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NOVEMBER 1982/$2.25

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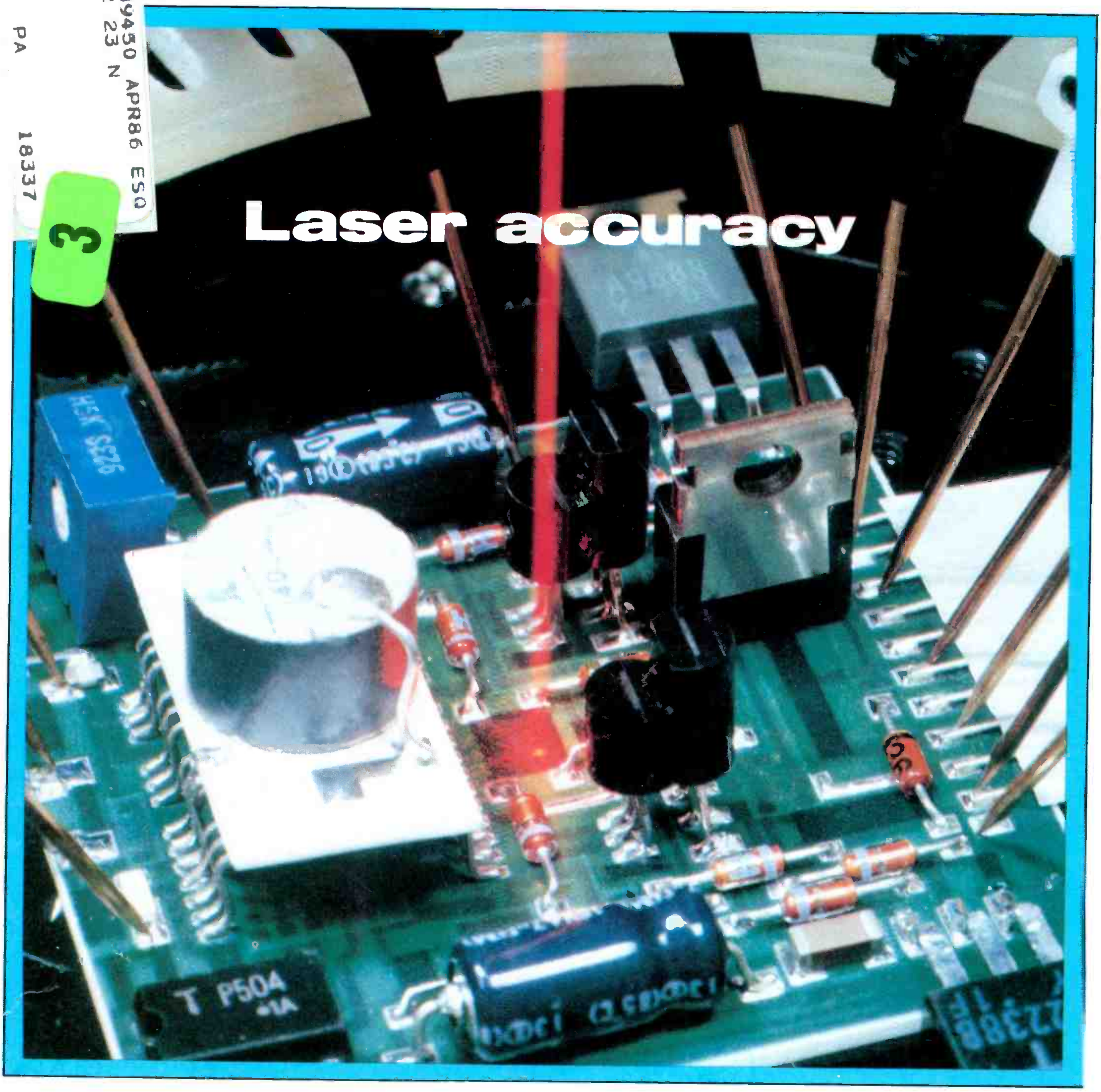
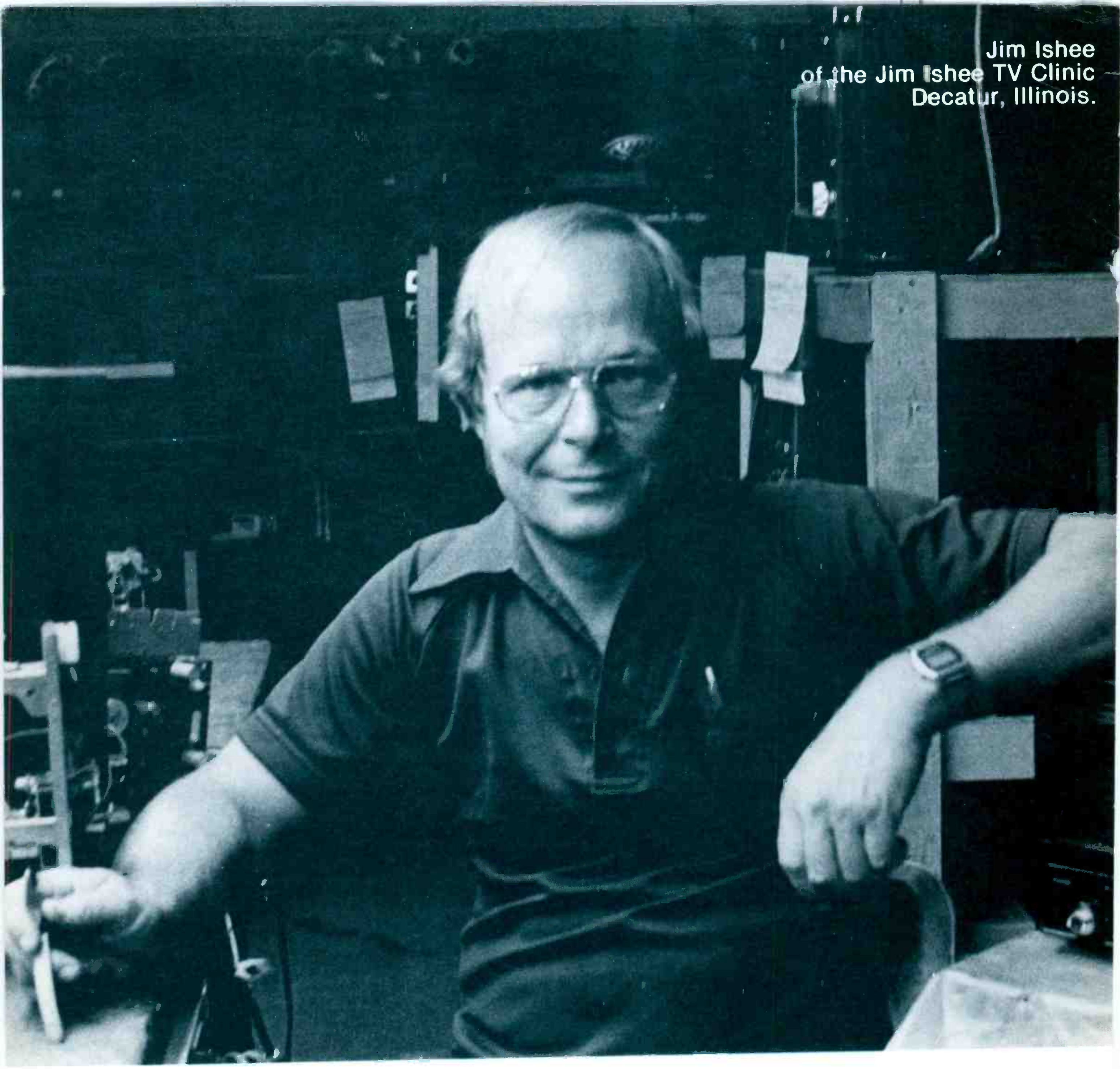
Locating power shorts





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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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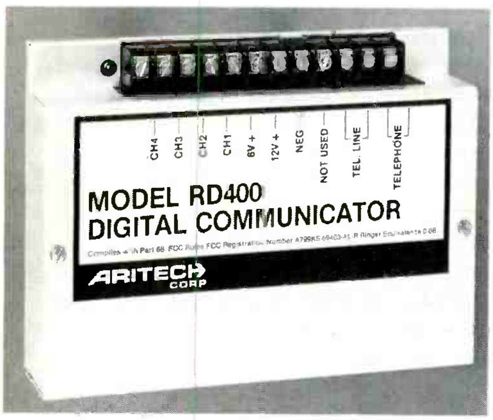
The how-to magazine of electronics...

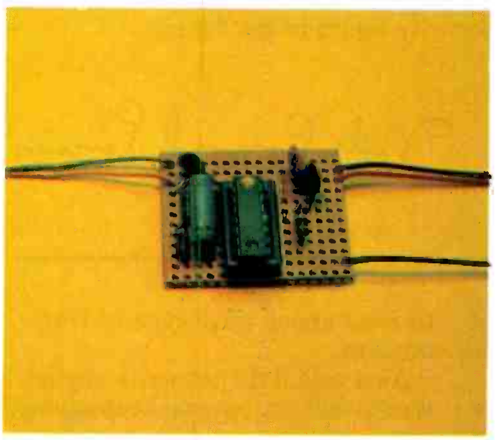
ELECTRONIC
Servicing & Technology

November 1982
Volume 2, No. 11

Laser technology has made the precision circuitry of the Citation XX amplifier possible. As test signals are fed into the hybrid circuit, a laser beam is shot into the hybrid circuitry, trimming the values of the components. See story on page 52. *(Photo courtesy of Harmon Kardon.)*



Page 26



Page 42

Page 56

Departments

Next month...

DBS: Opening up the satellite earth station market. With the unanimous approval of interim rules for licensing and operating direct broadcast satellites, the Federal Communications Commission gave official sanction to a potentially explosive new technology.

Security industry gains worldwide attention

On July 9, Michael Fagan, 31, was arrested in Buckingham Palace. He had climbed a wall and gotten past the barbed wire at the top. Somehow, he managed to slip past more than 60 guards. Fagan, who according to his father, is a great fan of the royal family, awakened Queen Elizabeth II and chatted with her for 10 minutes before he was apprehended.

Fortunately for the Queen, the motives of her intruder were benign. However, recently several other world figures have been less fortunate. President Reagan was wounded by a bullet from the gun of a disturbed individual. Pope John Paul II was attacked and wounded by a Turkish gunman.

These recent incidents have all had the effect of riveting public attention on the need for security. As if we need any reminders! Anyone who has flown in recent years has had the experience of walking through metal detectors and having carry-on luggage x-rayed. All of this to thwart criminals or terrorists who might be inclined to attempt to hold the aircraft and its passengers for ransom or hijack. Public buildings, particularly in Washington, are likewise equipped with weapon-detecting devices to discourage would-be assassins.

The need for security does not stop with the famous, or at airports, however. Crime rates, which have risen alarmingly in recent years, have prompted individuals as well as companies to scrutinize their homes, vehicles or places of business and determine if some degree of protection from potential criminal activity is in order. The general good health and growth in the security business is evidence that many are concluding that protection is necessary.

Security equipment runs the gamut of devices from steel doors and strong locks to well trained Alsatians and Dobermans. A lot of it, though, is electronic in nature. There are CCTV surveillance systems, microcomputer-controlled alarms, microwave and infrared sensors and telephone dialers, to name a few. All of this electronic equipment must be installed, maintained, and serviced and monitored by highly trained, professional, motivated people.

From research we have conducted in the past, we know that at least a handful of **ES&T** readers is either involved in, or thinking about the electronic security business. For them, there is an article describing the elements of an electronic security system.

No, we're not going to turn **ES&T** into a security magazine. There are enough good security magazines available already. Our intention is to round out our coverage so that we serve as many of the information needs of as many of our readers as we can. You will note that there's a questionnaire bound inside the front cover of this issue. It would be very helpful if you can fill it out and send it along to us. We'll carefully consider the results of the questionnaire when planning coverage of security topics in the future.

Nils Conrad Persson

FEEDBACK

Profax schematics

Allow me to congratulate you on your decision to include schematics of electronic equipment in your future issues. I have been a long-time reader of your magazine and was thinking of changing to another, basically for that reason. If I may make a suggestion, one of the faults of the other magazine was that some of the prints were repetitious, and there were not enough prints of other items that we sometimes have to service.

For instance, I know there are quite a few radio-controlled garage-door openers all over the country and an article on them, which includes how to service them, the operating frequency prints and power outputs would be very timely.

Also it wouldn't hurt to throw in a few prints of a few citizen band transceivers. We do not want a flood of prints on televisions that we may never see unless we go to Japan.

Another item that may be of interest to many of us is cable television. I do not intend to steal their service from them, but I would like to read about their type of transmission.

As a rule, I do not write any letters to editors, but you keep saying any comments would be welcome, so I had to dash this one off.

Isaad Moadus
McDonald, OH

Editor's note: We will do our best to always present schematics that have not appeared before. This is, of course, not a guarantee, but we will try. As for garage-door openers, look back in the February issue for an article on repairing them.

Mobile radio

I enjoy your articles very much. Your very informative articles in

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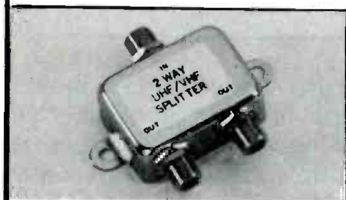

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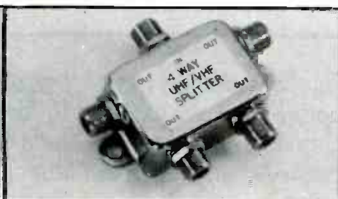

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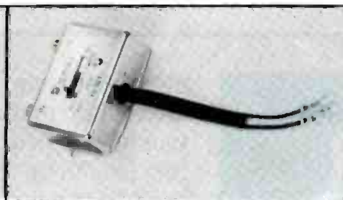

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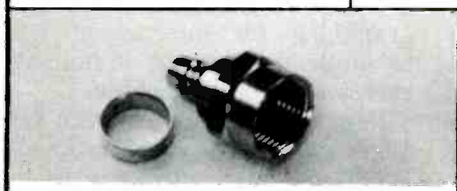

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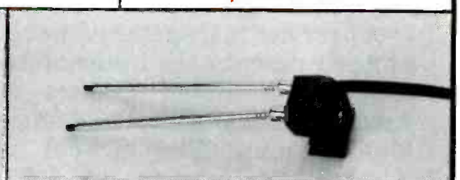

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ES&T on troubleshooting are an experience in themselves. I save all of the *Symcures* and *Troubleshooting Tips*.

I am also interested in 2-way mobile radio. I would appreciate it very much if articles on mobile radio troubleshooting would appear in your magazine.

Electronic Servicing & Technology is the greatest.

Michael Nahorniak
Fairport, Harbor, OH

Stereo-amplifier-repair rebuttal

These comments are in answer to a letter from J. Robert Leonard (page 8 in the August issue). He disagrees with many things in the article "Stereo amplifier repair" on pages 12-21 in the April issue.

Actually, I believe that we are in almost total agreement. The seemingly enormous differences are produced by our different *viewpoints*. Obviously, his viewpoint is that of an experienced, educated and competent audio technician who is rightfully concerned about making a living from his knowledge and labor. Just as obviously, the article was not primarily directed toward him or toward anyone else who does not need advice.

My primary reason for writing the article was to demonstrate superior servicing techniques vs. others that should not be used. And how can anyone better illustrate unsuitable methods than by describing the problems he brought on himself by using them?

Therefore, a few remarks will be made about most of Leonard's major points. In the first paragraph on page 8, he states it is a disservice to your business and your customer to undertake repairs on equipment that you are not familiar with, and where original components cannot be obtained. This is an essential management decision and is not the point of the article. Many manufacturers of replacement components (and a host of TV technicians who repair older color receivers) would dispute the necessity of using original replacement components, although there are cases where this is wise.

In the second paragraph, he pointed out the error of connecting two speakers in small baffles to an amplifier having power outputs of 100W per channel. However, it is wise to use expendable speakers until overload dangers are eliminated. In this case, the speaker danger was not known at first, because a powerful *normal* amplifier can be operated at

(Continued on page 63.)

ELECTRONIC SCANNER

NARDA offers annual School of Service Management

"Everything you want to know about service management" would properly describe the National Association of Retail Dealers of America Annual School of Service Management. The School is scheduled for February 6-9, 1983, at the University of Notre Dame, South Bend, IN.

The school functions on several levels. As a course of instruction, the session will cover the essentials of productivity; how productivity is measured; keeping tabs on parts stock; reducing bulging inventories; setting prices that are fair to the customer yet generate a profit; using money wisely in the business; routing, dispatching and truck stocking; and some valuable insights into customer satisfaction and employee motivation.

The School of Service Management also acts as a forum for new ideas and methods, new ways to tackle old problems, and sources for products, records and forms used in the industry.

Finally, this meeting serves as the crossroads of the service management industry. There will be hundreds of managers there from the United States and often from foreign countries as well. Managers from 2-man shops and those from 20-man shops all talk the same language, face the same problems and perhaps have found some solutions.

For more information, contact NARDA, 2 N. Riverside Plaza, Chicago, IL 60606, 312-454-0944.

USTV/General Instrument to provide direct satellite-to-home TV

United Satellite Television (USTV) and General Instrument Corporation (GRL:NYSE) have announced the world's first direct satellite-to-home pay TV broadcast service, scheduled to begin next year.

The announcement came four days after the Federal Communications Commission paved the way for satellite-to-home TV broadcast service. USTV expects to begin broadcasting four channels of high-quality TV programming within several months after Canada's satellite ANIK-C2 satellite is orbited by the U.S. space shuttle in April 1983.

In making the announcement, Francesco Galesi, chairman of USTV's executive committee, said, "With the inauguration of our service next year, USTV will become a major new source of TV programming for millions of nonurban Americans who do not have access to cable TV service."

Negotiations with program suppliers are currently underway and USTV plans to announce in the near future which suppliers will provide the firm with movies, sports, entertainment and news information programming for the satellite service.

EIA honors Ungar on 50th year

Noting the importance of soldering technology to electronics manufacturing, the Electronic Industries Association honored the Ungar Division of Eldon Industries on the 50th anniversary of its founding.

If we only tell you the features you'll never guess the price.

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LBO-523: 35 MHz
- 7 kV PDA 6" RECTANGULAR CRT
- INTERNAL GRATICULE
- 500 µV SENSITIVITY
- VARIABLE SWEEP HOLDOFF
- ALTERNATE CHANNEL TRIGGERING
- AUTO FOCUS
- CHANNEL 1 OUTPUT

LBO-522: 20 MHz
- 500 µV SENSITIVITY
- 6" RECTANGULAR CRT
- INTERNAL GRATICULE
- ALTERNATE CHANNEL TRIGGERING
- VARIABLE SWEEP HOLDOFF
- AUTO FOCUS
- CHANNEL 1 OUTPUT

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A certificate commemorating the milestone was presented to Ungar by Peter F. McCloskey, president of the national trade association.

"In the 50 years since its founding, Ungar has developed and manufactured increasingly advanced soldering products, helping to make possible today's quantity production of a wide range of electronic products," the certificate states.

"Conversely, Ungar has consistently made dramatic use of newest technical advancements from other segments of the electronics industry."

Management selected for direct-broadcast satellite

Progress has been announced in the formation and staffing of Alcoa-NEC Communications Corporation, a newly formed company that will assemble and market TV receivers to obtain programming directly from broadcast satellites. John Riley, manager, marketing communications, has announced the following appointments: Paul L. Abernethy, executive vice president; M. (Tony) Tajima, engineering vice president; R. Dennis Fraser, executive vice president; Robert G. Morrell, vice president, marketing and administration. A president remains to be elected for the new company.

EDS '83 participation details announced

The 1983 Electronic Distribution Show and Conference, May 3-5, has been officially announced to prospective exhibitors. Moving back to its ideal facility, EDS '83 will bring the entire industry under one roof, with exhibits, conferences, seminars and other official functions in the expanded Las Vegas Hilton Hotel.

Jack Kirschbaum, Cole-Flex, show corporation president, said that despite inflation, the cost of manufacturer participation will be $50 per unit less than EDS '82. This price reduction is in addition to a $50-per-unit rebate certificate applicable to 1983 participation, already mailed to 1982 participants.

The National Electronic Distributors Association will continue its well-received industry seminars in conjunction with EDS, beginning with an "Outlook" program Monday, May 2. In addition, concurrent programs for distribution management will be conducted by NEDA each show morning.

The National Sound and Communications Association again will conduct its conference in cooperation with EDS. This will be an independent event across the street at the Las Vegas Convention Center, and NSCA badgeholders will be admitted free to EDS exhibits.

For further information on EDS '83, contact Electronic Industry Show Corporation, 222 S. Riverside Plaza, Chicago, IL 60606, 1-312-648-1140.

ASSOCIATION NEWS

Technology in servicing discussed at convention

The 1982 National Electronics Service Convention in August was highlighted by examples of rapidly changing technology and ways to merge with that technology in the future. Seminars included business management, service franchising, computer sales and service, stress management and the annual conference for consumer electronics instructors.

At the annual meeting of the National Electronic Service Dealers Association, Bill Abernathy of Fort Worth, TX, was re-elected president, and George Bluze of Largo, FL, was re-elected vice president. At the International Society of Certified Electronic Technicians Board of Governor's meeting, Frank Grabiec was re-elected chairman and John E. Krier of Wichita, KS, was elected vice-chairman. The 1983 NESDA/ISCET National Electronics Service Convention has been scheduled for August 1-6, 1983, in Oconomowoc, WI.

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Ranges: Voltage	100mV–300mV–1V–3V–10V–30V–100V–300V–1000V ac/dc	200mV–2V–20V–200V–650V ac/dc		
dB read out	−40 . . . + 62 dB (9 ranges)	———		
Current	10μA–100μA–1mA–10mA–100mA–1A–10A ac/dc	2mA–20mA–200mA–2A–10A (15A max. 5 min., 20A max. 30 sec) ac/dc		
Resistance	1 Ω . . . 20 M Ω (5 ranges)	2 kΩ–20 kΩ–200 kΩ–2 MΩ–20 MΩ	Lo: 2 kΩ– 20 kΩ–200 kΩ–2 MΩ Hi: 200 Ω–2 kΩ–20 kΩ–200 kΩ–2 MΩ–20 MΩ	
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Accuracy analog: class (%) digital: basic ±(. . % rdg + . . . digit) on dc / ac / Ω	class 1.5 class 2.5 class 1.5	0.1% + 1D 0.5% + 3D 0.35% + 1D		0.1% + 1D 0.75% + 3D 0.35% + 1D
Frequency range:	15 Hz . . . 5000 Hz			
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	mirror scale		Diode test / Audio continuity test feature	Diode test / Audio continuity test feature True RMS
Prices US $ Instruments incl. test leads, battery, neck strap, manual	179.00*	199.00*	219.00*	259.00*
Accessories (US $)				
Clip-on current probe (1000:1)	WZ – 11: 49.00*			
Temperature probe	T 2001: 129.00*			
High voltage probe	GE 4196: 149.00*			
High frequency probe	GE 4087: 249.00*			
Power supply adapter	NA2-⁹⁄₂₀: 27.50*			

*Prices and specifications subject to change without notice.

Printed in USA, MR-USA 9/82

Locating power shorts

By Robert Dietrich

The origin of a serious power short-circuit is often difficult to identify because there is no time for tests before a fuse or breaker removes the ac power. Limiting the maximum current provides sufficient time for instrument measurements.

Severe overloads cause fuses to blow or protective breakers to trip instantly when ac power is applied, and such shorts are difficult to locate when the circuit has several paralleled branches. Resistance tests do not damage any additional components, because they are made after the ac power is turned off. Unfortunately, resistance tests are not infallible when locating ac overloads because some overloads are produced by defects that reduce the inductance of power transformers or relay coils without producing a corresponding reduction of dc resistance. Voltage tests of massive overloads are almost useless because the fuse or breaker removes these voltages immediately, and random replacement of components is not cost-effective.

My recommended time-saving method is to insert a current-limiting device in series with the main power line before using a current meter to identify which branch has the overload.

Specifically, I *connect a current-limiting incandescent light bulb* (of appropriate wattage) *across an open ac fuse or breaker, and then measure the ac current in each branch by using a clamp-on-type ac ammeter.*

The light bulb has two functions. It has resistance that limits the maximum current, thus protecting the circuit being tested. When the bulb operates, it glows with brightness that is proportionate to the power dissipated. Therefore, an instant visual indication of overload is obtained (Figure 1). Of course, voltage, current or power meters can be used if numerical readings are desired.

Testing industrial equipment

Figure 2 shows the power wiring of an X-ray machine. Many components are not accessible, thus it would have been difficult and time-consuming to perform conventional measurements.

Troubleshooting a power overload problem in a circuit of this kind should begin with disconnection of all plug-in accessories and any readily accessible components. Do not disconnect or cut any individual wires at this time.

A 100W bulb was connected across the 6A line-fuse clips because the fuse was open from a previous attempt at operating the control unit. When power was applied, the bulb had full brightness, indicating a dead short in one or more loads. Normal operation would have produced a dim glow.

Next, the clamp-on meter was placed in sequence around the power wires at points A, B, C and D (Figure 2). All locations except B showed very low current, while the ammeter at point B measured about 1A, which is the maximum current allowed by the 100W bulb. These symptoms indicate a serious short at T2.

