by block downconversion, a method by which all the signals of up to 12 horizontal or vertical transponders are downconverted simultaneously. Thus, the complete downlink signals of either vertically or horizontally polarized transponders are downconverted, and because the downlink band has a width of 500MHz, that is also the bandwidth of the resulting IF. This should be fairly obvious because the function of a downconverter is one of frequency, not bandwidth changing.

With block downconversion, then, the resulting intermediate frequency, containing all 12 transponder channels, horizontal or vertical, could be delivered via coaxial cable to any number of satellite receivers. Each of these could be equipped with its own downconverter which could be tuned to any desired channel, giving the viewer a channel choice.

Note the difference. In the usual arrangement, just a single downconverter is used, hence this setup is properly known as single downconversion. In block downconversion, a technique known as double downconversion, two downconverters are used.

Double downconversion not only permits program choice for the various television receivers that are part of the TVRO system but supplies better selectivity and greater freedom from interfering signals. However, because of the larger amount of circuitry required and increased manufacturing cost, the double downconversion commands a higher price. Single downconversion is the more commonly used method, and usually TVRO systems are single-conversion types unless otherwise indicated.

There are some other differences. With the single downconversion method, the IF is ordinarily 70MHz with a channel bandwidth of 36kHz. Although there is no standardization, 70MHz is the intermediate frequency most commonly used by manufacturers of single downconverter units. For block downconversion, the bandwidth is the full width of the downlink band, and that is 500MHz. However, the selected IF can be any range, possibly from 270MHz to 770MHz, 500MHz to 1000MHz, etc. Again, there is no standardization and unlike the 70MHz IF used for single downconversion, double downconversion uses many intermediate frequencies. There is no consensus among the manufacturers of downconversion equipment as to which IF should be used. The FCC is not involved here since the IF is a wired or guided signal, unlike open or broadcast signals.

The use of a balun between the LNA and downconverter or between the downconverter and the connecting cable to the in-home satellite receiver is not required. Input and output impedances are 75Ω, matching cable impedance directly. The coaxial cable leading to the in-home satellite receiver is also automatically impedance matched. ES&T

## What do you know about

# Components?

### *Actual capacitor action vs. the model*

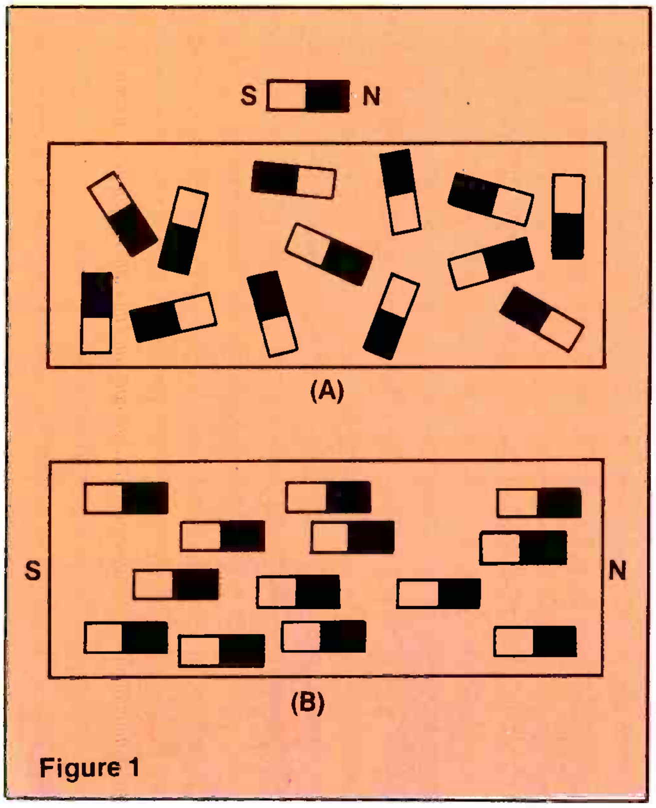
By Sam Wilson, CET

In the last installment of this series I talked about the problem of using models to analyze capacitor problems. There is nothing wrong with the use of models as long as you realize they *are* models. Unfortunately, many of us were led to believe that we were studying actual capacitor operation when we were told how it *appears* to work. Then, when we get into a situation where the model doesn't work, we get confused. In the last issue I gave some examples in which most models fail.

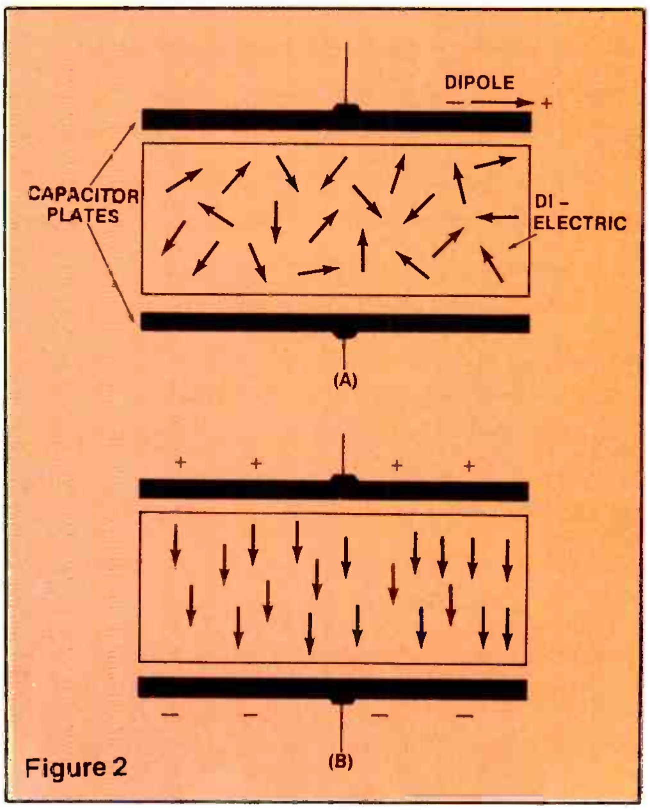
I learned to analyze capacitors in circuits by considering them to be *components that oppose any change in voltage across their terminals*. I still use that model whenever I analyze a capacitor circuit, but I learned (the hard way) not to try to defend it when it doesn't work. That situation came up when I was a very young electronics instructor.

I was teaching capacitors the way I learned about them to a class that was also studying physics. The students just couldn't reconcile what I was saying with what they were doing in their lab experiments.

At that same time, I was writing the CET tests and found that I could easily set the average grade (on a national average) by changing the number of questions on capacitors. If you have your own favorite model, try it out on the following questions. I'll give the answers later in the article.




A piece of iron becomes a magnet when magnetic domains are aligned, as by applying a magnetic field.




Capacitor charging is analogous to magnetizing iron. An electric field between the plates aligns dipoles in the dielectric.

• How can a capacitor be charged without a voltage, and without a charging current?

• How can a capacitor be discharged without connecting a conductor between the capacitor leads?

### What really happens when a capacitor is charged?

The best way to answer this question is to start with some concepts in magnetism. You may have learned about this subject by studying the Weber-Ewing theory. It is illustrated in Figure 1.

A piece of iron is considered to be made up of tiny magnets. When the iron is not magnetized, the little magnets are pointing in all directions as shown in Figure 1A. Magnetizing the iron causes them to all point in the same direction as shown in Figure 1B.

A surprising thing about the Weber-Ewing theory is that it is very near to what actually happens when a piece of iron is actually magnetized. The tiny magnets are called *domains*. They are little isolated regions that behave like magnets, and they can be aligned by applying a strong external magnetic field.

If the domains are rounded and smooth it doesn't take long for them to get out of alignment again. That is what occurs in a soft iron material. If the domains are rough they stay in place once the material is magnetized. That is what happens in a permanent magnet.

The reason for the existence of domains is well known. It has to do with spinning electrons and the structure of matter. However, for the purpose of discussing magnetic and electromagnetic materials and devices, the Weber-Ewing model works very well.

There is a surprising similarity between the magnetic theory just described and what happens in a capacitor dielectric. Instead of tiny magnets, the dielectric can be thought of as being made up of little dipoles, each having a positive and negative end.

Figure 2 shows the relationship between the dipoles in the dielectric and the charge on a capacitor. In Figure 2A, the capacitor is not charged and the dipoles are pointed in all different directions. In Figure 2B, the capacitor is charged and the dipoles are all pointing in the same direction. An electric field between the plates is used to align the dipoles in the same way that an external magnetic field is used to align the magnets in the Weber-Ewing model.

The presence of the dipoles can be explained on the basis of electron theory and atomic structures. However, for the purpose of explaining capacitor operation, the concept that is illustrated in Figure 2 works very well.

### The electret

If the dielectric is really like the magnetic material, it should be possible to pick certain materials that can be permanently charged. In other words, there should be some materials in which the dipoles can be permanently aligned.

In fact, there are such materials, called *electrets*. They are used for making certain types of microphones and memories.

I used to have my students take electrets to help them understand capacitor action. The setup is illustrated in Figure 3. A container of wax is melted and poured into a shallow pan. Then, a very high voltage (about 200,000V) is connected across the capacitor formed by the pan and upper plate. This aligns the dipoles. When the wax cools, the dipoles are *frozen* into their aligned positions.

The resulting electrets are removed from the pan – usually in small squares. They will pick up pieces of paper and straw. But they have a much more important application for explaining capacitor action.

Commercial electrets are not made like the ones described in the experiment, but the principle is the same. The overall result is a material with a permanent charge.

### Experimenting with the electret

What happens when you put an electret between two metal plates as shown in Figure 4? Surprise! You have a charged capacitor! Note that the capacitor was not charged by dumping a bunch of electrons into one plate and sucking them out of the other.

