60¢ ■ SEPT. 1974

# Radio-Electronics

THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

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**Lets You Tell The Time On The Screen Of Your TV**

**40 COSMOS CIRCUITS**
**IC Projects For Experimenters**

**WHAT'S A RAM?**
**New Technology Report**

**LEN FELDMAN TELLS**
**How To Test HI-FI Amplifiers**

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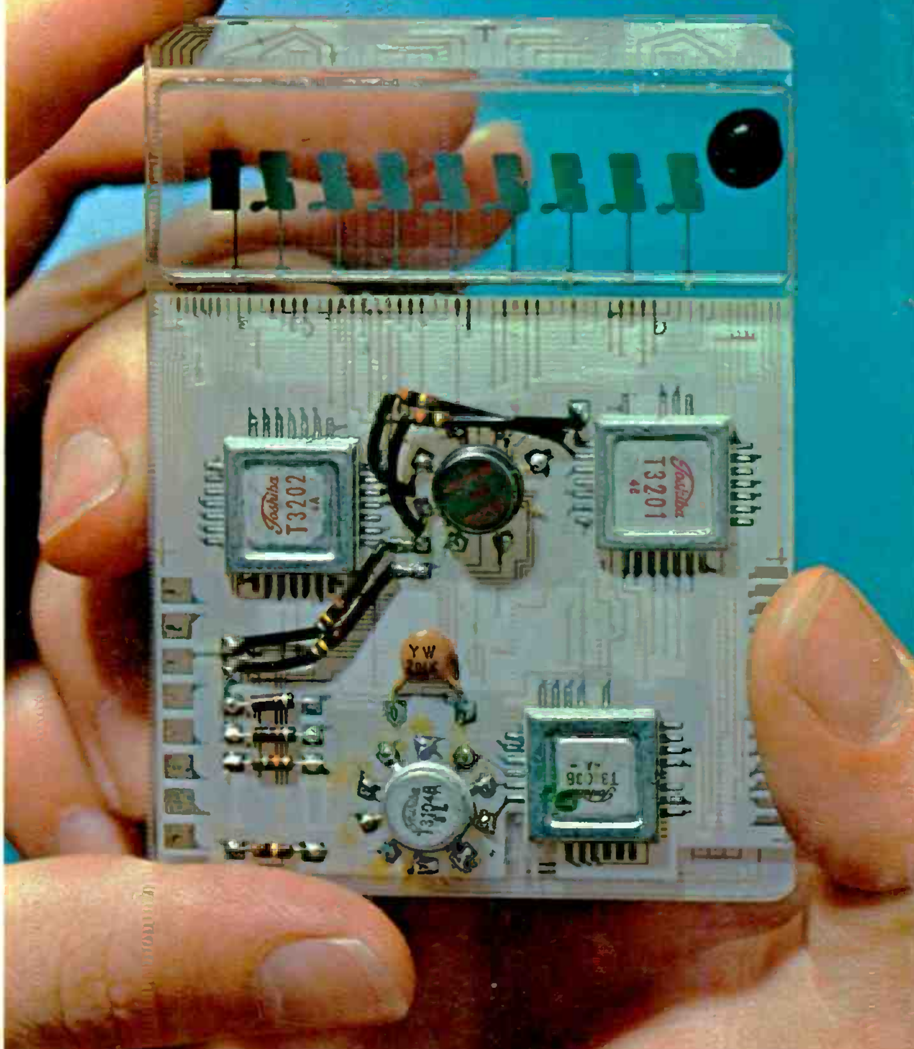
Jack Darr's Service Clinic



SPECIAL REPORT

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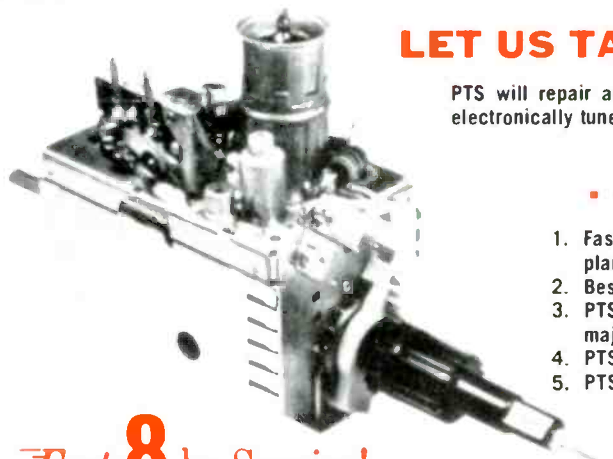

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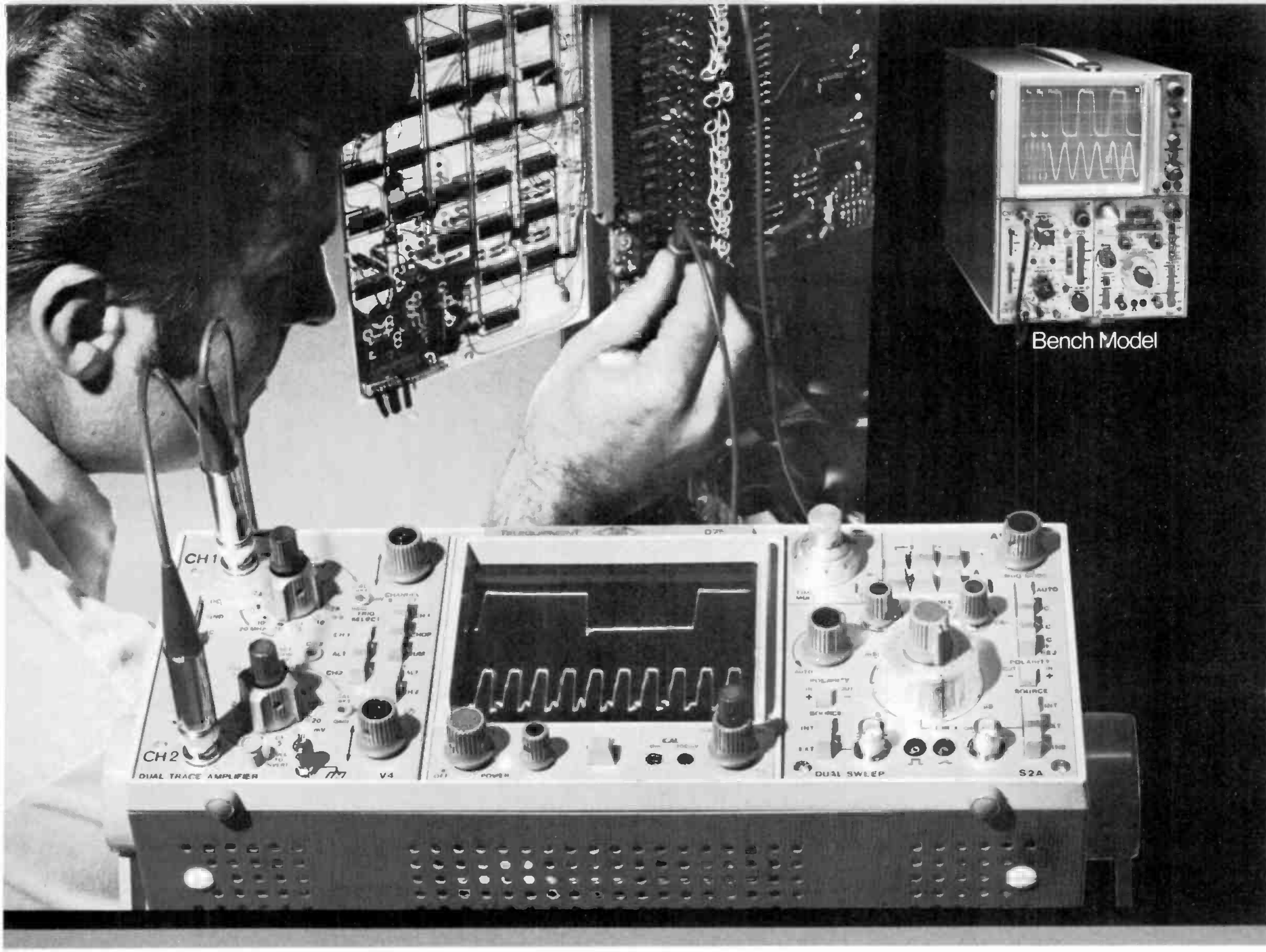


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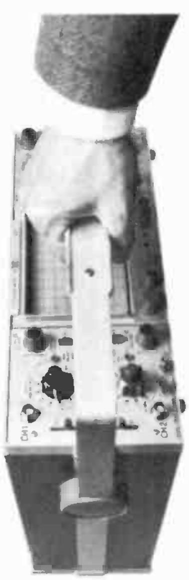

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# Radio-Electronics

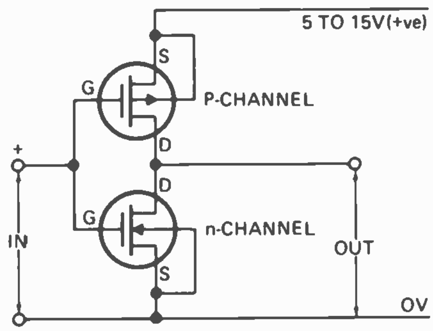
THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

More than 65 years of electronics publishing

SEPTEMBER 1974 Vol. 45 No. 9



**ON THE COVER**
**Here's the working heart of a new Sharp EL-805 calculator. The liquid-crystal readout and the circuit board are all on a single sheet of glass. For more details, see the article "New Opportunities For Technicians." It starts on page 43**




**40 COSMOS IC PROJECTS for the experimenter are here. They're part of a new series starting in this issue. The circuit shown here is a basic COSMOS digital inverter.**
**. . .turn to page 58**

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# guest editorial

# does servicing have a future?

Many electronic service technicians are uneasy about the future and with apparent good cause. All manufacturers of consumer electronic products are trying hard to design their products for 100% reliability. If they achieve that level, service of course would no longer be required.