Unsoldering one secondary wire of transformer T2 darkened the bulb, proving the T2 load was excessive. Motor M2 was disconnected and removed. It showed

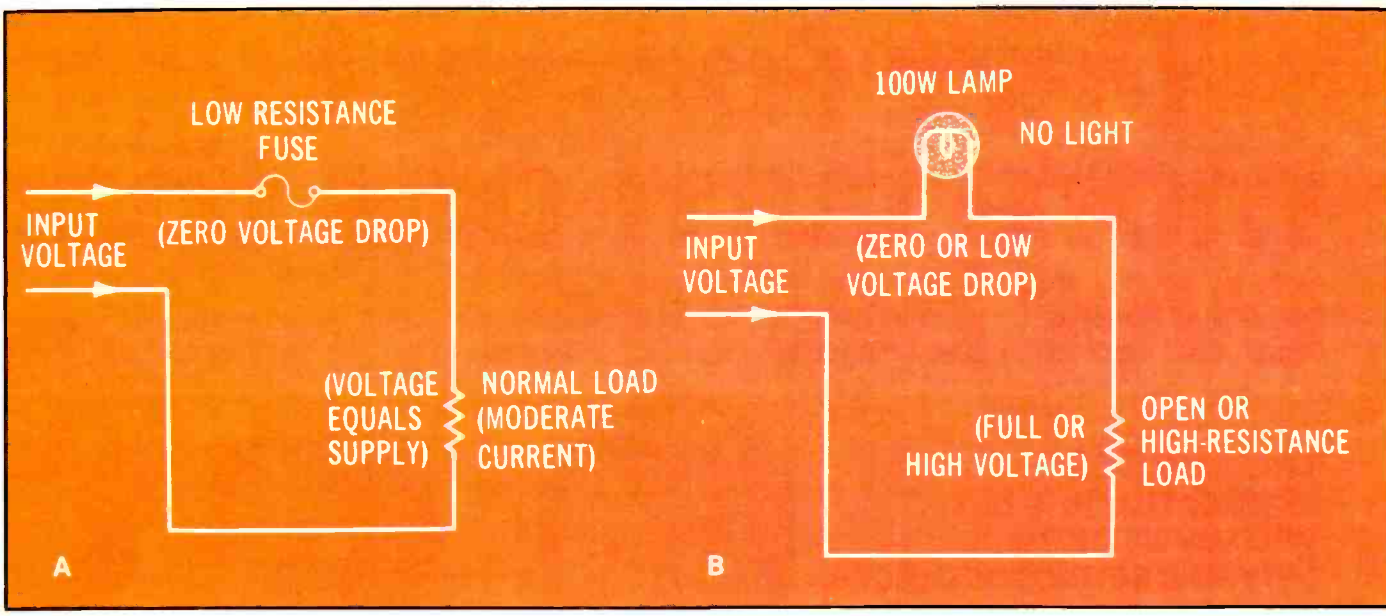
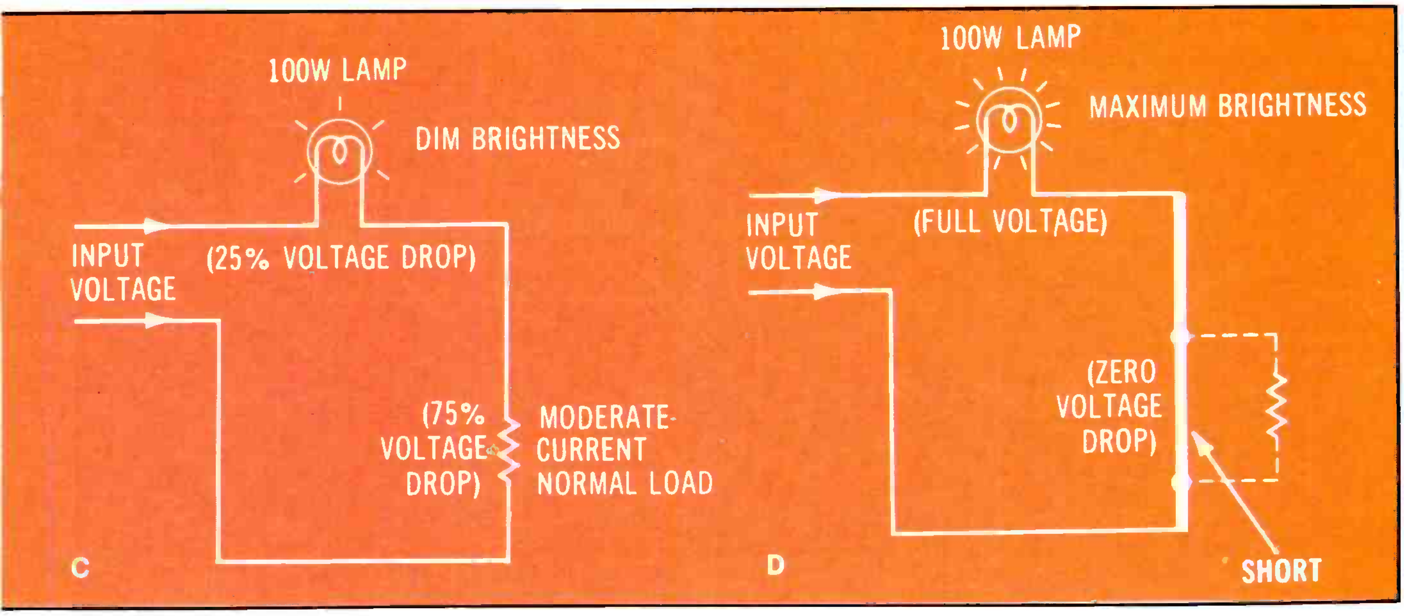


Figure 1 One application of a current-limiting incandescent light bulb is explained here. (A) In normal operation, a fuse is placed in series with the 120Vac line voltage. If the load current rises above the fuse rating, the fuse element melts open, protecting the circuit from further damage. A small voltage drop is produced across the fuse, but it does not reduce the load power significantly. (B) If a 100W bulb is used to replace the line fuse, a high-resistance load will receive virtually all line voltage, with low voltage across the lamp. Therefore, the lamp is not lighted. (C) When the load current is normal, most of the voltage is across the load, and some is across the bulb, lighting it dimly. (D) If the load has a short, the load has nearly zero voltage, while the bulb has almost all voltage. Therefore, the bulb has full brightness.

visual evidence of having been hot, so it obviously was shorted.

After a new M2 motor was installed and connected, the bulb brightness was dim, showing correct operation. The bulb was disconnected and a new fuse installed. When power was applied, the X-ray control circuit operated normally.



Testing power wiring

Testing with a current-limiting light bulb and the clamp-on ammeter has proved to be an excellent time-saving method of locating power overloads in home or business wiring. The method is appropriate for all power circuits where a current probe can be applied to only *one* wire at a time. (If the clamp-on probe encircles both wires, the ammeter will read zero, because the two currents are moving in opposite directions, and the equal currents of opposite phase will cancel in the probe.)

Of course, the voltage and wattage of the test lamp should be selected for the circuit requirements. The voltage rating should equal the supply-line voltage, because a shorted load will apply full line voltage to the lamp.

However, the wattage often should be *lower* than the circuit wattage. In the example of Figure 2, the X-ray control circuit had a 6A fuse, so it seems logical that the test lamp should have a 6A

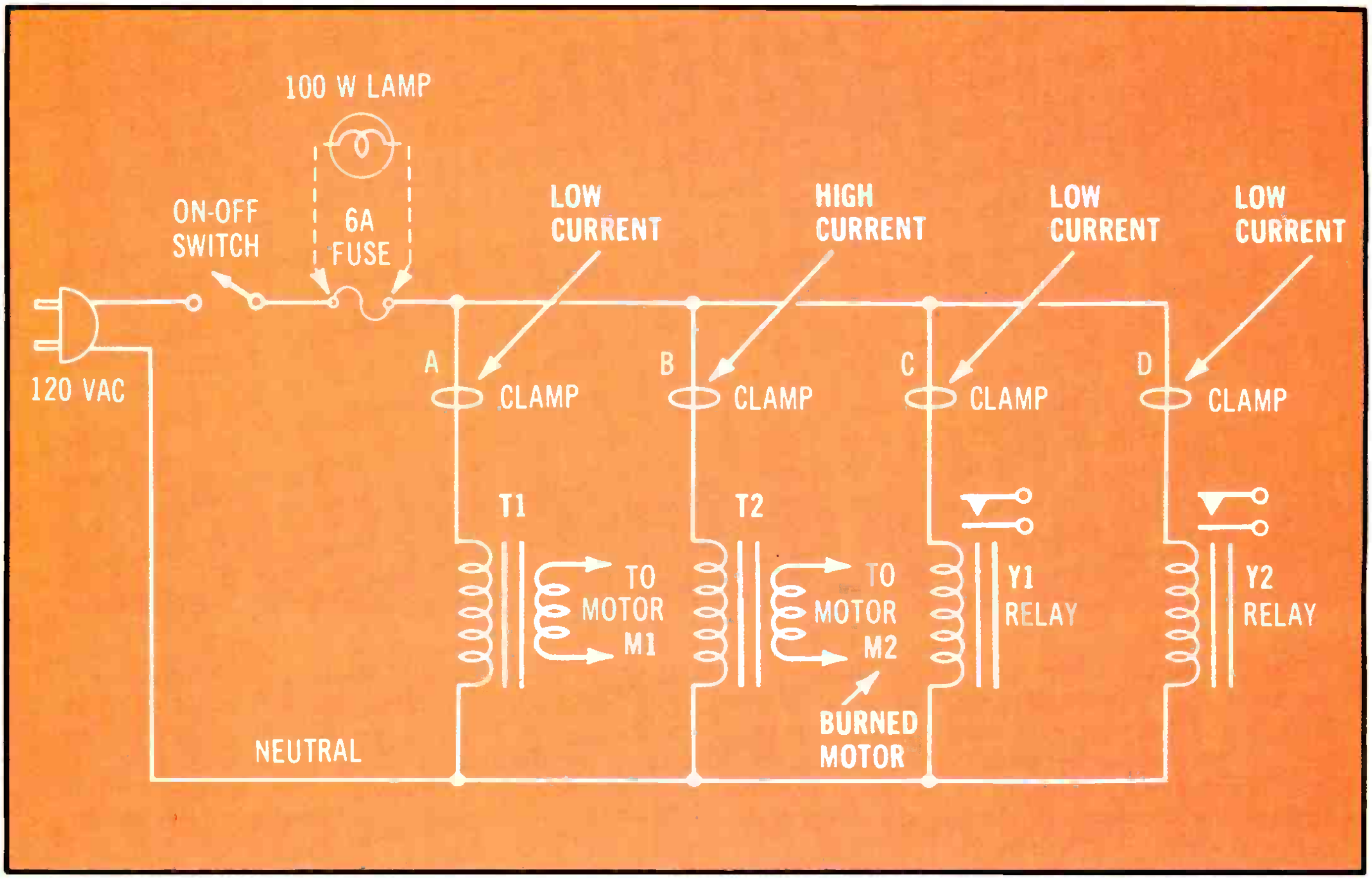


Figure 2 A simplified schematic of an X-ray control circuit shows a few of the 120Vac loads, and where the clamp-type ammeter should be placed to read the individual currents. The fuse has been replaced by a 100W bulb to limit the maximum current. Clamp position B was the only one showing high current, so the short must be in or around transformer T2. In this case, motor M2 was shorted.

rating (about 700W). However a lamp of lower wattage provides better protection of the circuit being tested. A 700W load would have allowed a higher current to reach transformer T2, thus increasing the possibility that the shorted motor might ruin T2 during the tests.

Test loads

If a test lamp is used regularly, a test-load circuit should be constructed on a board. As shown in Figure 3, it should have insulated wires and alligator clips (for connecting to fuses), three switches for selecting bulbs and three bulbs of the desired voltages and wattages. Any or all of the three bulbs can be switched on as needed.

Testing power transformers

Power transformers in TV receivers and stereo amplifiers can be tested for shorted loads or shorted windings by a method similar to the one described previously for power wiring.

After the line fuse is removed, a 120V light bulb of suitable wattage (usually 100W) is connected across the fuse clips. Then the current probe is placed around each secondary wire in turn while the amount of current is noted. Secondary wires in all-tube receivers should show several amperes, while wires feeding diode rectifiers in solid-state receivers will show a much smaller current. A knowledge of average currents is very helpful in evaluating the readings obtained.

If none of the secondary wires has excessive current, or if zero current is measured for each wire, the power transformer might have shorted turns or an open primary. To check these possibilities, the ammeter clamp is placed around *one* of the transformer's primary wires. Zero current indicates an open primary or a light load on the secondary windings. A strong primary current with zero secondary currents proves the transformer has internal shorted turns.

Current through the vertical and horizontal deflection-yoke coils will give readings on a clamp-type ammeter; however, these ammeters are intended for 60Hz *sinewave* operation, so the readings will have poor accuracy. Inquisitive technicians might experiment with their clamp ammeters to determine if the presence of deflection can be predicted from the yoke-current readings. Although the readings will be wildly incorrect, they should be consistent.

Low-voltage dc circuits

The basic principle previously described of locating shorts and overloads by analyzing current paths can be used (after some modifications) with low-current, low-voltage dc circuits such as those in transistor circuits.

Figure 4 illustrates the principle that dc voltages are measured directly, while dc currents are calculated by the voltage drops they produce across circuit resistances.

A simple 2-stage B+ filter is shown in Figure 4. When all four components are normal, the voltage drop across R1 or R2 is produced only by the load current.

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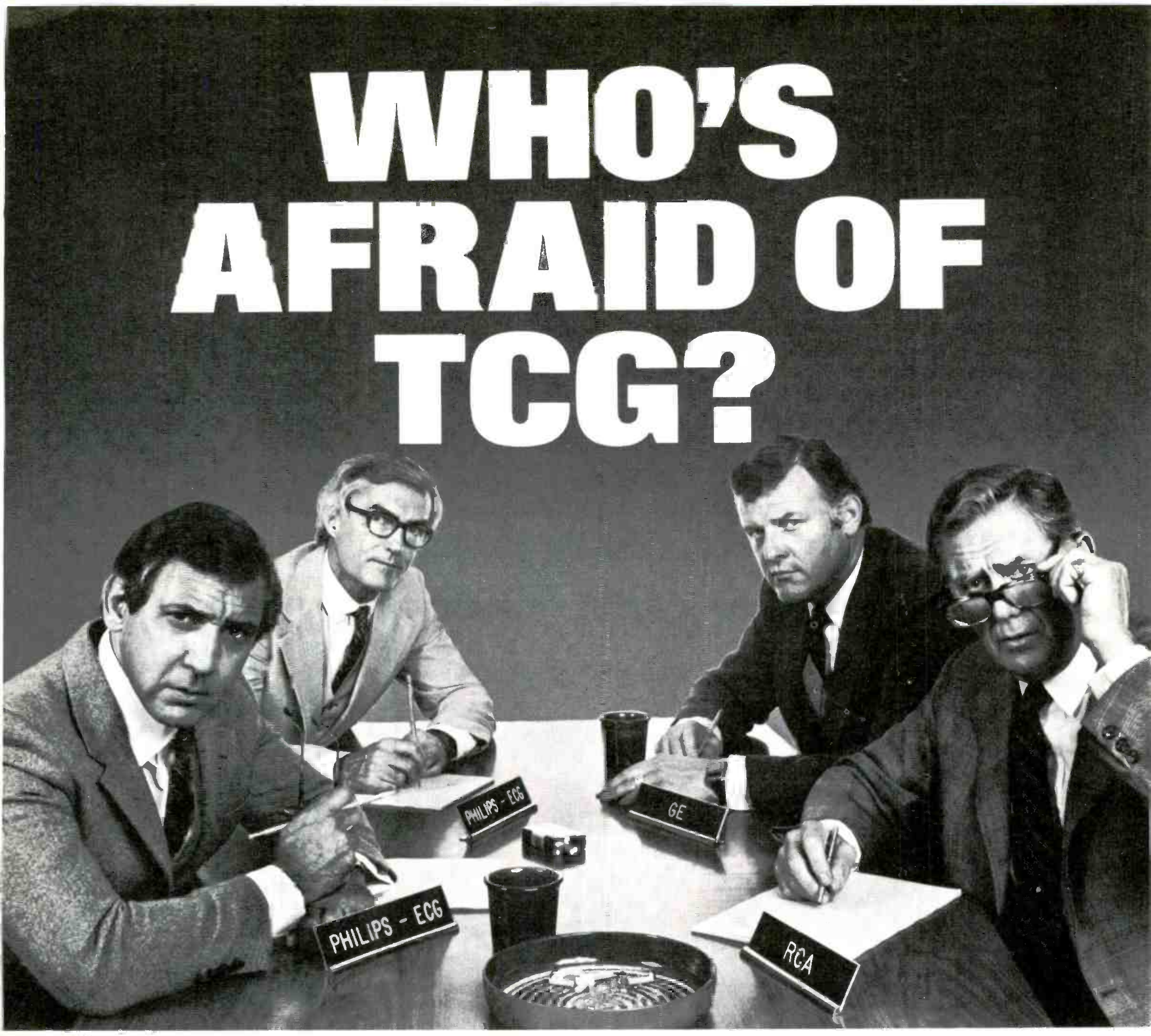

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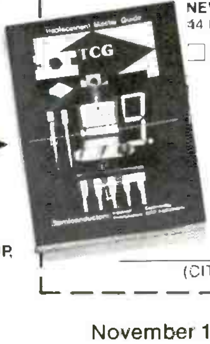

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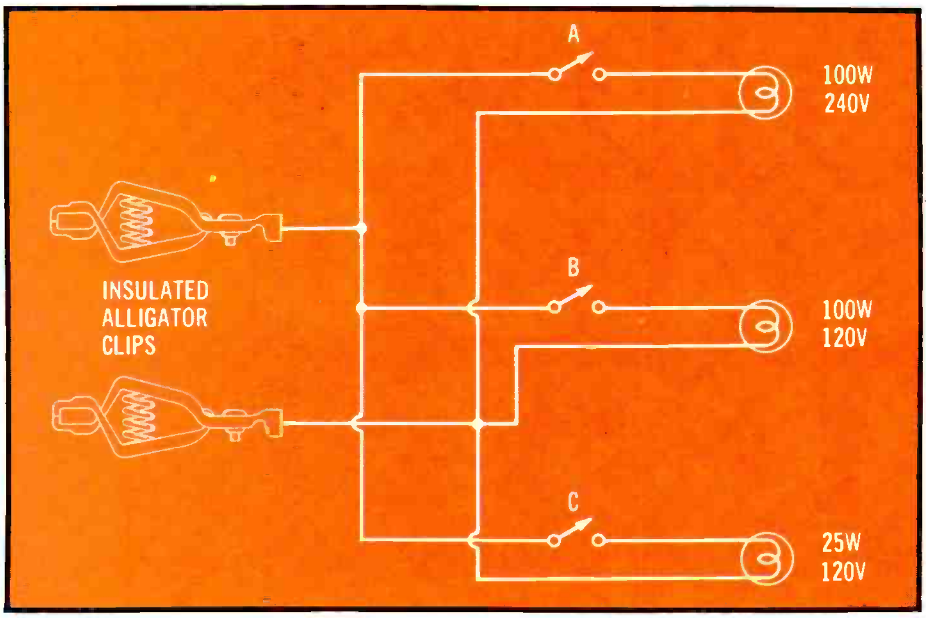

Figure 3 Safety and convenience are improved when the current-limiter components are mounted on a flat board, with the various bulbs in sockets. Use conventional wall switches in boxes. Do not leave any wiring exposed.

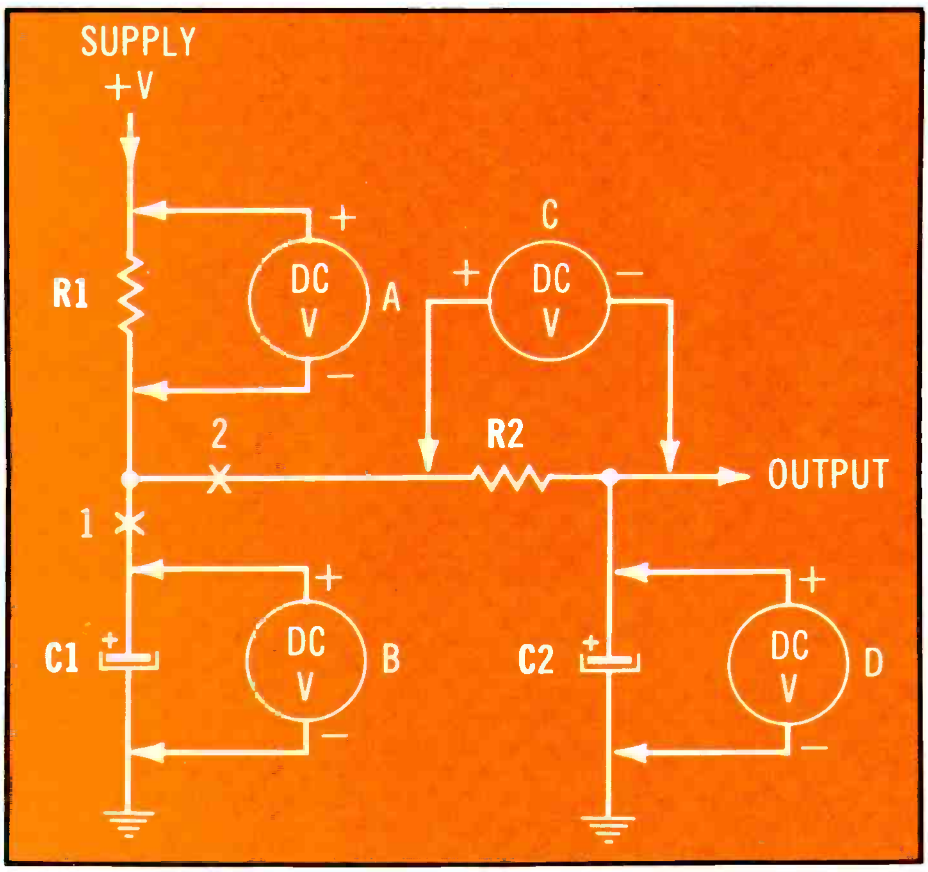

Figure 4 Many low-voltage, low-current circuits can be analyzed by the current-limiting technique, where resistors limit the current by developing voltage drops across themselves. Testing techniques are described in the text.

Let's assume that R1 and R2 have the same ohmic value. Therefore, the R1 voltage drop (voltage A) should equal the R2 voltage drop (voltage C), except for any C1 leakage that increases the R1 voltage drop but not the R2 voltage drop.

If R1 and R2 have different ohmic values, the current must be calculated separately to find a leaky C1. A larger current through R1 than through R2 proves C1 is leaky.

Because it paralleled the load current, leakage current through C2 was not checked by the previous method. However, C2 leakage can be tested by disconnecting the output-load current temporarily. When the output dc voltage is the same as the input dc voltage (except for loading by the voltmeter), neither C1 nor C2 has any leakage current. If the no-load output voltage is lower than the input voltage, a capacitor is leaky, but it must be identified. If *both* R1 and R2 have voltage drops across themselves, C2 has leakage. But if R1 has a voltage drop when R2 has the same voltage at both ends, C1 has leakage.

Additional analysis can be made if the circuit is opened temporarily at point 1 or point 2, because questionable components can be segregated.

These test methods are very simple, but after they are thoroughly understood, you can revise them slightly for use with many other circuits of greater complexity. Just remember that *dc voltage is measured directly* (either to ground or across resistances), while *dc current is measured indirectly by the voltage drop across circuit resistances.* According to Ohm's Law, voltage divided by resistance (in ohms) equals current (in amperes). But remember that these resistances *must* be linear with all voltages; diodes and voltage-dependent resistors (VDRs) change resistance according to the amount of voltage across them.

Comments

Previous articles in **Electronic Servicing & Technology** (such as "Servicing HV Triplers," by Homer Davidson in last month's issue) have described the advantages of using a 100W light bulb in series with the B+ supply to the horizontal-output or across a blown ac fuse in a TV receiver. This is an excellent way of obtaining extra testing time without added damage when the power supply or horizontal-sweep circuits have massive overloads.

The methods described here can multiply the value of the protective current-limiting technique, which can be a valid diagnostic tool.

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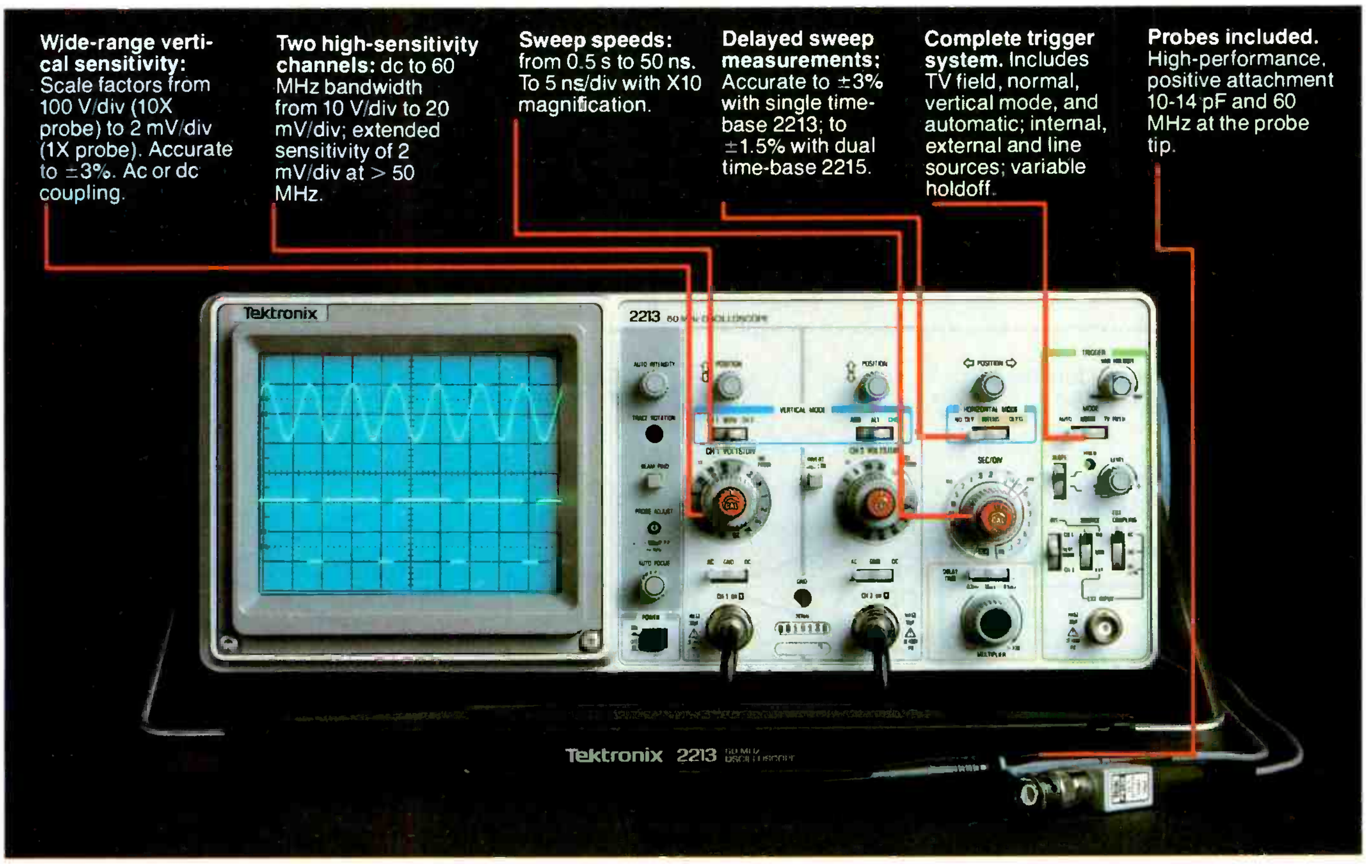

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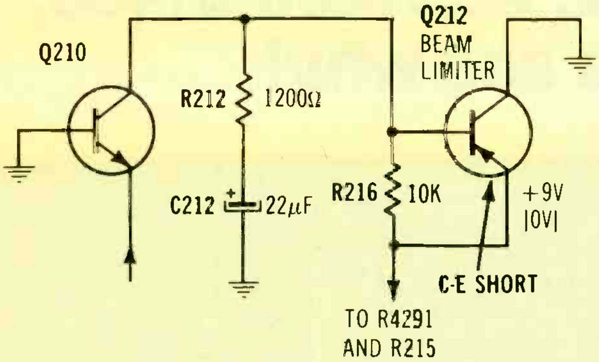
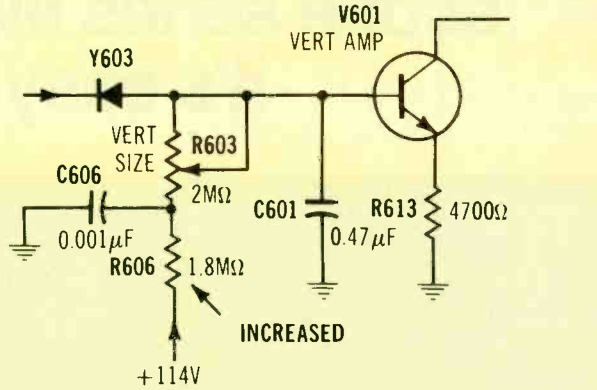
Chassis — General Electric EC 1
PHOTOFACT — 1918-1



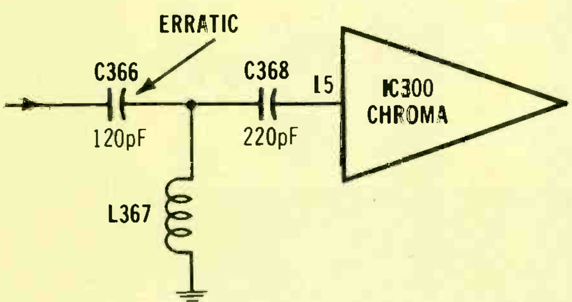
Symptom — No raster, but has sound and high voltage
Cure — Check Q212 and replace it if open or shorted.

Chassis — General Electric EC 2
PHOTOFACT — 1918-1



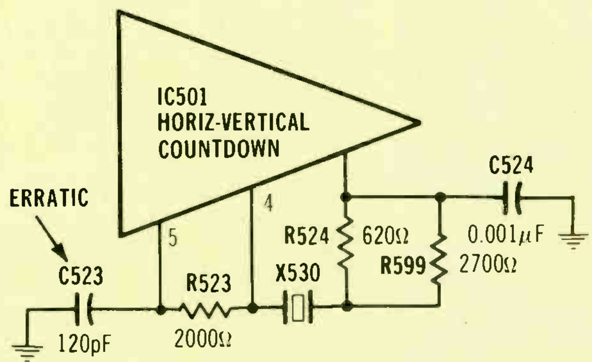
Symptom — Insufficient height of picture
Cure — Check resistor R606 and replace it if open or increased in value.