Take the capacitor in Figure 4

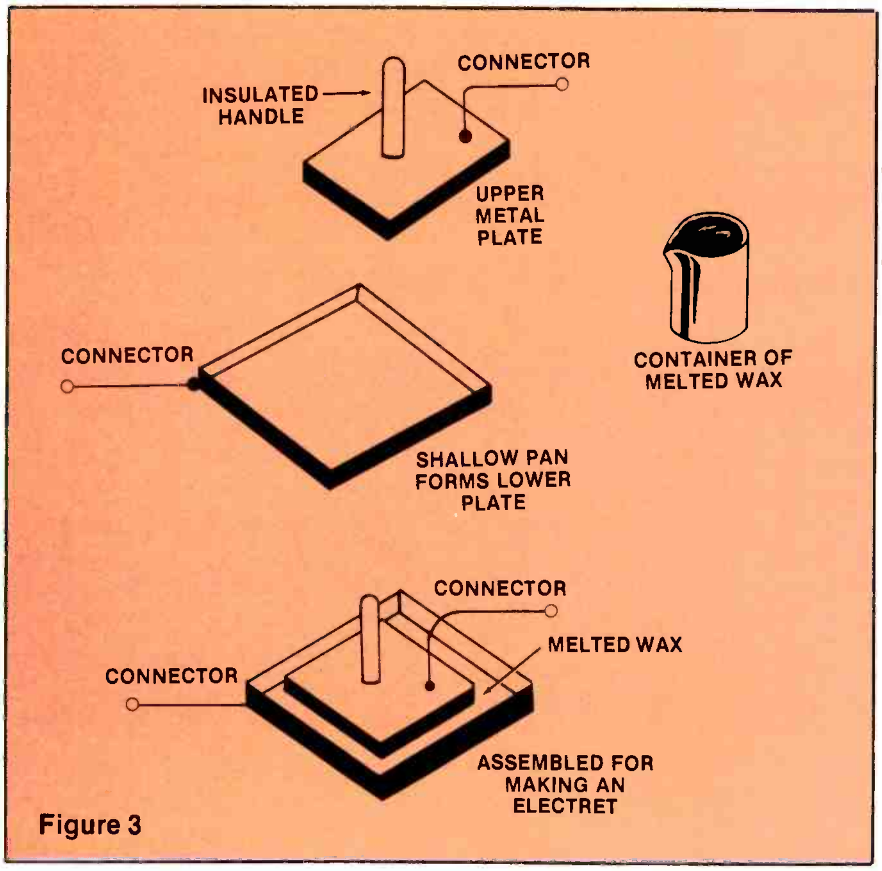



**Figure 3**

An electret consists of dielectric material in which the dipoles have been permanently aligned. You can make an electret as shown.



# Symcures Wanted

**Electronic Servicing and Technology** needs a broader variety of television Symcures. Especially needed are reports of Quasar, General Electric, Sylvania (or Philco), Sony Sears and Magnavox.

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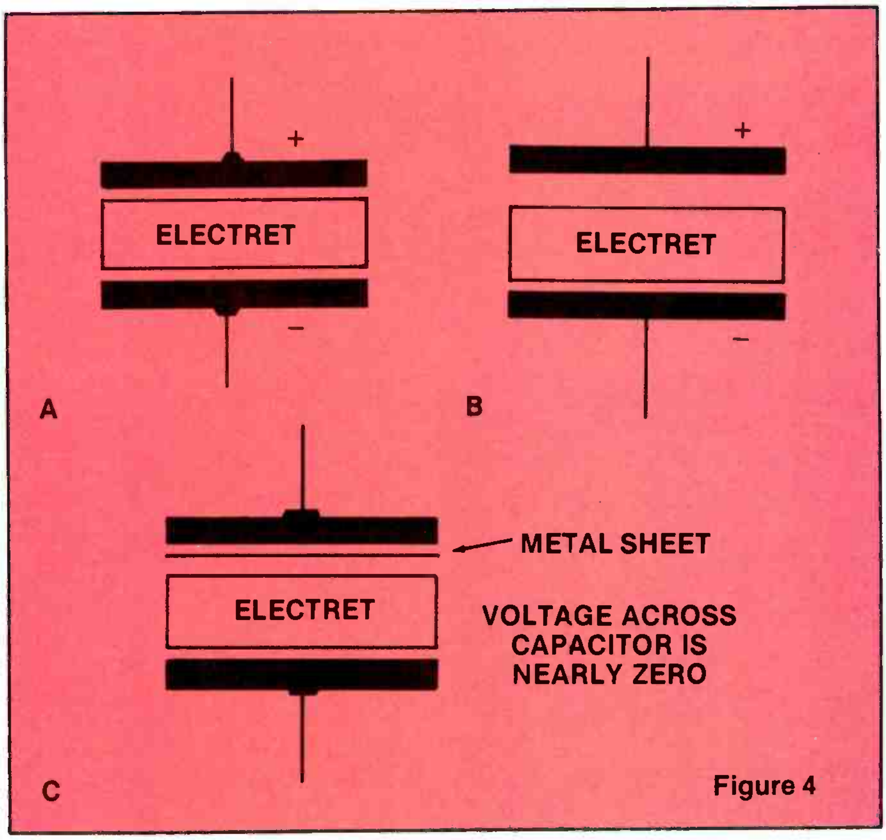



(A) Placing an electret between two metal plates yields a charged capacitor. (B) Even if you move the plates apart, the capacitor remains charged. (C) Slipping a metal plate between the electret and one of the plates reduces the voltage across the capacitor to near zero.

apart, touch the plates together, then put it back together as shown in the illustration. You still have a charged capacitor.

Move the plates apart as shown in Figure 5. The capacitor is still charged. Then, slip a thin sheet of metal (or metal foil) between the plates as shown in Figure 6. The capacitor is now discharged. Remove the metal and the capacitor is again charged. Note that the capacitor was effectively discharged *without* connecting the plates together with a shorting conductor.

### Summary

When a capacitor is charged, a physical change takes place in the dielectric. An electric field between the plates causes alignment of dipoles in the dielectric.

One way to get the required electric field between the plates is to force electrons into one plate and pull them out of the other in the classic description of capacitor charging. However, the only thing the electrons accomplish is setting up a field between the plates. It is the field that causes the alignment

PART 2

# Low-power microwave generators

By Joseph J. Carr

Part one of this series on low-power microwave generators examined vacuum tube methods used prior to the solid-state era, transistor-diode frequency multipliers and the Gunn device (which finds so much use in police speed radar transmitters). This installment will conclude the theoretical discussion by considering the IMPATT, TRAPATT and BARITT devices. A future article will cover practical applications of microwave generators, such as those in satellite TV receiving equipment.

### IMPATT Devices

The IMPATT (Impact Avalanche Transit Time) diode was proposed in 1953 by W.T. Read of Bell Laboratories. Read's suggestion was that the phase delay in a PN junction diode between an applied RF voltage and an avalanching current could be used for negative resistance operation at microwave frequencies. Read's model diode would have carriers drifting through a depletion region cause the negative resistance. Fabrication difficulties prevented the construction of a working Read diode until the mid-60s. In 1965, however, R.L. Johnson of Bell Labs verified the validity of Read's model when he generated approximately 80mW of RF energy at 12GHz from a silicon PN junction diode. Read's diode, which depends upon impact avalanche and transit time phenomena, was given the acronym IMPATT. It has now been recognized that Read's structure is just one of several that will result in IMPATT operation.