Then is the service industry about to become another victim of the technology? Should it prepare to go out of business?

The answer to both of these questions is *no*. There are good reasons why service will be around for a long time to come. For one thing, it is difficult to close our eyes to the fact that products in the home have become more and more complicated through the years. To keep our customers coming back, Zenith—like all other successful manufacturers—must continually add new features and conveniences to its products. Television for example has progressed from black-and-white to color, and the color TV set is the most complex electronic device ever mass-produced. Radio too has progressed from the simple five-tube AM set to FM, and FM stereo. Stereo is of course merely a duplication of channels with a balancing network. But now, multi-channel devices are coming into use which include quite complicated decoding systems. Quadriphonic FM broadcasting will be especially complex.

And this trend will continue. Extrapolating from experience, new products such as the video disc player will involve some fairly precise and complex mechanical equipment. Also, the product may have optics which have never before played a role in consumer electronics, and the design is quite likely to involve some little tricks that are completely different from anything done in the past.

And speaking of new products, when flat-panel television comes on the market, the panel itself, like the present picture tube, probably will not be serviceable. However, the peripheral electronics promise to be a relatively complicated array of a great many circuits arranged on circuit boards, or in some other integrated form. These will require occasional servicing.

So products have become more complex, and this trend to greater complexity will continue. This means that servicing will continue to be in demand to keep those complicated devices operating. But along with complexity, reliability has also increased greatly.

Reliability per active device in a solid-state circuit is quite a bit better than with vacuum-tube circuits. On the surface, it may not seem that way, but instead of a simple radio set with four or five vacuum tubes, we are likely to be faced with a complicated product equipped with many integrated circuits each containing dozens of active devices. In a flat-panel TV display system, that number could increase to several hundred IC's corresponding to thousands of individual transistors. So it has become a race between the reliability of individual components and the complexity of the assemblies of those components.
cuits each containing dozens of active devices. In a flat-panel TV display system, that number could increase to several hundred IC's corresponding to thousands of individual transistors. So it has become a race between the reliability of individual components and the complexity of the assemblies of those components.

It is well that reliability has increased. If it had not, the situation would be hopeless, for these complicated new products would never operate.

How will all this affect servicing? Fundamentally, the job of the electronic service technician is not going to change. But I think that the job will become more challenging in that he will have to be much more of a detective to find out what is wrong. The technician is going to be faced with many types of products; no two will be exactly alike, nor exactly like what he saw last week. He will have to use his brain and his education and his training to find the trouble quickly—he won't be able to spend all day plugging in one board after another. Rather than such a machine-like approach, he will have to rely on his experience, intuition, and his ability for intelligent deduction. The job of servicing is definitely going to become more intellectual and less physical—that is, less tinkering, less soldering will be needed.

And as equipment gets more complex, it will be necessary for the technician to learn how these complex devices operate. It will not, however, be necessary for him to learn everything in complete detail. Take a very complicated IC, for example—understanding its operation is a real challenge for almost anyone. The technician won't have to understand the theory of that IC; he will, however, have to know its function in the circuit and its effect on the entire system if it develops a fault. Learning these facts alone is a big challenge, for there are a great many IC's, and the number is steadily increasing.

Fortunately, most technicians will try to understand as much as they can. That's built into the nature of the man who makes a career of electronics—that curiosity about how things operate is what brings him into the field. If he doesn't have that inborn curiosity, he won't go very far in the technical end of the business.

Servicing is here to stay. The number of service calls per product per year may decrease due to increased reliability. This factor, however, will be offset by the increase in the number of products that will require servicing, and their greater complexity.

The services of the electronic technician will continue to be in demand as long as electronic equipment is manufactured.

***—by Robert Adler, Vice President of Research, Zenith Radio Corporation, Chicago, Ill.***

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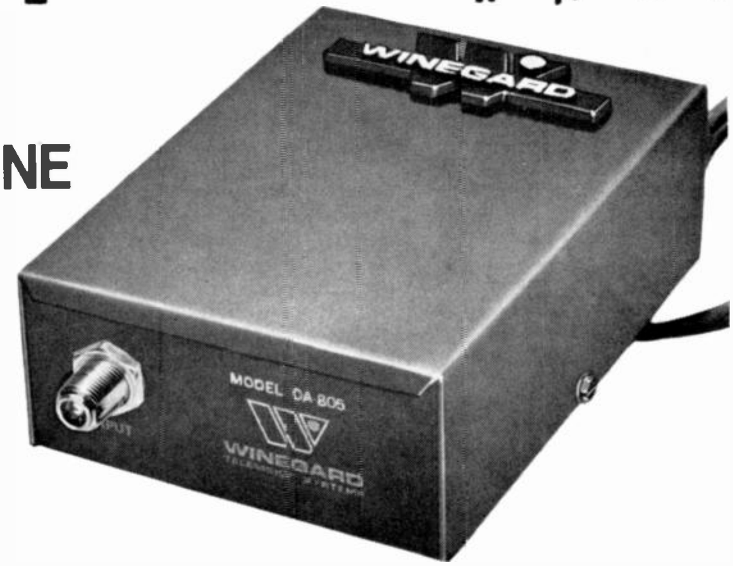


Winegard's new Metro-Line amplifiers are specifically engineered to accommodate strong signals and eliminate overload economically and efficiently. Because they have the same commercial quality construction and circuitry as the DA-830, DA-825B and DA-815, they are ideal for home, hotel, apartment and office building systems.

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| | UHF | NA | NA | NA | 35dbmv | 35dbmv |
| INPUT PER CHANNEL* | VHF | 31dbmv | 31dbmv | 40dbmv | 31dbmv | 31dbmv |
| | UHF | NA | NA | NA | 26dbmv | 26dbmv |
| GAIN | VHF | 15db | 15db | 13db | 12db | 14db |
| | UHF | NA | NA | NA | 9db | 9db |
| IMPEDANCE | | 300 ohm | 75 ohm | 75 ohm | 300 ohm | 75 ohm |
| Bandpass | VHF | 54 to 300MHz | 54 to 300MHz | 54 to 300MHz | 54 to 300MHz | 54 to 300MHz |
| | UHF | NA | NA | NA | 470 to 810MHz | 470 to 810MHz |
| NOISE FIGURE | VHF | 4.2db | 3.3db | 4.8db | 4.3 db | 3.3db |
| | UHF | NA | NA | NA | 10.0db | 7.3db |
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*Circle 3 on reader service card*

# looking ahead

## RCA drops audio

Next year will be the end of an era which started in 1922 when RCA marketed its first radio. The RCA Corporation (whose name was changed in 1969 from "Radio Corporation of America") in 1975 will discontinue marketing audio products — radios, tape equipment and phonographs — to concentrate on television and such "video-related products" as home VTR's and videodisc systems. RCA's radio career ends as it began—its last and its first radio products were made by others. Its radios now are all made overseas to its specifications. Its first home radio introduced in Jan. 1922 was a GE-made crystal set at $18 list (antenna $7.50 extra). The first Victor phonograph was made at the dawn of the 20th century, and RCA absorbed the Victor Talking Machine Co. in 1929. With Victor, it inherited Nipper, the famous "His Master's Voice" dog trademark. Poor Nipper! Do you remember him?

Another pioneer is also dropping out of radio. Philco, whose name was synonymous with radio, particularly in rural America of the 1920's, will also discontinue radio marketing, and drop compact stereo systems as well (but remain in the stereo console business). The change in the mass-market audio business has also affected Warwick Electronics, long-time supplier to Sears Roebuck, which has discontinued stereo manufacture to concentrate on color TV.

## Super-fi cassette

Unisette, a completely new tape cassette system designed for the professional and audiophile market, is expected to make its debut next year. Designed by BASF, German tape and equipment manufacturer, it's expected to be introduced simultaneously by several manufacturers. The new cassette uses high-performance quarter-inch tape which can travel at 1⅞, 3¾ or 7½ ips. The cassette is about the size of a paperback book, is designed so that all transport functions are accomplished by the recording and playback system and aimed at performance equal to that of open-reel recorders. The first such recorders are expected to retail at about $400.

## The real cost

To find the real cost of a new color TV set today—the amount it will set you back over its lifetime—just multiply the retail price by two. A set selling at about $400 will cost you $800 over its expected 10-year lifetime, including purchase price, electricity and service. These are conclusions reached in a two-year study entitled "Consumer Appliances: the Real Cost," made by MIT under the sponsorship of the National Science Foundation.

The study found that the purchase price of the average 1972-model television set was about 53% of its "life-cycle cost," service was 35% and power 12%. Among other findings: (1) A typical modern color set fails approximately once a year as opposed to three times a year for a set built in 1960 and six times a year for a 1954 model. (2) The one-year parts-and-labor warranty now standard on most solid-state color sets costs the manufacturer about $25 per set, as compared with $3 for the 90-day parts-only warranty which once was standard. (3) Fully 30% of all warranty service calls are caused by consumer ignorance rather than set failure. (4) From 1965 to 1972, the average service call cost rose from $20 to $30 and is expected to reach $50 by 1980. (5) TV technicians spend about 42% of total repair time scheduling calls and traveling to customers' homes. (6) TV carry-in service is expected to rise from 57% of all service in 1970 to 74% in 1980. Since the total number of technicians is expected to decline by 1980, while the number of calls a technician can make per day stays the same, the report concludes that continued improvement in reliability is one of the best ways to meet service problems. It also recommends that manufacturers inform consumers of life-cycle costs.

## New videotape

3M is quietly distributing to equipment manufacturers a new type of videotape which it believes is so revolutionary that it could lead to tiny hand-held video cameras with built-in recorders and make practical other home videotape devices. A 3M spokesman said the new tape had six times the magnetic strength of today's tapes, but declined to elaborate. Such an increase in signal strength theoretically, at least, could make possible videotape transports running at one-sixth the speed of today's units. The tape is so radically different that it requires the development of special heads and other hardware. The production of both the tape and the equipment is several years off.