Chassis — General Electric EC 3
PHOTOFACT — 1918-1



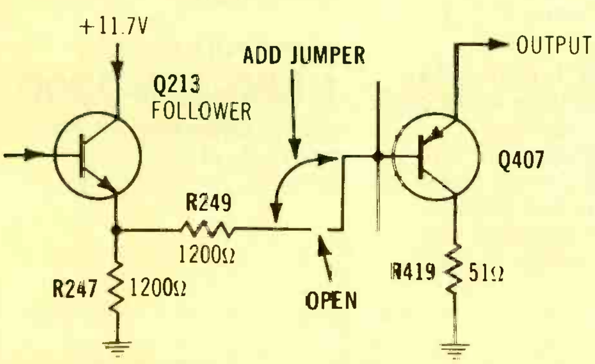
Symptom — Intermittent color saturation
Cure — Check capacitor C366 and replace it if intermittent

Chassis — General Electric EC 4
PHOTOFACT — 1918-1



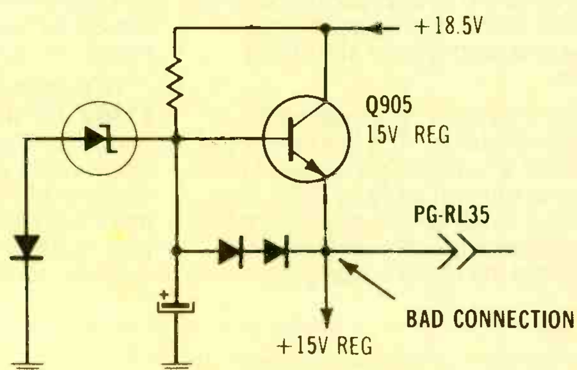
Symptom — Erratic horizontal drive
Cure — Check capacitor C523 and replace it if intermittent

Chassis — General Electric EC 5
PHOTOFACT — 1981-1



Symptom — No raster, but has sound and high voltage
Cure — Solder jumper between 37A and 37B connections on foil side (intermittent between top and bottom of rivets)

Chassis — General Electric EC 6
PHOTOFACT — 1981-1



Symptom — Intermittent sound (with loss of 15V supply)
Cure — Check and repair bad griplet between Q905 emitter and RL-35 pin 6 board connector on EP93X295 circuit board

CALENDAR OF EVENTS

November

1-2
15th Annual Connector Symposium, sponsored by the Electronic Connector Study Group, with the cooperation of more than 50 connector manufacturers, Franklin Plaza Hotel, Philadelphia. Contact Electronic Connector Study Group, P.O. Box 167, Fort Washington, PA 19034.

30-Dec. 2
Midcon/82 High-Technology Electronics Exhibition and Convention, Dallas Convention Center. Contact Electronic Conventions, 999 N. Sepulveda Blvd., El Segundo, CA 90245, 1-800-421-6816 (in California, 1-213-772-2965).

January

6-9
International Winter Consumer Electronics Show, Las Vegas. Contact Consumer Electronics Shows, Two Illinois Center, Suite 1607, 233 North Michigan Ave., Chicago, IL 60601; 1-312-861-1040.

18-20
Southcon/83 High-Technology Electronics Exhibition and Convention, Georgia World Congress Center, Atlanta. Contact Electronic Conventions, 999 N. Sepulveda Blvd., El Segundo, CA 90245, 1-800-421-6186 (in California, 1-213-772-2965).

April

19-21
Electro/83 High-Technology Electronics Exhibition and Convention, and Mini/Micro-Northeast, New York Coliseum and Sheraton Centre, New York. Contact Electronic Conventions, 999 N. Sepulveda Blvd., El Segundo, CA 90245; 1-800-421-6816 (in California, 1-213-772-2965).

May

4-6
Electronic Distribution Show, Las Vegas Hilton, Las Vegas. For information, call 1-312-648-1140.

10-12
Northcon/83 High Technology Electronics Exhibition and Convention, and Mini/Micro-Northwest, Portland Coliseum, Portland, OR. Contact Electronic Conventions, 999 N. Sepulveda Blvd., El Segundo, CA 90245; 1-800-421-6816 (in California, 1-213-772-2965).

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Needed: Sylvania CK-3000 color jig; must be very good condition. *George Lazoryszak, George's TV, 4432 N. Chadwick St., Philadelphia, PA 19140.*

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Needed: Operator's manual for Sony tape player/recorder, model TC580. Will pay for copy. *George H. Bleeker, 271 Emporia, San Antonio, TX 78209.*

Needed: 3-inch Toshiba picture tube #85FB4 and schematic. For a chason model #3-cha-1 (TV/clock radio comb.). *A. Connolly, 23460 Manistee, Oak Park, MI 48237.*

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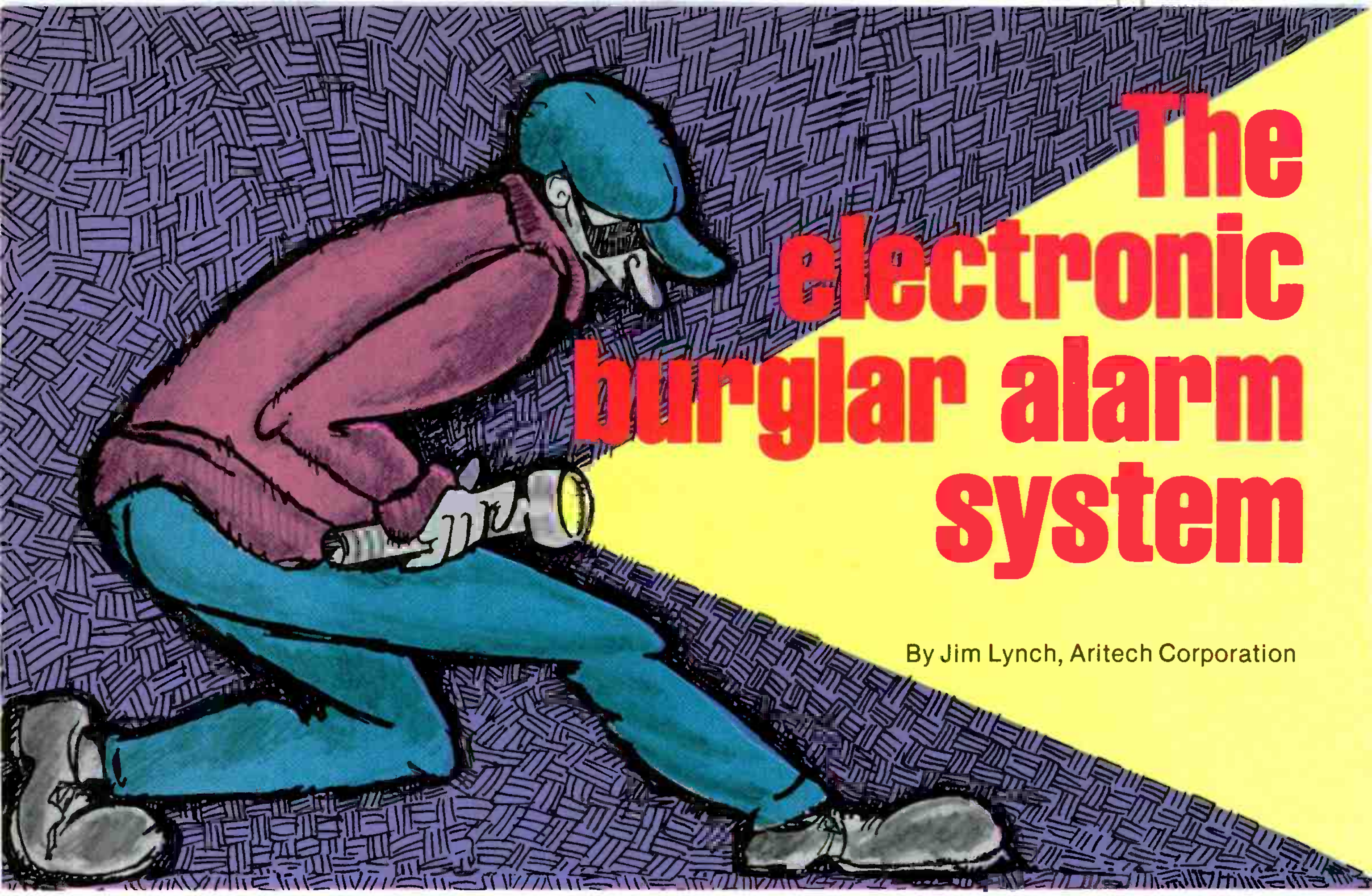


The electronic burglar alarm system

By Jim Lynch, Aritech Corporation

Most people view a burglar alarm system in either one of two ways: As an intricate electronic labyrinth of wires and super-sensitive components capable of zapping an intruder into the next galaxy, or as the next-door neighbor's "pain in the neck" system that is seemingly timed to go off mistakenly only at 2 a.m. every other morning.

To a limited extent, both these views are valid. Some systems are so elaborate that only highly trained security professionals can and should service or install them. And there are systems – mostly installed by amateurs – that are not as stable as they would be if they were installed by a professional.

The alarm's function

Simply put, the function of a burglar alarm system is to detect an unwanted intruder in a building and to initiate some action that will encourage the intruder to leave and/or to summon the appropriate authorities. Every burglar alarm system consists of three basic groups of components: the alarm sensors, the control panel and the reporting devices.

These components are usually connected by wires (recent innovations in RF transmitters and receivers have resulted in some wireless systems). Figure 1 shows the flow of information in a simple system. The control panel, in the center of this information flow, is, in a sense, the "brain" of the system. The control panel receives signals from the alarm sensors, processes these signals and then controls the appropriate response, if any, from the reporting devices. The status of the control panel, whether it is on or off (a function controlled by the user) determines the nature of any response.

Choosing the combination of products from these component groups is of major importance in constructing a burglar alarm system. Because each installation is different, the products chosen will vary. Alarm product distributors offer a wide selection of products and can provide comprehensive information on virtually every product.

With this help there is no reason why qualified electronic professionals cannot install burglar alarm systems. Much of the wiring is similar to that used in telephone and speaker systems. The sales people at most distributors have hands-on experience with alarm products through installation and service and can recommend products for each installation.

Control panels

The electronic circuitry in the control panel controls all system functions. It accepts inputs from the alarm sensors, initiates output to the reporting devices and controls the arming and disarming of the system.

Most burglar alarm control panels are powered by low-voltage alternating current – usually between 6 and 24V. This power is supplied by a breakdown transformer that plugs into an ordinary 120Vac outlet. Some control panels require direct connection to a 120Vac source.

Virtually all models of control panels have a provision for backup power in the event that the primary power is interrupted. Usually some kind of standby battery system provides this backup power. Some control panels are equipped with automatic charging circuitry that keeps a standby battery at full charge at all times. Two popular batteries currently used in the alarm industry for standby systems are the gel cell and the nickel-cadmium. The gel cell's electrolyte is suspended in a gelled material, doing away with water, plates and the attendant problems. A gel cell will not be damaged by high rates of discharge and is relatively inexpensive in comparison to other batteries. Nickel-cadmium batteries are small in size but are capable of high current output and resistant to the damage that overcharging often causes on other batteries.

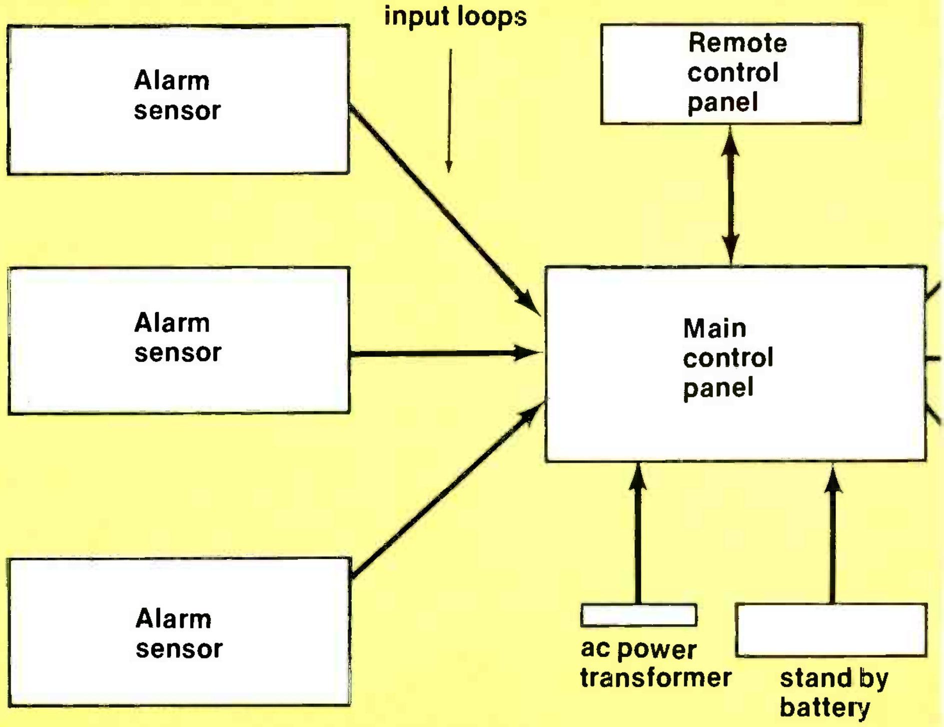


Figure 1. The drawing depicts the flow of information in a burglar alarm system. The main control panel, in the center, is the "brain" of the system and controls the flow.

The control panel receives signals from the alarm sensors on its *input circuits*. In most cases, these input circuits are simple closed-circuit loops. Alarm actuation occurs when an alarm sensor is violated, causing the loop to open. Closed-circuit input loops will accept input only from normally closed alarm sensors. Most control-panel, closed-circuit input loops allow up to 1Ω impedance in the wiring and connections.

Some control panels use *balanced-bridge* input circuits. Using an end-of-line resistor of a specific value to balance the loop permits connection of both normally open and normally closed alarm sensors, giving the installer more flexibility in choice of sensors and design of the circuit. A balanced-bridge circuit will actuate an alarm either when the circuit opens or when it shorts.

Many control panels are equipped with multiple-input circuits, which are designed to provide different levels of protection to a burglar alarm system. For example, the control panel in Figure 2 contains four input circuits. Two of these circuits are designed to connect to alarm sensors on perimeter doors and windows, and two other circuits are designed to connect to internal alarm sensors that detect an intruder walking inside the building. The perimeter sensors comprise the first level of protection and the internal sensors the second. When home, the user may arm just the perimeter sensors, foregoing the internal sensors so that he can move around freely, but still have protection. When leaving, the user may arm both the perimeter and internal sensors, using both levels of protection to get the most complete protection.

Many control panels are equipped with an *exit/entry-delay* input circuit. When the user arms the alarm system, the alarm sensors connected to the exit/entry circuit are bypassed for a specific amount of time, permitting the user to exit the building without tripping the alarm. An entry delay gives the user time to enter the building and turn the alarm off. The user must be careful not to trip any alarm sensor not connected to the delay circuit when entering and leaving the building or an alarm will result. In an alarm system with a control panel that does not have the exit/entry-delay input circuit capability, provision for outside arming and disarming must be made.

As stated earlier in this section, the control panel controls the arming and disarming of the system. However, because the control panel is often installed in a location that was chosen for its convenience for wiring rather than its accessibility to the user, it is often necessary to install a limited-function arming station at most accessible locations.

Arming stations increase system-use flexibility because the user can arm and disarm the alarm system from more than one location. This is often a requirement in a home alarm. If the control panel does not have an exit/entry-delay input circuit, an arming station must be installed on the exterior of the building.

There are various kinds of arming stations. The simplest is a key switch mounted to a single-gang plate; turning the key arms and disarms the system. Most systems require more secure arming stations. A good example of this is a panel containing a group of numbered push-buttons. There are many different versions of this by many manufacturers. The user presses a preprogrammed combination of the numbers to arm and disarm the system.

Alarm sensors

Whereas the control panel is the brain of an alarm system, the alarm sensors, because they send signals to the brain, are analogous to nerve endings. Specifically, the alarm sensors are protective

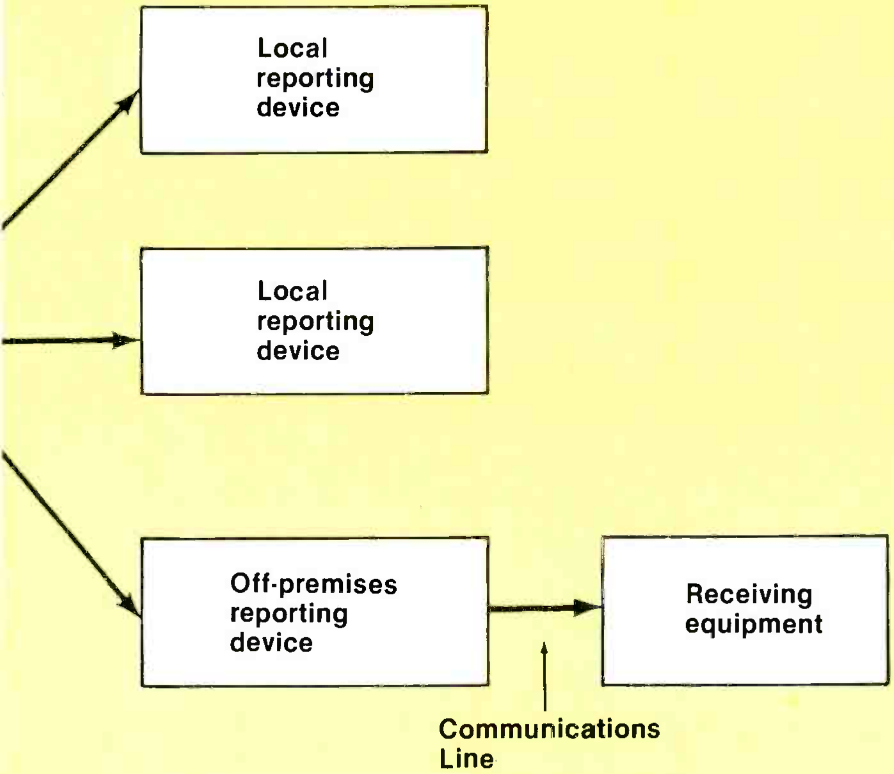
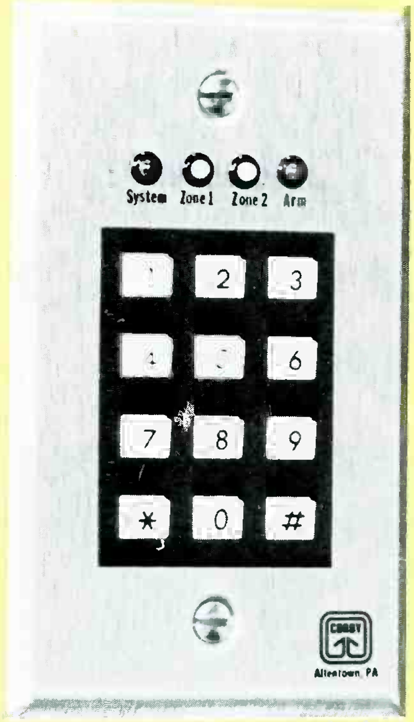
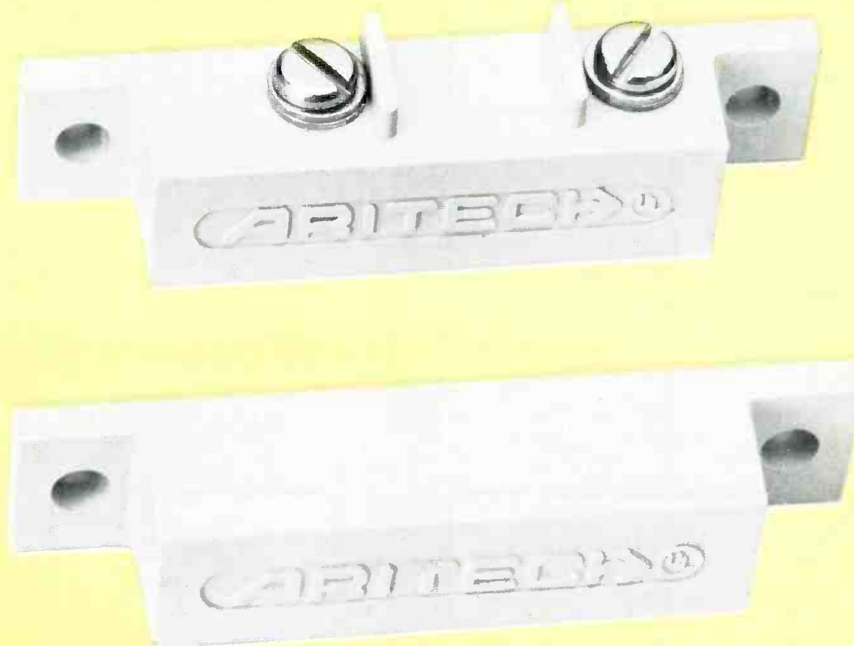
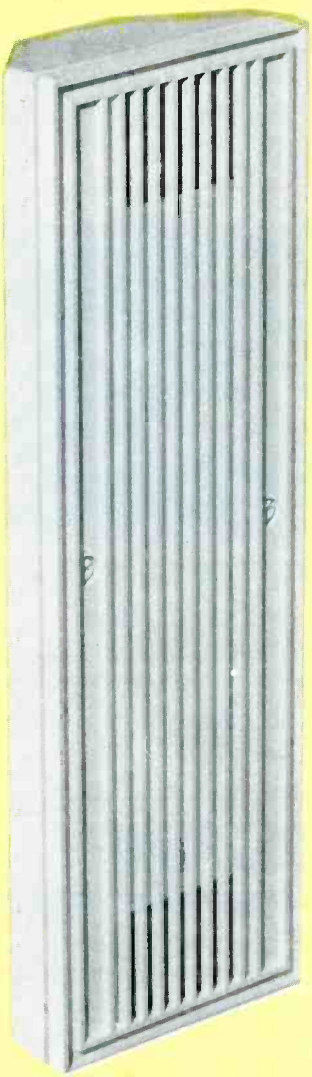


Figure 2. A burglar alarm control panel.



A remote arming system.


Magnetic contacts.


An ultrasonic motion detector.

devices that connect to the input circuits of the control panel. Which input circuit an alarm sensor connects to depends on the nature of the sensor. It is more appropriate to connect some sensors to an input circuit that provides internal protection, while other sensors are more appropriate for perimeter circuits. However, no sensor is restricted to one or the other. The following is a list of commonly used types of alarm sensors. There are many versions of each type of sensor made by many different manufacturers.

Electromechanical switches. These switches attach to a door or window (or any kind of opening that must be protected) and are usually wired into a perimeter input circuit. There are many kinds of electromechanical switches; the most widely used is the magnetic contact. A magnet, attached to the door or window, lines up close to a switch that is attached to the frame and contains the connection to the input circuit. The two line up when the door or window is closed, which keeps the contacts in the switch closed (remember, most alarm circuits are closed circuits). When the door or window is opened, the magnet moves away from the switch, causing the contact, and therefore the input circuit, to open.

Other electromechanical switches include the push-button switch, which recesses into the frame on the hinge side of a door. When the door is closed, the button is closed; when the door opens, the button springs out.

Motion detectors. These sensors are ordinarily designed to provide internal space protection. This means that, instead of detecting the opening of a door or window as does an electromechanical switch, these devices detect an intruder's movement.

Ultrasonic and microwave detectors basically consist of two transducers (transmit and receive) signal processing circuitry and an alarm relay that connects to an input circuit (usually an internal circuit). The transmit transducer transmits ultrasonic waves into the protected area; they then bounce off the walls, ceilings, floor and any other objects, back to the receive transducer. The frequency of the ultrasonic waves transmitted is identical to the frequency of the received waves, provided no movement occurs in the area. The signal processor verifies this. If an intruder enters the area, the motion will reflect the ultrasonic waves onto the receive transducer at a different frequency (i.e. the Doppler effect). The frequency change will be noted by the signal processor, which will activate the alarm relay.

A passive infrared detector (PIR) senses the change in the infrared energy level of a protected area caused by the heat emitted by an intruder. Each PIR contains a sensing element, that reacts to infrared energy. Some PIRs use a thermopile for a sensing element, while others use some pyroelectric material. The protection area covered by a PIR is divided into small sections by an optical antenna (or lens), which, because it reflects infrared energy onto the sensing element, controls where the sensing element "sees." Therefore, the construction of the antenna determines the dimensions of the protected area. Good PIR detectors can detect protection area temperature changes as low as 2°C.

Reporting devices

In accordance with the flow of information depicted in Figure 1, when an alarm sensor detects an intruder, the control panel activates the reporting devices. The twofold function of the reporting devices is to encourage the intruder to leave and summon the appropriate authorities.

Generally reporting devices fall into two categories: *local* devices and *off-premises* devices. Local reporting devices provide an audible or visible signal at the protected location by means of such equipment as bells, sirens, speaker/driver systems and lights.

Off-premises reporting devices transmit an alarm signal to another location, frequently using standard telephone lines.

The *tape dialer* uses a preprogrammed 8-track tape to transmit a verbal message over standard phone lines to an off-premises location – often a police station. Many local police departments have a special number for taped message transmissions. The tape automatically starts when an alarm condition occurs and dials the phone with digital pulses or tone sequences that are recorded onto the tape with a special programmer. Most alarm equipment distributors will program dialer tapes for alarm dealers.

Unlike the tape dialer, which depends on a party at another location to answer the phone in order to complete verbal transmission of

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1. Sales through dealers and carriers, street vendors and counter sales	402	402
2. Mail subscriptions	39,658	55,631
C. Total Paid Circulation	40,060	56,033
D. Free Distribution (including samples) by mail, carrier delivery or other means	6,815	1,434
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G. Total (Sum of E and F should equal net press run shown in A)	46,976	59,124

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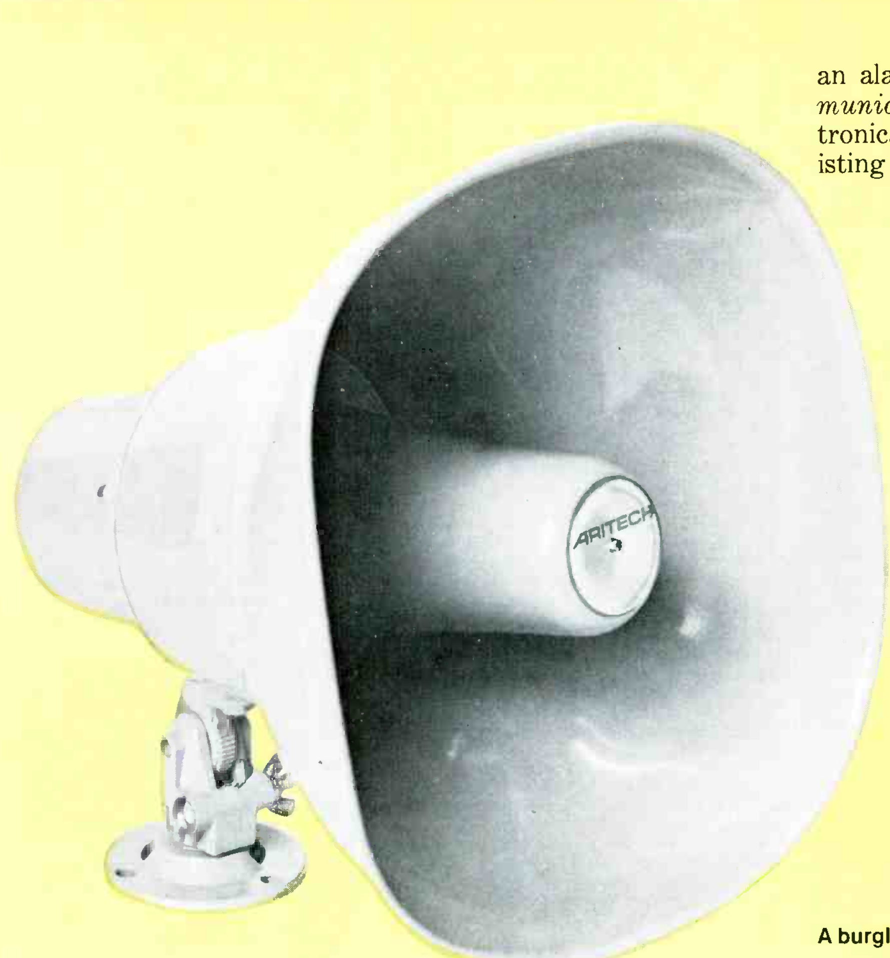
an alarm signal, the *digital communicator* transmits an electronically coded message over existing phone lines to a special digital receiver, installed at another location, which translates the code into pertinent information about the alarm. Most alarm companies have digital receiver hardware set up in a central alarm station that can receive messages from many communicators. These companies often sell this service to alarm dealers who do not have receiver facilities. Distributors have infor-



A burglar alarm siren.