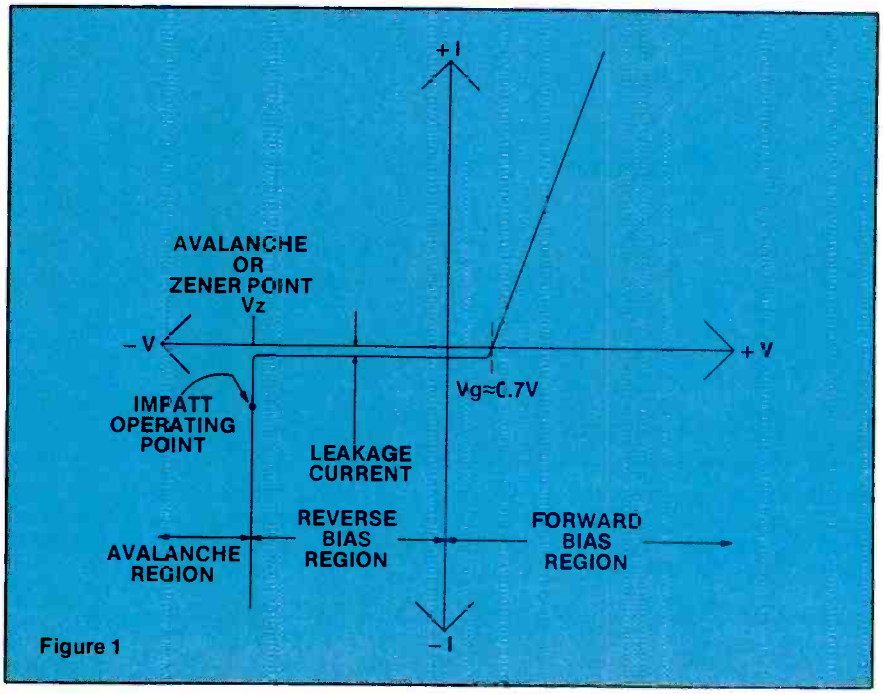


Figure 1

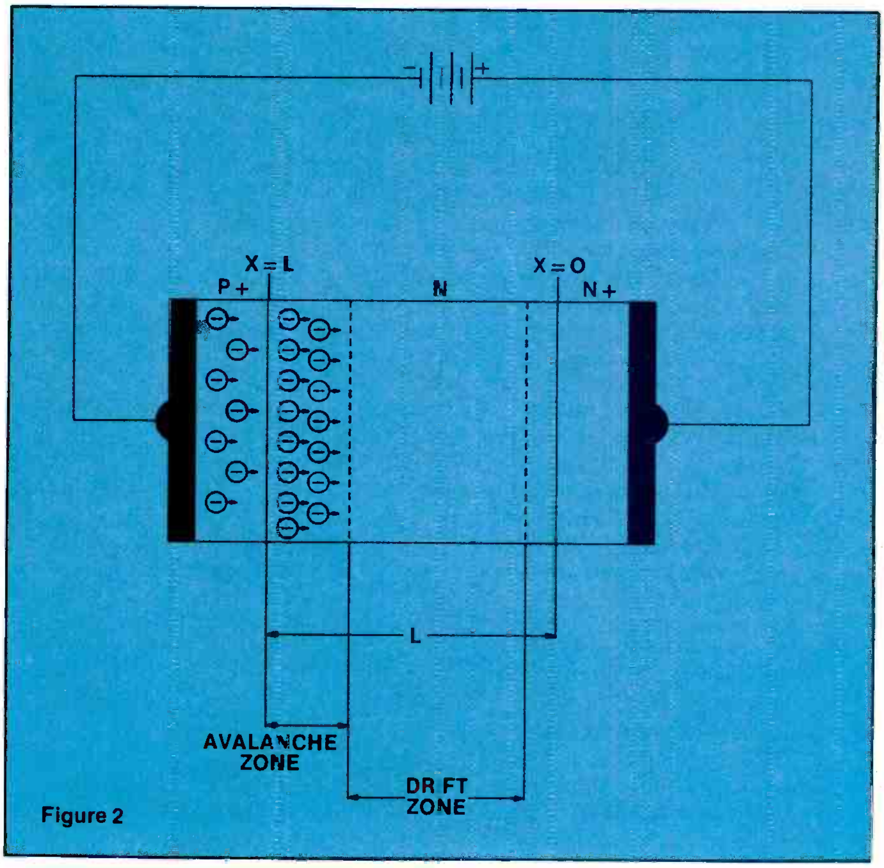


Figure 2

**Figure 1.** IMPATT operating point occurs in zener region of diode's characteristic curve.

**Figure 2.** IMPATT diodes are especially doped to give them the desired characteristics for IMPATT operation.

## Avalanche phenomena

Figure 1 shows the *I-vs-V* curve for a PN junction diode. let's look at operation in the reverse-bias region, i.e. the region in which V is less than zero. There is a critical breakdown voltage $V_z$ in the reverse-bias region. At reverse potentials less than this value, the current through the PN junction is very small, a tiny leakage current.

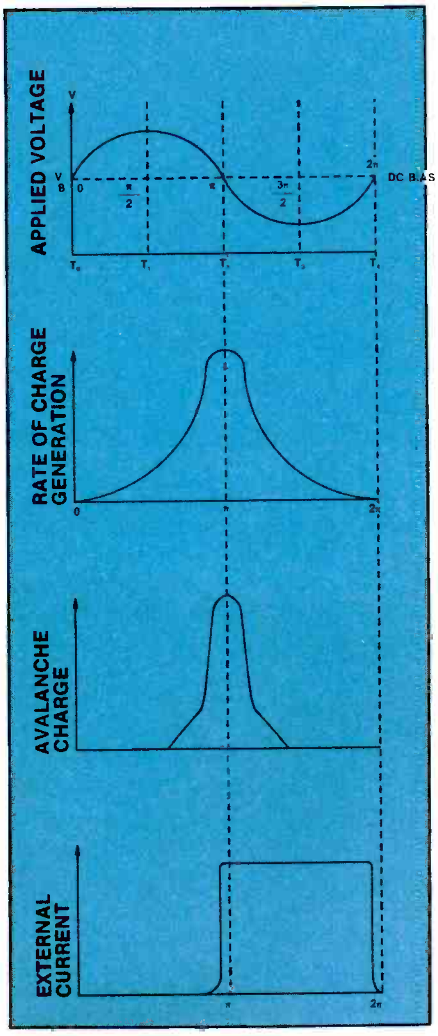



**Figure 3.** These curves for an IMPATT diode demonstrate that the RF voltage leads the current by more than 90 degrees, a characteristic of a negative-resistance device.

But the current suddenly increases when the voltage exceeds $V_z$: the junction is operating in avalanche. The increased current is due to secondary emission or avalanche multiplication, in which electrons of the leakage current have a high probability of being multiplied. The result is a very rapid increase in reverse current. In ordinary signal or rectifier diodes, the avalanche phenomenon can be destructive. Certain types of diodes, however, are able to control the avalanche process by using properly doped semiconductor material. Zener diodes and controlled avalanche rectifiers are in this category.

Consider the pnn$^+$ IMPATT diode shown in Figure 2. The PN junction that we will discuss is on the left side of the structure. Note that the right-hand junction is an n-n$^+$ structure. The n$^+$ region forms a contact of low resistivity for the electrode, and prevents metallic ion migration (much as in the Gunn structure) from entering the active region.

The center *n* region is the active zone, and must be doped such that it is fully depleted at breakdown. It is desired that a very small electrical field will cause velocity saturation of the electrons. The transit time of the IMPATT is defined as $T = L/V_{sat}$.

The electrons generated in the avalanche zone of the IMPATT diode shown in Figure 2 will flow into the drift zone of the n-region. It takes very little added voltage to cause a large increase in current in this mode.

## IMPATT oscillation

Consider a situation in which an IMPATT device is biased to a potential just below $V_z$ (i.e. in the reverse-bias region but not quite to the avalanche point)–a bias such that a small added potential will throw the device into the avalanche region. Assume that this IMPATT device is operated in parallel with a high-Q resonant tank circuit (i.e. the IMPATT device is operated inside of a resonant cavity). The reverse-biased PN junction will create a noise signal that shock excites the tank circuit into oscillation. The RF voltage produced by the oscillatory tank is added to the bias voltage, causing the diode to go into the avalanche mode on positive peaks of the cycle. The junction will exhibit negative resistance operation if the RF current can be made to lag the RF voltage by 90 degrees or more.

The number of electrons generated by avalanche multiplication is a function of the applied voltage (Figure 3A) and the number of charge carriers present. Because of this dual dependence, the avalanche current pulse (Figure 3B) continues to increase even after the RF voltage cycle has passed its peak. During this process, the charge density at the avalanche point grows exponentially, while the avalanche charge current (Figure 3C) drifts toward the other end of the drift zone at velocity $V_s = 10^7$ cm/s.

Does the IMPATT produce negative resistance? Note that the current reaches a peak (Figure 3C) as the sine wave RF voltage goes through its zero crossing (Figure 3A) – a 90-degree delay with respect to the voltage peak. The criteria for negative resistance is a phase difference of 90 degrees or more between the applied voltage and the series current, so the IMPATT *is* a negative resistance device.

The avalanche current pulse drifts through the n-region at velocity $V_s$ until it is collected at the output of the $N^+$ region. The drift time, then, is proportional to the length of the drift region and inversely proportional to the saturation velocity: $T = L/V$.

**Where:**

T is the drift time in seconds.

L is the path length in centimeters.

$V_s$ is the electron saturation velocity ($10^7$ cm/s).

The pulse of current in the external tank circuit (Figure 3D) is semi-square and represents a current lag over applied voltage of more than 90 degrees. These two factors are shown together in Figure 4. Two factors combine to cause the positive external current during the negative portions of the RF waveform: the time delay of the avalanche process and the drift time of the avalanche charge. Instead of absorbing energy, in the manner of a positive, or ohmic, resistance, the IMPATT offers a negative resistance.

The IMPATT device, which was shown previously, is known as a *single-drift*. But an avalanching PN junction produces both kinds of charge carriers, i.e. holes and electrons. The single-drift IMPATT uses only the electrons and returns the holes to the cathode p-region. This fact limits the efficiency of the single-drift devices to less than 15 percent.

Greater efficiency is obtained through the use of a double-drift

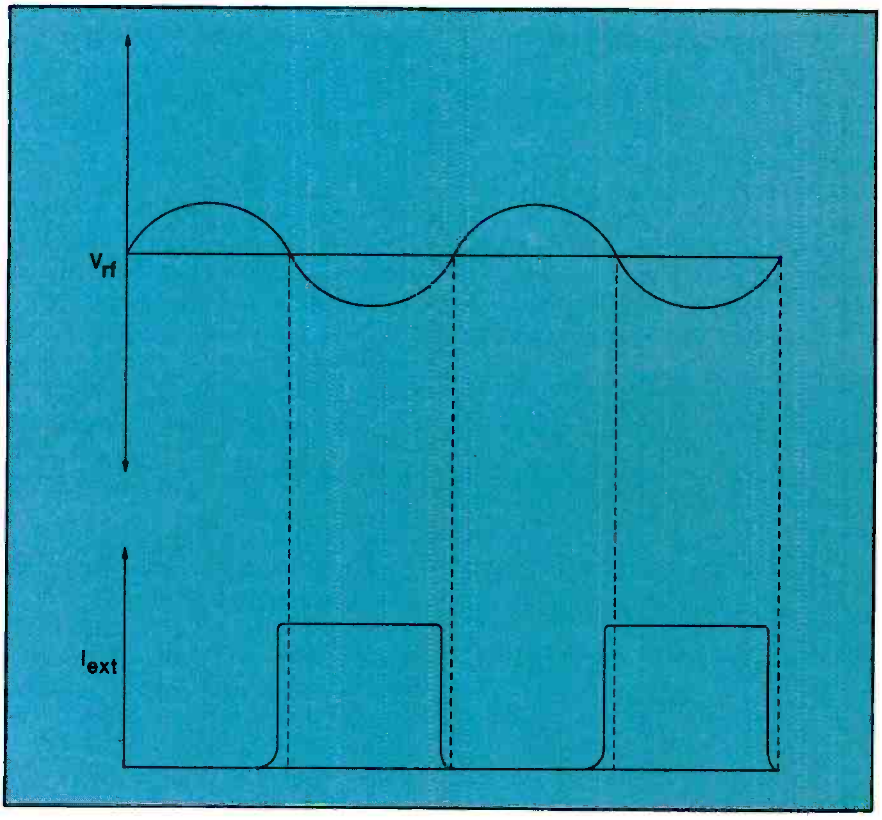



**Figure 4.** A comparison of several cycles of the RF voltage applied to the IMPATT diode with the current pulses occurring in the external circuit emphasizes the greater-than-90 degree phase difference between the voltage and current.