## Quasar by Matsushita

Over the years, Motorola has developed Quasar into a major brand name. And now it's no longer "Quasar by Motorola" but Quasar by Matsushita, as the result of the first purchase of an American television manufacturer by a Japanese firm. Matsushita, which probably is the world's largest television manufacturer, also makes Panasonic television for sale in the U.S. It will continue to manufacture Quasar TV in the U.S. and will continue to sell Panasonic sets here as a separate line (although it may make some Panasonics in Quasar's plants). The sale of Motorola's television business to the Japanese giant culminated two years of unprofitable operation, after which Motorola decided to concentrate on its highly profitable semiconductor, communications and automotive electronics businesses. Zenith and Magnavox attempted to halt the sale on anti-trust grounds at the zero hour. Matsushita is now operating Quasar and it will spend many millions of dollars on plant-modernization.

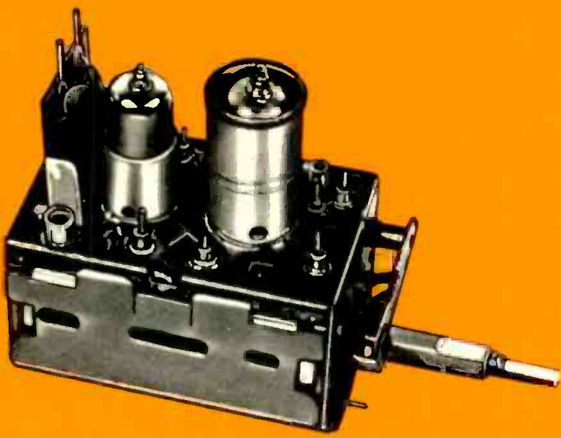
## Dolbyized FM

The FCC has ruled that FM stations are free to process their signals with a combination of Dolby B-type noise-reduction unit and reduced pre-emphasis of 25 microseconds instead of 75. For listeners without Dolby units, it's claimed that this move will reduce high-frequency distortion and/or increase the program level. With a Dolby unit in the receiver and proper pre-emphasis, the move should result in improved S/N ratio, better dynamic range, better fringe area reception and reduced susceptibility to interference, says Dolby Labs. Existing Dolby B home units would require modification to realize the full benefits of Dolbyized transmissions. Several FM stations are already broadcasting under the new standards, and new Dolby units with the proper pre-emphasis are expected on the market soon.

## Exit Packard Bell

After a rough-and-tumble, turbulent year which saw the television business of Admiral, Motorola and Philco offered for sale, one of America's pioneer TV manufacturers — Packard Bell — has decided to call it quits. A West Coast television brand since 1948, Packard Bell's parent company, Teledyne, is now in the process of shutting down its plants in Los Angeles and Nogales, Mexico, and selling off its inventory. The decision was obviously a sudden one. The company had already started producing its 1975 line.

**by DAVID LACHENBRUCH**
CONTRIBUTING EDITOR



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***Franchises available-Contact headquarters for information.***

*Circle 4 on reader service card*

# Compare what you get training and you'll

## Compare costs

Only NRI offers complete TV/Audio Servicing Courses from $312 to $955 . . . with terms as low as $10 down and $22 monthly. In the Master Course in color TV servicing, with a 25″ diagonal solid state color TV, you save $800 or more over other comparable courses. And NRI provides you with a handsome TV cabinet and other equipment at no extra charge.

NRI saves you money because our costs are lower. We pay no salesmen, and we design our own kits and equipment. We don't buy "hobby kits" from others. Nor do we penalize you with big interest charges for time payments. We pass the savings on to you.

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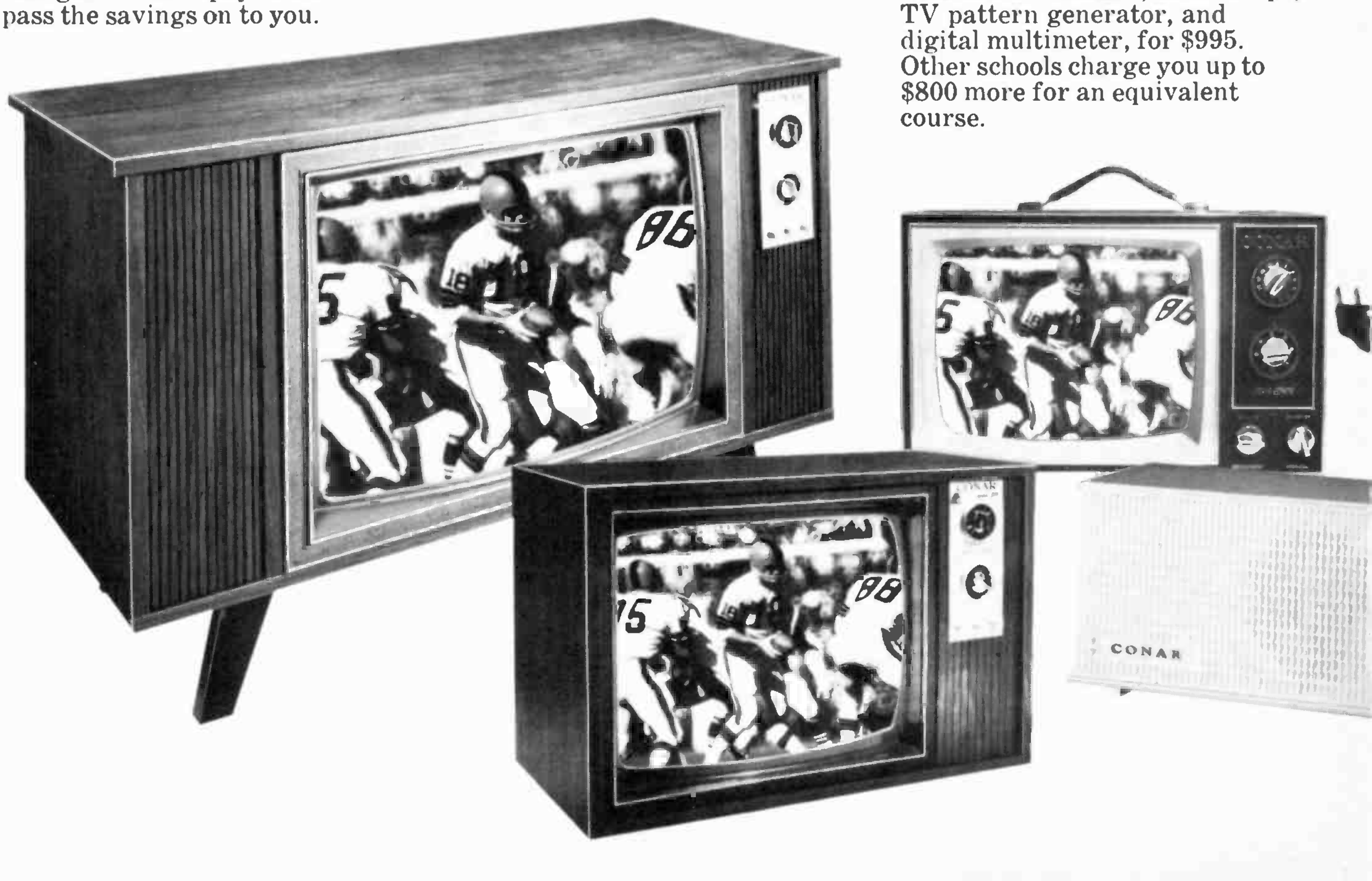

# in TV/Audio home choose NRI.

## Compare equipment

NRI has engineered the widest variety of professional electronic lab equipment ever designed entirely for training at home. When you enroll in the master course in TV/Audio Servicing, for instance, you receive kits to build a wide band, solid-state, triggered sweep, service type 5″ Oscilloscope; color pattern generator; solid-state radio; and a digital multimeter.

Before you settle on any home training course, compare the over-all program. See if you are getting kits engineered for experimentation and training . . . or merely "hobby kits". Count the experiments . . . compare the components. Don't just count kits. (Some schools even call a slide rule a kit.)

## Compare schools

Home study isn't a sideline with NRI. We've been its innovating leader for 60 years. Ask any of the hundreds of thousands of NRI graduates. They'll tell you . . . you can pay more but you can't buy better training.

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# new & timely

## Second 1974 Scholarship Award won by David C. Greene

The winner of the Second 1974 Hugo Gernsback Scholarship Award—a $125 grant made annually to an outstanding student in each of eight leading electronics home-study schools—is David C. Greene, 26, of Knoxville, TN. He is a home-study student of the Grantham School of Engineering, Los Angeles, CA.

After a short period as an instrumentation technician for an Oak Ridge firm in 1966, Mr. Greene got a job as transmitter engineer on the local radio station, WATE. Having much free time on watch, and an interest in two-way FM radio, he took a training course from a two-way radio manufacturer, supplementing this training by buying parts from the local distributor and setting up interesting circuits he saw in the manuals, running tests on them and making measurements, to improve his understanding of their action.

Discovering that he needed more theory and mathematics, Greene wrote to several of the schools advertising in the electronic magazines, and selected the Grantham School of Engineering as the one likely to be best suited to his needs. He is continuing with Grantham toward an Associate degree in Science in Electronic Technology.

David C. Greene

Sale of the station — now renamed WETE — resulted in promotion to chief engineer — with the side effect that the many duties of the new job cut down on time available for study.

In 1972, he was able to put his new knowledge to work. He joined Ultra Electronics, Inc., of Knoxville, manufacturers of scanning FM monitors, and is now engaged in designing multi-channel FM scanning receivers. In a letter to Grantham, he thanks the dean of students for allowing him so much time on the fifth semester of his studies, since his time is still limited. Mr. Greene holds a First Class FCC license and an Advanced Class amateur license. •

## Do something extra

Identification programs are among the more effective approaches in the spreading citizens' campaigns against crime. In such programs, an identification number — car license, social security number or other identification — is engraved on valuables most likely to be stolen. Since no experienced thief will knowingly steal a marked item, identification is a significant deterrent.