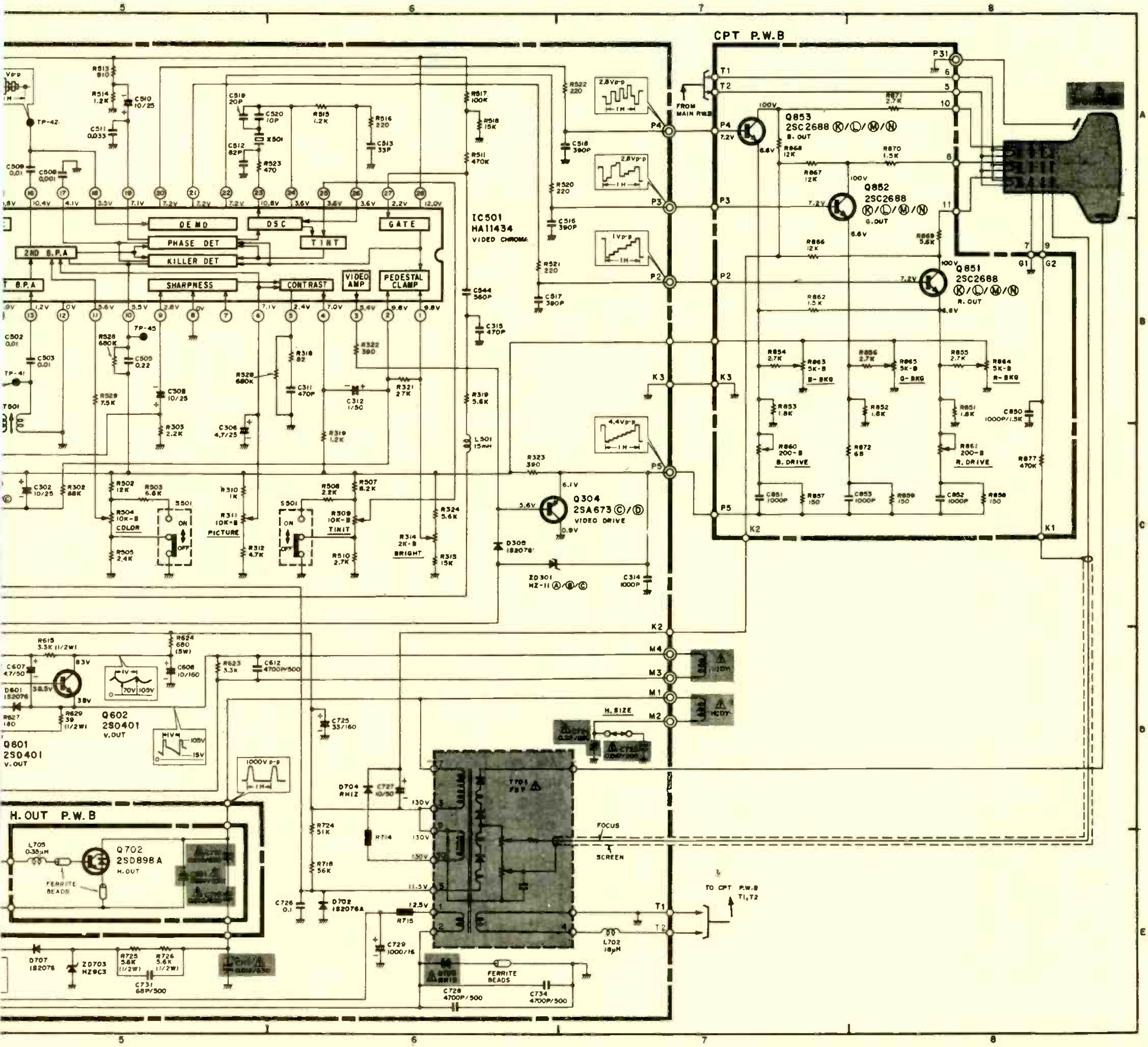
ES&T Manufacturers' schematics **PROFAX**

2003

Hitachi
Color TV
Chassis NP80SX

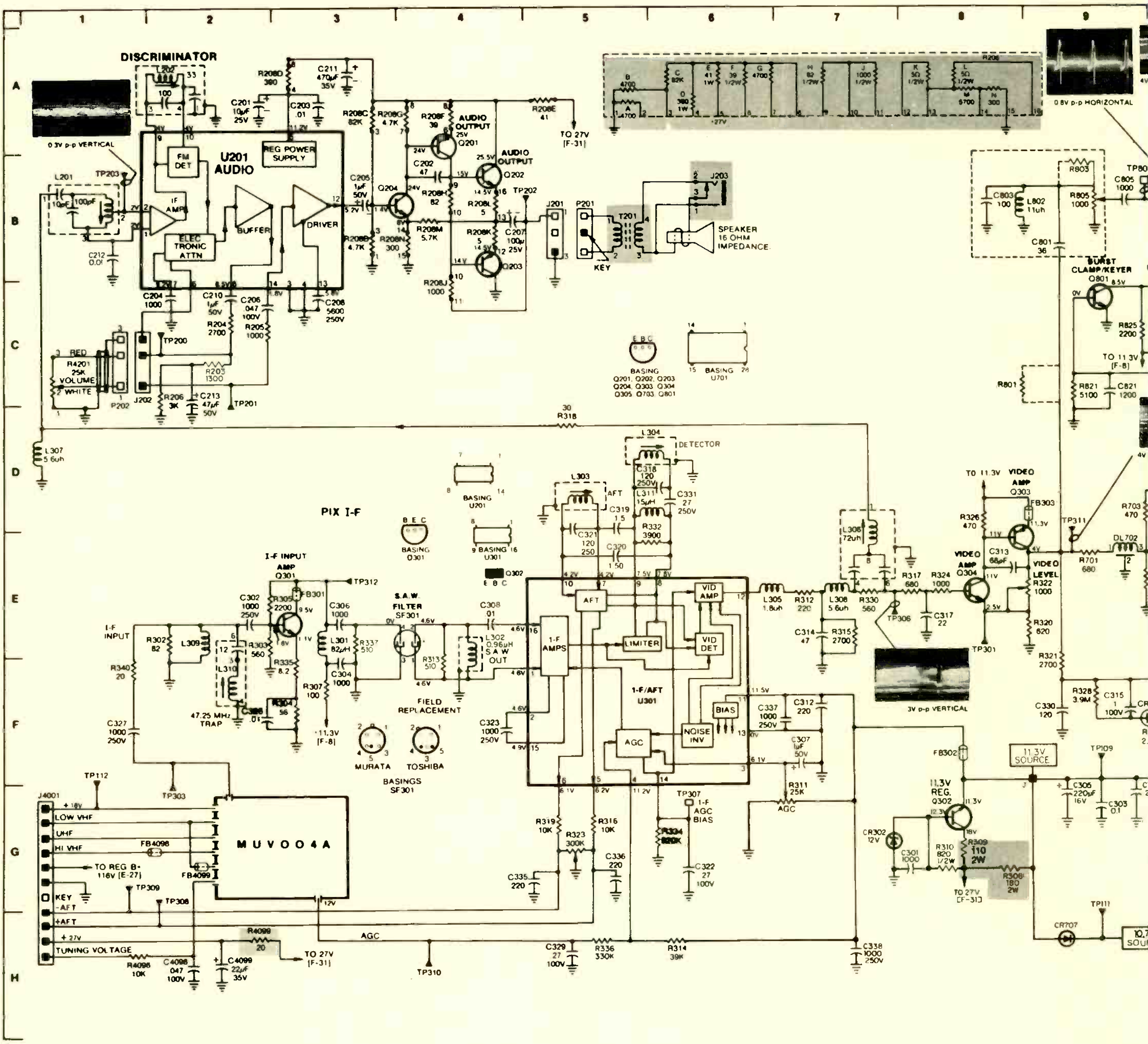
November 1982

PRODUCT SAFETY NOTE: Components marked with a ⚠ and shaded have special characteristics important to safety. Before replacing any of these components, read carefully the PRODUCT SAFETY NOTICE of this Service Manual. Don't degrade the safety of the receiver though improper servicing.



- Since this is a basic circuit diagram, the value of the parts is subject to be altered for improvement.
- All DC voltage to be measured with a tester (100kΩ/V).
  Voltage taken on a complex color bar sgnal including a standard color bar signal.

es Corporation of America.
, P.O. Box 12901, Overland Park, KS 66212.



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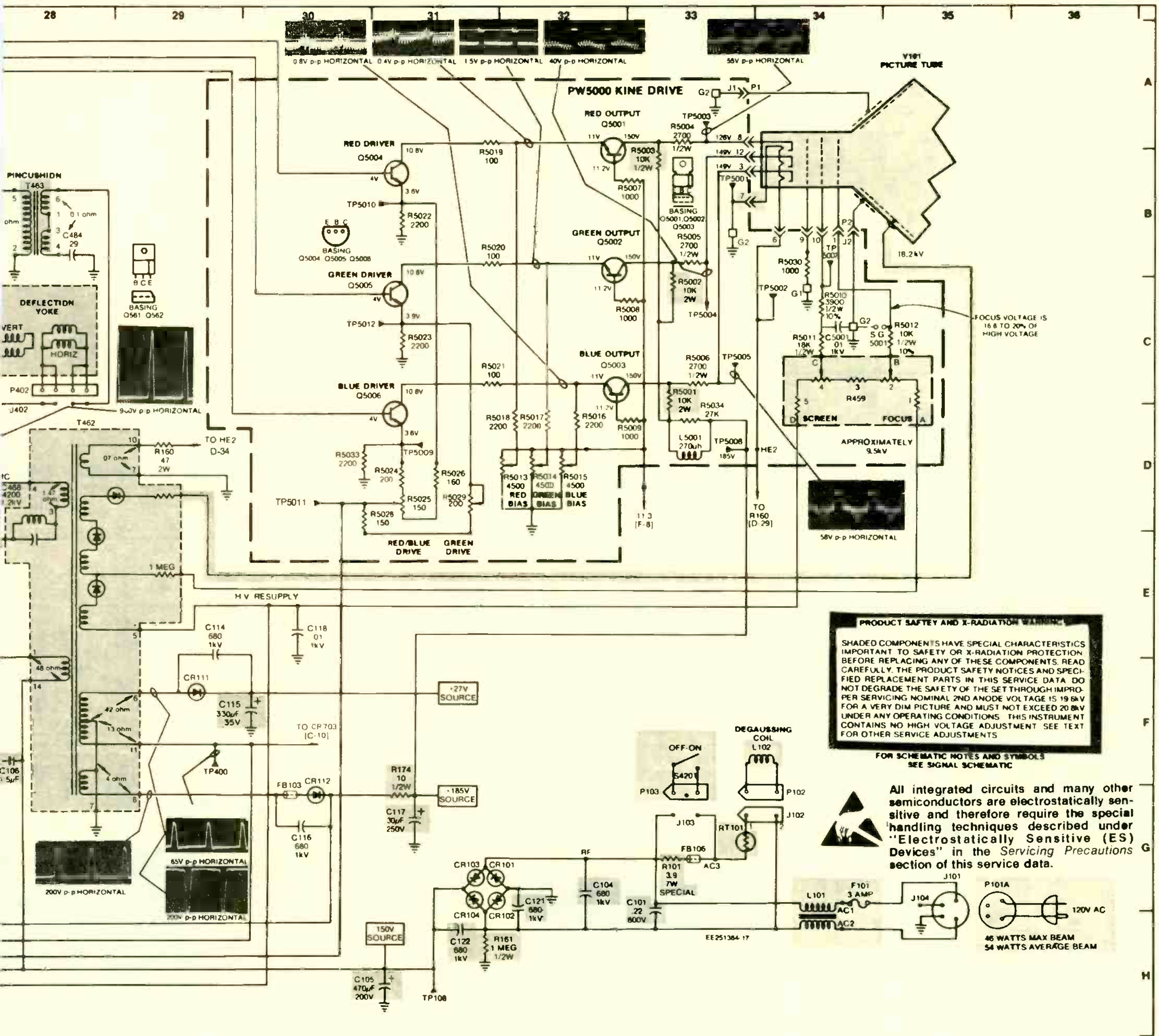
ES&T Manufacturers' schematics **PROFAX**

2004

RCA
Color TV
Chassis CTC 115

November 1982



PRODUCT SAFTEY AND X-RADIATION WARNING

SHADED COMPONENTS HAVE SPECIAL CHARACTERISTICS IMPORTANT TO SAFETY OR X-RADIATION PROTECTION. BEFORE REPLACING ANY OF THESE COMPONENTS, READ CAREFULLY THE PRODUCT SAFETY NOTICES AND SPECIFIED REPLACEMENT PARTS IN THIS SERVICE DATA. DO NOT DEGRADE THE SAFETY OF THE SET THROUGH IMPROPER SERVICING. NOMINAL 2ND ANODE VOLTAGE IS 19.6kV FOR A VERY DIM PICTURE AND MUST NOT EXCEED 20.8kV UNDER ANY OPERATING CONDITIONS. THIS INSTRUMENT CONTAINS NO HIGH VOLTAGE ADJUSTMENT. SEE TEXT FOR OTHER SERVICE ADJUSTMENTS.

FOR SCHEMATIC NOTES AND SYMBOLS SEE SIGNAL SCHEMATIC

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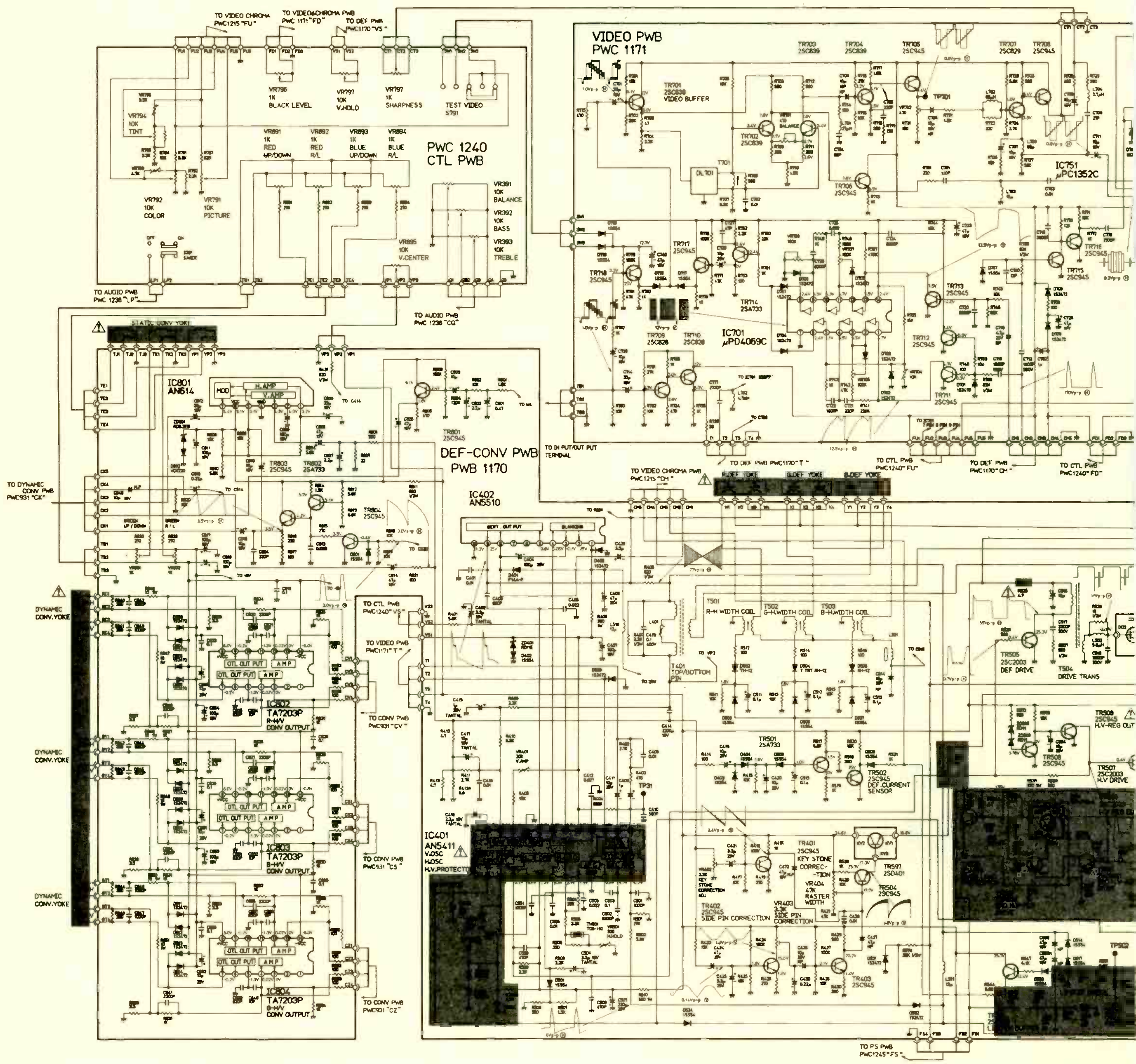

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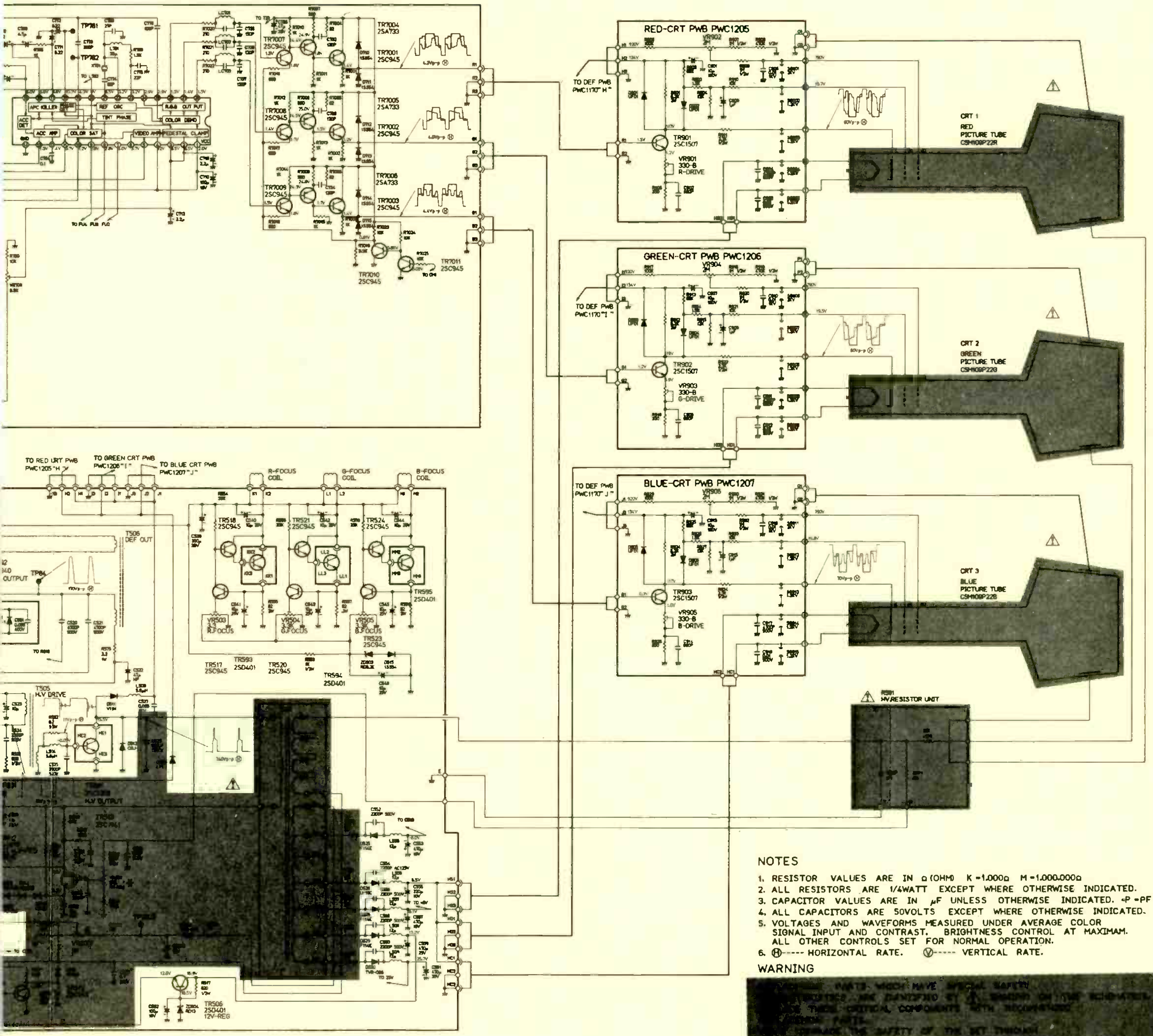
ES&T Manufacturers' schematics **PROFAX**

2005

NEC
Video projector
Chassis W2A-1

November 1982



NOTES

1. RESISTOR VALUES ARE IN Ω (OHM) K = 1.000Ω M = 1.000.000Ω
2. ALL RESISTORS ARE 1/4WATT EXCEPT WHERE OTHERWISE INDICATED.
3. CAPACITOR VALUES ARE IN μF UNLESS OTHERWISE INDICATED. μP = PF
4. ALL CAPACITORS ARE 50VOLTS EXCEPT WHERE OTHERWISE INDICATED.
5. VOLTAGES AND WAVEFORMS MEASURED UNDER AVERAGE COLOR SIGNAL INPUT AND CONTRAST. BRIGHTNESS CONTROL AT MAXIMAM. ALL OTHER CONTROLS SET FOR NORMAL OPERATION.
6. Ⓗ----- HORIZONTAL RATE. Ⓥ----- VERTICAL RATE.

WARNING

[illegible] PARTS WHICH HAVE SPECIAL SAFETY [illegible] ARE IDENTIFIED BY ⚠ SHADING ON THE SCHEMATIC. [illegible] THESE CRITICAL COMPONENTS WITH RECOMMENDED [illegible] PARTS. [illegible] THE SAFETY OF THE SET THROUGH [illegible] SERVICING.

CONTROL (S) MARKED ✱ IS PERMANENTLY FROZEN.
DO NOT ATTEMPT TO DEFEAT OR IMPROPERLY REPLACE.

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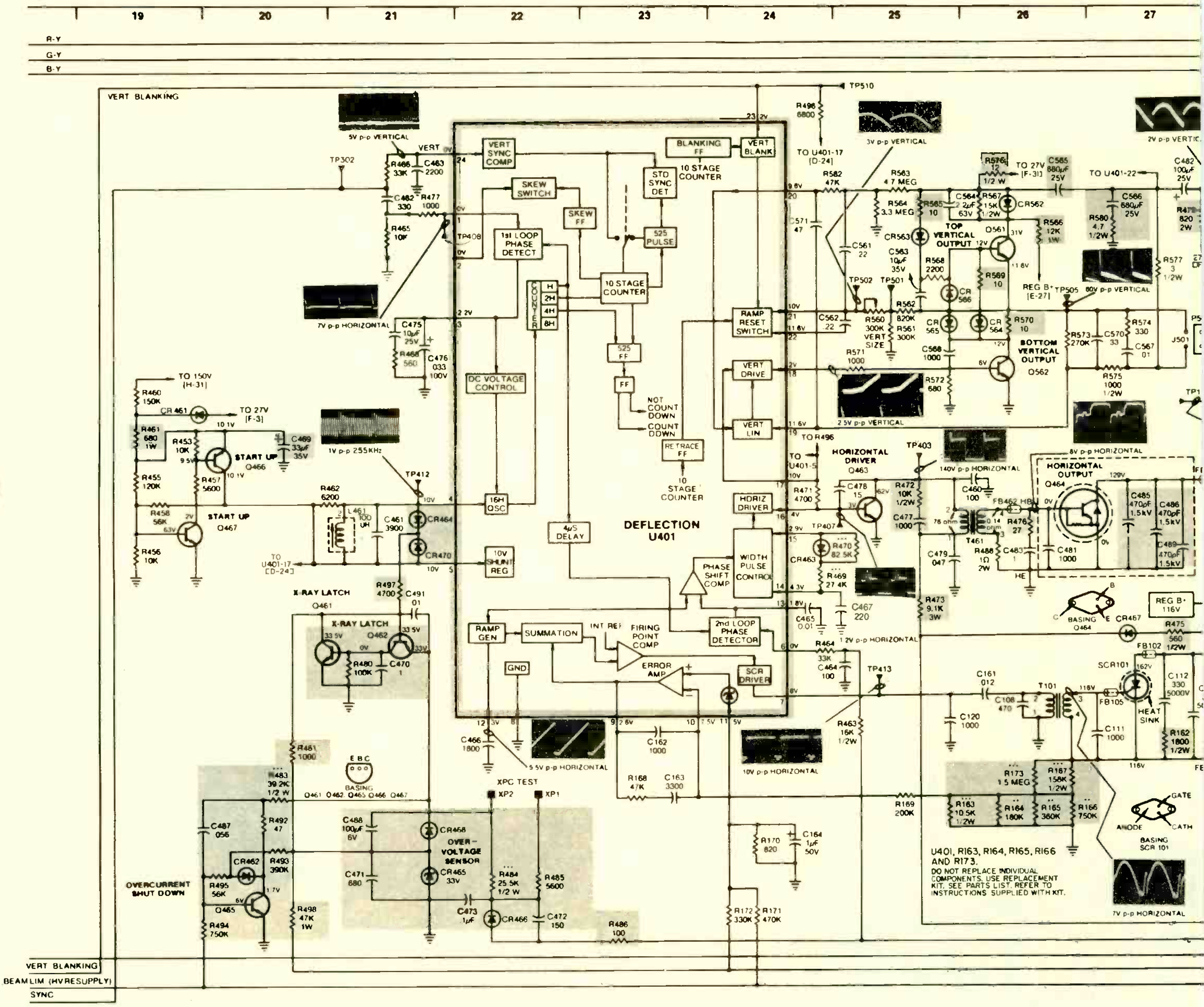
ogy, P.O. Box 12901, Overland Park, KS 66212.