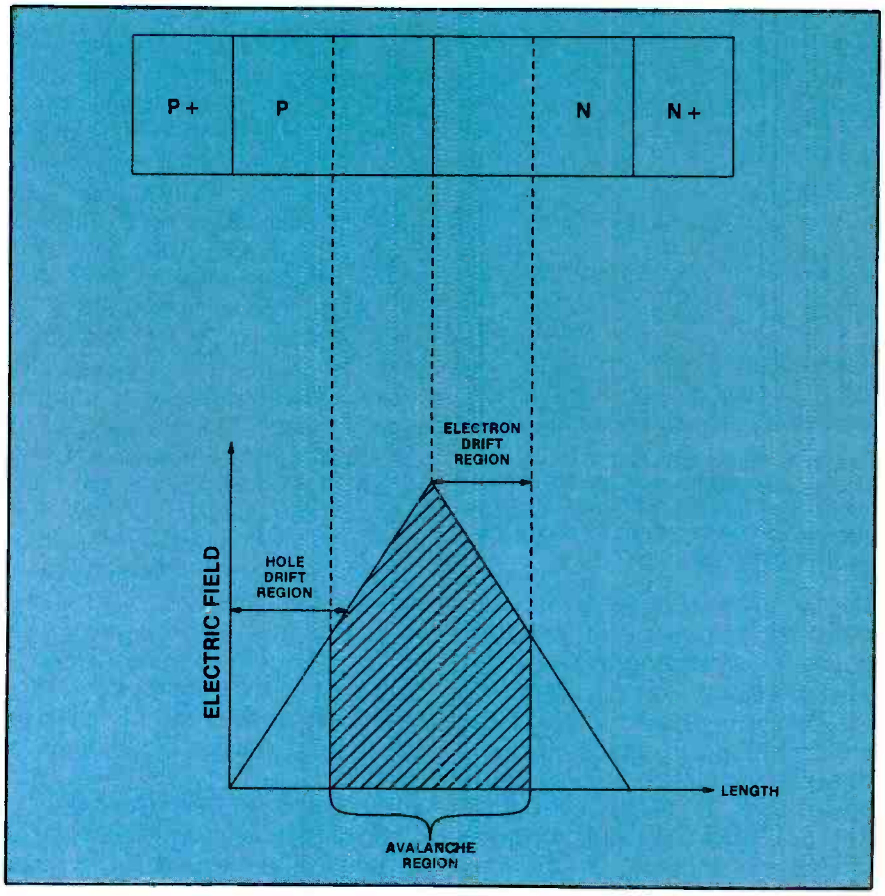



**Figure 5.** Double-drift IMPATT diode is more efficient than single-drift device because holes drift across the p-zone very nearly in phase with the electrons drifting across the n-zone.

IMPATT device, such as that shown in Figure 5. This structure is a $p^+$-p-n-$n^+$, in which the avalanche region brackets the PN junction. The $p^+$ *zone serves as an ohmic contact for hole charge carriers, while the* $n^+$ region serves the same purpose for electrons. The output efficiency is increased over that of the single-drift variety because the holes drift across the p-zone very nearly in-phase with the electrons drifting across the n-zone.

### IMPATT applications

The above discussion has shown that the IMPATT device will function as an oscillator at microwave frequencies. If an IMPATT is placed inside of a high-Q resonant cavity, and biased with a dc potential slightly below the avalanche potential, then noise pulses will ring the cavity to produce the RF sine wave that actually drives the junction into the IMPATT mode of oscillation. IMPATT operation occurs because the voltage of the ringing waveform (an RF signal) algebraically adds with the static dc bias, causing the junction to go into avalanche mode on peaks of the RF cycle. If the device is correctly biased, the junction will be in the avalanche condition for most of the positive half of the RF sinewave excursion.

Although the IMPATT device is an oscillator that is capable of producing substantial peak pulse powers at microwave frequencies, it is not universally applied because it is a noisy source (avalanching is a noisy process). For this reason, one does not ordinarily see IMPATTs as receiver local oscillators.

IMPATTs are used primarily at frequencies above 3 or 4GHz, to as high as 100GHz. Many high-power IMPATTs require operating potentials between 75V and 150V dc, considered a disadvantage by some. IMPATTs are usually operated from constant current power supplies, another potential disadvantage. The efficiencies obtained from IMPATTs range from 12 to 15 percent for single drift devices, and 20 to 30 percent for double-drift devices made of GaAs material.

The applications of the IMPATT are not limited to oscillator service. There is one report of IMPATTs being used as a microwave frequency multiplier. Many IMPATTs are used as amplifiers. In fact, it has been claimed that most IMPATT applications are as amplifiers, not as oscillators. IMPATT amplifiers have only one port, so they must be coupled to a *circulator* in order to isolate input and output ports of the amplifier (see Figure 6). This type of amplifier is called a *reflection amplifier.*

### TRAPATT diodes

IMPATT diodes are generally limited to operation at frequencies above 3 or 5GHz. The problem of lower operating frequencies (e.g. 0.9 to 3GHz) is one of finding a method for stretching the duration of the transit time. Until 1967, it had proven difficult to use solid-state devices to generate any significant amount of power in the 1GHz region. In 1967, however, engineers working for RCA succeeded in exciting an IMPATT-like device into a different mode of operation. One set of trials produced pulse powers of 425W with

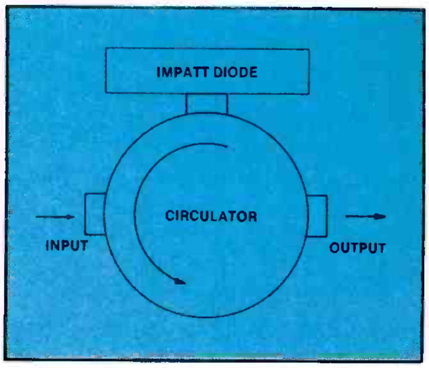



**Figure 6.** IMPATT amplifiers have only a single port, and so must be coupled to a circulator in order to isolate the input and output.

an efficiency of 25 percent. Further work with this new mode yielded efficiencies up to 60 percent, with later work producing efficiencies as high as 75 percent. Tuned tank circuits developed at RCA in that era permitted a tuning range that was continuous over 0.9 to 1.5GHz.

It appeared that the problem of increasing the transit time had been solved, but no one really knew why! At the time the basic work on the TRAPATT device was going on there was no good theory that explained the observed behavior. RCA workers dubbed the new mode the anomalous mode, perhaps reflecting the fact that they had no theory of operation.

At least two different theories were advanced to explain the behavior of the anomalous mode. Bell laboratories advanced the theory that the high efficiency and lowered frequency of operation was explained by the fact that a trapped plasma was created in the device between sweeps of the IMPATT mode of operation. The theory held that the trapped plasma shielded the charge carriers from the external voltage field, causing them to drift out of the plasma at low velocity. This theory led to the acronym by which the device is now known: TRAPATT (trapped plasma triggered transit).

The difficulty in determining the proper theory of operation caused a two-year delay between the first observations of the TRAPPATT mode and the explanation of how it worked. Part of the problem is that TRAPATT operation is not amenable to small-signal analysis, so the correct theory had to be worked out somewhat more laboriously than would have otherwise been possible.

It has been demonstrated that ordinary PN junction diodes (silicon) can be made to oscillate in the TRAPATT mode. Because it's tricky to adjust such circuits, they don't find much application. Most commercial TRAPATT devices use the $p^{+}$-n-$n^{+}$ structure of the single-drift IMPATT. A typical TRAPATT device is shown in Figure 7A.

### TRAPATT oscillators

The structure of the TRAPATT device is very similar to that of the IMPATT. In fact, some TRAPATT devices will oscillate in either the TRAPATT or the IMPATT modes, depending upon the bias and other circuit conditions. It is noted that numerous TRAPATT oscillators actually start out in the IMPATT mode for a few nanoseconds after turn-on, and then convert to the TRAPATT mode when certain circuit conditions are satisfied. In order to make the device switch from the IMPATT to the TRAPATT mode it has to be driven hard with a current pulse. Since the rise time of this pulse must be very short, it is usual to use the IMPATT mode to generate the pulses (it is very difficult to obtain the rise times needed with external circuitry).

What is a trapped plasma, and how does it behave? A plasma exists wherever there is a large density of charge carriers (holes and electrons) present. If the electric field in that region is very low, then the plasma is said to be *trapped*, i.e. it takes a long time to sweep carriers out of the region under the influence of the electric field. The carrier velocity is considerably lower than the saturation velocity.

Figure 7B shows the electric field distribution of the n-region (Figure 7A). The device is biased to just punch-through, i.e. the depletion zone reaches through the entire length of the n-region, but is biased to a point less than the avalanche voltage $V_Z$. The slope of the electric field (Figure 7B) is dependent upon the charge density. Be-

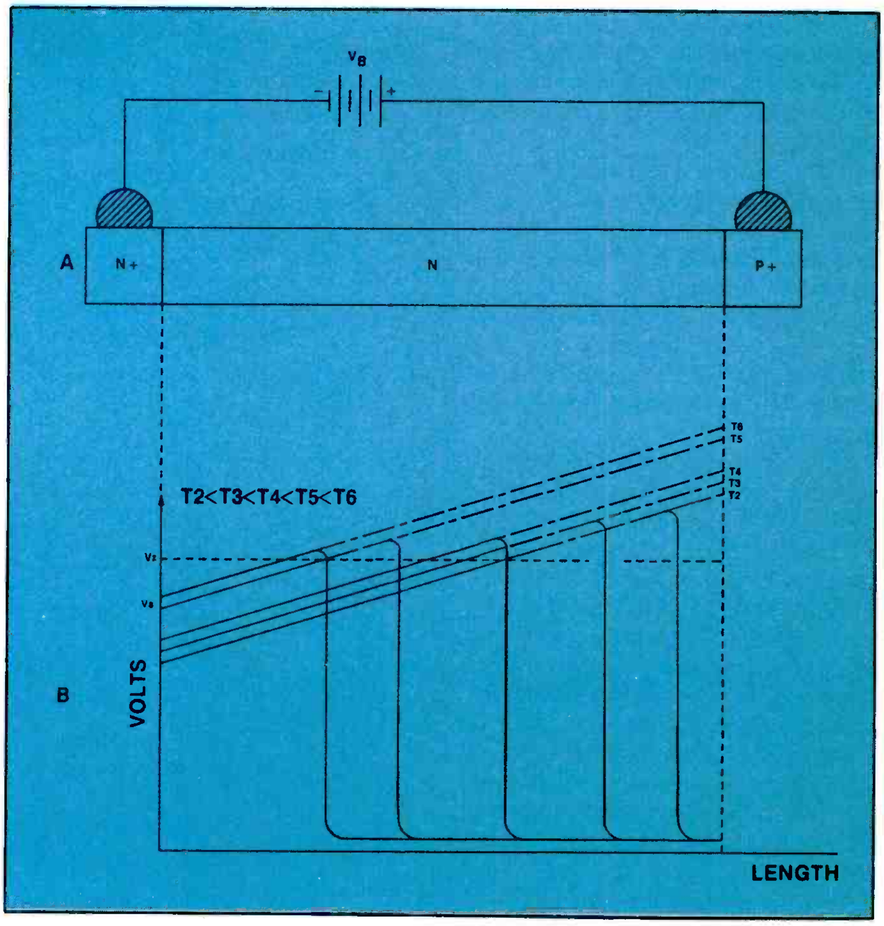



**Figure 7.** TRAPATT device allows operation at lower frequencies than is possible for IMPATT diode.

cause operation is in the punch-through region, there will be no free charge carriers present.