**IDENTIFYING A PIECE OF EQUIPMENT with an engraving tool is almost as easy as writing down one's name with a fountain pen. The tool writes on metals, plastics, glass and ceramics. Writing is not easily removed.**

In areas where such programs have been put into effect — usually by block groups with police cooperation — thefts and burglaries have dropped substantially. But the programs are not as widespread as they might be, due in many cases, to lack of information, as well as lack of engraving equipment on the part of most home owners. Neighborhood groups, who could often borrow the tools from local police departments, are slow to organize, and in many areas the police themselves have not been active in identification programs.

Now a Wisconsin manufacturing concern, Dremel Division of Emerson Electric, has a plan to change all that. Briefly, the proposal is that electronic service technicians take the lead in promoting identification projects, thereby building up a positive image for their own concerns and the profession, and good-will with their customers, as well as a modest source of supplementary income from identifying valuables for homeowners. The electronic service technician is a natural for this work, since the burglars' most common targets by far are electronic entertainment appliances.

The technician can offer the service as a good-will benefit to his customers, or make a special charge for identifying valuable items. Either way, he's providing an important service to his customer, for TV's, recorders and expensive audio equipment are the first things a burglar will look for — as long as they're not engraved.

As Dean Peel, Dremel's project theft-guard coordinator, sees it, the project has three basic elements:

1. **The engraver.** (Dremel naturally suggests their model 290, a rugged and long-lived device with a carbide or diamond tip that will mark indelibly any material the service technician is likely to encounter.)
2. **Theft-Guard stickers.** These are posted in conspicuous spots to warn off potential thieves. An ideal place is on the glass panes with which most exterior doors are provided. There, the warning may even forestall an attempt to enter.
3. **Inventory of protected property.** All engraved items should be listed, and where local police participate, a copy furnished to them. In some cases, police with such lists have restored stolen property before the owner missed it!

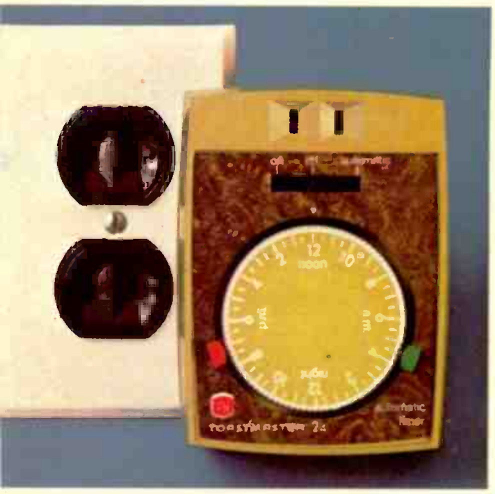
And there is no question that the technique works! Mr. Peel tells of an incident

in San Antonio, Texas, where two neighbors had their valuables engraved the same day. Burglars broke in that night, before the homeowners had got around to posting the warning stickers, and took

*(continued on page 16)*

# RCA's Free & Easy Dealer Awards

RCA Electronic Components Harrison, New Jersey 07029




**Toastmaster Plug-in Automatic Timer for Lamps and Appliances**
Cordless timer plugs directly into outlet. Time cycle extends from 90 minutes to 22½ hours. Turns lamps and appliances *on* or *off* any time of day or night and repeats the operation every 24 hours without resetting.
**FE-630**


**Polaroid Colorpack 5 Land Camera and Kit. Enjoy Instant Photography in Color and Black and White**
• Big 3¼ x 4¼ color pictures in one minute • Black and white pictures in seconds • 3-element lens and unique face-in-the-square viewfinder
**FE-687 Value: $44.95**


**Canon Palmtronic LE-83 Calculator**
Slender enough to put in your pocket, the Canon Palmtronic LE-83 combines convenience with precision. • Adds, subtracts, multiplies, divides, performs mixed calculations, calculations with a constant and n-th power calculations. • Comes with an AC adapter or can be used with 4 penlight batteries. • Smooth key touch, easy to read LED indication panel.
**FE-LE-83 Value: $44.95**


**Schick Styling Driers, Man's & Lady's Models**
For Women: Quick drying with more natural styling
For Men: Dries fast while it styles and grooms
• 2 Speeds, 2 Heats • Dry setting — high airflow and high heat • Style setting — low airflow and low heat • Professional styling brush and styling comb • Air concentrator nozzle
**Man's FE-336 Lady's FE-338 Value: $15.98**


**Spalding "Rebel" Golf Balls (One Dozen)**
Spalding is the premier distance ball with indestructible Surlyn cover. Two-piece construction gives you extra yards for the power you pack into your drive.
**FE-11117 Value: $14.90**


**Spalding "Collegiate" Football**
The best value you'll find in a full-grain leather football. Tough butyl rubber bladder. Triple fabric lining with lockstitch construction.
**FE-61448 Value: $17.00**

When you buy RCA tubes from your participating RCA tube distributor, he delivers the goods the easy way. No muss, no fuss, no constant cutting of carton flaps, no torn cartons on your shelf or in your caddy. Just give your tube order to your RCA distributor and get your premium the free and easy way. The bigger your tube order, the more valuable your gift. So visit him soon and select your Free and Easy RCA award with your purchase of RCA tubes. *(The values are really extra special.)*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**Place Your RCA Tube Order**
**and Select Your "Free and Easy" RCA Award!**

**Remember, the Award Values Are Extra Special!**


**Omaha Steaks** Ten RCA "Steak-out '74" certificates can be redeemed for one package of tender, succulent Omaha steaks as follows:

| | |
|---|---|
| 6 (11 oz.) Boneless Strip Sirloins | 1⅛″ thick or |
| 8 ( 6 oz.) Filet Mignons | 1¼″ thick or |
| 8 ( 8 oz.) Top Sirloins | 1⅛″ thick or |
| 6 ( 8 oz.) Filets of Prime Rib | 1″ thick |

Choice cuts, generous portions and outstanding flavor! **1A2116**

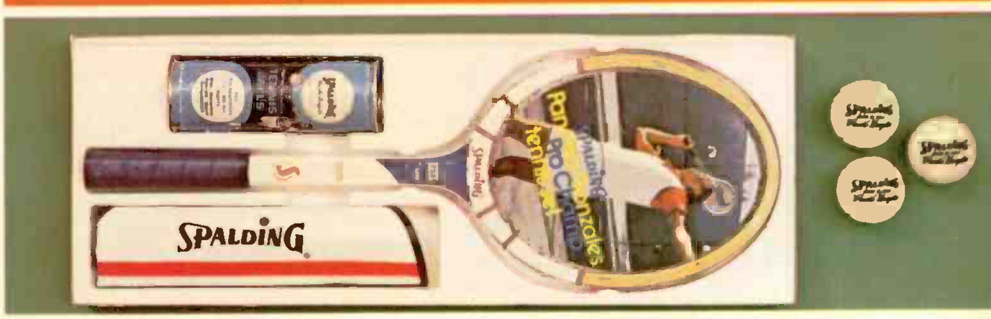
**BULOVA . . . The watch you wear with pride. Bulova . . . synonymous with quality, craftsmanship, precision and style.**

**Oceanographer** — Highly contemporary 17 jewel, automatic instant change day/date calendar; depth tested to 333 feet. **FE-12604 Value: $110**

**La Petite** — Stunning feminine timepiece with 23 jewels, 4 diamonds, 10K rolled gold plate case. Adjustable mesh bracelet. **FE-55775 Value: $110**

**Sea King** — Stalwart Bulova Sea King, 17 jewel precision timepiece, water-resistant with luminous dial. **FE-12280 Value: $65**

**Concerto** — Prettily sculptured model with 17 jewels, 10K rolled gold plate, stainless steel back and silver dial. **FE-63628 Value: $65**




**Compass Binoculars**
Perfect for use at the track, at the stadium, in the woods. Field of view is a large 367 Feet at 1000 yards. Hard-coated optics. Complete with case and strap.
**FE-3022 Value: $44.95**

**Shakespeare Deluxe Spinning Combo Balanced Tackle Set**
Shakespeare #2210 Marina Green spinning reel, matching Shakespeare SP-160 6′ 6″ Wonderod, 200 yards 6-pound monofilament, box of stainless steel hooks and spinning lure. For fresh and light salt-water fishing. **FE-S460 Value: $42.00**

**Spalding Pancho Gonzales "Pro Champ" Tennis Set**
Pancho Gonzales "Pro Champ" racket, waterproof racket cover, plus three Pancho Gonzales tennis balls.
**FE-531063 Value: $18.65**

a number of TV's, a quantity of audio equipment and a tape recorder. The burglars apparently spotted the markings as they were loading the stuff, for the owners found their property stacked in the driveway between the two houses when they came home.

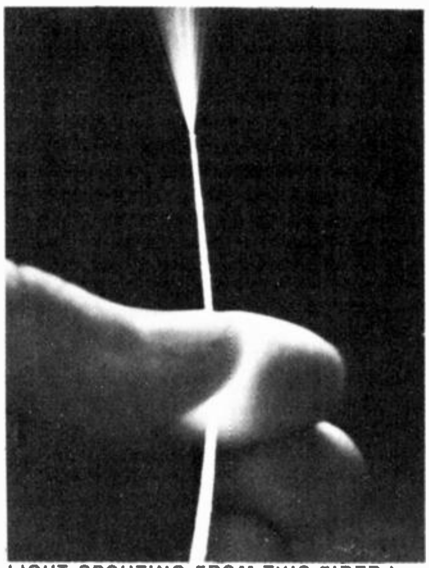
Such dramatic instances are not needed to demonstrate the method's effectiveness; police statistics show significant drops in burglaries in neighborhoods where they have promoted identification programs.

And, of course, when using the project to help him in his business, the technician can take time out and mark his own equipment! He has plenty of expensive test equipment, plus ordinary business machines. And the stickers may prompt customers to ask questions! •

## "Most transparent glass fibers" set new 1.2 dB/km loss record

The world's most transparent glass fibers have been made by scientists of the Bell Laboratories. Their achievement represents an important step toward practical long-distance communications circuits using light, where the fantastic bandwidth, independence of losses from frequency, light weight and immunity from electrical interference of glass light conductors offer many advantages.