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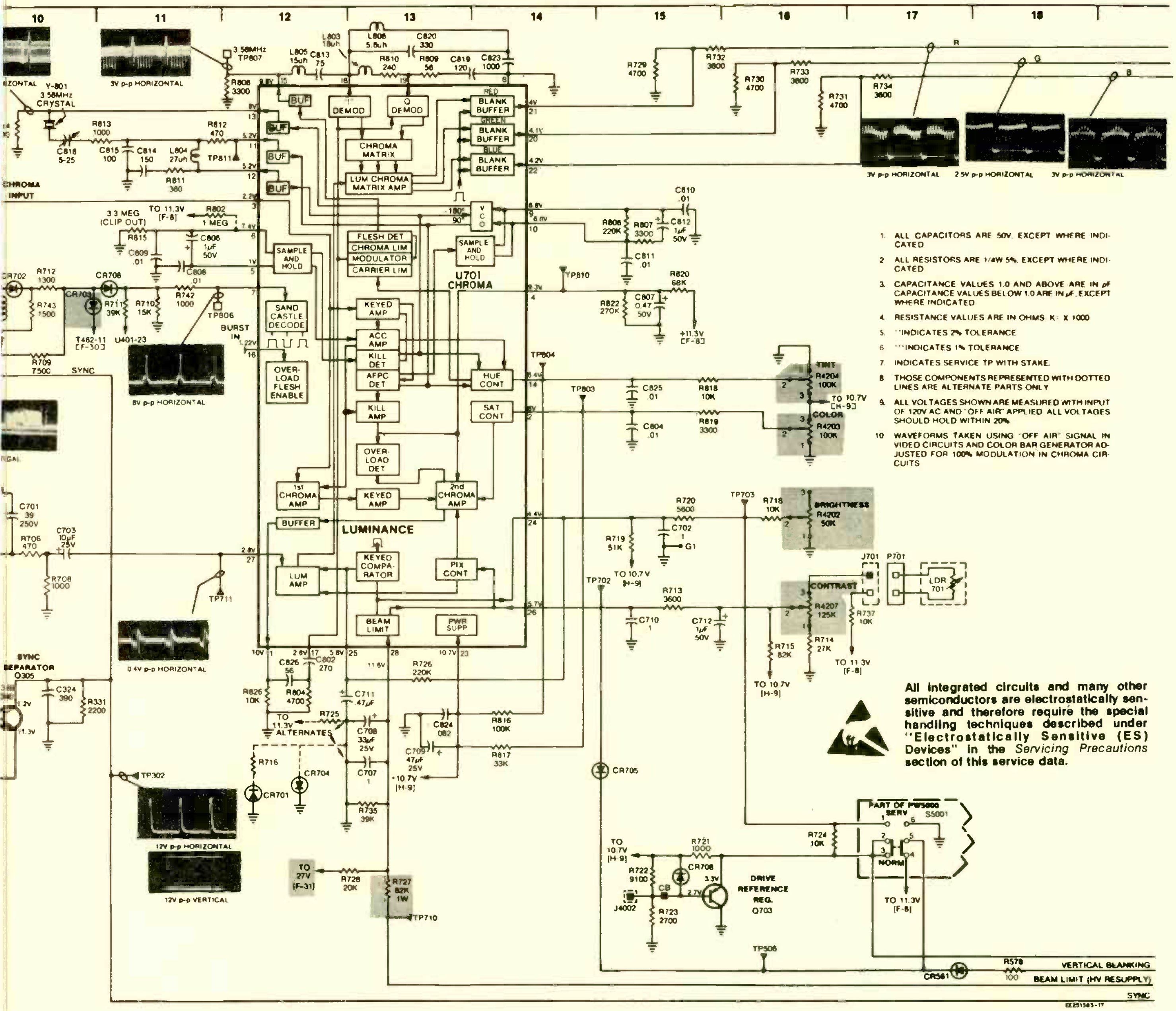
2004

RCA
Color TV
Chassis CTC 115

November 1982



1. ALL CAPACITORS ARE 50V, EXCEPT WHERE INDICATED
2. ALL RESISTORS ARE 1/4W 5%, EXCEPT WHERE INDICATED
3. CAPACITANCE VALUES 1.0 AND ABOVE ARE IN pF CAPACITANCE VALUES BELOW 1.0 ARE IN μF, EXCEPT WHERE INDICATED
4. RESISTANCE VALUES ARE IN OHMS K = X 1000
5. **INDICATES 2% TOLERANCE
6. ***INDICATES 1% TOLERANCE
7. INDICATES SERVICE TP WITH STAKE.
8. THOSE COMPONENTS REPRESENTED WITH DOTTED LINES ARE ALTERNATE PARTS ONLY
9. ALL VOLTAGES SHOWN ARE MEASURED WITH INPUT OF 120V AC AND "OFF AIR" APPLIED ALL VOLTAGES SHOULD HOLD WITHIN 20%
10. WAVEFORMS TAKEN USING "OFF AIR" SIGNAL IN VIDEO CIRCUITS AND COLOR BAR GENERATOR ADJUSTED FOR 100% MODULATION IN CHROMA CIRCUITS

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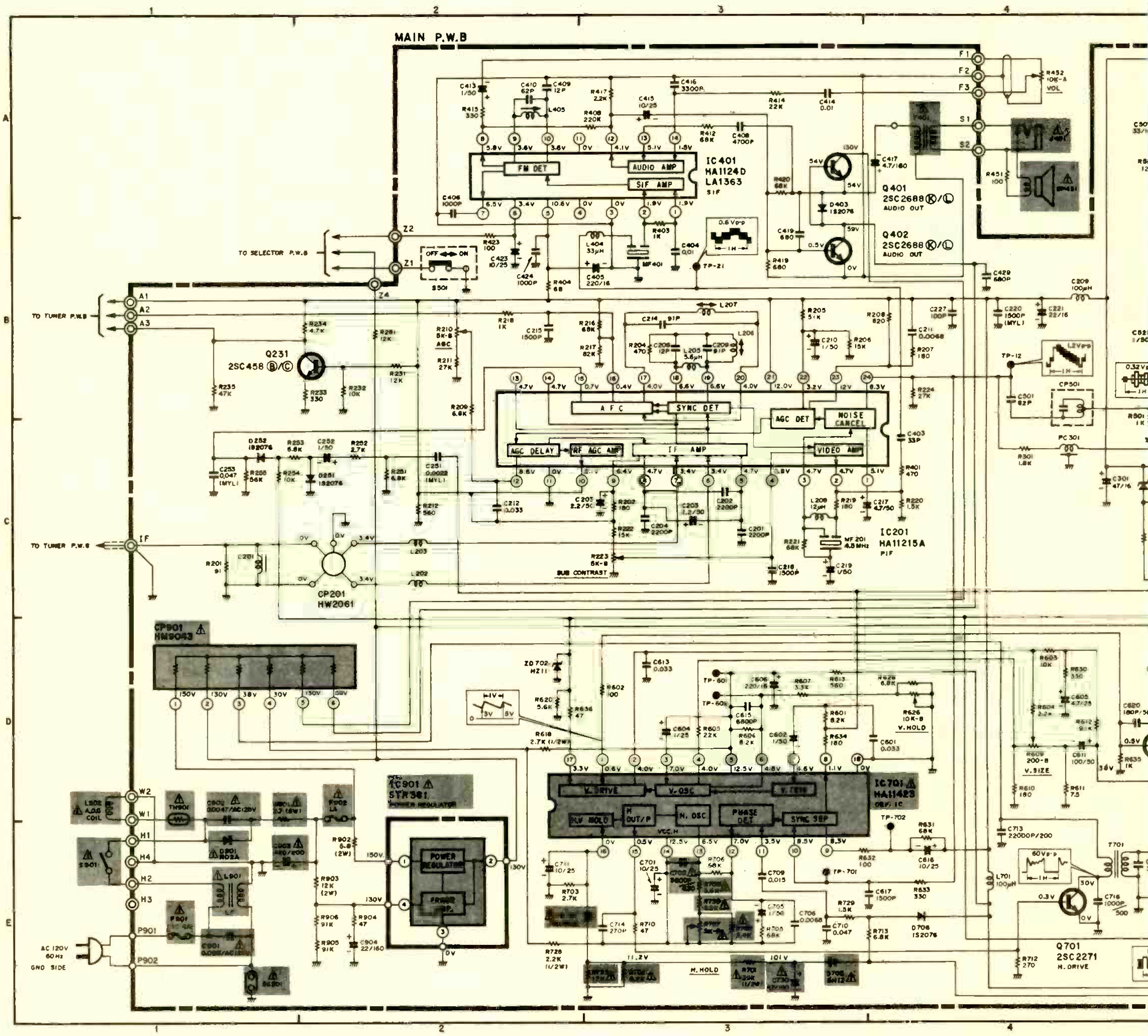
ES&T

Manufacturers' schematics PROFAX



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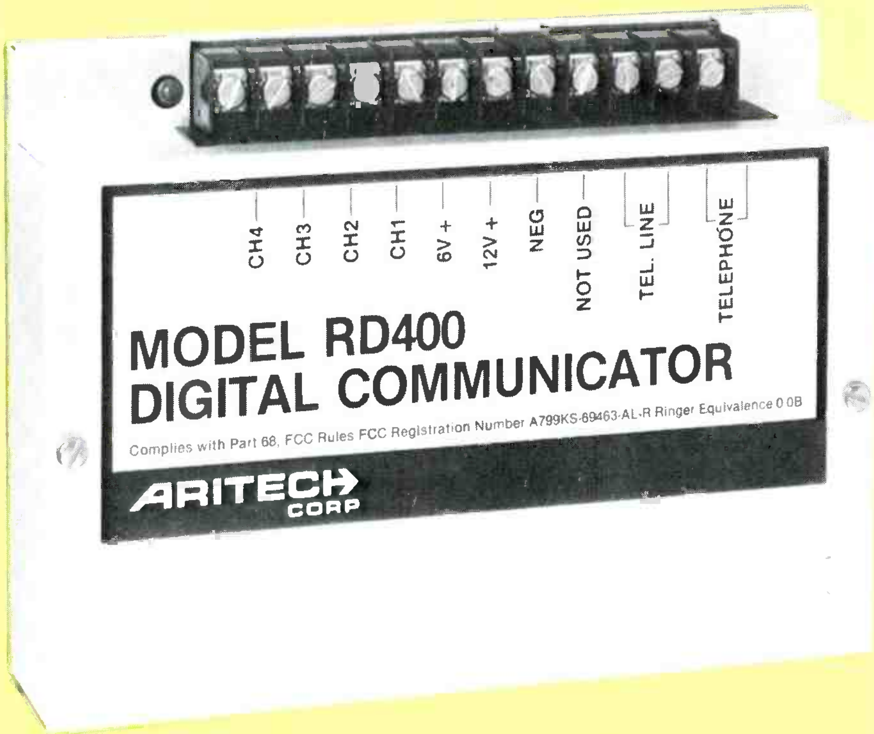
A digital communicator.



mation on these types of arrangements and are well equipped to advise new installers.

A fertile field

Many experts believe that the alarm industry offers opportunities for those who enter it. It is closely related to other electronics industries in the equipment used and in installation and service procedures. The professionals in these industries should perhaps look at the alarm industry as another avenue in which to apply their skills and derive profit.

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PC boards the easy way

By Les Svoboda

For years I have experimented with making my own etchings and boards. Needless to say, I have spent lots more time than money! Some of the boards didn't come out so hot, yet some were very good. For one-time-only projects, my experience suggests that buying pre-etched boards is usually a better solution.

Pre-etched board

"Veroboard" is the trade name for one manufacturer's punched phenolic or fiberglass insulating boards. They have 0.04-inch diameter holes arranged in rows and columns, spaced 0.1 inch apart. Veroboard has the same mounting arrangements as most current digital, DIP and PC components.

The holes are connected with continuous copper foil strips along the length of the board. Each strip is separated from the next row and can be interrupted, at any desired point, by cutting it with a sharp knife or a special hand-drill-type tool available from a Vero distributor.

Using a motorized hobby tool and drill press, I usually chuck a ⅛-inch bit into the tool and adjust the penetration depth with the press table to cut only through the foil, not the board. If you're careful, a small hand drill will work too. If you drill completely through the board, it will not necessarily affect the circuit's operation, only the appearance.

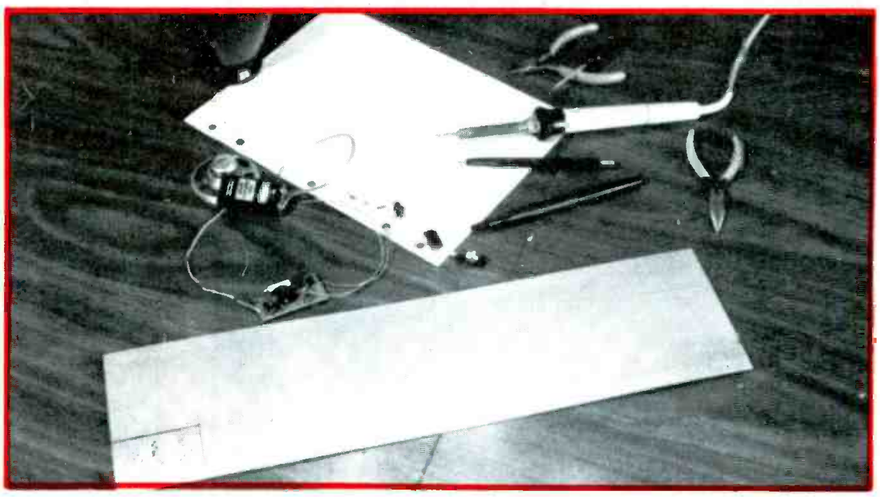
The paper layout

First obtain 2-sided graph paper. I use five squares to the inch quadrille or quadrant graph sheets. These sheets are exactly twice the actual size of the finished board, making it easier to visualize. This paper is available at most school-supply counters.

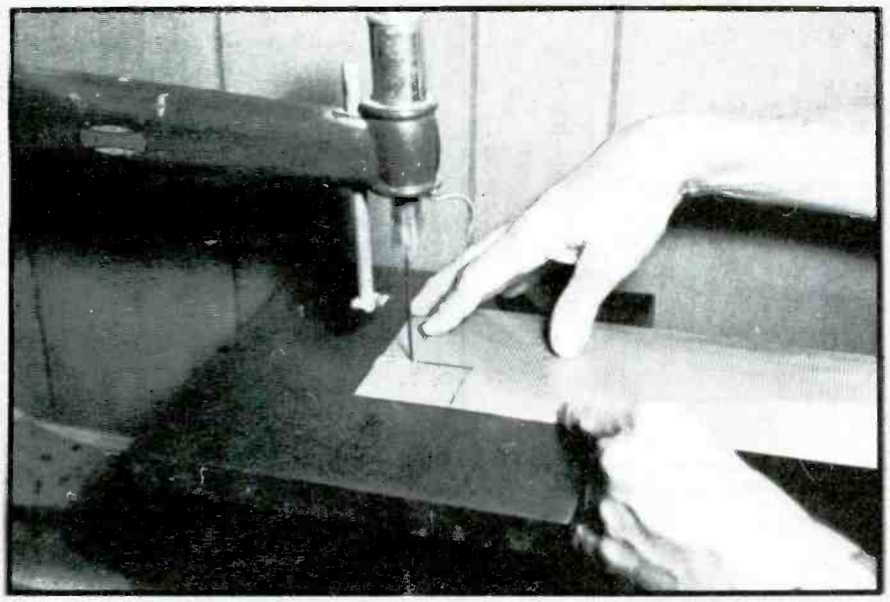
The center of each square may be considered as an available mounting hole. Using an erasable lead pencil, place a dot in the center of a square to represent a hole where a component lead will terminate with a soldered joint. Naturally, the in-line pins of an IC would be placed perpendicular to the foil traces. A line is drawn from the dot with the proper schematic symbol of the component reaching to its other mounting hole, again terminating as above. Plain lines are used to indicate jumpers between dots. Remember to leave enough space of you might end up crowding parts together in one area.

An "X" within an "O" is drawn in squares where foil strips need to be interrupted. Always center the interruptions on a hole, because this hole will act as a center-pilot and drilling guide. The symbol ⌧ indicates a component mounting hole, while the symbol ⌧ indicates a support hardware mounting hole. A dot surrounded by a circle is my indicator for a pre-punched hole in the board that will have to be enlarged for larger-than-normal component leads or pins. The mounting holes most likely will also need to be enlarged.

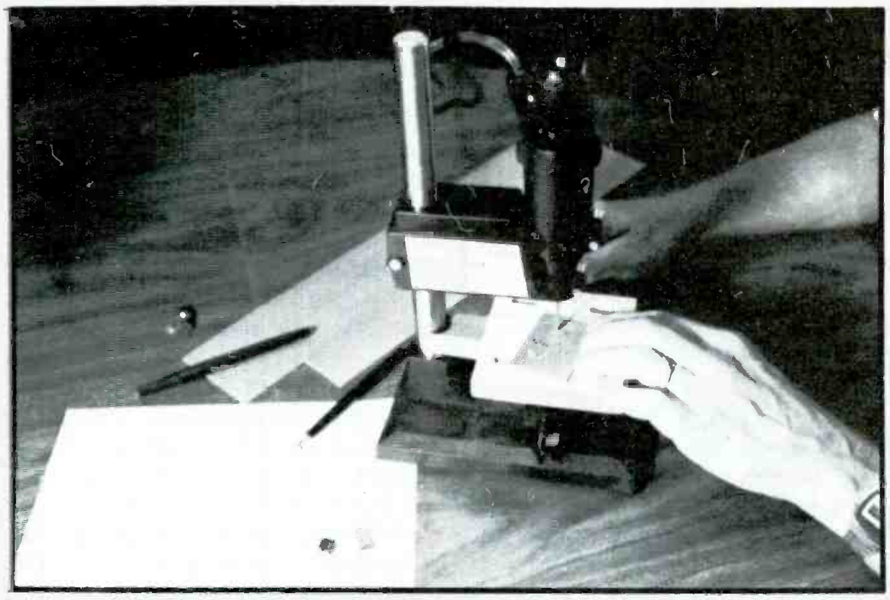
Be sure you can recognize a *top* view drawing and a *bottom* view. Begin by drawing the layout as a top view. Once this drawing is complete, place the sheet face down over a window or a lighted glass surface and retrace all the markings on the reverse side of the sheet. If the quad sheet is not printed on both sides, use another sheet over the original or fold the original. The top view will be used for placement of components and the bottom view for soldering the leads. Therefore, all foil interruptions need to be marked on the bot-



Stock Veroboard marked and ready for cutting and drilling.



Cutting a segment needed for a project. Note that markings for cutting lines and interruption locations are marked.

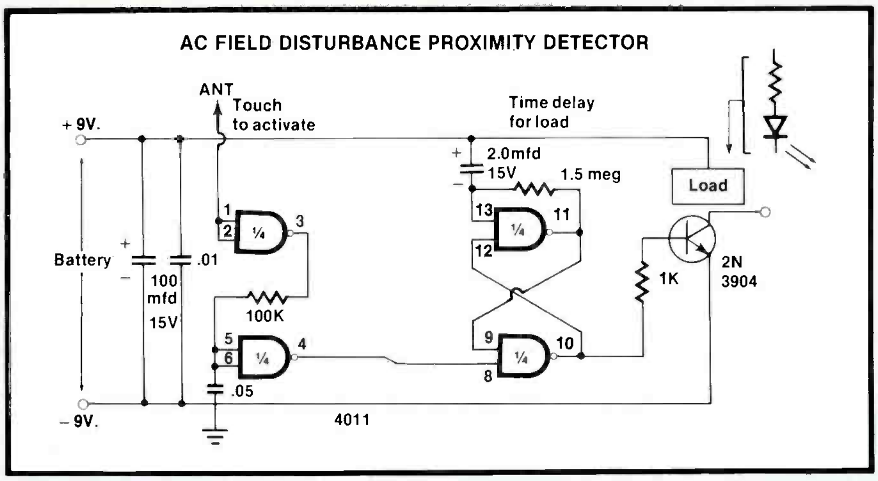


Drilling interruptions.

Legend of layout symbols

- Enlarged hole for component mounting.
- Enlarged hole for board mounting.
- Enlarged hole for larger component leads or pins.
- Foil trace interruption.
- Direct jumper.
- Direct jumper on opposite side of board.
- Flexible and longer than necessary jumper.
- Wire lead leading off board to other circuit(s).

Symbols used on paper layout.



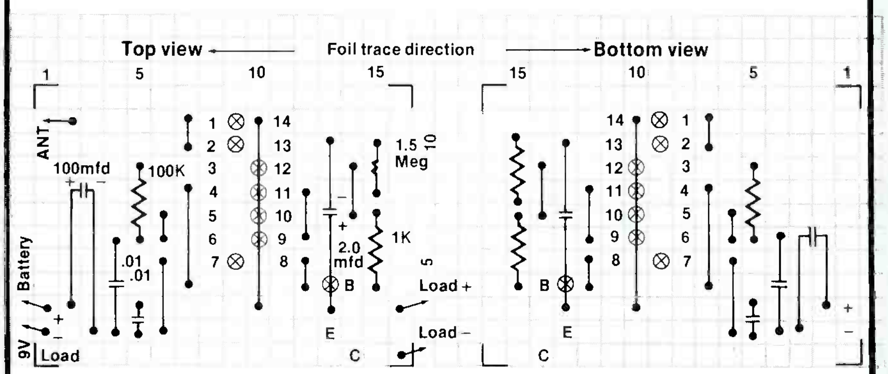


Figure 5.

Schematic and paper layout for an ac field-disturbance proximity detector.

tom view for drilling purposes. The bottom view can be helpful for troubleshooting, if necessary.

Many jumpers can be placed directly under DIP sockets, and in some cases, under larger components. Solid-tinned wire, of AWG 24 or so, will offer little or no interference to the socket or component. Check your components. The leads on most are longer than necessary and may be of the fine wire needed for this purpose. Clip them and use them.

Careful placement of the interruptions vs. jumpers must be considered when both are placed under DIP sockets (Figure 7).

If there are any continuous rows or columns that were not used or needed for a component's physical spacing after completing our layout, they can be scratched out. This compresses the size of the board. By the same token, if you need more space, a notation can be made that you will have to provide an additional row or column.

Preparing the board

After you determine the proper size of the blank board you will need for the project, mark the cutting lines with a small-tipped felt or nylon permanent marking pen. Phenolic board may be cut to size on a jigsaw. Tin snips or shears work quite well with fiberglass board. Use the space between the foil strips as a cutting guide and a line of holes for the perpendicular dimension.

The boards contain 38 rows of punched foil strips. The first four and last four additional rows are unpunched along the length of the board. These may be used as "bus" lines or heat sinks in some projects, or they may be cut off as waste in others. Special "plug-in" versions of Veroboard are available that mate into matching sockets if you desire to use plug-in cards.

Mounting the components

Before mounting any components, all foil interruptions should be completed. Check that all burrs are removed. The foil strips should now be rubbed with fine steel wool or liquids designed for making clean solder joints. A 25W, pencil-type iron works very well for soldering. The placement and soldering of jumpers should be done now, particularly if jumpers are to fall under IC sockets or other large components. If you are using sockets, their pins should be soldered to the board foils next. All remaining components should be mounted and soldered in a logical manner. If ICs are not going to be socketed, they should be soldered in last.

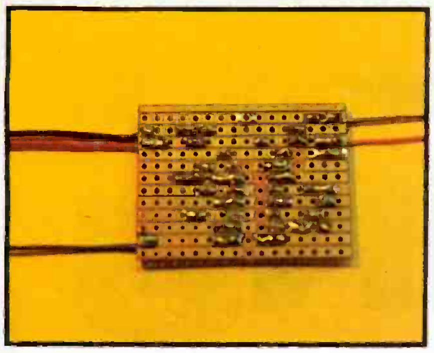
Mountings

If nut and screw mounting of the board above a chassis or within a "mini-box" is desired, the mounting hardware should be provided for by drilling out the necessary holes on the board to size. Use 2/56-inch diameter, round-head screws because they will not occupy more space than one foil strip width. Thus, the heads can even be placed over the foil trace if the trace will not be affected by the direct contact of the screw head. An expended ballpoint pen refill, cut to length, will make a beautiful spacer and fit over this diameter screw. A short spacer can be added before the nut, and it will act as an insulator. If components have larger diameter leads than the board holes provide, simply drill out the desired hole to the proper diameter. Make sure that the placement of mounting hardware or drilling will not produce a short circuit or an open circuit for your board.

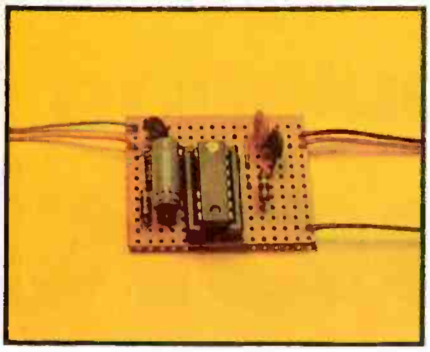
Various workable terminals are also available for fitting the mounting holes for wrapping, spacing, connecting wire, "high-rising" resistors or components that may run hot away from the board, or even floating the entire board above another. Sometimes unused segments of the foil strips can be interrupted and used as a small "on-board" heat sink. Remember that you can add jumpers to other nearby unused strips as another heat-sink aid.

Errors? Additions?

Have you forgotten a component or made an interruption in the



Bottom view of completed board.



Top view of completed board.

wrong place? Just make another interruption at a convenient point and add jumpers and the component. Have you ruined an entire circuit segment? Saw or cut it off or completely out, and replace it with a newly cut segment of board. Hard-wire jumper or flex-wire the new segment to it. I've even used this method to correct previously *etched* boards as well as to add more circuitry to existing boards. If you have cut your board too short, just add to it using the above method. I have replaced an old rectangular segment of board by sawing it out with a tiny circular saw blade chucked into the motorized hobby tool and mated a new segement of board into the opening, letting the flow of solder become the jumpers.

Solder and re-solder...the foil strips are well fused to the board and usually will not lift off easily, even with *more* than normal heat from the soldering iron. This is an aid in component removal or replacement.

With today's digital and most other circuits, these boards work like champs. Their only limitation might be in VHF up to GHz circuits where direct, short pin surrounding foil shielding is critical or necessary.

A few shots

A few shots of flux remover from a spray can will quickly rid all your solder joints of any darkened flux that remains on the board, giving it a professional look.

Using pre-etched board is one of the "slickest" ways to make neat and professional looking PC boards at reasonable costs. Its versatility is equal to no other, limited only to your design. It is certainly ideal for those one-time-only projects and prototypes, and it saves on etching time and money.

The fiberglass-base board is somewhat higher in price, but is more pliable. Both the fiberglass and phenolic boards are available in various stock lengths and widths. I use the phenolic base in the 17.9" x 4.7" dimension. It is available from Redel Laboratories, 3405A N. Kennicott Ave., Arlington Heights, IL 60064; 1-312-253-5000. It costs $13 PPD for one piece. ES&T

Digital building blocks: Clocking

By Bernard Daien

Early attempts at digital systems were plagued with a variety of problems. When the problems were understood, *clocking* was adopted as a major cure. Clocked systems run synchronously, controlled in an orderly fashion by a stable series of pulses that control the logic devices in the system. The controlled devices are said to be *clocked logic devices;* the pulse generator that initiates the clock pulses is called a *clock.* Because the clock signal is distributed throughout the entire digital system, it has a distribution system of its own. The clock may be a multiphase generator followed by drivers needed to accomplish the fan-out to the many different loads on the clock. We are therefore looking at a subsystem with rigid requirements placed on distortion, phasing, delays and so forth.

Often the clock system is not clearly understood – yet, if the clock system does not function properly, the entire digital system will malfunction in an unpredictable manner. Despite this, most digital texts provide only fragmentary attention to clocking. This article clarifies clocking, putting many of the pieces together into a comprehensive whole.

What is a clock?

Lucidly explaining what a clock is really requires including a description of what a clock does, so we'll try to define the clock first, and follow up with some of the things the clock does.

First, a definition:

The clock is a pulse generator that controls the timing of computer switching circuits and memory states. It controls the speed with which computer operations are performed and also synchronizes various operations in the digital system. The clock regulates the sequence and timing of logic levels; *races* are eliminated by the use of clocked logic devices; *glitches* are prevented by clocking; and other effects due to *propagation delays* of the various digital devices are minimized by clocking.

In order to understand the above, we have to define the terms we just used.

A *race* is a condition that occurs when two or more signals compete with each other in determining which will cause an operation to occur.

A *glitch* is a spurious, unwanted pulse generated by the operation of the digital system. (Glitches are often generated as the result of a race.)

Propagation delay is the time required for a logic signal to pass through a logic device. It is the total of several internal delays, such as rise time and fall time. It should be noted that the low-power TTL family of devices has quite a long delay (more than 30ns), while the high-speed Schottky TTL family has a delay of less than 5ns. Emitter-coupled logic (ECL) has even less delay.

Further complicating the picture is the fact that even within families, different device types have different delays. A simple gate with few transistors has less delay than a more complex device with many transistors inside. Each semiconductor the signal passes through adds its own propagation delay.

The word *synchronous* in digital descriptions is interchangeable with *clock* or *step,* thus *synchronous logic* is *clocked logic* or *stepped logic.* Modern digital systems are synchronous. Because TTL was the earliest large family and MOS came later, MOS is usually synchronous (clocked).

Why do we need a clock?

Perhaps the most direct way to show the need for a clock is with the aid of an elementary, common problem – a race that generates a glitch. This is illustrated in Figure 1A, the logic diagram of a 2-input AND gate, which has been set up so that the output goes high when input-line A is high and input-line B is low. Line A goes straight into the AND gate, but line B goes through an inverter, which inverts it to NOT B, which is indicated by the overbar above the B, ($\overline{B}$).

Because B is inverted, B goes through an additional propagation delay – the delay in the inverter. Figure 1B, which shows the input and output waveforms, illustrates what happens as a result of this added delay. The input pulses shown are at the input to the AND gate. The overlap results in a narrow pulse appearing at the output of the AND gate – a glitch. This is an example of a glitch caused by a race. Of course this glitch has the capability of falsely triggering digital devices, because it is a pulse with amplitude required for digital use, and it has a rise and fall suitable for edge-triggered circuits.