If the TRAPATT diode is excited with a large, fast risetime current pulse, $I_O$, then a point in the constant bias field $V_B$ will move as an avalanche shock front with a velocity $V_X = -I_O/eN_D$. The velocity of this shock front, $V_X$, can be faster than the saturated velocity of the holes and electrons, a phenomenon that is much like the behavior of water waves at the beach striking the shore with an angle other than 90 degrees. Typical times for the avalanche shock front to traverse the n-region are around 100ps.

Notice what happens to the terminal voltage in Figure 7B. Shortly after the initiation of each shock front, the terminal voltage drops from a very large value down to a very small value. The fall-time of this drop is very rapid, so the TRAPATT operates as a very fast, low impedance electronic switch. If we were to place the diode at one end of a half wavelength transmission line (Figure 8A) then this phenomenon would result in a pulse being applied to the transmission line at L=O. The current pulse has a fast risetime, and a nearly square waveshape, so it is rich in harmonics. The harmonics are taken out by a lowpass filter so that the fundamental can be applied to the local $Z_L$. The value of the current pulse will be $I = V_B/Z_O$ where $V_B$ is the applied bias potential and $Z_O$ is the characteristic impedance of the transmission line.

The description above required a current pulse to be applied to the TRAPATT diode before the TRAPATT mode could occur. This pulse could easily be an IMPATT pulse when the device is operating in the IMPATT mode. But the TRAPATT mode will be observed to build up in a nearly exponential manner until it becomes self-sustaining. But that doesn't explain how the TRAPATT mode could become self-oscillatory. For this type of operation we must rely on the actions of the low pass filter at the end of the resonant half wavelength transmission line. It will transmit energy at the fundamental TRAPATT frequency, but will re-

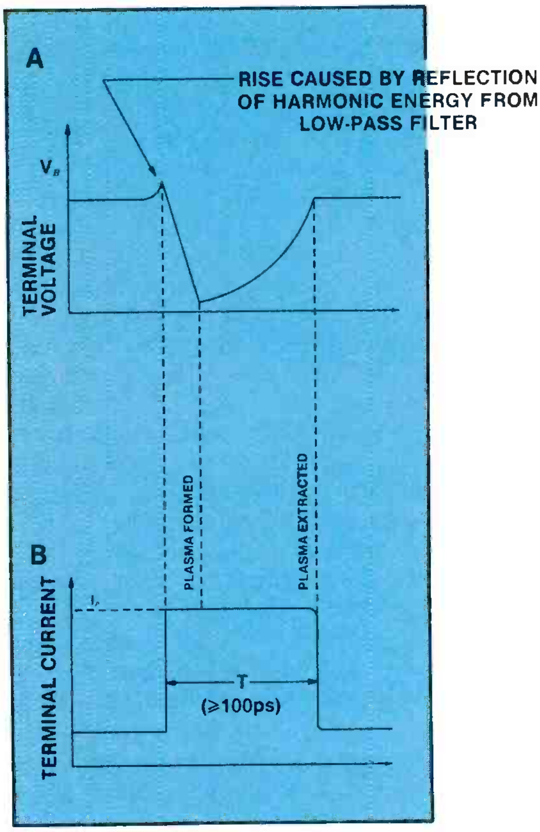



**Figure 8.** Curves show relationship between terminal voltage and current in a TRAPPAT device.

flect energy at the harmonics of the fundamental frequency. These harmonics are reflected with phase reversal (i.e. reflection coefficient −1 in the ideal case) so they will initiate another avalanche shock front. The small rise in the terminal voltage in Figure 8B is caused by this returning reflection. The return pulse will, then, cause the TRAPATT mode oscillations to be continuous. In the typical TRAPATT oscillator, the device will begin in IMPATT operation. The IMPATT mode oscillations will build up in an exponential manner until the current becomes large enough to trigger a shock front transit (hence the use of triggered transit in the device acronym!).

### BARITT Devices

Consider the $p^+$-n-$p^+$ structure shown in Figure 9A. This device is a pair of abrupt junctions back-to-back. One of these junctions will be slightly forward-biased, while the other junction is slightly reverse-biased. Current under conditions when the bias voltage is less than the punch-through voltage will be limited by the ordinary leakage current of the reverse-biased junction. If the bias is increased to the point where the device is operated in the punch-through mode, then the depletion region exists across the entire n-region until it reaches the forward-biased junction. This will cause all of the carriers (holes) at the forward-biased junction to be swept across the n-region, causing the current to increase rapidly (Figure 9B). This current can be used in a microwave oscillator provided that: (a) the field is large enough to make the holes drift across the n-region at the saturated velocity ($10^7$ cm/s) and (b) the voltage applied be kept below the point at which avalanching will occur. Devices that use this phenomenon are called BARITT oscillators *(Barrier injection transit time).*

Suppose that a BARITT device is biased with a dc potential close to the potential required for punch-through operation. Further suppose that this device is operated in parallel with a resonant tank circuit (as was discussed in the first installment about the Gunn device). Noise pulses will ring the tank circuit and cause an RF alternating potential to appear across the diode, which will add algebraically with the bias potential (Figure 10A). When the total bias goes over the punch-through potential on positive excursions of the RF waveform, a sharp current pulse is injected (Figure 10B, see also Figure 9B). During the period when the injected current is peaking, the terminal current (from the dc bias) is added with it, causing a reversal of the current direction for that period (Figure 10C). A plot of the power (i.e. product of Figures 10A and 10C), will give the power-vs-time waveform of Figure 10D. Notice that, for substantial periods during the cyclic excursion, the power is negative, meaning that the device is oscillating and will deliver energy to the external tank circuit. There is only a brief period in which the terminal current and terminal voltage are both positive ($T_2$ - $T_3$), and this will limit the efficiency of the BARITT oscillator.

The BARITT device is a low-power microwave energy source, and is, in many ways, considered superior to the Gunn device for service such as microwave receiver local oscillators, doppler intrusion alarms and certain shoplifting protections devices.

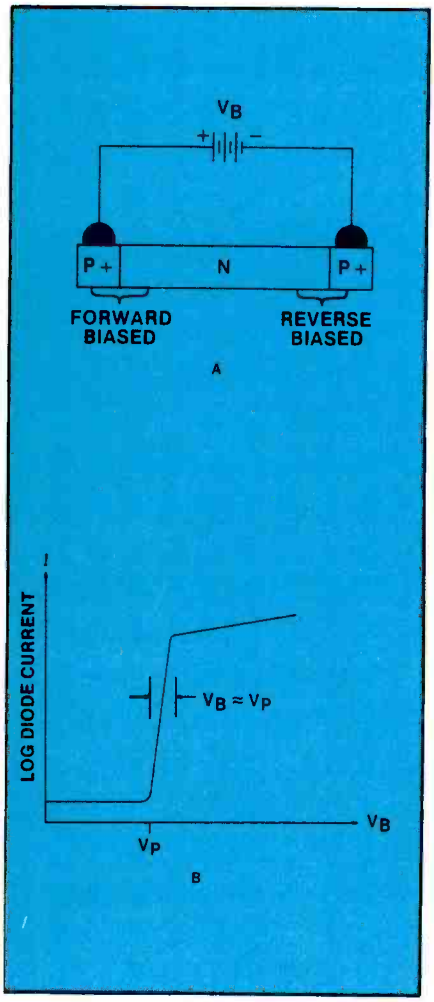



**Figure 9. (A)** BARITT device has two pn junctions, one forward-biased, one reverse-biased. **(B)** When potential across device is such that the reverse-biased junction reaches its punch-through voltage ($V_p$), current increases rapidly.

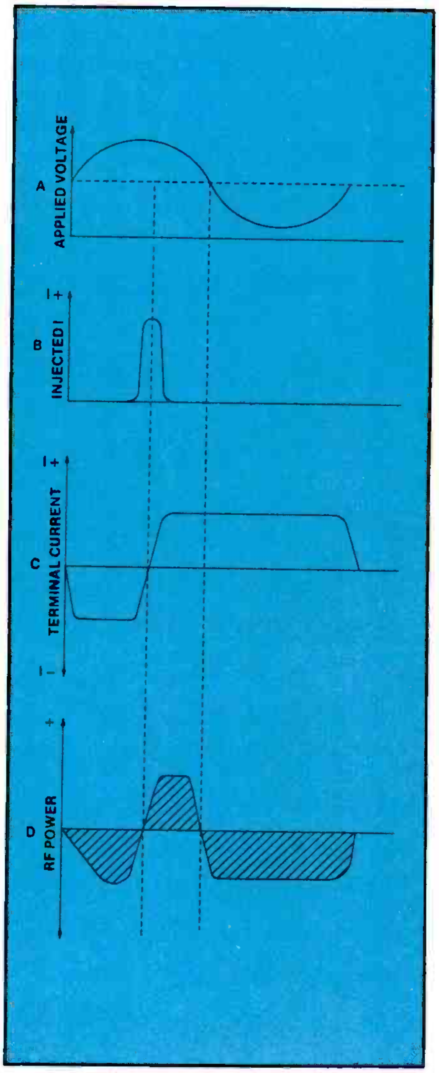



**Figure 10.** Voltage, current and power in a BARITT device are related as shown by these curves. See text for a detailed explanation.

Artwork for this article was prepared for **ES&T** by Howard W. Sams & Company, Inc., on a Prime computer assisted design (CAD) system.