The new fibers are made by a vapor-deposition method. The materials that compose the fiber are heated to the vapor form and deposited on the inside of a quartz tube. The tube is then collapsed by heating and the glass drawn into a thin fiber. A ten-inch section of collapsed tube may be drawn into a tube a mile long.



**LIGHT SPOUTING FROM THIS FIBER has traveled a half mile inside the glass tube.**

The new fibers are also made to combat dispersion, or smearing of light pulses in transmission. Some of the light in a pulse travels straight down the center of the fiber; some of it may follow a zig-zag path, with repeated reflections from the boundaries, thus traveling farther and reaching the end of the fiber later than the light that went straight down the center. This makes the pulses longer and gives them smeary trailing edges. If pulses are closely spaced and the transmission distance great enough, pulses can run into each other and make the signals unintelligible.

This can be remedied by making the center of the fiber out of a glass with a lower speed of light conduction and the outer portion of a glass that lets the light travel faster. Thus the light that goes farthest goes fastest and tends to arrive at the same time as light that went straight down center.

The vapor-deposition technique makes it easy to construct such fibers. In Bell's best fiber, borosilicate was first evaporated against the inside of the quartz tube, and the center core was formed of fused silica. It was fiber so made that showed, under certain conditions of excitation at a wavelength of 1.06 millionths of a meter, a loss as low as 1.2 dB. •

## New communication system "works under water"

A self-contained underwater communications system enables sports divers, underwater photographers, and diving instructors and students to communicate with ease under water. The device uses straight audio frequency. A transmitter only is needed, the listener picking up the audio-frequency pressure waves by direct conduction through the skull, aided slightly by the ears.

The D.U.C.S. (Divers Underwater Communication System) as it is called by its manufacturer, Micro-Tech Electronics, of St. Louis, consists of a throat microphone feeding into a speech-processing network that eliminates the distorted low-frequency sound waves from the larynx, improving the intelligibility. This inputs to an audio amplifier, also tailored for greater speech intelligibility and elimination of breathing and other extraneous noises. The final unit is a transducer which converts the electric signals into pressure waves. No volume control is needed, but a feedback control — which is adjusted just below the level of feedback squeal — is provided.

The D.U.C.S. is designed to work well with the almost universal demand regulator and half-face mask. A certain amount of skill must be developed, since lip movement is hampered by the demand regulator and mouthpiece. Once this difficulty is mastered, intelligibility is greatly enhanced. Special microphones are available for use with the less common full-face mask.

Range of the D.U.C.S. is up to 165 feet, depending on water conditions and ambient noise. The equipment can be used down to 300 feet. Output power is 3.5 watts. •

**UNDERWATER COMMUNICATION IS EASY with the units shown strapped to the air tanks. Voice communication is feasible up to 165 feet.**

## Radio may affect human health at lower levels than thought

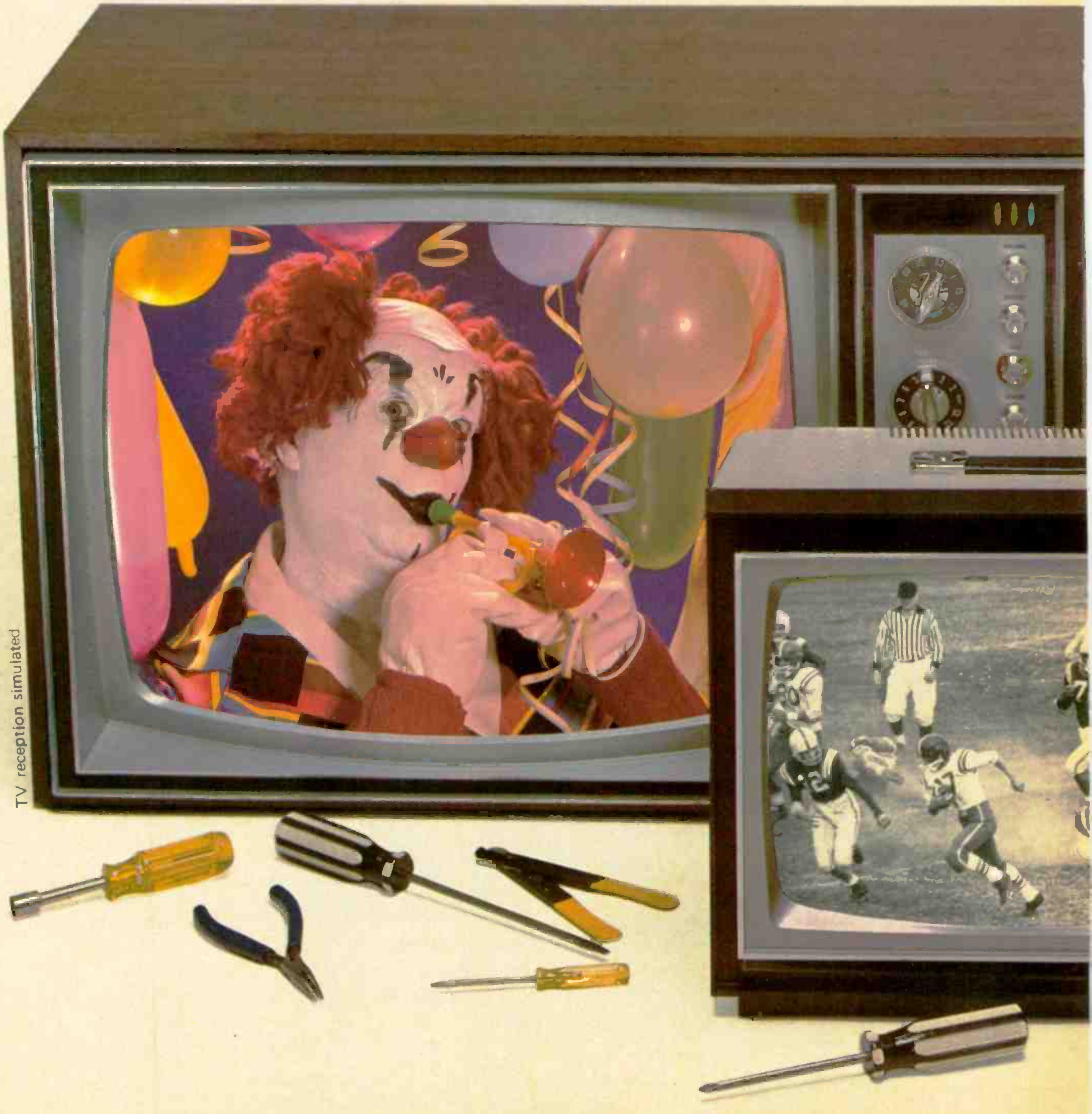
Radio waves may affect the nervous system and behavior, and normal development and growth processes "at lower levels than anticipated in the past," the government Office of Telecommunications Policy stated in a report to Congress. The Office warns, however, that the tentative findings are based on a small number of experiments on a limited number of subjects, and that "casual relationships between the electromagnetic fields and observations are not yet clearly established."

High-intensity radio-frequency radiations are known to cause adverse biological effects by generating heat in the tissues. The thermal effects are well understood, and it has been fairly well established that power densities of less than 10 mW per cm² are harmless to human beings, as far as their heating effects are concerned.

Less is known of other effects of rf radiation, though they have been suspected to exist for some time, especially in the microwaves. (In the 1940's, de Forest suggested a study of "the non-thermal effects of higher radio frequencies.") Some effects of radio waves are rather sharply

*(continued on page 22)*

# Sylvania goes



TV reception simulated

# new & timely

(continued from page 16)

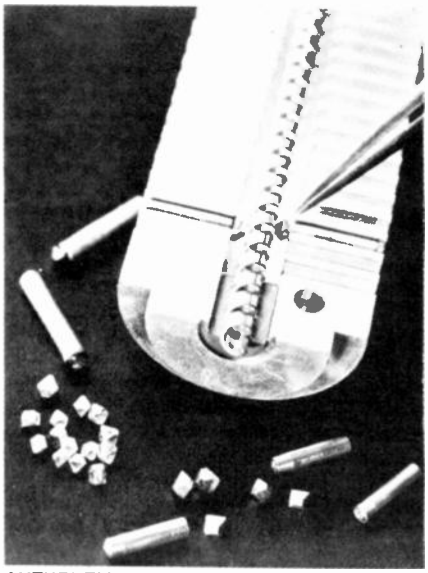
tuned: ants align their antennas parallel to an electromagnetic field at 9 MHz; emissions at 29 MHz have been used to kill bugs in bread, and radiations at 388 MHz have killed monkeys. On the other hand, radiation at 21 MHz increases the germination of gladiolus bulbs. These phenomena cover wide frequency bands.

### EASAC elects officers

The Electronic & Appliance Service Associations Council of the State of New York elected Henry Wawryck, of Henry's Radio & TV, Hicksville, president of the Council for the 1974 season.

Thomas Delaney, Elgot Service, Long Island City, was elected executive vice president, Hy Latman, Flatbush Park Washer Service, vice president, appliances, and Warren Baker, Baker Electronics, Albany, vice president, electronics. The recording secretary is Phillip Holt, Holt & McLamb TV Service, Bayshore, and the corresponding secretary John Organist, Ganmar Electronic Co., Glen Cove. Hy Sheffron, Factory Servicenter, Brooklyn, is treasurer and Robert Plunz, Bob's Radio and TV Service, Scotia, Sergeant-at-Arms.