Ordinarily it is not possible to insure that every digital signal path will go through exactly the same number of devices, with the same propagation delays, because dif-

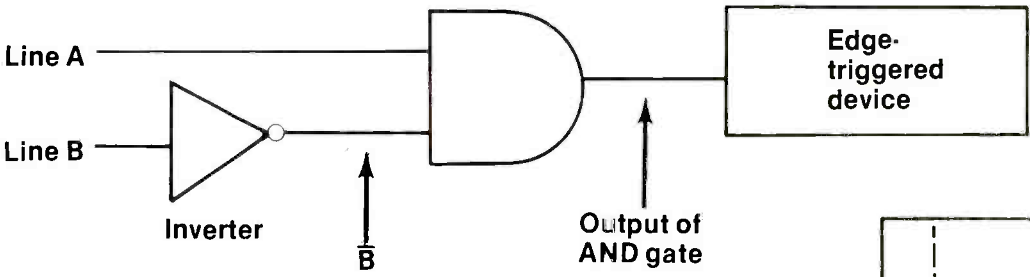


Figure 1A. A 2-input AND gate driving an edge-triggered digital device.

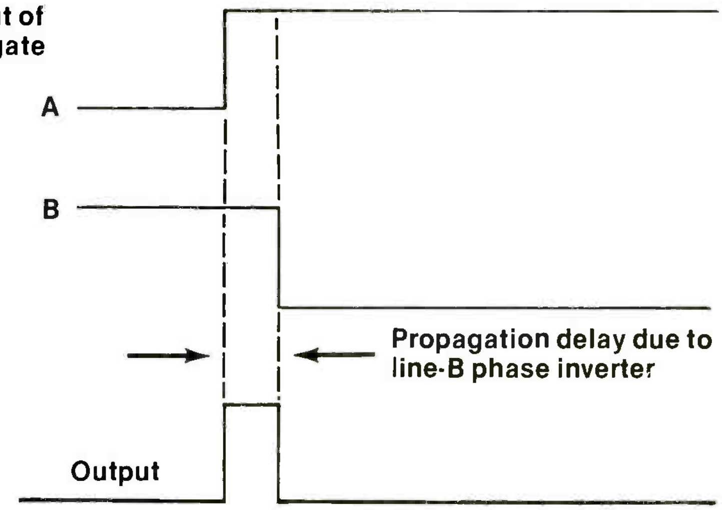


Figure 1B. Because B input was delayed in the phase inverter, A and B overlapped, causing a narrow pulse to appear at the output of the AND gate. This pulse can trigger a following-edge-triggered digital device or circuit. This is a glitch, caused by a race.

ferent types of logic devices have different numbers of semiconductors internally. Even worse, as you will see shortly, ordinary gates do not have the ability to discriminate between wanted and unwanted input pulses. (Sometimes we do not want the logic device to respond to pulses at the input). The way to beat this problem is with a clock system, using clocked logic devices.

Clocked digital devices

As mentioned previously, modern digital systems are clocked (synchronous). The major families of digital logic all have numerous devices specifically designed to work with a clock. To better understand the need for these clocked logic devices, we'll look at the derivation of one of the most popular digital devices: the flip-flop. Flip-flops are used for a wide variety of purposes, including bistable applications, which form the basis for latches, registers and memories. In such use, a pulse sets or resets the flip-flop, which then holds its state for as long as desired. We say that the flip-flop stores one bit of information, as either a high or a low output state.

Unfortunately the flip-flop has some problems in its basic form. To illustrate this, we will hook up a flip-flop, using a pair of 2-input NAND gates, as shown in Figure 2A. This basic flip-flop is known as a set-reset flip-flop (RS), and its truth table is in Figure 2B. Note that the output of each NAND gate is the input inverted and that there are two outputs available, out of phase with each other. It should be noted that the input marked "Reset" is often labeled "Clear".

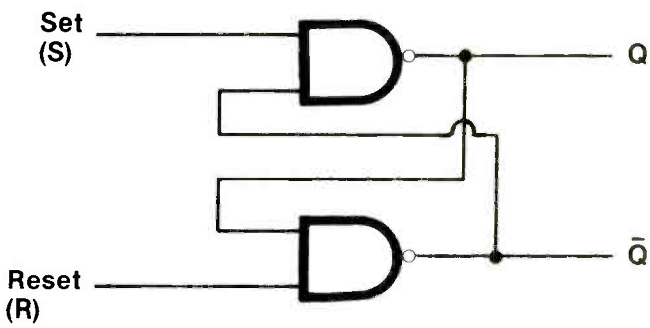


Figure 2A. An RS flip-flop (cross-coupled, monostable flip-flop). Note that the NAND gates invert the input signal.

Inputs		Outputs	
S	R	Q	$\bar{Q}$
0	0	1 not allowed	1
0	1	1	0
1	0	0	1
1	1	no change	

Figure 2B. A truth table for an RS flip-flop in Figure 2A. Note that "reset" is often labelled "clear".

The truth table indicates some problems with the RS flip-flop; it is forbidden to apply a digital 0 to both inputs simultaneously, because both outputs become 1 as long as both inputs remain at zero. But eventually the inputs have to change, and therein lies the heart of the problem. When both inputs are removed, even simultaneously, the NAND gates race each other to change state and the resulting outputs cannot be predicted in advance. Therefore, this condition is said to be forbidden.

The RS flip-flop has a major drawback: It responds to every input pulse, even when you do not want it to. For example, when used as a memory cell storing one bit of data, the RS flip-flop will respond to pulses following the one you wish to preserve. In this case, the desired data stored is lost. We need some way to get the flip-flop to disregard unwanted pulses occurring after the desired one when we wish to do so. This problem is overcome by changing the circuit to the one shown in Figure 3A, which uses four 2-input NAND gates. The pair of NAND gates at the input are used for clocking via the third input labeled "T" for trigger (clock). This flip-flop is therefore called an *RST* flip-flop, and its truth table is in Figure 3B.

Note that when the T input is low, the output of the first pair of NAND gates does not change, regardless of the input RS states. This input pair thus acts like a switch, permitting the RS inputs to trigger the flip-flop, or preventing the inputs from having any effect on the output state. In order for the RS inputs to cause a change of state in the flip-flop, the T input must be in the high state. This solves the problem of avoiding unwanted inputs triggering the flip-flop. The clock controls the passage of wanted or unwanted input pulses to the digital device, which might affect the flip-flop's output state.

This type of clocking is called *single-phase clocking* because only one state of the clock controls the output of the flip-flop. As you will soon see, there are other clocking arrangements that control inputting and outputting separately, and they are therefore used with devices that are said to be *2-phase clocked* (two separate steps). The input is clocked first, the output later. This prevents a race condition.

Note also that the annoying forbidden condition of applying a "0" to both inputs (no signal) is eliminated with the RST flip-flop.

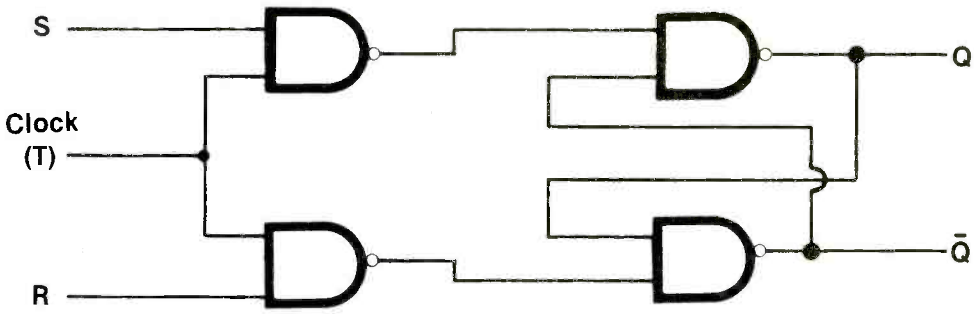


Figure 3A. An RST flip-flop schematic.

Inputs			Outputs	
S	R	T	Q	Q̄
0	0	1	No change	
0	1	1	0	1
1	0	1	1	0
1	1	1	1 1 not allowed	
x	x	0	No change	

Figure 3B. The truth table for an RST flip-flop. Note that x = doesn't matter.

Figure 4A illustrates a *master-slave* flip-flop, which employs 2-phase clocking. If you examine the diagram, you will see that it is simply two RST flip-flops in series, with an internal inverter in the clock line to the output flip-flop. The input (master) flip-flop is clocked when the clock goes high (the leading edge of the positive-going clock pulse). The output (slave) flip-flop is not clocked until the falling edge of the clock pulses. Obviously, the output flip-flop is always clocked after the input flip-flop, and it is this characteristic that gives the master-slave flip-flop its major advantage.

Information is passed into the master flip-flop from the RS inputs when the master flip-flop is clocked. The master flip-flop changes states but the change of state is not passed into the slave flip-flop until later, when the slave is clocked. Thus the master flip-flop changes state in accordance with the inputs, when properly clocked, but the output state of the slave flip-flop is not affected by what happens at that moment. Later, when the slave is clocked, during the time the slave is going through its change of state, the master cannot change because it has a low clock input (due to the inverter. Even though a single clock pulse is used, there are two distinctly separate actions, one on the rising edge of the pulse and one on the falling edge. Hence the name 2-phase clocked is applied to the master-slave clocked digital device, unlike the simple RS flip-flop, which was said to be a single-phase clocked device.

It should be noted that some digital clocked devices are *edge-triggered* on either the rising or falling edge (or both), while others are *level triggered*. This can lead to severe headaches if the technician fails to note the difference.

If you have ever used a laboratory or industrial-grade oscilloscope, with all of the various triggering options, such as *dc level, ac high frequency, ac low frequency, positive edge* and *negative edge,* you know the tremendous difference it makes in being able to select the waveform you want and disregard the others. I assume the reader has already been exposed to such a scope and will not belabor the point, other than to state that slowly rising or distorted waveforms can cause problems with edge-triggered devices. This problem can sometimes be alleviated by the use of a Schmitt trigger, which has a built-in snap action that converts slowly rising waveforms into fast-rise-and-fall pulses. (The Schmitt was covered in the September issue.)

The master-slave flip-flop is said to be *cocked* when the master is clocked and *triggered* when the slave is clocked.

The master-slave flip-flop is much like a single-action revolver, which must have the hammer pulled back manually before it can be fired (while an automatic pistol requires only a touch on the trigger to fire repeat shots). Master-slave flip-flops are often used.

Due to clocking, information moves in synchronous steps throughout the entire system, using clocked-logic devices. Therefore, pulses occurring at random, such as transients, are not likely to occur in synchronization with the clock timing, and as a result, system immunity to such unwanted pulses is greatly improved, in much the same way that gated automatic gain control improves color TV receiver perform-

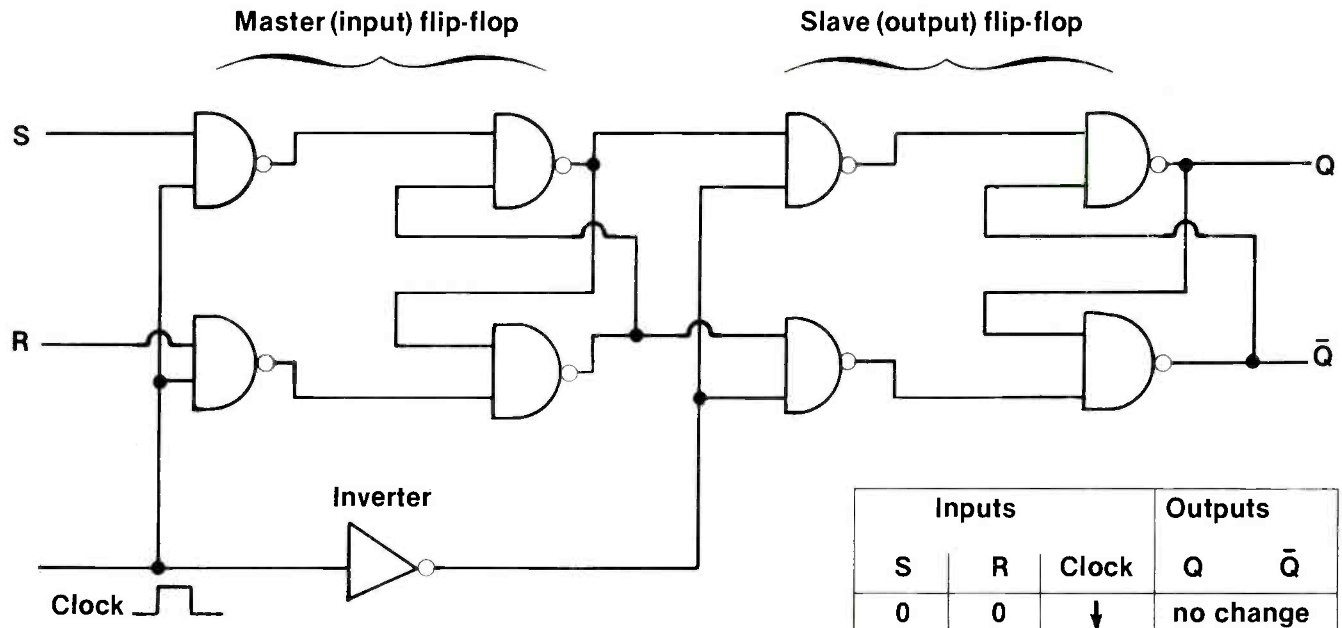


Figure 4A. A master-slave flip-flop schematic.

Inputs			Outputs	
S	R	Clock	Q	Q̄
0	0	↓	no change	
0	1	↓	0	1
1	0	↓	1	0
1	1	↓	1 not allowed	1

Figure 4B. The truth table for a master-slave flip-flop. Note that the output changes on the negative-going clock pulse edge (see text).

↓ = negative-going edge.

ance. The clocking also avoids unwanted pulses from triggering flip-flops and other clocked logic devices.

Not all digital devices have the same propagation delays, due to internal design, yet it is necessary that the slowest device in the system be allowed to complete its function in the system. By clocking at a rate that permits the slowest device to function properly, the entire system can be made to operate in a predictable way. This point is often neglected in discussing clocking.

Clocking and MOS

MOS devices offer the advantage of low power consumption and can pack more circuitry on a small chip. Further reductions in current drain are made possible by the use of *dynamic* circuitry, in which the device is switched on for a short time and off for part of the time. To accomplish this, the clock pulses are modified to a multiphase signal, called a 2-phase clock. It should be carefully noted that there is a possibility of confusion of terminology here. We are now discussing the clock, and consequently, 2-phase clocking. We had previously discussed clocked devices, which were *2-phase clocked.* In the present case, we are talking about the generator and its pulses; earlier, we were talking about the devices that received and used the clock pulses. Just remember that a *2-phase clock* (generator) is different from a *2-phase-clocked device.*

MOS dynamic memories offer large storage capacity with low power-source current drain, but because the data are maintained through the use of small capacitors inside the chip, the charge on these small capacitors leaks off rapidly. In order to maintain the data stored, the dynamic memory must be *refreshed* (renewed, recharged) at a rapid frequency. The pulse that does this is part of the clock system. Because of the requirements of MOS logic, dynamic memories and dynamic logic (which works the same way that dynamic memories do), MOS digital systems generally use a multiphase clock, with two or more phases. A simple 2-phase MOS-system clock is shown in Figure 5A, which illustrates the waveforms. Figure 5B shows a method for generating such a 2-phase clock, using common digital devices.

Clocking and computing systems

Computing systems, such as the popular microprocessor-based small computers, require a clock to control the various operations performed within the system, such as transferring data or performing arithmetic and logic calculations, in addition to avoiding races. Figure 6 gives one example of this for the 6800 microprocessor. We are looking at the 2-phase clock waveform, which has been labeled to show how the operations of the Instruction Register are sequenced by the clock cycle. Of course the Instruction Register is only one part of many in the computer, but similar actions take place in the other parts too.

This is just a sample for those readers already familiar with microprocessors. For the technician just entering the digital world, this will still have some meaning in a general sense. The computer transfers data from one section to another in accordance with an orderly program, which is timed by the clock. The waveform is the output of the clock as would

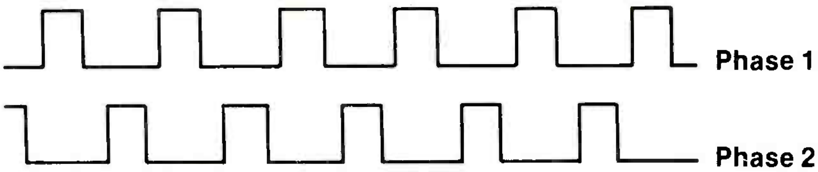


Figure 5A. MOS 2-phase clock pulses.

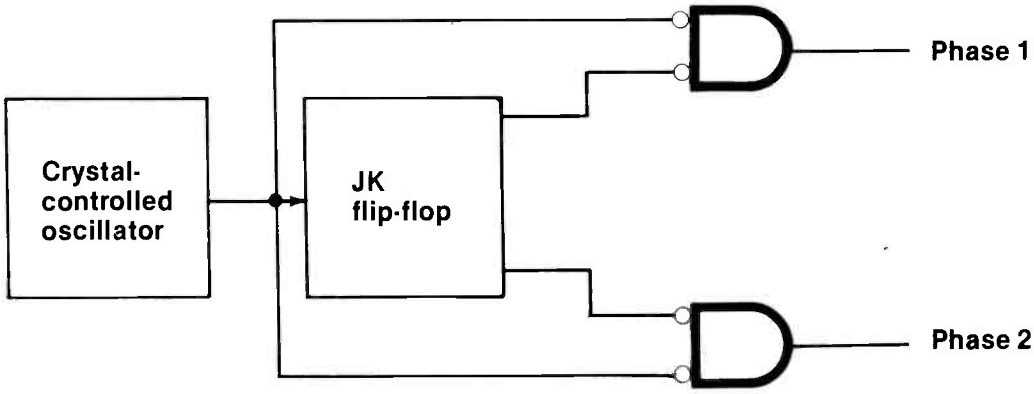


Figure 5B. An MOS clock-pulse schematic. Note that the JK flip-flop acts as a frequency divider, halving the output of the oscillator. The pulse widths of the phase 1 and phase 2 are equal to one half of the oscillator period.

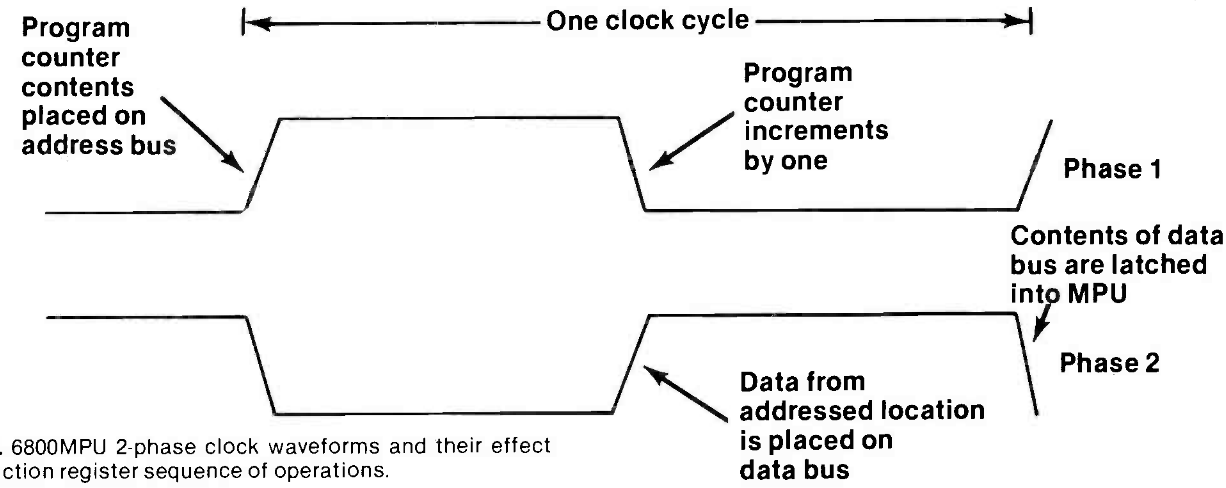


Figure 6. 6800MPU 2-phase clock waveforms and their effect on instruction register sequence of operations.

be seen on a dual-trace scope. It is not the waveform shown earlier for MOS circuitry. This type of clock pulse is generated with an oscillator and a simple inverter, so no schematic is required.

Clock fan out

Because the clock drives many digital devices in a system, the oscillator is usually followed by a *clock driver*. The primary purpose of the oscillator is to create a reliable and stable signal. The driver then provides power gain and isolation from the loads. The clock driver acts much like the power RF amplifier in a transmitter, which isolates the oscillator from the antenna.

Because the clock signal propagates through internal buses and external cables to input and output terminals, memory banks and other devices, and in the process passes through connectors, the stray capacitances, lead inductances and impedance mismatches all combine to degrade the waveform. Rise and falltimes slow and ringing appears. This causes problems, especially in edge-triggered circuits. It is therefore not uncommon to see buffers in the clock circuitry, in order to maintain the clock signal at a healthy level, and to provide added fan out when needed and further isolation as necessary. In short, the clock has a sub-system of its own. This implies that the clock pulse may be fine at one location in the system, but not in some other location, so the clock must be examined at the input to any device suspected to be malfunctioning; a point often overlooked. It should be a regular part of testing in any digital system to check the clock, just as the supply voltage is routinely checked, with this exception: It is not enough to check for the amplitude of the clock pulse, and for the presence of transients. The waveshape of the clock, and its timing relative to the other clock phase and to the inputs to the device under test, must be carefully examined with a triggered oscilloscope, using the clock generator as a sync source. The clock is one of the digital device inputs, even though it is not always thought of as such.

Like any other input, transients on the clock line can cause difficult problems, because they are intermittent or random in nature. Be warned! Poor grounds and insufficient bypassing are common causes of such problems. ES&T

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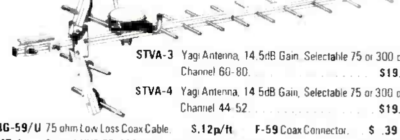

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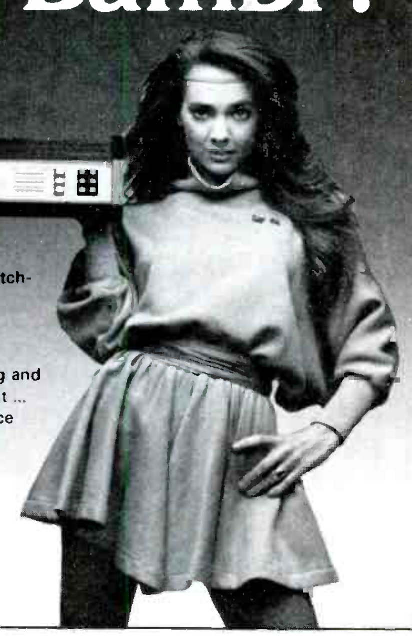

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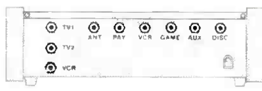

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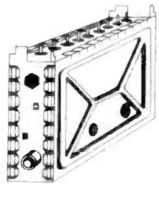

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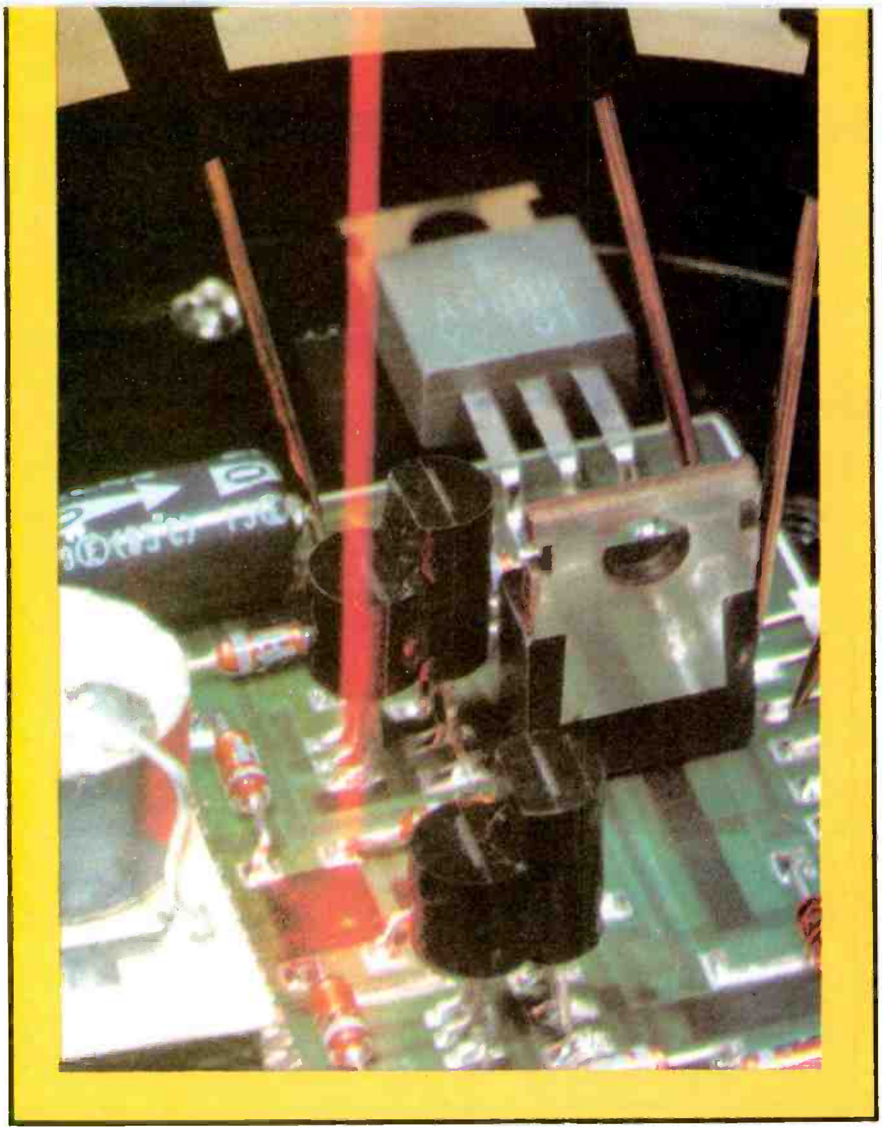

In search of the ultimate amplifier

You, the audiophile, are constantly in search of accurate sound reproduction. Harman Kardon agreed with this quest and developed the new Citation Division to meet this challenge.

The cost of the Citation XX is $7500. Although the price is prohibitive to most audiophiles, it should be noted that this same system has been incorporated in some of Harman Kardon's lower priced units. The profile of the Citation XX is provided here as an illustration of a newsworthy innovation.

As a result of the meeting of some of the finest engineering minds in the fields of electronics, acoustics, psycho-acoustics, physics, plus a group of puristic musicians, the Citation XX has evolved.

Heading the team of scientists was Dr. Matti Otala, well known for his research and writings on the subject of Transient Intermodulation Distortion (TIM), a problematic phenomenon he discovered and then resolved. Dr. Otala's work concerning TIM is evident in most sophisticated amplifiers today.

Before beginning work, Otala set six precepts for achieving the goal of the ultimate amplifier.

1) Previous amplifiers could be improved on.
2) No problem is insurmountable.
3) Audio is not fashion.
4) The simpler the solution to a problem, the better.
5) The dynamic state is more important than the steady state.
6) Evaluate results with your ears.

The intensity of these thoughts require some further examination and explanation, because their impact is the cornerstone of the technology used to create the desired result.

First, Otala felt that previous amplifiers left a vast area for improvement upon which he and his group of experts could concentrate.

The second philosophy was that no problem was insurmountable. When a question arose, the method used to answer it was to initially research and understand the area being pursued, accept what is fact, and determine reasonable theoretical and experimental and measurement techniques accordingly. When existing techniques could not provide the solution, the recourse was to develop new methodology, which resulted in new technology for which several patents are now pending.

The third and fourth philosophies dealt with principles of circuit design. He is a firm believer that audio should not be style or fashion oriented to suit a marketing whim, but should be designed only for the ultimate in sound. By using the concept that *The simpler the solution to a problem, the better,* he sought clear-cut circuit layouts, keeping in mind only the acoustic properties.