**Editor's note:** Material in this article is based in part on the author's contribution to James Coleman's book *Microwave Devices,* which is available from Reston Publishing Company, 11480 Sunset Hills Road, Reston, VA 22090. This book is recommended for those who have an interest in microwave generators and amplifiers, and also for those whose professional interests in electronics lead them to regard VHF and UHF as IF frequencies. ES&T

of the dipoles. The experiment shows that the capacitor is charged when the dipoles are aligned – regardless of whether the electrons are moved. Any method used to align the dipoles can be used to charge the capacitor. Also, any method used to shield the dielectric from the capacitor plates can, in effect, discharge the dielectric.

It is easier to align the dipoles in some dielectric materials than in others. So, an important method of rating capacitors is by the characteristics of their dielectrics. That is why capacitors are identified as mica, film, paper, air, oil, and so on.

Manufacturers are faced with a trade-off between the ability of the dielectric material to store energy (by aligning the dipoles) and its ability to withstand a voltage difference without conducting. Of course, cost is another very important factor that must be considered. If you know how capacitors are rated, you will have a good understanding of how they are used, tested, and chosen for replacement.

### When is a capacitor not a capacitor?

Actually, there is no such thing as a pure capacitor in real life.

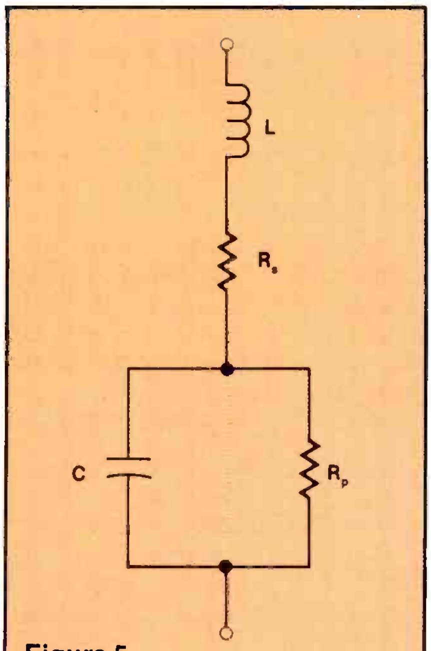



Figure 5

This is the equivalent circuit for a capacitor, illustrating the inductance, series resistance and leakage resistance exhibited by a real capacitor.

They are often made by rolling foil plates together with some form of dielectric, and this construction produces inductance. Also, since there is no such thing as a perfect conductor – at least, at room temperature – there will be some resistance associated with every capacitor.

In many applications, the resistance and inductance can be ignored. However, the manufacturer doesn't know how you are going to use their product, so the resistance and inductance are included in their specifications.

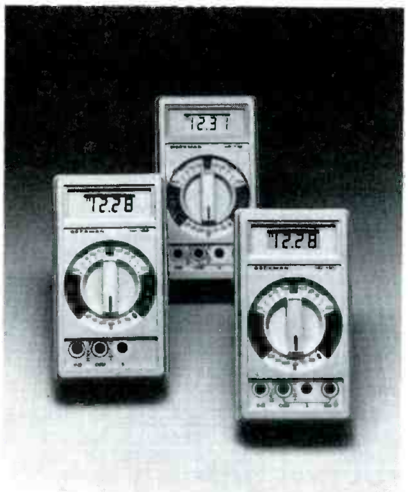
Figure 7 shows the equivalent circuit for a capacitor. The leakage resistance ($R_p$) is due to the fact that there is no such thing as a perfect insulator or dielectric. The series resistor ($R_s$) represents the fact that there are no perfect conductors. The inductance is caused by the construction of the capacitor, and the fact that all conductors have a certain amount of self inductance.

The equivalent circuit of Figure 7 is very important for understanding capacitor ratings and types. ES&T

# Products

### Hand-held DMM

*Beckman Industrial Corporation,* Brea, CA, has added a new ruggedized, handheld DMM to its HD100 series. The HD130's True RMS capability allows it to accurately measure non-sinusoidal waves such as pulse trains, triangular waves or distorted sine waves, common in such applications as switching power supplies or motor speed controllers. The dc voltage accuracy is 0.1 percent compared to an outstanding 0.25 percent on the HD100 and HD110, the other models in the series.



These DMMs feature special o-ring seals, ultrasonically welded display window and sealed input jacks to protect the internal electronics from contamination. All dc inputs are protected up to 1500Vdc or 1000Vrms. Current ranges are protected to 2A/600V with resistance ranges protected to 600Vdc. Transient protection extends up to 6kV for 10μs.

**Circle (100) on Reply Card**

### Replacement magnetrons

*MCM Electronics,* Centerville, OH, has introduced low-cost replacement magnetrons for microwave ovens. These magnetrons were designed for use in


microwave ovens with typical oven power of 600-700W, 960W maximum. MCM's new magnetrons work in all microwave oven brands, such as Sharp, Tappan, Litton and Hotpoint. Mounting studs provide easy installation and are removable for applications not requiring them.

**Circle (109) on Reply Card**

### Digital multitester

*Universal Enterprises,* Portland, OR, offers a pocket-size digital multitester, DM20, measuring only 4" x 2½" x 1". Accurate and easy to use, the DM20 is a practical choice for the service technician, field engineer, the growing electronics market and for do-it-yourself use. Fourteen ranges cover most electrical and electronic measurements. Zero-500V of ac power tests hot water heating elements, small appliance power cords, fuses and wall-mount switches, 0-20V of dc power tests car and truck batteries, and for electronics, resistance ranges from 0-2KΩ for measuring resistors, diodes and transistors, to 2MΩ for checking electronic circuits and general circuit troubleshooting. It also has a range of 0-200dc mA.

DM20 features a 3½-digit, 0.5-inch LCD display, auto polarity, overrange indication and diode test function. All current ranges are fuse and varistor protected and circuitry is protected to 250V minimum.

**Circle (121) on Reply Card**

### Bus added to waveform analyzer

*Sencore,* Sioux Falls, SD, announces the first instrument to feed all conventional oscilloscope measurements to a computer or automatic test system through the IEEE 488 General Purpose Interface Bus (GPIB). Model SC61 waveform analyzer serves multiple functions, and dual-channel inputs may replace up to six instruments in many bus setups. Because it's a full bus talker and listener, the computer/controller can select any of the SC61's digital readout functions for fully automatic tests.

The SC61 brings wideband peak-to-peak voltage readings to the IEEE bus. Its VPP circuit measures the peak-to-peak level of any signal to 60MHz (−3dB). The designer is able to feed signals to the IEEE bus that agree directly with conventional oscilloscope readings.


The SC61 has two ac channels that each measure PPV and frequency. The two dcV inputs are normally connected in parallel with the ac channels for simultaneous measurement of dc but can be electrically isolated from the ac channels. Therefore, up to four separate test points can be monitored at one time. The unit's functions also eliminate connecting a separate frequency counter and meter to a test point to monitor frequency and amplitude. In many cases, the SC61 replaces six separate instruments (two dc meters, two frequency meters and two amplitude meters) for data logging or automated testing applications.

**Circle (122) on Reply Card**

### Desoldering station

The model SA-4 Desoldering Station, manufactured by *Davle Tech,* features a self-contained, high-volume vacuum pump for easy removal of solder from through-hole and multilayer applications. Additional features include trigger-actuated pistol grip design, no-clog system with transparent solder collector, easy collector cleaning, grounded for use with delicate MOS and CMOS components, and specially processed long-life nozzle. The SA-4 is available for either 115V or 230V

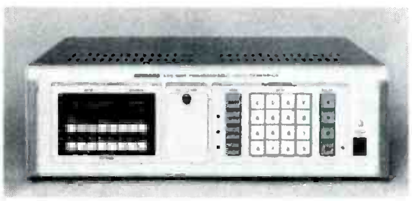
50/60 Hz input, and is compact and lightweight for portability. A handy tool holder is built into the control unit. Includes 0.039-inch (1mm) nozzle. Optional nozzles available from 0.031-inch (0.8mm) to 0.063-inch (1.6mm) diameter.

**Circle (125) on Reply Card**

**Programmable video generator**

*Leader Instruments,* Hauppage, NY, has introduced the LVG-1600 programmable video generator, which has the functions to fully test almost any monochrome or color display system.

The LVG-1600 generates both RGB and Sync signals and composite video signals for testing monochrome and color CRT displays. Nine standard patterns, stored in an EPROM, allow testing of color purity, bandwidth, focus, resolution, linearity, brightness and convergence. Patterns include a full ASCII and JIS character set, color bars and gray scales. The EPROM is removable so that user-created patterns (up to 55) can be used.

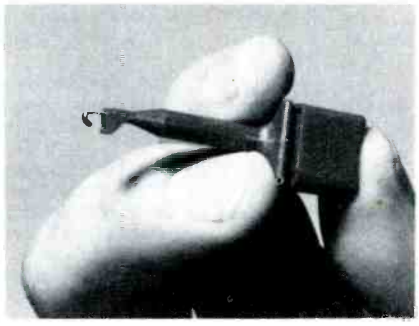


Test conditions can also be created via the front panel. Programmable features include clock frequencies between 5 and 40MHz, character size up to 16x16, number of rasters and color. Outputs are available via three formats: RGB and horizontal sync, H/V composite sync and vertical sync on BNC connectors; TTL sync and video signals on an Amphenol 57 series-type 24 pin connector; and analog 75Ω outputs on an Amphenol-57 series-type connector. Composite video is available on both the BNC and 24-pin connector. All outputs are fully protected.

**Circle (126) on Reply Card**

**Test Clips**

A new line of *Clipper* plunger-type test clips have been introduced by *Mueller Electric Company,* Cleveland, OH. Clippers feature a spring-loaded hook that attaches to delicate component leads and terminals to free hands while circuit testing. A beryllium copper hook retracts into a plastic housing when removed from the contact point to prevent possible shorting of components. Mueller Clippers are available in four sizes,



1¾-inch, 2½-inch, 3½-inch and 5-inch. Smaller sizes assist testing on high-density boards and general-purpose applications, while larger sizes test through wiring nests and hard-to-reach areas.