The officers are also members of the board of directors. They have selected Warren Baker as Chairman of the Board and Robert Plunz as secretary. R-E



**AUTHENTIC DIAMONDS SEPARATE the tiny helix rings from the outer shell of this traveling-wave microwave tube, made at the Waltham, MA, plant of the Raytheon Co. Total weight of the diamonds, used because they are excellent heat conductors as well as electrical insulators, is about four carats per tube.**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*Circle 8 on reader service card*

# letters

## CAUGHT YOU

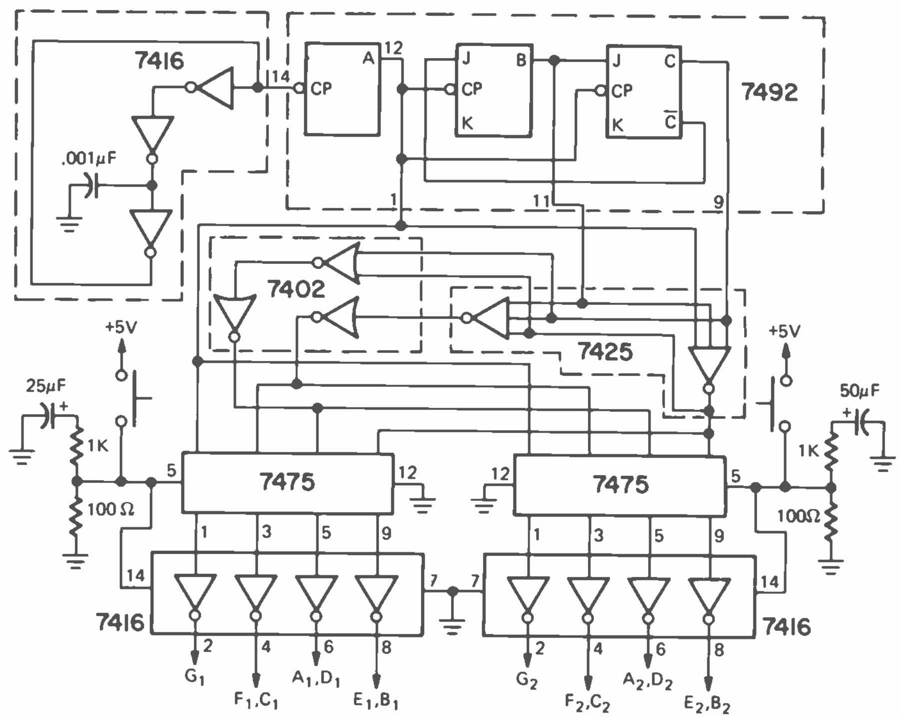
In reference to Waller Scott's article (Electronic Casino, **Radio-Electronics**, March 1974).

Interestingly enough, I was working on an idea for electronic dice just before I received this last issue. I was curious to see how Mr. Scott performed his logic. In comparing the two, it would appear that mine is much simpler, both because it eliminates most of the discrete components and reduces package count and interconnections.

In the die, you can see that instead of a shift register, I use the first three units of a mod-12 counter, already wired, in one 7492. This eliminates the need for a reset since there can be no disallowed count as in the shift register (such as 010 and 101). It also simplifies the gating required for decoding. In addition, rather than than use two counter-decoders, I use only one and use two Quad Latches (7475) and two switches to control them. This reduces the IC count from 11 to 7 and the component count to 7, to perform the same function.

In closing, I would like to say that I am looking forward to future articles of this nature and of other logic uses. I have found that they are good practice both in space and cost reduction. There has rarely

DICE



been an issue from which I did not profit in some way.
JAMES D. TUCKER
*Knob Noster, Mo.*

### MINICOMPUTER PC BOARD PRICES

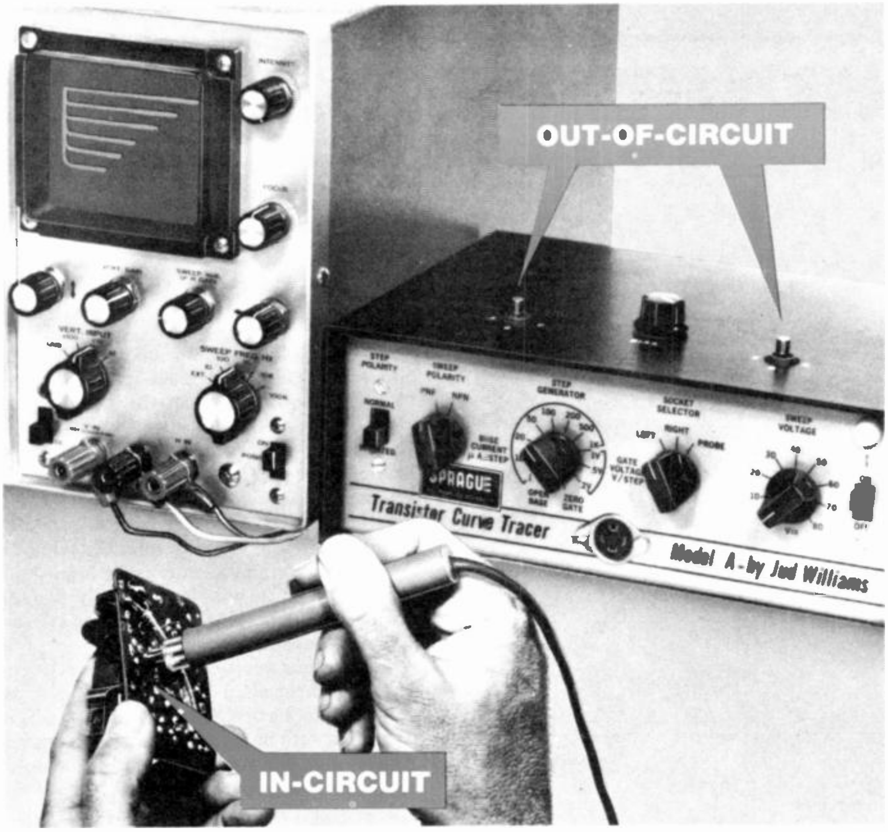
Somehow, the prices listed for the PC boards for the Minicomputer in the July issue were transposed. The prices are right but were not matched to the proper items. The correct pricing should be:

| | |
|---|---|
| Input multiplexer board | $ 7.50 |
| Memory board | 10.50 |
| CPU board | 9.50 |
| Output ports board | 8.45 |
| Address latch board | 8.45 |
| LED register display board | 8.50 |
| Complete set of boards (one of each) | 47.50 |

LARRY STECKLER
*Editor*

### TV TYPEWRITER COMMENTS



# equipment report

## Winegard Cablemate Model CTS-1

*Circle 97 on reader service card*

MOST CABLE TV (CATV) SYSTEMS OFFER a greater variety of programs than is generally available to the viewer with a single fixed TV antenna. Too, signal strength is greater and more constant than with the usual unamplified antenna. Thus, when CATV is available, it offers the viewer a chance for improved reception and greater enjoyment from his TV set.

Often when the home owner subscribes to CATV service, he may find that he no longer gets one or more stations from an adjacent service area. This doesn't matter when the more distant stations carry network programs duplicated on local channels. But, he is out of luck when the distant station originates educational programs and local athletic events that he wants to view. Also, with the rapid expansion of uhf TV into the suburbs, the average CATV system (12 channels) does not have the capacity to provide the viewer with all the uhf channels available from his vhf/uhf antenna on the roof. Therefore, if the viewer wants access to all available TV channels, he must use a separate antenna for those stations not sent over the cable.

Uncoupling the cable and its balun from the TV set's antenna terminals and connecting the antenna lead-in is an inconvenience that soon discourages the viewer from watching programs not on the cable. The job of disconnecting and connecting the cable and TV lead-in—a real chore if the set is a console or a large color model—can now be easily overcome by installing Winegard's model CTS-1 Cablemate TV Signal Selector.

This handy gadget is a switch that allows the cable TV subscriber to select either CATV or his own antenna with the flick of a switch. It mounts on the back of the TV set where its selector switch lever is within easy reach.

There are three type "F" coaxial cable connectors and two parallel-screw non-strip twin-lead connectors on the switch box. One coax connector is the input for the CATV cable, one is for a 75-ohm antenna lead-in (if needed) and the third is for a TV set or multi-set coupler for 75-ohm lines. One of the twin-lead terminal strips is for connecting a TV set or coupler designed for 300-ohm lines and the other is the input from a 300-ohm antenna lead-in. Two slide switches match the Cablemate to 75- and 300-ohm impedances.

For several years I have used a roof-top vhf/uhf antenna with a rotator and an amplifier-splitter to distribute the signals to three TV sets in my home on Long Island. The rotator control box sits atop the color set in the living room. Invariably, when the antenna is pointed west so my wife can watch a network program from Manhattan, I want to watch wrestling or roller derby on a Connecticut station to the north and my teen-age son and his gang want to watch local high-school news or events telecast on a uhf channel to the east of us. We needed three separate antennas with rotators—a very impractical arrangement, particularly when all available roof space was needed for my quad and Yagi hamband antennas. My solution was to subscribe to CATV service with three taps.

This was satisfactory for a while but we soon missed programs that we had formerly watched on vhf and uhf channels in outlying areas. I resisted pleas from my wife and son to reconnect the old MATV system because of the inconvenience of disconnecting and properly terminating the unused signal cable each time we switched from one system to the other.

When Winegard announced the Cablemate, I thought that they *had* something. After using one for several weeks, I know that they have really come up with a useful TV accessory. I can now connect the main TV set to the antenna or CATV cable with the flick of a finger. As soon as I can get two more Cablemates, we'll have the same convenience on the den and bedroom.

### What's inside

The diagram is a simplified circuit of the Cablemate CTS-1. A dpdt rotary switch with a long lever-type handle selects the signal source to be connected to the set and provides a 75-ohm termination for the CATV cable or coax antenna lead-in when not in use. Two broad-band balun transformers with toroidal ferrite cores can be switched into the circuit to match 75-ohm unbalanced coax to 300-ohm balanced twin-lead lines.

### Enter Casper

As soon as the MATV system was returned to service, we began noticing odd types of interference on most channels. Sometimes, there were faint floating venitian-blind type lines resembling co-channel interference. More often, there was a real crazy ghost (we named him Casper) that was displaced about half the screen width to the left *or* right of the main image. The weird thing about Casper is that he wouldn't stay put. When a camera switches or moves in for a close-up, Casper races smoothly from one side of the screen to the other—passing either in front of, or behind the main image. *And* sometimes, Casper appeared as a *negative* ghost.