But it was his fifth philosophy that led to many of the discoveries and innovations incorporated in the final design. This was his concept of dynamic design and measurement vs. the steady state. Otala determined that an amplifier's performance in handling music (dynamic) differs drastically from its performance in a test using a single pitch or sine wave (steady). This is the difference between the dynamic, constantly moving state and the steady state of normal test methods. The dynamic state is especially difficult to design for, because most standard and commonly understood test methods are of a steady nature. Therefore, complex evaluation techniques and performance criteria are first created in order to test the dynamic state of a given circuit design. Otala's design, to achieve his ultimate goal, would have to perform exceptionally well in the dynamic state.

Finally, the strongest of Otala's beliefs is that the educated listener is the supreme and final judge of sound quality, regardless of clinical electronic measurement. This philosophy was many times the force behind new achievements and innovations that are incorporated in the Citation XX.

Design parameters that make the difference

1. *High Current Capability (HCC)*

The concept of the dynamic state plays an important role in the design of an amplifier's power capability. When an amplifier's power characteristics are measured by conventional test signals (steady state), it means only half of the story is told. Standard measurement technique for output capability uses a static 8Ω resistant load. Speaker impedance varies greatly according to the input signal. Therefore, the actual impedance may decrease to as low as 2Ω. At low impedance, it becomes even more critical that an amplifier increases its power output. This is the reason this amplifier is designed with 200A of instantaneous current capability, enabling it to react to constant impedance variations caused by the dynamic characteristics of the music signal. HCC also enables the amplifier to accurately control speaker cone movement by affording the energy necessary to force the speaker cone to precisely react to transients. This performance has paramount importance in high fidelity reproduction.

2. *Phase Intermodulation Distortion (PIM)*

Phase intermodulation distortion can be an unwanted by-product of negative feedback. Negative feedback, which is used in virtually every amplifier on the market, is the routing of part of the output signal of an amplification stage back into the input, 180° out-of-phase with the original input signal. The combination of these two signals, out-of-phase with each other, causes partial cancellation (attenuation) of the input signal but, more importantly, creates an error-correction signal that greatly reduces the harmonic distortion inherent in the amplifier.

By its very nature, negative feedback converts amplitude non-linearity to a proportionate amount of phase non-linearity – or phase intermodulation distortion (PIM) in place of the harmonic distortion it eliminates. This was proved by Otala and presented to the Audio Engineering Society in 1980 at a convention in Hamburg. This amplifier used a special circuit of two nested feedback loops (one reactively coupled) so that the time constants coincide. This, along with low driver impedance, causes dramatic reduction in PIM.

Rather than transform distortion from one type to another, by way of negative feedback, the unit is designed to have minimal inherent distortion. The result is low PIM and THD.

3. *Interface Intermodulation Distortion (IIM)*

Interface intermodulation distortion (IIM) occurs in the speaker/amplifier interface. The moving cone and coil structure in the speaker generates a voltage that returns to the output stage of the amplifier. This voltage is called the back electromotive force (Back EMF). Once this voltage passes the output stage, it travels through the negative feedback circuit and returns to the input stage where it combines with the input signal. This mixing of the legitimate input signal and the Back EMF results in increased dynamic distortion. The effects of excessive IIM result in obscured lower mid-range, which makes the sound appear vague and lacking definition. The minimization of IIM is carried out by reducing the negative feedback and by decreasing the internal resistance of the output stage. The result is clear mid and low frequency reproduction, which is pure and well balanced.

4. *Transient Intermodulation Distortion (TIM)*

Transient intermodulation

distortion (TIM) occurs when fast transients, such as in dynamic music passages, pass an amplification stage before the return of the output signal, arriving back at the input stage via the negative feedback circuit. This allows the input stage to operate without negative feedback. These transients can then overload the first stage sufficiently to cause internal clipping – hence, TIM.

These negative aspects of TIM are countered with three special design parameters:

- a super-low distortion driver stage that exhibits proper localized feedback (feedback within each stage vs. feedback in the entire circuit).
- the introduction of transistors with extremely quick response speed, excellent linearity and a large, safe operating area.
- the incorporation of a dual source system with high and low voltage sources. The high voltage source, dedicated to the driver, has the ability to supply the proper voltage under any condition.

Controlling negative feedback and utilization of circuitry not dependent on negative feedback virtually eliminates TIM.

New circuit technology

1) *Custom engineered hybrid circuitry (U.S. patent pending)*

The heart of the amplifier is a thick film hybrid circuit specifically developed by the Technical Research Centre of Finland. The thick film hybrid consists of transistors and thick film resistors whose electronic values are measured by a computer. Special test signals are fed into the hybrid circuit and as the computer measures the values of the components, a laser beam is shot into the hybrid circuitry, trimming the values of the components. This makes the components accurate within hundredths of a percent. Because of the exceptionally high accuracy of the components within the hybrid circuit, audible distortions are reduced to virtually nothing.

2) *Dual Independent Power Transformers*

The massive power supply section is comprised of dual toroidal transformers with a total capacity of electrolytic capacitors that amount to 80,000μF. This power supply design is capable of delivering the current necessary to meet the 200A HCC requirements of the new circuitry, yielding excellent dynamic range, transient response and sound quality.

3) *24-karat gold-plated transmission line*

Conventional large-diamater wiring inductance greatly restricts the flow of high frequency current from the power supply to the output transistors. To overcome this limitation, a transmission line consisting of three parallel plates was designed, providing a low impedance path for the positive and negative power supplies and ground. Each plate is 24-Karat gold-plated, which further enhances high frequency conductivity.

4) *Self-correcting circuitry*

Each amplification stage has been designed to have self-correcting ability with regard to temperature matching, keeping thermal induced distortion to a minimum.

5) *Protection circuitry (U.S. patent pending)*

A completely electronic protection circuit operates without compromising sonic quality. The protection circuitry is capable of ultra-high speed cut-off in all circuits, ensuring safety in the event of shorted speakers or speaker cables.

6) *Custom designed heat sinks*

To complement each power transistor assembly, there is a custom-designed heat sink. These special heat sinks have a contact wall thick enough to absorb instantaneous heat generation, preventing thermal distortion. At the same time, they dissipate the heat and reach thermal equilibrium quickly.

7) *3-position bias switch*

Naturally, a high quality amplifier must be suitable for all user situations. Therefore, Citation has incorporated a new operating feature, a 3-position bias switch. This adjustment enables the user to choose the best biasing for the given application. The higher the bias, the smoother and cleaner the sonic characteristic of the amplifier, however, there will also be greater heat generated. Normal bias position relates to standard measurement position and low bias allows for high power demand under high temperature environment – but at a slight increase in distortion. With the 3-position switch, the user can adjust bias current according to the output level required, and the ambient temperature of the room or the amplifier storage area, to achieve adequate cooling and optimum acoustical results.

8) *Ultrasonic filter*

Improved linearity at low output and reduced distortion at greater output levels is achieved through an extremely broad bandwidth of 550kHz. As a result, RF (radio frequency) signals from local broadcasters have the possibility of being reproduced in the amplifier. To prevent such interference, a phase-linear Bessel filter with a cutoff frequency of 400kHz, eliminates RF from the input. There is a front panel warning light to indicate the presence of RF below 400kHz. This alerts the user to activate the ultrasonic filter switch on the front panel, which reduces the cutoff frequency to 100kHz. The extremely wide bandwidth also allows the ultrasonic warning light to function as a clipping indicator, to warn the user to reduce the output level of the preamplifier.

9. *Infrasonic filter*

As a preventive measure, the amplifier has a dc component filter, which is designed to be initiated by the user – alerted by a front panel warning indicator. This filter is designed to be operated at very low level dc voltages – prior to voltages sufficient to operate the overall amplifier protection circuits at 3V. The overall protection circuits shut the amplifier completely off if voltage of dc should be high enough to cause loudspeaker damage.

ES&T

NEW PRODUCTS

Calculator-style DMM

Simpson Electric Company has introduced a calculator-style DMM, the 470, with 25 ranges, including 1000Vdc, 750Vac and 10A ac/dc. All voltage and resistance ranges are protected against transients up to 6 kV at 100μs.

Recessed thumbwheel knobs control ranges and functions. An audible tone on the 2000Ω range provides fast checks for shorts and continuity. A diode test provides quick, good-bad checks of semiconductor functions.

The high-contrast, 3½-digit, 7-segment LCD display also features a low-battery indicator (battery life is about a year's average use).

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Quad-vertical-input scope

The *B&K-Precision* test instrument product group of Dynascan Corporation has introduced a full-feature 70MHz quad-vertical-input triggered sweep oscilloscope. Designed for applications requiring the highest degree of measurement sophistication, model 1570 provides 1mV/division sensitivity over the entire 70MHz bandwidth. For applications requiring extremely high single-channel sensitivity, 500μV cascade sensitivity is also available.

Another of the significant features is quad-vertical-input operation. Because of its unique "V-mode," the four vertical signals displayed need not be related in frequency. This is a major advantage that can eliminate the need to use two scopes to compare four signals.

Circle (52) on Reply Card

Voltage spike protector

The *RCA* SK400 voltage spike protector guards TV sets and other appliances from breakdown due to high-voltage surges that often occur when lightning strikes near a power line. Housed in a small adapter, the SK400 plugs into any 15A-125V grounding receptacle or cord connector.

Circle (53) on Reply Card

Hand-held DMM

BBC-Metrawatt has introduced two new hand-held DMMs. The new models M 2011 and M 2012 give the user 2000 hours battery life, along with 10A current range.

Other features are 3½-digit oversize LCD, single-dial selector switch for all ranges and standard banana plugs and terminals that are protected against accidental shock. All meters come with a 2-year warranty.

Circle (54) on Reply Card

Circle (32) on Reply Card

The basics of tape recording, part II

Physical operation of audiocassettes

By Carl Babcoke, CET

Audiocassettes are available in three sizes at present: the standard Philips type, (largest of the three), minicassettes and microcassettes. Although many of the general facts presented here apply to all three sizes, the standard cassette (Figure 1) is the only one covered specifically.

Cassette features

Audiocassettes and the compatible machines that record and play them offer many *conveniences* over reel-to-reel operation. No tape threading is required, because the tape remains on internal reels. Cassettes can be removed or inserted at any point, not just at the beginning or end. Unintentional erasure of recordings is prevented by removal of plastic tabs. Many machines have automatic stop at the end of each tape.

Also, the cassettes and machines generally are smaller than reel tapes and machines, and they usually sell for much lower prices. Battery operation is practical because of the low voltage and current required.

The cassettes are easy to catalog and store when not in use. Cassettes are available in a wide range from bulk-duplication types through cheap drug-store bargains, which usually have poor performance, to expensive premium tapes, which can provide excellent performance. Many pre-recorded music tapes are available.

For tape users who have no technical education, cassettes offer the best compromise between audio quality and convenience.

Facts about cassettes

Audiocassettes have reels for the tape, but they are merely small-diameter hubs with the cassette housing acting as sides for the tape pack. Figure 2 shows the mechanical details of a standard cassette housing and its tape.

Figure 1 Two views of a standard audiocassette are shown. The housing is made of two identical moldings held together by five screws. (Top) At the left is an opening for the erase head. An opening for the recording/playing head is at the center, and the right-hand opening is for the capstan. Symmetrical construction allows the cassette to be turned over for another recording or playing in the opposite direction, thus doubling the operating time of each cassette. (Bottom) Arrows point to two knock-out-type plastic tabs that determine whether or not the machine can record. This prevents unwanted erasure of recorded material.

Notice that the cassette housing has symmetrical right and left layouts. That is, the housing contours and openings are the same at both sides. This is necessary so the cassette can be turned over for recording or playing the reverse track (or tracks, see Figure 3). Usually a cassette is recorded from the beginning (starting with the tape pack at the left) to the end, when all tape is at the right on the take-up reel. Then the cassette is turned over by lifting up and cross-switching right and left sides of housing. Turning over the cassette places the tape pack at the left in position for another recording or playing that moves the tape to the take-up reel at the right. Notice that the supply reel and take-up reel are named for their *functions at the moment,* according to the cassettes' turn-over position. A supply reel becomes a take-up reel after cassette turn-over, while a take-up reel becomes the supply reel after turn-over.

This turn-over function doubles the maximum recording or playing time of each cassette, but with the trade-off of narrower tracks, which degrade the signal-to-noise ratio by reducing the signal level more than the tape hiss. Another advantage is that rewinding is not necessary, unless the tape is not operated to the end.

Guidance of the moving tape is accomplished primarily by the rotating guide posts (Figure 2) and any guide tabs that might be mounted on erase or recording/playing heads. Alignment of the tape machine's capstan shaft and its rubber-tired capstan roller also affects the tape position and azimuth gap-tilt at the heads. Tape position at the recording/playing head also is affected by whether or not the tape pack is centered exactly between walls of the cassette housing. There is not much space there, and an uneven, concave or convex tape pack can stop or slow tape motion (by extra friction), in addition to moving the tape tracks away from the head. Extreme misalignment of these various things can cause permanent damage to tapes used on the machine.

Two *slip sheets* are placed in each cassette housing between the tape packs and the housing (Figure 4). These slip sheets are coated or impregnated with graphite or a similar substance that reduces sliding friction, and they attempt to prevent layers of the tape pack from moving too near the housing.

A common cause of jammed or stalled cassettes is a tape pack becoming convex or concave until the friction between a slip sheet and the tape becomes excessive.

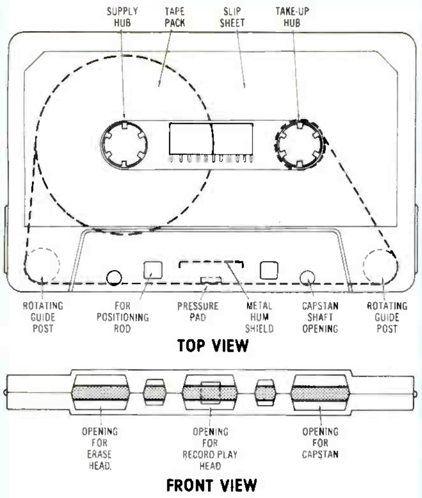


Figure 2 These drawings show many external and internal details of standard cassettes. Dotted lines indicate internal components. (The slip sheet outline also should be dotted.) Notice the window at the center that allows views of the tape pack, while the markings give some idea of the time remaining. For clarity, the pressure pad spring is not shown.

Each tape pack should be smooth and straight across its surface.

At the right and left corners of *some* cassettes, the tape passes around a fixed plastic post *and* the usual rotating guide post (Figure 2). The purpose of these fixed posts is not clear. They appear to duplicate the rotating posts' function. Most premium tapes do not have the fixed posts, and all low-priced tapes seem to have them. Perhaps these fixed posts damp out any tendency for the tape to oscillate mechanically during fast-forward or rewind modes.

All cassette housings have windows (Figures 2 and 4) that permit visual observations of tape movements and the amount of tape time remaining. Some housings have linear markings to indicate the non-linear amounts of used vs. unused tape.

A small rectangle of felt or sponge material (Figure 5) is mounted on a flat spring. When the cassette is inserted and the play or record button is pushed, the spring holds the felt against the back of the tape so the magnetic tape side is pressed firmly against the recording/playing head. Solid contact between the tape and the head is essential for good high-frequency response.

Behind the felt pad is a piece of metal with a right-angle bend at each end. This metal acts as a hum shield that minimizes the pickup of external hum by the head during playback. Usually the hum shield holds the pressure-pad spring in position.

If a cassette is opened for any reason, these components tend to fall out. Use care, because they are often difficult to locate. Incidentally, most cassette housings are fastened with five Phillips-head screws.

When the cassette is intact, the reel hubs and tape pack are loosely held in proper position by shallow depressions of the housing. When the housing is opened, these hubs can fall out, trailing many yards of tape. Restoring all these components is a tedious and frustrating job, so take care that these minor disasters do not occur.

In each tape recorder/player, the supply and take-up shafts have plastic caps with three rounded teeth. These 3-tooth caps then slip into the 6-spaced center holes in the cassette hubs (Figure 2) to prevent slippage when the caps rotate the cassette hubs during operation. The shaft caps are spring loaded so they retract until the cassette is almost seated, then the spring pushes the cap into the cassette hub. This system of drive-shaft insertion is almost foolproof, giving dependable operation.

Two arrows on the Figure 1 photograph show locations of the removable plastic tabs that permit recording when the tabs are intact. After a recording is made, and it is desired that it not be erased accidentally, the tab or tabs must be pried out with a knife blade or a small screwdriver. Of course, the removal of one tab does not prevent recording of the other side. To re-record over a protected side later, place a strong piece of tape over the hole left by removal of the tab.

Notice that the erasure-prevention system does not protect against loss of recorded material if a tape demagnetizer is used on the cassette or when a cassette is stored too near a power transformer or a permanent-magnet speaker.

A typical recorder mechanism

Figure 6 shows the top view of a typical portable recorder/player. Several major components are identified by arrows. This machine normally is operated flat, but some models are designed for vertical operation, with the cassette openings for heads at the top.

Various functions are selected by *piano-key* push-buttons that are hinged at their rear sections. These buttons usually latch mechanically in the down positions, and while activated, each button controls both mechanical and electronic actions.

For example, pressing the *play* button turns on battery power, connects the playing head to the amplifier input, and connects a speaker to the output. At the same time, levers are activated to move the pressure roller against the capstan (with tape in between) and the heads against the tape. Rotation power is applied to the

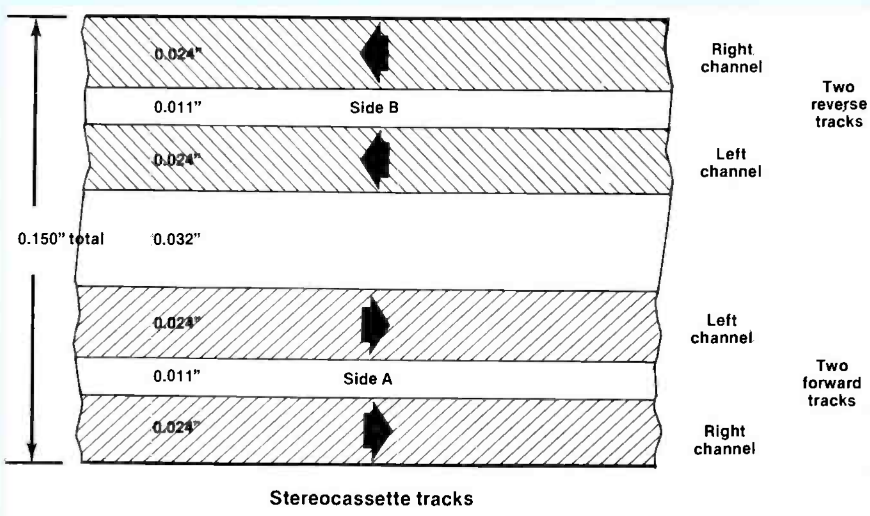


Figure 3 Stereo cassette tracks should conform to these specifications. Monaural tracks occupy the width of two stereo tracks plus the guard band between.

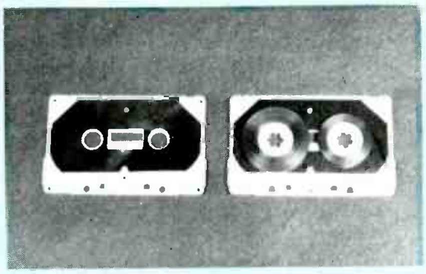


Figure 4 All components of a cassette tape are shown here (except the five screws that hold the halves together). The two black areas are the slip sheets.

capstan shaft, and weak rotation power is applied to the take-up reel. Therefore, the tape moves and the recorded material is heard in the speaker.

All mechanical power for operation of the tape recorder comes from the motor and its pulley (top arrow in Figure 7), which drives a round rubber belt. First, the belt rides against *one* edge of the take-up pulley (center arrow in Figure 7). However, the area of contact is small, and slippage is intentional. When the take-up pulley attempts to wind the tape faster than the capstan can provide it, the take-up pulley slips on the belt. The pulley revolves, but with little torque at a slower-than-normal speed. The torque is sufficient, when all is working correctly, to wind the tape into a proper solid pack, but to allow slippage above that point.

Strong and absolutely constant rotational speed is required of the capstan shaft and its heavy flywheel. Therefore, to prevent all slippage, the belt is wrapped around almost the entire circumference of the capstan flywheel. This is vitally important, for the slightest variation of capstan shaft rotation produces pitch (frequency) changes that are unpleasant even to untrained ears.

When a cassette (with its full pack at the left on the supply hub) is placed in the machine and the *play* button is latched down, the capstan roller is moved by levers to pinch the tape against the capstan shaft. The shaft rotation begins to move tape from the left-side supply reel past the erase head and the recording/playing head, through the capstan/roller and toward the right-side take-up reel. If no rotational power is applied to the take-up spindle and reel, the tape soon will pile up in the cassette housing or wind around the capstan shaft. Within a few seconds, the tape will jam the housing and stop the machine (although the motor will continue to rotate).

This take-up reel torque should be the first item tested after a tape jam. Often, the tape is bent in small folds or it has many turns wrapped around the capstan. Sometimes the tape can not be repaired, and in fact, it might be difficult to remove the cassette. If gentle tactics do not work, the cassette must be taken out in pieces. After a bad cassette has been removed, the capstan shaft should be examined and all turns of tape removed before the take-up torque is tested or repaired. Failure to remove tape from the shaft has the effect of increasing the shaft diameter, which increases the tape-travel speed and the pitch of the recording.

Figure 8 shows the mechanism in *play* mode, but without a cassette. Heads and capstan are moved forward, with the finger and thumb around the take-up cap showing tape drag against the weak torque provided by a below-deck belt. Between the two tape hubs is a white plastic wheel that is moved physically to contact the supply hub's rubber tire (at left) for rewind or to contact the take-up hub's rubber tire (at right) for fast forward. The positions of these components for other functions are shown in subsequent photographs.

Figure 9 shows *fast-forward* mode. The heads and capstan roller are moved back (down in the picture) for no contact, and the high-speed white plastic wheel is touching the rubber rim of the take-up hub.

Rewind operation is illustrated in Figure 10. The finger and thumb around the supply-reel hub symbolize the load on the hub when a cassette is used. Notice that the white plastic wheel is touching the black rubber-tired idler wheel, and the idler wheel in turn is touching the rubber tire on the supply hub. Therefore, a strong torque is applied to move the supply hub clockwise and thus move the tape to the supply hub.

Behind each reel hub is a flat piece of metal that functions as a crude friction *brake*. When the machine is turned off, these brakes are pushed against the rubber tires on the supply and take-up reel hubs.

Figure 5 The left arrow points to the pressure-pad spring, a flat spring between ends of the hum shield. The pressure pad is shown by the center arrow. Usually the pad is glued to the spring. The right-hand arrow points to the metal hum shield that effectively encloses the head gap during operation. Slots in the plastic housing hold the hum shield in place.

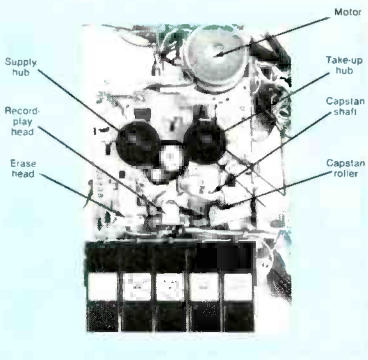


Figure 6 Arrows point out important components of this Sears tape machine, which is typical of many small battery-operated portable models. Not shown in the picture at the right is the counter.

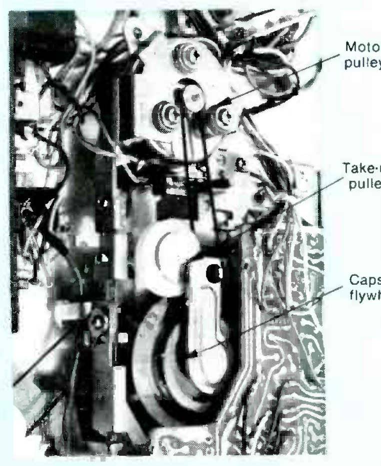


Figure 7 This is a bottom view of the typical tape recorder. The arrow at top points to the motor pulley, at the center the arrow indicates the take-up pulley that drives the take-up reel hub, and the lower arrow points out the comparatively large and heavy capstan flywheel.

Figure 11 is a close-up photograph of the head area. The arrow at left points to the tape guide on the recording/playing head, while the arrow at right indicates the tape guide on the erasing head.

Figure 12 shows how a cassette fits the machine. In Figure 12A, the machine is turned off. Therefore, white leader tape can be seen inside the cassette, and the erase head, recording/playing head and capstan pinch roller are not protruding into the cassette. In Figure 12B, the machine is in the *play* mode, the erase and recording/playing heads are contacting the tape inside the cassette and the pinch roller is pressed against the tape and the capstan shaft.

Operation of the recording-prevention feature of cassettes is illustrated in Figure 13. When the tab has been removed (Figure 13A), the right-angle bracket is not moved to the mechanism's rear, so the other end of the bracket remains flat against the baseplate (see arrow). An extension of the bracket below the baseplate blocks movement of the recording switch, so the *record* button will not stay down when pushed and recording is prevented.

When the tab has not been removed, insertion of the cassette moves the top of the right-angle bracket toward the mechanism's front (Figure 13B). This forces the other part of the bracket to rise above the baseplate (see arrow) while the lower section of the bracket does not block movement of the recording switch, which can be activated by the *record* pushbutton.

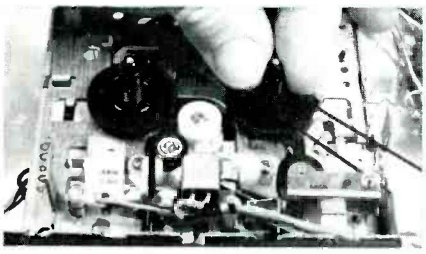


Figure 8 Finger-and-thumb pressure around the take-up hub symbolizes the drag produced by tape being wound on the take-up reel during playback (or recording). A deliberately weak rotational torque is applied to the take-up hub by the main drive belt below decks. (If this torque is insufficient, the tape will pile up and jam the cassette.) Notice that the white drive pulley (between the reel hubs) is not contacting anything, and the capstan shaft is against the capstan pinch-roller, as required to move the tape at constant speed. Also, the heads are moved forward where they would contact the tape, if a cassette were in place.

Typical mechanism repairs

Each malfunctioning cassette machine should be tested first by using a test tape (an expensive blank tape kept for quick tests) while you attempt to record, playback, move tape fast-forward and rewind. During the recording step, include music (such as piano music) that will show up any lack of high-frequency response or the presence of speed changes. For portable machines without an external input, place the microphone near the speaker of a hi-fi system, then play the same record or tape each time, so you can judge easily whether or not the performance is normal. High-performance tape decks should also be checked by test equipment.

One of the first decisions is to determine whether the problem is in the mechanism or the electronic circuits. The following list should help you find the areas where these typical problems are found.

Extreme audible distortion usually will originate in the electronics. Perhaps the bias oscillator (or the dc-bias source) has failed, a transistor stage or an IC might be defective, or the microphone might be bad. Don't overlook the speaker; it is susceptible to damage from liquids spilled on the machine. Undistorted sound in the earphone (if the machine has such a jack) proves the speaker is bad.

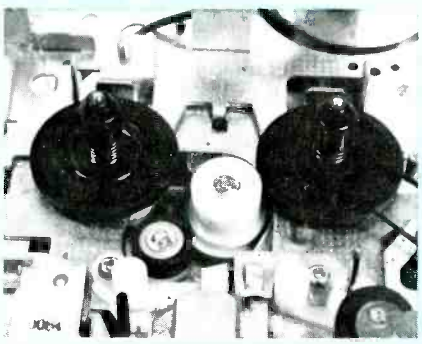


Figure 9 For the fast-forward mode, the white drive pulley rides against the take-up reel's rubber tire to provide fast and power torque to the take-up reel. The heads are moved back away from the cassette position and the capstan roller is not touching the capstan shaft.

A loud hum could be caused by bad filter capacitors in the power supply, or by an open shield in the microphone cable. Use a test microphone to evaluate the microphone cable condition. An open wire to the playback head can cause hum on playback.