**Circle (128) on Reply Card**

**Glue Gun**

A lightweight, solid-state hot-melt glue gun designed specifically for commercial use has been introduced by the *Bostik Division* of the *Emhart Chemical Group,* Middleton, MA. The T.G. 3 offers sturdy, lightweight construction, 1-hand operation and clean modern design to make it suitable for florists, upholsterers, carpet layers, electricians, craftsmen and

electronics professionals. The new glue gun may also be used for light industrial and product assembly applications. The T.G. 3 also features a tough, impact resistant plastic housing. It weighs less than 8 ounces and measures 6½ inches. A no-drip nozzle assures neat, clean operation for a wide variety of assembly and mending opera-

*Continued on page 61*

# Readers' Exchange

**Needed:** Oscilloscope, 3-inch or 5-inch, 4.5MHz. Tube or solid-state with instructions manual. *O.D. Mann Jr., 158 Prospect St., Schoharie, NY 12157; 518-295-8930.*

**For Sale:** B&K 1077-B analyst, $150. B&K 415 sweep/marker generator, $150, like new. Manuals and cables included. *J.M.S. Electronics, S.E. 881 Binns Swiger LP, Shelton, WA 98584; 206-426-7220.*

**Wanted:** Schematic for AM/FM cassette unit, Craftman model SL-7702. Will pay or copy and send back. *Robert Alvarez, 424 Denver, San Antonio, TX 78210.*

**For Sale:** Bell & Howell home entertainment electronics course, 100 lessons in 10 3-ring binders, includes laboratory module, $100. NRI Master automotive machine course, 75 lessons in three oversized 3-ring binders, $75. Television and video recorder service manuals for Sony, GE and others. Send s.a.s.e. for list. *Don Hicke, Apt. 2, 3351 Madison Ave., San Diego, CA 92116.*

**For Sale:** Fluke model 803B differential ac/dc voltmeter, $100. Hewlett-Packard model 400 AB ac VTVM, $50. **Need:** High voltage transformer for Hewlett-Packard model 130B oscilloscope, or will sell for $80. *Bill Garbutt, 1680 Kingsbury, Casper, WY 82609.*

**For Sale:** Two Jerold gelbraltar amp models 3660 and 3661, in good working condition, $100 each. Also UHF and VHF converters and headend amps, Jerold channel master. For details call: *R. Garcia; 707-279-1938.*

**For Sale:** VA48, in mint condition with manual and probes, $850. *Robert L. Blount, 40 SW 8th Ave., Delray Beach, FL 33444.*

**For Sale:** Sylvania RE25AMP22 Kine, $45 plus postage. Alliance U100 rotor, $25 plus postage. Assorted points rebuilt RCA modules, 50 percent off list price. Send s.a.s.e. for details. *Bill Messina, 52 Railroad Ave., Morwood, MA 02062.*

**Wanted:** Module #8945-2 for Admiral TV. *Joe Koesin, Woodbridge Radio and Television, 75 Schoder Ave., Woodbridge, NJ 07095; 201-634-1306.*

**Needed:** Hickok generator model 661. Hickok generator model 656. Precision generator model E-310 and E-2000. *Jim Shoemaker, 600 First St., Leechburg, PA 15656; 412-842-8321.*

**For Sale:** Many older, but new flys, yokes, vert. About 30 parts in all. All for $50 plus postage. *Dan's TV, P.O. Box 42, Osakis, MN 56360; 612-859-2851.*

**Needed:** High voltage transformer for Tektronix type 453 oscilloscope, part #120-0360-00. *Frank Beckerle, 313 Woodcrest Dr., Buffalo, NY 14220; 716-823-1571.*

**For Sale:** WP-26A Isotap, $45. Heathkit EES-320-1B digital training course with trainer kit, $89. NRI TV color course with CRT kits for study projects, build TV or test jig, $95. *Bob Begun, 1056 Fraser, Aurora, CO 80011.*

**Needed:** Current tube chart or manual for Precision apparatus/PACO model 612 tube tester or more recent PACO model. Will pay reasonable price to copy and return, or will buy. Also need updated receiving tube manual. *Donald Wildermann, 1412 N. Jackson St., Salisbury, NC 28114.*

**For Sale:** Ryder radio manuals, 23 books. Also Sams' folders, #1 to #512 in 5-drawer file cabinet. Take either or both, make offer. You pay shipping costs. *Dennis Tipton, 17E 57th Terr., Kansas City, MO 64113.*

**Wanted:** Johnson's CB transceiver tester with operating manual. Heathkit isolation transformer, model IP-10 in good working order. Military surplus (Bird) wattmeter in good condition. *Harv Dowdle, Route 1, Box 71, Wilcox, PA 15870; 814-929-5591.*

**For Sale:** B&K 747 tube checker, new and old tubes. Ryder radio manuals. *Alvin J. Jacobson, Prior Electronics Service, 416 W. Second St., Williston, ND 58801; 701-572-5712.*

**Needed:** Schematic or servic manual for a color TV receiver by Seville Enterprises, model #C191. *Marvin Ludolph, P.O. Box 273, Walker, IA 52352.*

**Needed:** Power transformer and picture tube socket for GE TV model WM373CWD-2. Please state price. *George Saylor, 2319 Parrish St., Philadelphia, PA 19130.*

**Needed:** Schematic or service manual for a Toyo AM/FM cassette stereo, model #CRH-508. *Rev. F. C. Lewis Sr., 5728 Hemming Way, El Paso, TX 79924.*

**For Sale:** Sencore scope PS 148A. B&K analyst #1075. B&K radio analyst #960. Take all for $300 plus shipping. *Charles Okun, 501 Riverdale Ave., Yonkers, NY 10705; 914-968-8259.*

**Needed:** Schematic for Atwater-Kent radio model 627. Will copy and return or buy a copy. *Jeff Pelzel, Pelzel TV, 521B W. Main, Sleepy Eye, MN 56085; 507-794-7443.*

**For Sale:** Tektronix 7613 mainframes, $2550. Tektronix 465 with probes, $1425. Sams' Photofacts #704-1472 with full suspension files $775/best offer. Large assortment of late model tubes, mostly compactrons with caddys. *Charles S. Bryant, Palos Verdes Estates, CA 90274, 213-375-3006.*

**For Sale:** B&K transistor tester model 520B, $135. American Technology model ATC-10 color bar generator, modes: crosshatch, gray quad., red raster, color bars, 3.58MHz monitor outputs, RF/1F (video + and −) video, sync (horz. and vert.), $195. American postal order. Both in excellent condition, complete with cables and operating manuals. *Frank B. Hill, Hill's TV, Box 160, Glen Ewen, Saskatchewan, Socico, Canada.*

**Needed:** Schematic for Stromberg Carlson No. 225 radio receiver. *Gene Victori, 528 Mansel Drive, Landing NJ 07850.*

**For Sale:** 40-foot semi-trailer full of new and used electronic parts and components, including recording console, 2-inch tape machines, recording electronics, racks, electron microscope. Send s.a.s.e. for list or call *Richard Autry, 1909½ Santa Monica Blvd., Santa Monica, CA 90404; 213-829-1360/829-2237.*

**For Sale:** Elco model 460 scope in good working condition. Send $10 for shipping plus $100 c.o.d. to *Gad Barzily, 84-39 120th St., Kew Gardens, NY 11415.*

**For Sale:** Heath IG-14 marker generator, $95. Heath TV alignment generator TS4A, $70. Heath 10-1128 vector monitor, $50. Heath TT1A mutual conductance tube checker, $90. Prices include UPS charges. All include manuals and cables. *J.M. Thurston, Thurston TV & Radio, 5738 US 33 N., Fort Wayne, IN 46818.*

**Wanted:** Schematic or service manual for B&K model 970 transistor analyst, and Intellevision video game model 2609,. *Glaser's TV Service, Box 116, Bruno, Saskachewan, S0K 0S0 Canada.*

**Wanted:** Documentation schematics operating manual service; also want information about Hazeltine H2000-A video terminal. *Samuel Pearlman, 25 Wolcott Road, Lynn, MA 01902; 617-598-0610.*

**Needed:** Schematic for ADX model 5000 bass frequency mixer, bass guitar amplifier. *McPherson Electronics, 1219 S. College Ave., Dixon, IL 61021.*

**For Sale:** B&K analyst, model 1077B. Will ship, $300. *Al Rose, 650 Daphne St., Broomfield, CO 80020; 303-466-6798.*

**Needed:** Chronetics pulse generator, model PG13-B. Will buy or copy and return, plus cash. Also want the company's new address or status. *Richard Curtis, 1911 Santa Monica Blvd., Santa Monica, CA 90404; 213-829-2237/829-1360.*

**Wanted:** Diagram of Lloyd's 8-track stereo, model 2m75w-07a. *Lynn Weigle, CET, Lynn's TV & Electronics, 6805 Forest Court, Des Moines, IA 50311.*

**For Sale:** Electronic technician schematics from October 1965 to December 1977, $25, plus shipping. *Jerome Stanisz, 163 Richard Drive, Elmhurst, IL 60126.*

**For Sale:** Sencore CA55 Capacitor analyzer, in mint condition. Asking $400. *Daniel C. Lee, P.O. Box 42, Osakis, MN 56360; 612-859-2851.*

**Needed:** Manual or schematic for a B&K 1077B TV analyst. Will copy and return or purchase. *David O'Blenes, Rt. 8, Box 287F, Gainesville, GA 30501.*

**Wanted:** Zenith factory service manual for chassis 14N27 TV receiver. *Paul Capito, 637 W. 21st St., Erie, PA 16502.*

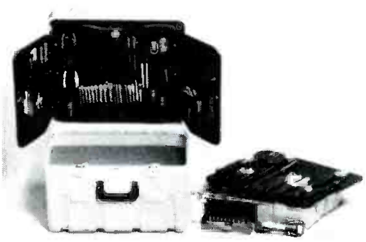
**For Sale:** Heathkit, IT-3120 transistor tester, also IM-5228 VTVM, assembled with manuals. $40 each, including shipping. *Calvin S. Logue Jr., 17 J Washington Lane, Westminster, MD 21157.*

*Continued from page 59*
tions. The redundant Glue Gun operates on standard 110/120V.

**Circle (129) on Reply Card**

### Deep kit for service technicians

*Jensen's* JTK-99 tool selection for service technicians is available in a super-deep polyethylene case layered with 5-inch high-density foam. Measuring 17¾" x 14½" x 13", the new case is designed to provide additional room for protection and storage of meters, oscilloscope or other delicate instruments and test equipment used in the field. Foam may be cut to conform to any shape or completely removed for full five inches of storage space in the bottom of the case.