### The exorcist

This problem was so unusual and intriguing that I had to lay this ghost to rest. It was finally traced to radiation from *both* the MATV and CATV cables inside the house. I tried separating the coax feeder cables and even rearranged them so they were at right angles as much as possible without any noticeable reduction in Casper's activities. Attenuator pads at the input and output of the MATV amplifier/splitter didn't help either. I haven't completely exorcised Casper but he is not as noticeable now that I've moved the amplifier/splitter and mounted it on a convenient cold-water pipe for good ground and replaced the three branch lines with *shielded* 300-ohm twin lead.

The CTS-1 Cablemate is a TV accessory that the cable TV subscriber will really appreciate. The choice of 75- and 300-ohm antenna input and output connections makes the device easy to attach to any existing antenna or MATV system. Installation takes only a few minutes. The model CTS-1 costs $14.95. If yours is a multi-set family of avid TV watchers, be prepared to add one Cablemate to each set—you'll need them. I can hardly wait for my Winegard dealer to get them in so I can get two for the bedroom and den. **R-E**

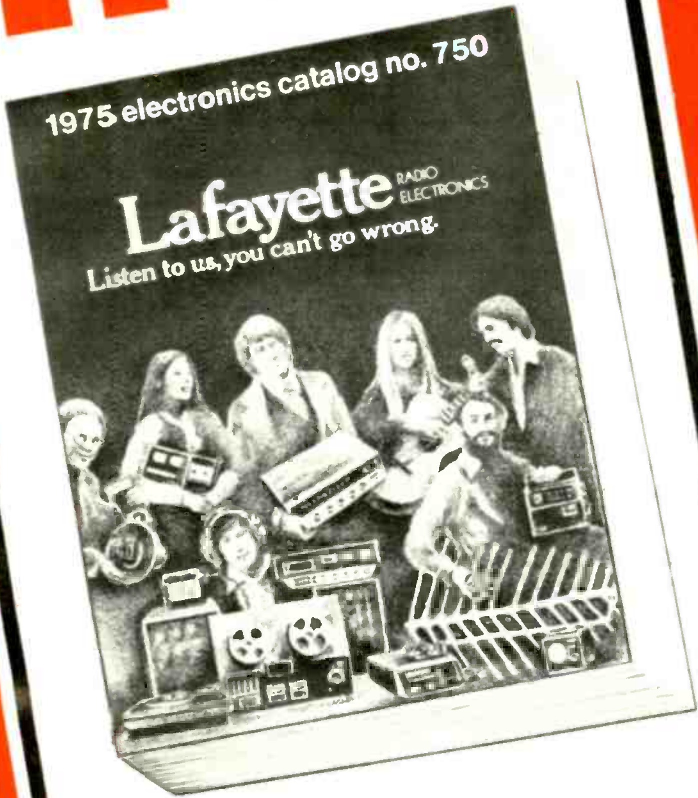
## Proto Board by Continental Specialties

FOR THOSE OF US PROFESSIONAL AND AMATEUR circuit designers who have spent many exhausting hours wiring and rewiring complex breadboards, and have sometimes succumbed to the relative crudeness of our methods, Continental Specialties Proto-Board may well be a panacea.

The Model 103, third in a four model series, is 6" × 9" × ⅛" solderless breadboarding system mounted on a heavy gauge, black anodized aluminum ground plane with rubber feet. It is an assemblage of sockets, bus strips, and 5-way binding post. A double horizontal bus spans its width and four double vertical bus strips run along its length, arranged to distribute a pair of supply leads. An external power supply is connected to

*(continued on page 30)*

# free

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# EXPERTS AGREE
# The TV of the future is here... in the Heathkit Digital-Design GR-2000 TV

At **ELEMENTARY ELECTRONICS** they said: "The fact is, today's Heathkit GR-2000 is the color TV the rest of the industry will be making tomorrow ... there is no other TV available at any price which incorporates what Heath has built into their latest color TV."

The **FAMILY HANDYMAN** reviewer put it this way: "The picture quality of the GR-2000 is flawless, natural tints, excellent definition, and pictures are steady as a rock. It's better than any this writer has ever seen."

**POPULAR SCIENCE** pointed out "more linear IC's, improved vertical sweep, regulators that prevent power supply shorts, and an industry first: the permanently tuned I.F. filter."

The **RADIO-ELECTRONICS** editors said the Heathkit Digital TV has "features that are not to be found in any other production color TV being sold in the U.S.:

"*On-screen electronic digital channel readout* ... numbers appear each time you switch channels or touch the RECALL button ... *On-screen electronic digital clock* ... an optional low cost feature ... will display in 12- or 24-hour format ... *Silent all-electronic tuning.* It's done with uhf and vhf varactor diode tuners ... *Touch-to-tune reprogrammable, digital channel selection* ... up to 16 channels, uhf or vhf ... in whatever order you wish ... there's no need to ever tune to an unused channel. *LC IF amplifier* with fixed ten-section *LC IF bandpass filter* in the IF strip ... eliminates the need for critically adjusted traps for eliminating adjacent-channel and in-channel carrier beats. No IF alignment is needed ever. *Touch volume control* ... when the remote control is used ... touch switches raise or lower the volume in small steps."

**POPULAR ELECTRONICS** took a look at the 25-in. (diagonal) picture and said it "can only be described as superb. The Black (Negative) Matrix CRT, the tuner and IF strip, and the video amplifier provide a picture equal to that of many studio monitors ..."

Furthermore, the Heathkit GR-2000 is an easier kit-form TV to build. **POPULAR ELECTRONICS** pointed out that "Each semiconductor has its own socket and there are 12 factory-fabricated interconnecting cables ... The complete color adjustments can be performed in less than an hour."

To sum up, **POPULAR ELECTRONICS** concluded its study by stating, "In our view, the color TV of the future is here — and Heath's GR-2000 is it!"

Why not see what the experts have seen? The Heathkit Digital Design Color TV — without question the most remarkable TV available today.

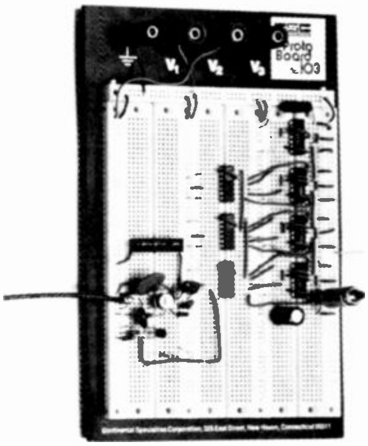
Mail order price for chassis and tube, $659.95. Remote Control $89.95 mail order. Clock, $29.95 mail order. Cabinets start at $139.95. (Retail prices slightly higher).

*Circle 100 reader service card*

## EQUIPMENT REPORT

*(continued from page 26)*

two of the binding posts, one of which, the ground post, is electrically connected to the aluminum ground plane. Jumpers connect the binding posts to the horizontal buses which are then jumpered to the vertical bus strips. By using these dual buses, the bread-




*Circle 98 reader service card*

board power is distributed among three double columns of interconnected terminals, interlocked with the buses. The remaining binding posts, which are insulated from the ground plane, can be used for input and output connections.

The contacts are connected in groups of five with spacing on a 0.1-inch grid meant to accomodate dual-inline integrated circuits spaced across the insulated separating gap between the sides of the dual terminal strips. Twenty-four 14-pin or twenty-one 16-pin IC's will fit on the 103, and since the five terminal clusters radiate laterally from the plugged in IC's, wider devices such as 40-pin DIP's also work. In all there are a total of 2250 terminal contacts in the 103. Transistors, diodes, resistors, capacitors, and other integral lead components are simply plugged into the terminal grid after bending and cutting the leads to reach their proper terminations. Switch and potentiometer like components are managed by soldering No.22 bus wire to their terminals. Interconnections are made with No.22 solid jumper wires, a collection of which rapidly accumulates. Individual terminals can be removed to retrieve jumper ends that break off at or below the terminal surface level.

With this system circuits of moderate complexity can bewired on a single board, and very complex circuits wired by a combination of Proto-Boards. Wiring errors and design changes are easily handled with a minimum of component attrition because there is no repeated soldering of component leads, with the resulting heat and flexure damage. Circuit sections are isolated for debugging by selectively disabling the various supply buses by disconnecting jumpers. The end result is that a circuit design can be carried to completion in a fraction of the time burned up by more traditional methods.

We used the Proto-Board 103 to lash together some fairly complex linear and digital systems using IC's and transistors, and found it to be really effective. The layouts were unusualy neat for designs in such early stages of development. Neatness cuts troubleshooting time and makes it unecessary to rewire a half-completed nightmare that has become unmanageable and useless. Snipped component leads when inserted in the contacts formed test points to clip test instrumentation onto. We preferred this breadboarding system to the less expensive pre-patterned printed circuit boards, because of its reusability. However, it is desirable to transfer a completed design to one of these printed boards to free the Proto-Board for its next assignment.

The one limitation of the system is working at high frequencies. Relatively long signal paths will generally cause the method to be impractical. There may be exceptions when only small parts of the overall design operates at high frequency, so these components can be confined to a small breadboard area.

The 101-104 Proto-Board series are priced from about \$30 to \$80. The model 103 sells for \$59.95. If your breadboarding requirements are more modest the QT (Quick Test) socket and bus strips are available unmounted in a variety of sizes. Units with the same lengths are agglomerated by their interlocking 'Snap Lock' design. Cylindrical protrusions at each end of the strips slide into matching blind cylindrical slots on the companion part. **R-E**

**OCTOBER IS HI-FI MONTH**

For all the latest dope on the world of hi-fi make sure you get the October issue of **Radio-Electronics**. It goes on sale September 19.