A noticeable lack of high-frequency response can originate either in the mechanism or in the electronic circuits. A tilted-head azimuth is the most likely physical problem. However, that is not a strong possibility, unless no locking glue was placed on the tilt-adjusting screw, or the head bracket has been bent. A coating of iron oxide across the head gap can reduce the high frequencies, but that probably would weaken the volume during *recording* more than it would reduce the high frequencies during playback. Clean the heads, then make the same tests again. Electronic defects that reduce high frequencies are also rare, but an open in a compensation capacitor is a possibility. Remember that the individual tape might not be capable of handling high frequencies. Try a pre-recorded music tape of known quality and compare the response.

Abnormally loud hissing noises might come from either the tape and its recorded program or the playback-amplifier circuit. Pink noise from transistors or resistors sounds very much like pink noise from tape hiss. If the noise is heard when playing a blank *leader,* the origin is in the playback amplifier. If the pink noise is heard on tapes recorded by this machine (but not on tapes recorded on other machines), the recording amplifier

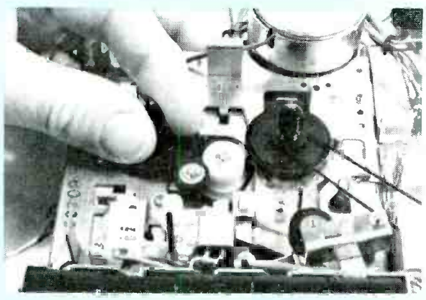


Figure 10 Fast-forward mode is shown by the finger-and-thumb pressure around the supply reel, indicating the drag of tape. The white pulley is driving the smaller rubber-tired drive pulley, and it in turn is driving the rubber-tired rim of the supply hub. Of course, the heads are back from the cassette, and the capstan roller is away from the capstan shaft.

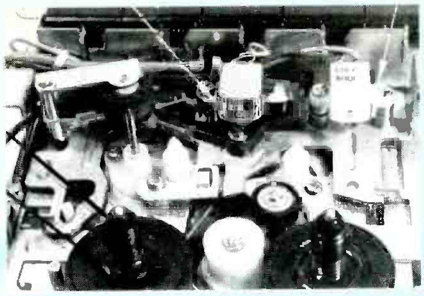


Figure 11 Many erase and recording/playing heads have U-shaped brackets that help guide the tape across the heads. Arrows point to guides on the recording/playing head (left arrow) and the erase head (right arrow). This photograph also shows the head wiring, which must be flexible to prevent premature breakage.

has excessive noise or the bias system has a defect. Of course, dc bias can also produce a high noise level.

A rapid change of volume, or a rapidly repeated low-frequency noise might indicate flutter. Flutter usually is associated with dents in rubber-tired wheels and often originates in the capstan pinch-roller or one of the idlers. Gently feel these suspected rotating parts while they are running. Sometimes a vibration that is synchronized with the flutter can be detected. If so, check those components carefully for bad spots.

A slow change of pitch in the music that sounds as if the speed is slowing down usually is not a *steady* slow speed, but an alternate slowing down and speeding up. This is called *wow* and it is one of the most disagreeable sounds possible, even to non-musicians.

Weak audio without distortion or excessive noise probably indicates a problem in the playback amplifier. Of course, the recording might have been made on a weak tape. Some low-priced and least-desirable tapes have playback volume between –2dB and –10dB below that of premium tapes. In addition, the tape noise appears low because of the weak playback (just mentioned) and the extreme lack of high-frequency response. A reduction of highs gives an apparent reduction of tape noise because human ears are more sensitive to high-frequency noises.

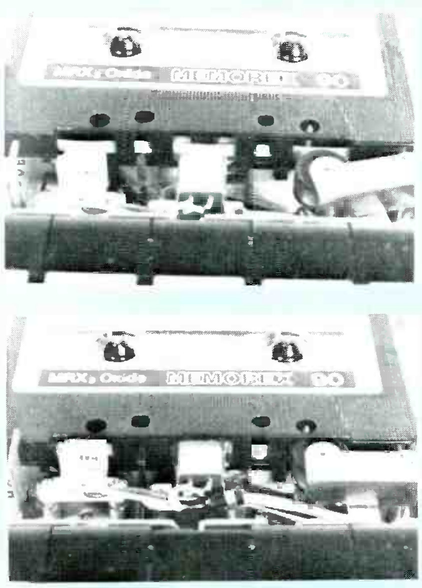


Figure 12 Movements and positions of both heads and the capstan pinch-roller are shown with a cassette installed. (Top) With the machine in the off mode, the erase head (left), the recording/playing head (center) and the capstan roller are moved back away from the cassette where they do not interfere with insertion or removal of the cassette. (Bottom) In the play or record modes, the gap ends of both heads are moved slightly inside the cassette housing where they securely contact the tape surface, while the capstan roller is pressed firmly against the tape and the capstan shaft.

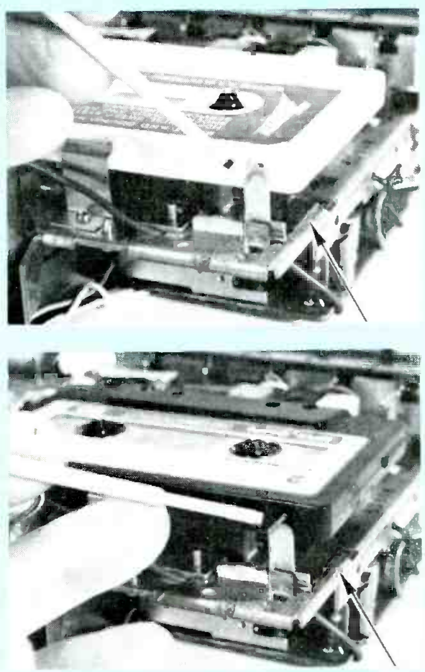


Figure 13 Location of the anti-recording tab on the cassette housing is shown by the screwdriver tip. (Top) When the tab has been removed, the sensor-bracket tip can move into the housing hole, thus moving the other end of the bracket down to the deck, where the unseen section below blocks the recording-switch activation. The arrow shows the bracket flat against the deck. (Bottom) With the tab still in place, insertion of the cassette drives the sensor-bracket tip backwards, thus lifting the front section up away from the deck (see arrow), while the unseen section below allows movement of the electrical switch to the recording position.

Comments

Tape-recorder mechanisms have been produced in many designs, and some are different from the portable machine described here. That is why no attempt was made to cover all fine points of components or operation. However, the machines must perform the same basic operations (record, play, rewind and fast-forward), and the previous description should help technicians understand what actions and component movements to look for when an unfamiliar machine is to be repaired.

Of course, the cassette is the same, whether the machine is a top-of-the-line model with microprocessor control or a $24, sale-special portable.

Some manufacturers advise a thorough cleaning (of heads, capstan shaft, capstan pinch-roller and any other tape-path components that can be reached in the machine) after every 10 hours of operation. That would be a cleaning procedure after recording or playing of *only seven* 90-minute cassettes. This seems more often than necessary, according to my own experience. At any rate, occasional cleaning is essential.

Coming features

Future articles in this cassette-tape series will not emphasize circuits and the mechanics of tape machines, but rather will feature methods of testing tape characteristics, along with many tips for obtaining best quality from cassette recordings.

Details of mixing signals, rerecording and other activities necessary for producing tape programs of near-professional quality will also be described. These things tie in naturally for anyone doing high-speed duplication of cassettes. Many facts and recommendations will be made about duplicators and duplicator tapes.

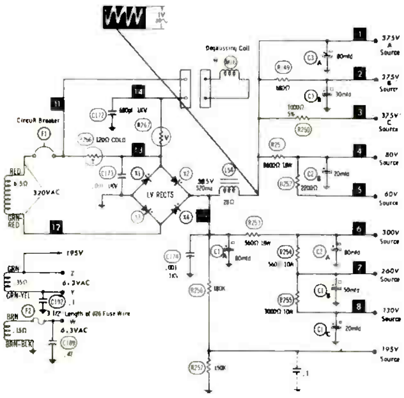
If you have specific questions about any facet of cassette tapes or the cassette recording/playing machines, write to the author in care of the **Electronic Servicing & Technology** editor.

TROUBLE-SHOOTING TIPS

Whistles and low HV RCA CTC38
(Photofact 1092-3)

Shortly after power was applied, a high-frequency sound could be heard. As the whistle stopped, a very dim, blurred picture could be seen. After another minute, the sound quit, and the horizontal-output-tube plate began to glow red.

New tubes in the horizontal and high-voltage sections gave no improvement. And the high voltage measured only 5kV, while the horizontal-output grid measured only −45V. When I unplugged the yoke, the high voltage rose to 10kV. At this point, I suspected



that either the yoke or the flyback had shorted turns, so I replaced them with spares I had on hand, but there was no improvement.

Next, I searched through older issues of **Electronic Servicing,** trying to find a Troubleshooting Tip or Symcure that would give a clue. Finally, I found a Symcure that told of a whistle caused by an open filter capacitor.

When I quickly scoped the filter capacitors, I found large amplitude hash at one terminal of C3, the multiple-section filter can. It was anticlimatic to find completely normal operation after the C3 can was replaced.

From now on, when the symptoms do not make sense, I always scope the filter capacitors for evidence of unwanted signals.

George M. Marecheck Jr.
Cheverly, MD

Erratic horizontal locking Admiral 19C658C
(Photofact 1522-1)

After about 10 minutes of operation, this 19-inch Admiral color portable developed erratic horizontal locking.

First suspect was a defect in the horizontal-oscillator control circuit or the horizontal-phase detector. However, tests and parts substitutions proved the problem was not there.

Cooling spray applied to the oscillator circuit made no changes until I cooled D803, the 19.75V zener voltage-regulator. When D803 was cool, the lock seemed slightly better, but not enough to be considered a cure.

At zener D803, the dc voltage was within tolerance, but when I scoped the D803 cathode signal, horizontal pulses of about 3VPP were present. Of course, this point should be virtually pure dc voltage, because of the zener action plus filter capacitor C811 (10μF). Tracing back on the schematic, I found that a higher dc voltage was produced by diode rectification of the horizontal-sweep power, then R821 reduced the voltage for D803 zener.

Therefore, it was clear that C811 was open, allowing horizontal pulses to reach the phase detector and horizontal-oscillator stages.

Replacement of C811 eliminated the erratic horizontal locking, giving a normally stable picture.

George Campbell
Lancaster, CA

Keithley introduces top-of-the-line DMM

Keithley Instruments has introduced the model-132 hand-held DMM as their top-of-the-line, 3½-digit meter. The unit combines the rugged field-service capabilities of Keithley hand-held DMMs with the most-often required additional measurement capabilities, TRMS ac and TEMPERATURE.

Available in both a Fahrenheit version (132F) and a Celsius version (132C), the 132 has a complete dc voltage range from 200mV to 1000V with 0.25% accuracy, current ranges from 2mA to 2A and resistance ranges from 200Ω to 20MΩ. The 132C measures temperature from −20° to 1370°C, the 132F from 0°F to 2000°F, using optional type-K thermocouple sensors or probes. There are several advantages to employing a type-K (NiCr-NiAl) thermocouple input for temperature measurement, such as wide use throughout industry, broad selection of probes and sensors available, low cost, versatility and durability.

In order to fully realize all the advantages of a type-K thermocouple, the 132 provides a standard TC connector for sensor termination. This effectively eliminates stabilization time required with banana jack inputs for immediate, accurate readings. Cold junction electronic circuitry automatically compensates for ambient temperature changes, and the TC input is protected from overloads up to 300V.

TRMS ac response is provided to make precision measurements of non-sinusoidal waveforms that averaging cannot handle. Examples include square waves, pulse trains and SCR waveforms. The model 132's ac bandwidth is designed to capture the necessary spectral components for minimal error on 50Hz and 60Hz waveforms, where most measurements are made.

The 132 blocks out any dc signal combined with the ac information that you are really after. This allows you to measure the ac and dc components of a signal separately, as when measuring ac ripple on a dc voltage, for example.

Circle (99) on Reply Card

ES&T

(Continued from page 8.)

moderate volume for listening tests. Power-output tests and listening with hi-fi speakers may be done later. These two speakers had been taken from junked televisions, so they had little value.

In reply to the third-paragraph complaint (about replacing the non-defective R740 and modifying the board during installation), the control *was* noisy and erratic, as stated clearly on page 18 of the article, and *should* have been replaced, even though it was not the primary defect. After its replacement, R740 is shown in Figure 3 on page 16, and no evidence of the board modification is seen. In fact, only a minute amount of drilling (perhaps 1/16 inch) was necessary to admit *one* mounting lug. The board was *not* ruined for installation of an original-type control in the future, as was asserted.

In the fourth paragraph, Mr. Leonard discussed the damage from a carelessly placed test probe. The article truthfully described all damage caused by the accidental short, and this was included to show the hazards of using large, blunt-tipped test probes on any crowded compact circuit board. Although not stated here but covered in many previous articles, I have consistently advocated turning off the line power before an *insulated-hook* type of test probe is *attached* to a transistor lead. Then, following that test, the power is turned off while the test hook is removed and perhaps attached to the next point. In haste I tried to save time and caused much grief. Incidentally, the customer was not charged for these ruined components.

Connection of a current-limiter incandescent light bulb in series with the ac line has been advocated many times in this magazine; it is not a new idea. In fact, a bulb was used this way with the Marantz, but after the burn-outs occurred.

However, ac-power current limiting cannot *always* protect against all overloads. Large filter capacitors can release damaging amounts of power, even after the line voltage is reduced or eliminated. A safer connection is in series with the main B+ and B− supply lines.

Regarding the output transistors mentioned in paragraphs five and six, the new vs. old transistors were checked on a dynamic curve tracer and found to be as near matched as transistors ever are. It was not considered necessary to detail all such tests. The Photofact data (which came from Marantz) gave no power output or distortion figures. However, it is well known in the industry that tests using sinewaves should not be continued very long unless the power was held to no more than 30% of the maximum rating. Therefore, both amplifiers were given quick distortion tests (showing less than 1% THD before the incomplete balancing was completed) and the scope waveforms observed when the output was 30W of 400Hz sinewaves. The scope waveshapes showed no glitches, ringing or bursts of supersonics.

Incidentally, I want to dispute the question of distortion. Super-low total-harmonic distortion (THD) and noise figures sell a lot of stereo equipment, and sometimes they help blunt a customer's complaint that the repaired stereo does not sound right. But it never has been totally proved that THD of less than about 0.5% is detectable by human ears. After all, many multi-track, multi-generation tape dubs have more total distortion than that when they are considered "clean." It is true that intermodulation and certain kinds of THD can be audible. For example, steep risetime distortion such as crossover problems with bipolar transistor and some noise pulses are more audible than the meter readings imply. No complaints have been received since this repair.

About the incorrectly wired power transformer (paragraph 7 on page 61), my concern was about the higher supply voltages and the possible damage to the output transistors. The filters were already formed at the higher voltage. The dc overvoltage was about 10%, even at normal 120V line voltage. But what if the line voltage was 125V or even 129V?

Such excessive line voltages are commonplace in many areas. Overvoltage of 10% to 20% combined with a time of loud volume from the power amplifier might easily exceed dissipation ratings of the transistors, causing them to fail.

The customer was not charged for the time expended in checking the wiring and drawing the schematic. This time is the dues that I pay to stay in touch with practical troubleshooting (originally my primary job).

The complaints about lack of instrument tests (page 61, paragraph 8) have been answered previously. The moderate-volume operation for several hours (mentioned in the article) was a combination time test and heat run, not a test of power and distortion.

In paragraph 9 of page 61, the 1975 Marantz bulletin M-2325-2 was mentioned as "advising of a problem with the same intermittent diodes." However, another reader sent a photocopy of this bulletin, and it did not mention intermittent diodes or erratic loud popping sounds. It commanded that diodes H718 and H719 on each amplifier board *must* be replaced (regardless of the immediate complaint) with part number HD2-0011-050 diodes. Another statement was that if diode failure (not specified) had already occurred, the speaker-protection relay contacts might be damaged, and if so, the relay should be replaced. No hint was given about *what* symptoms might be caused by the diodes or that the problems might be intermittent. One more sentence would have added great value.

Again in paragraph 10 (page 61), Mr. Leonard comments about the inadvisability of receiving all kinds of merchandise for repair. **Electronic Servicing & Technology** has made the same suggestions many times over the years. However, these are management decisions that have no place in an educational article. The article does not say, or imply, that a shop or technician should begin repairs that are likely to lose money.

The sentences under the "Comments" heading on page 21 in the original article explained the reasons the article was written. It was *not* primarily to explain all about repairing a model 2325 Marantz stereo-component radio/amplifier, but to serve as a case history showing effective vs. ineffective testing methods that are used with complex audio products.

Of course, the final judgement about the value of specific articles must be made by an average of all readers. We invite you to give your opinions.

Carl Babcoke, CET
Consumer Repair Consultant
for ES&T

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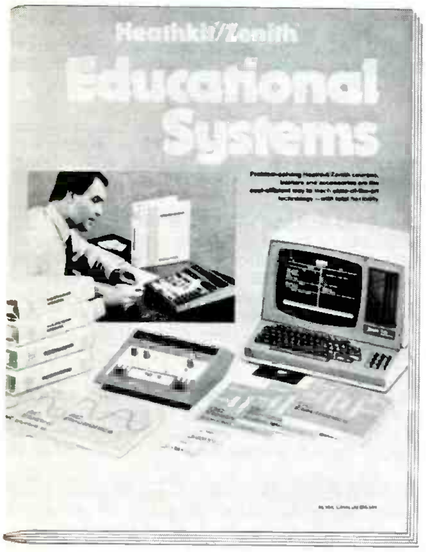
Heathkit/Zenith Educational Systems has released its latest, free, full-color catalog of technical education courses, computers and test instruments.

The catalog features more than 38 electronics and microprocessor/computer related courses designed for group, classroom or individual learning situations. Courses featured have been developed in series form, starting with fundamental electronics (ac/dc electronics through semiconductor devices) and moving through advanced electronics to digital and microprocessor technology.



Several new state-of-the-art advanced-electronics courses are highlighted in the catalog, including courses in optoelectronics, CMOS digital electronics, voice synthesis and microprocessor interfacing and programming.

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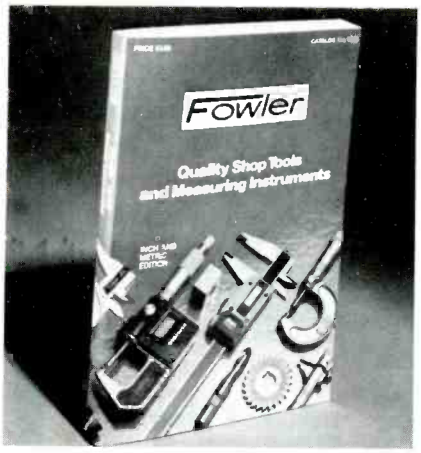

The new edition of the **Fowler** tool catalog is now available at no cost. The catalog describes and illustrates precision inch and metric shop tools and instruments. A special feature of the catalog is a wide range of digital readout; electronic calipers; micrometers; and internal, vertical, horizontal and linear measuring tools.

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A new 40-page *Printed Circuit Handbook and Accessories Catalog* from **GC Electronics,** a division of Household International, features step-by-step instructions and diagrams and explains in careful detail how to produce professional-quality printed-circuit designs.

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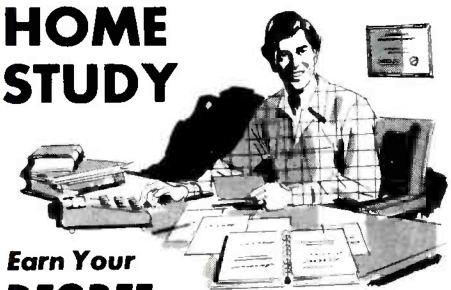

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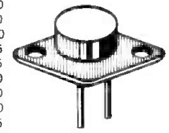

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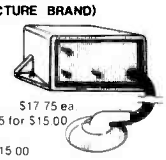

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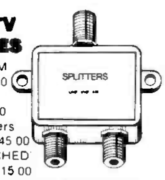

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ECG 532	977-Z9532
ECG 533	977-Z9533
ECG 534	977-Z9534
ECG 535	977-Z9535
ECG 536A	977-Z9536-A
ECG 537	977-Z9537
ECG 538	977-Z9538
ECG 539	977-Z9539

GE 521	977-Z9526-A
GE 522	977-Z9536-A
GE 523	977-Z9522
GE 524	977-Z9531
GE 525	977-Z9532
GE 526	977-Z9533
GE 527	977-Z9500-A
GE 528	977-36
GE 529	977-Z9529
GE 534	977-Z9534
GE 535	977-Z9535
GE 536	977-Z9537
GE 537	977-Z9538
GE 538	977-Z9539
GE 539	800-791
GE 540	977-Z9530

N2A	977-Z9529
N2A-1	977-Z9529
N2A-2	977-Z9529

SK 3301	977-Z9531
SK 3302	977-Z9533
SK 3303	977-Z9522
SK 3304	977-Z9500-A
SK 3305	977-Z9534
SK 3306	977-36
SK 3307	977-Z9529
SK 3308	977-Z9526-A

14B348-1	977-36
14B348-2	977-36
14B348-3	977-36
[illegible]348-4	977-36
[illegible]8-5	977-36

[illegible]X	977-Z9500-A
[illegible]1	977-46

32-29778-2	977-Z9500-A
32-29778-3	977-Z9500-A
32-33057-2	977-Z9522

32-33057-3	977-Z9500-A
32-33057-4	977-Z9500-A
32-33057-5	977-Z9500-A
32-33094-1	977-Z9522
32-33094-2	977-Z9522
32-33094-3	977-Z9522
32-33094-4	977-Z9522
32-33094-5	977-Z9522
32-33094-6	977-Z9522
32-35894-1	977-Z9500-A
32-35894-3	977-Z9522
32-35894-4	977-Z9522
32-35894-5	977-Z9500-[illegible]
32-35894-6	977-Z9522
32-35894-7	977-Z95[illegible]
32-39091-1	977-36
32-39091-2	977-36
32-39091-3	977-Z95[illegible]
32-39091-4	977-36
32-39091-5	977-36
32-39091-6	977-36
32-39091-7	977-Z9526-A
32-39091-8	977-Z9526-A
32-39091-9	977-36
32-39704-1	977-Z9522
32-39704-2	977-Z9522

66F-159-1	977-Z9522
66F-159-2	977-Z9522
66F-159-3	[illegible]
66X0060-[illegible]	977-Z9530
66X0060-[illegible]	977-Z9530
[illegible]	977-36

76-14327-1	[illegible]
76-14327-2	[illegible]
76-14327-[illegible]	[illegible]
76-[illegible]	977-Z9500-A
[illegible]	[illegible]500-A
[illegible]4327-8	977-Z9[illegible]

86-106-3	[illegible]
86-127-[illegible]	[illegible]

[illegible]	977-Z9522
530165-1	977-Z9522
530165-2	977-Z9522
530165-3	977-Z9522
530165-4	977-Z9522
530165-6	977-Z9529
530165-8	977-Z9534
[illegible]0165-10	977-Z9534
[illegible]	[illegible]7-Z9529
[illegible]	[illegible]9529
[illegible]	[illegible]535
[illegible]	[illegible]34
[illegible]	[illegible]34
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93D96-3	977-Z9500-A
93D99-2	977-Z9538
93D99-3	977-Z9538
93D99-4	977-Z9538
93D99-5	977-Z9539
93D99-6	977-Z9539
93D99-7	977-Z9539

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72180	977-36

146364-1	977-Z9536-A
1464607-1	977-Z9532
1464607-2	977-Z9532
1464607-3	977-Z9532
1464607-4	977-Z9532
1464607-5	977-A9532

1464607-6	977-Z9532
1464607-7	977-Z9531
1464607-8	977-Z9531
1464607-9	977-Z9533
1464607-10	977-Z9533
1464984-1	977-Z9532
1464984-2	977-Z9532
1466860-1	977-Z9532
1466860-2	977-Z9537
1466835-1	977-Z9532

1826065-1	977-Z9532
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1826065-3	977-Z9531

S-88539	800-791
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212-102	800-791
212-103	800-791
212-104	800-791
212-105	800-791
212-106	800-791
212-108	800-791
212-109	800-791
212-110	800-791
212-128	800-791
212-129	800-791
212-130	800-791
212-131	800-791
212-132	800-791
212 133	800-791
212 134	800-791
212-135	800-791
212-136	800-791
212-137	800-791
212-138	800-791
212-140	800-791
212-140-01	800-791
212-141	977-36
212-141	977-36
212-141-01	977-36
212-141-01	977-35
212-141-01	977-36
212-141-01	977-36
212-141-02	977-36
212-141-02	977-36
212-141-03	977-37
212-142	977-46
212-142	977-38
212-142-02	977-46
212-143	977-40
212-145	977-41
212-145-01	977-41
212-145-01	977-42
212-146	977-41
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212-149	977-45
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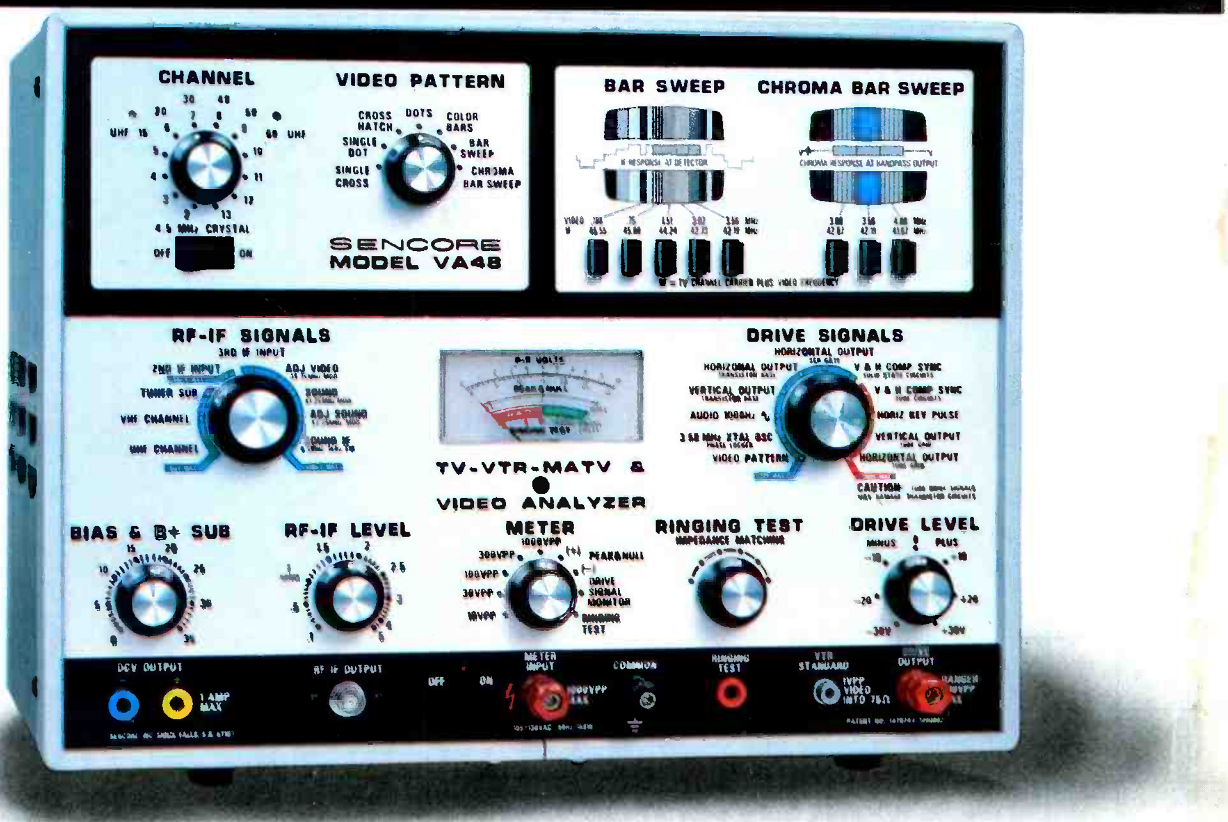

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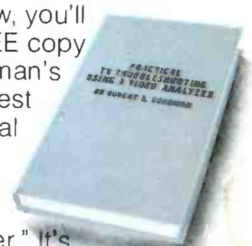

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