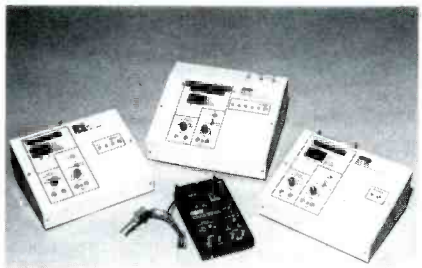
Standard JTK-99 tool selection includes pliers, wrenches hex and nut drivers, punches, files, measuring tools, wire strippers, soldering equipment and other instruments totaling more than 85 tools used in the service and repair of radio-TV, sound equipment, communication systems and other electronic devices. Custom fit tool pallets are removable. Bottom pallet is hinged to a 16" x 13" x 3" lift-out tray ideal for small parts.

**Circle (130) on Reply Card**

### Floppy disk drive tester

Earlier this year, *Teaco,* Michigan City, IN, introduced a portable unit of floppy disk drive tester exercisers, model 1024. Three new ac powered bench models, using the same configuration, are now being added to the line. All Teaco 1024s will exercise and service micro drives, 5¼-inch mini floppy drives, and 8-inch drives with standard interface. They provide status indication of all signal lines from the drive under test and supply the necessary signals to the drive, enabling service personnel to exercise and troubleshoot faulty drives down to the component level.

Model 1024-P is the basic ac powered bench version. Model 1024-MPC, ac powered, also powers 5¼-inch and micro drives.



Model 1024-PC adds the capability of powering 8-inch drives to the features of the MPC. Models MPC and PC have power monitor LEDs to indicate overloads on all supplies. Both regulator and fuses are used for tester protection.

**Circle (131) on Reply Card**

### Variable isolated ac power source

*VIZ Test Equipment,* a new division of VIZ Manufacturing Company, has announced a variable output isolated ac power source, model WP-29A.


The VIZ WP-29A is designed to provide isolated ac output from 0V to 150V, 0-2.25A continuous at 60kHz. Input voltage and isolated output voltage can be monitored on a large, taut band meter with an accuracy of ± 2%.

The unit is suitable for incoming or outgoing quality control, servicing or design work where testing circuits at higher or lower than normal voltages is required.

The WP-29A "ISO-V-AC" is one of a series of nine new products being introduced by VIZ in 1984. The unit measures 3⅜" x 8⅝" x 9½", and weighs 15 pounds.

**Circle (60) on Reply Card**

# Troubleshooting Tips

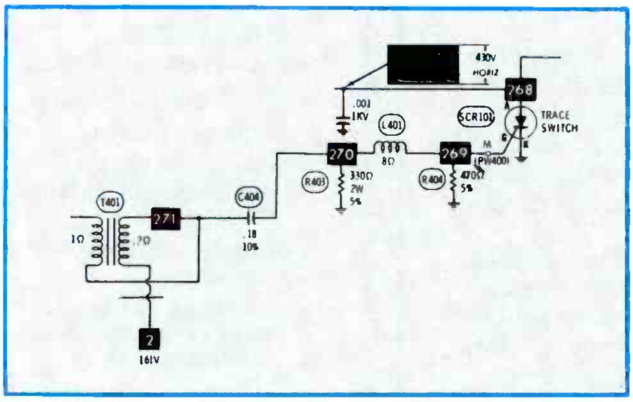
**Resistor burning, and no high voltage**
**RCA CTC68** (Photofact 1437-2 and 1517-1)

Occasionally, local TV-shop owners ask me for help with difficult repairs. This RCA CTC68 with SCR sweep was one of those. There was no high voltage and resistor R409 on the PW400 board was overheating. However, during the initial testing, the symptoms changed to tripping of the circuit breaker a couple of seconds after power was applied.

About that time, I remembered an article about troubleshooting SCR-sweep circuits, found the article and read it. Armed with this knowledge, I decided the commutator circuit must be open. However, I checked all parts and wiring in this area and found no opens. Then I remembered a technician had told me about bad SCR sockets. After installation of new sockets, the original symptoms of no voltage with a smoking R409 returned.

Next, I decided – erroneously – that R409 was the cause of the HV loss. After wasting several hours testing the R409 circuit, I finally knew that R409 was affected by the problem; it was not the problem.

Next, I checked waveforms in the sweep circuit (something I should have done much sooner). At the SCR102 (retrace) anode was a jagged-top square wave instead of the correct waveform. I found we had accidently placed two trace SCRs in the sockets instead of one trace and one retrace type. After the error was corrected, the SCR102 anode waveform was more nearly correct, but the symptoms remained unchanged.




When I scoped the SCR gate waveforms, *there was no drive signal* at the gate of the trace SCR101. I checked the signal path from the SCR101 gate back to T401 and found that coil L401 was open.

After L401 was replaced, the high voltage returned and R409 no longer overheated. A normal range of high voltage was obtained by adjustments, and was left at the recommended voltage. Because R409 had been severely burned, I replaced it with a new 2-percent flameproof type. A time test of several hours showed no abnormal operation, and the high voltage remained constant, so the receiver was released to the shop owner for delivery to the customer.

Several lessons can be learned from this one case. Both SCRs in the RCA circuit must have gate-to-cathode drive, although the two waveforms are different. Component overload that is produced by a defect somewhere else should not be confused with a defect in that component itself. And finally, a scope should be used when deflection signal amplitude or waveform is important to the circuit operation.

Phillip M. Jones, CET
Martinsville, VA

**Puzzling symptoms**
**Most brands and models**

Thanks to the many servicing articles in **Electronic Servicing and Technology,** my troubleshooting times have been reduced considerably. A discussion about techniques I have learned (or polished) from **ES&T** articles might benefit other readers.

When the symptoms are unusual and do not point to any certain defect, check the various Vdc supplies carefully. After the dc voltage is measured, use your scope to show any waveforms that should not be riding on the dc. These undesired signals can cause many strange symptoms, from bending pictures to lines in the picture. The symptoms disappear with the waveforms. New filters usually are the solution.

A meter measurement of the ac input-line *current* shows excessive power consumption that might indicate a leakage or short circuit in a B+ supply source.

If the receiver is tripping its circuit breaker or blowing the line fuse, I turn off the ac power and test all the B+ and/or B− supply-voltage sources for low resistances. Do not apply full line voltage until you are certain no shorts exist on these voltage sources. And don't stop with the filter capacitors, but remember that bypass capacitors can leak and reduce the voltage, also.

When the overload is not severe enough to trip the breaker, apply ac-line power through a variable-voltage transformer (with ac meter). Limit the line voltage at the receiver until the threat of damage from a short is over.

All these suggestions are simple and, in fact, most technicians know them already. But most of us need reminders now and then. Following these suggestions can save time and reduce damage to the electronic components.

Bill Gilbert
Lincoln, NE

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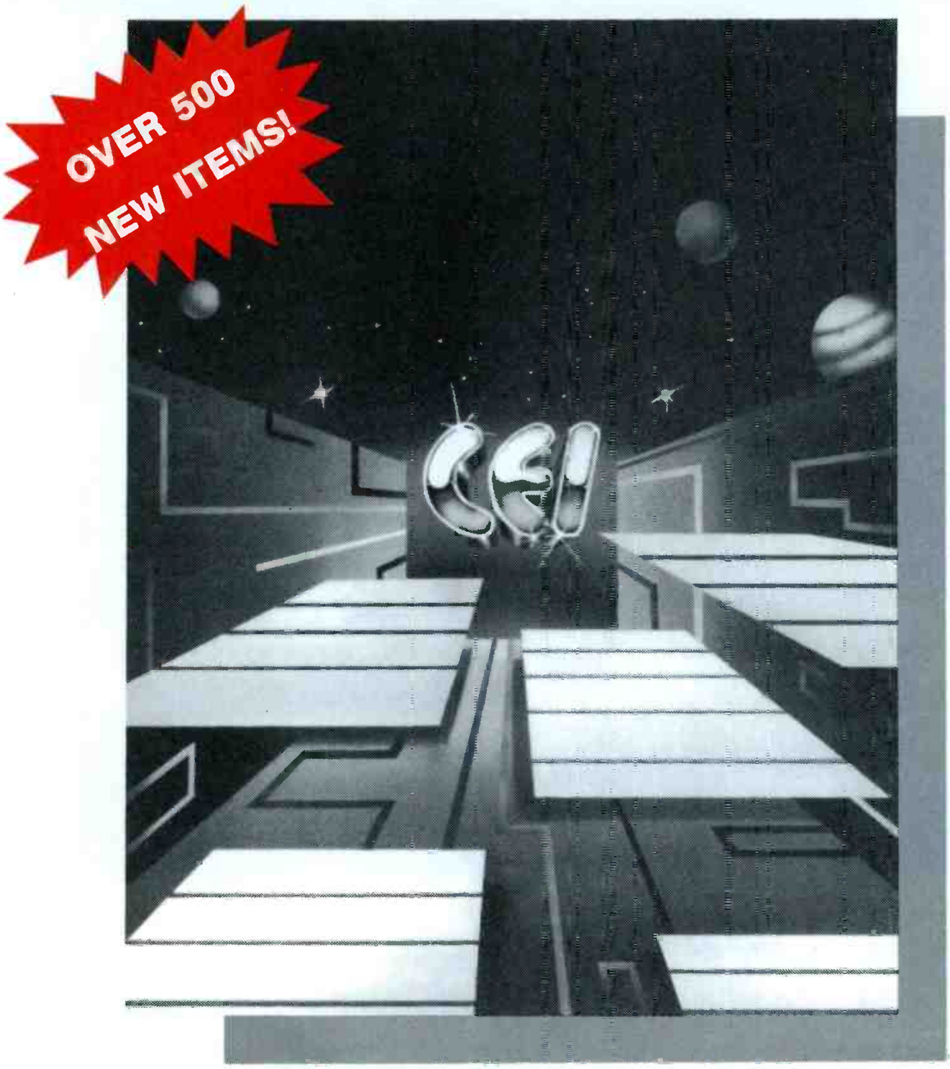


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