*Circle 12 on reader service card*

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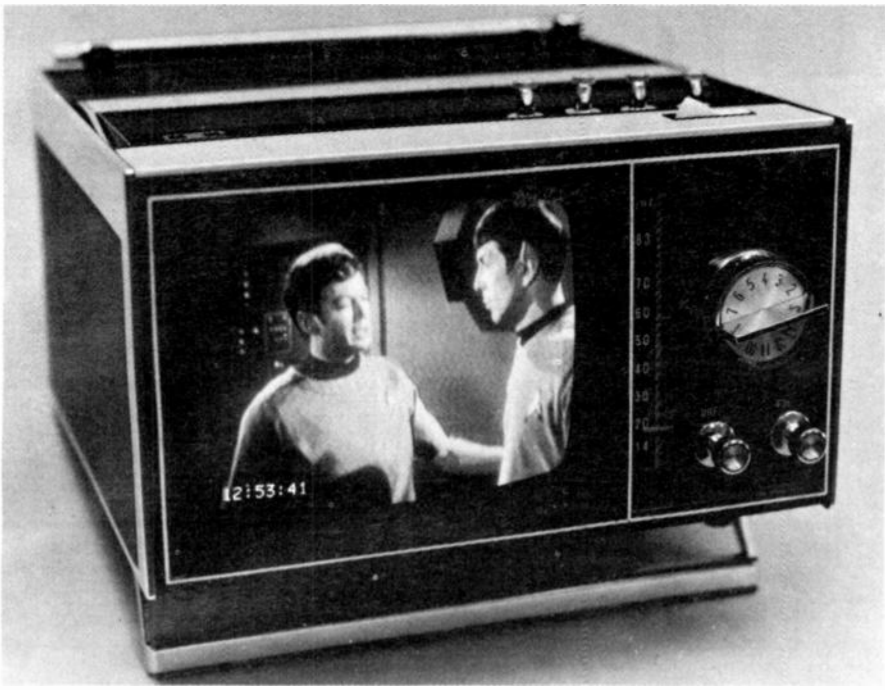



*Get the exact time on your TV screen without interfering with the picture*

# Put the TIME on your TV screen


MANY RADIO-ELECTRONICS READERS HAVE asked for a way to connect their Superclock II (R-E, July and August '72) or other digital clocks to their TV set, so they can display time directly on top of an existing TV program. This eliminates the high cost of the self-decoding LED readouts from your Superclock design and is the ultimate in convenience for the discriminating TV viewer. When and if it is approved, the NBS (National Bureau of Standards) TV timing system is a natural source of self-resetting, always accurate signals for your Superclock, and the Revideo unit is the ideal output display.

You can also use the unit to transmit plant-wide or school-wide time, or to add time to a video recorder, cable TV system, or industrial recorder. While the unit was intended to give you an 08:18:36 style time display of any reasonable size positioned anywhere you want on the TV, it can be made to display *any* combination of eight letters, numbers, punctuation, or blanks. For instance, you could display the calendar date, the TV channel number, the temperature, the weather "CLOUDY"; "WARMER"; "RAIN"; etc. Or you can use it as a security monitor, a calculator readout, or anywhere else you want to display a changing, limited amount of alphanumeric information on a TV set or oscilloscope. The unit gives you complete control of presence, size, position, and contrast.

The Revideo unit consists of 14 IC's on a 4½×6¾-inch PC board and needs 5 volts dc at 200 mA and −12 volts dc at 25 mA. This is picked up from the clock, a lab supply, or from a small custom supply. The cost of the IC's come-to around $23, buying from the back ads in **Radio-Electronics**, and a complete kit of all *other* parts is available, as are individual PC boards—see parts list.

The TV Revideo unit will interface with the "1-2-4-8" *counter* outputs of any digital clock provided it uses the BCD code.

If you are using a one-chip or multiplexing clock circuit, you havce to make sure a BCD output is available and then add suitable simple latches so that all the outputs (1, 2, 4, 8, 10, 20, 40 minutes, and 1, 2, 4, 8, 10, (20?) hours are available all at once in parallel form.

The final outputs must be TTL compatible. Regardless of what type of clock you use, you have to end up with these parallel BCD outputs. Since these rarely already exist as output terminals or pins, you usually add a *short* piece of multi-conductor flat cable to the respective pins on the *counters* in the clock.

Before you begin—note two important things: The TV set *must* be modified to bring out horizontal and vertical trigger pulses and a video input. If done properly, this is easy and cheap, and only adds to the value of the TV. In no way will it hurt normal operation. Secondly, if the receiver is a hot-chassis type, you'll have to either use an isolation transformer or else run the entire clock "hot-chassis" and properly safely-isolated as well. A schematic of the TV you're going to use is a must; a good scope will also be essential to modify the TV.

## Understanding TV scanning

A TV set has a raster scan. Once every 1/60th of a second, a spot starts at the upper left hand corner and rapidly scans to the right and slowly downward, generating a series of 262 1/2 lines. Video is produced by controlling the brightness of, or *modulating*, the spot. During the next 1/60th of a second, the TV generates another 262 1/2 lines, putting these *between* the ones it did on the previous go-around. The two *interlaced* 1/60th second *fields* make up a 1/30th second *frame*, the time needed to display one complete, stationary picture of 525 lines. By presenting 30 staionary frames per second, the pictures appear to move, since the eye cannot respond to each individual frame, but can only average them out for a final result. The fancy interlace scheme is used to reduce the apparent flicker.

The horizontal scan time, or the time to generate one line, is around 62 microseconds, of which 50 microseconds is spent in the actual scan and the rest in returning the *blanked* or turned off beam to the left side of the picture. A horizontal *synchronizing* pulse of some 5 microseconds is centered in the return blanking interval. It is used to lock the TV's horizontal scan to the scan at the TV camera. Obviously, the camera has to be looking at the same place the TV set is at the same time if we don't want a rolling or scrambled picture.

The vertical scan time lasts the entire 1/60th of a second. About 800 microseconds of this time is reserved for retrace. A vertical sync pulse 180 microseconds wide is centered in the blanking interval to lock the TV's vertical scan to that of the camera and the transmitter.

We can't change what the TV scan is doing or where it is at any particular time. This means we can't use stroke or segment style numerals on our time display. We have to use a bunch of dots, gettings the dots to crop up at the right place and the right time to present a final numeral or character in a stationary and recognizable place.

We can easily sum an output signal from the Revideo unit right into the TV's video amplifier and present a composite time-on-picture display. The problem is to get the right dots in the right place at the right time. Fortunately, there is a stock MOS computer-on-a-chip that does most of the work for us.

To generate the dots, we have to derive a horizontal trigger pulse and a vertical trigger pulse from the working TV and use these to synchronize and control the number generator. The vertical pulse is easily obtained from the vertial output stage and is attenuated to logic levels with external resistors and a coupling capacitor. While we could alsouse the horizontal output signal, this is usually a bit too strong and could detune the TV's flyback transformer. So, we have to find an equivalent positive-going horizontal pulse, such as off the plate or collector of the agc keyer. This signal is also attenuated with external resistors and capacitors to present a logic-level-sized, positive-going output pulse.

Fig. 1 is a block diagram of the TV Revideo unit, while Fig. 2 takes you through the timing sequence of a single field. The Revideo unit has two parts—the *timing* portion and the *signal processing* portion. The signal processing portion picks the right input number and converts it to the proper dot sequence at the proper place in the picture. The timing tells the signal processor when to do what, and locks things into the TV's vertical and horizontal scanning.

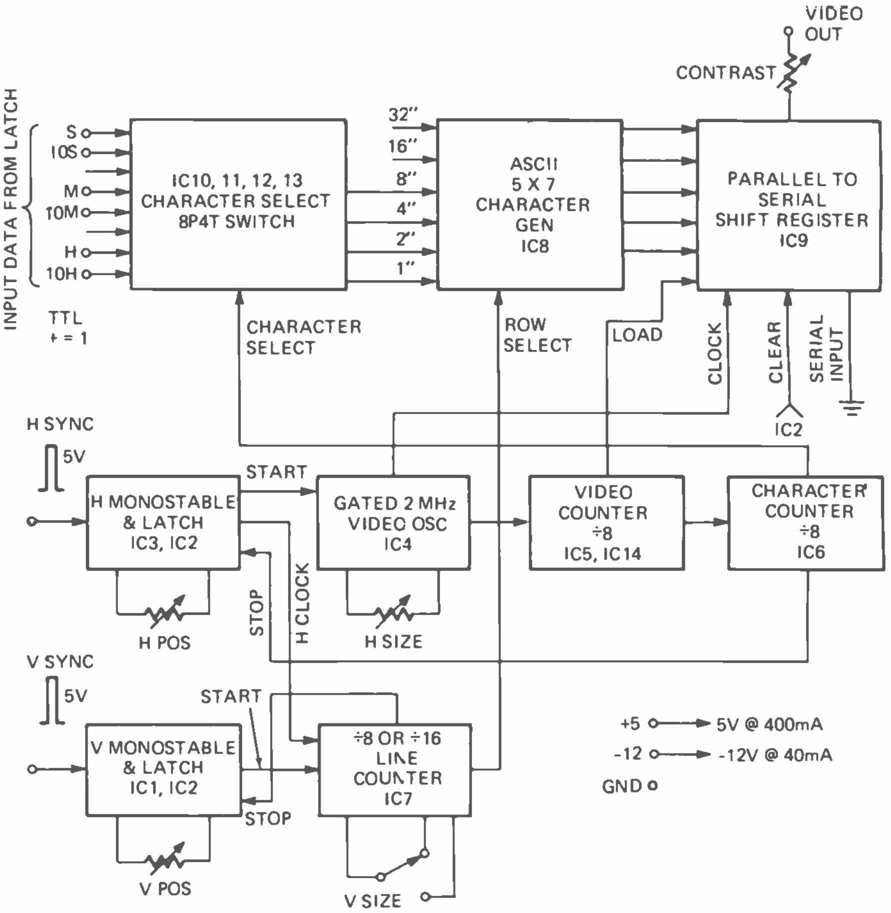



**FIG. 1—REVIDEO UNIT for digital clocks, showing input and output connections.**

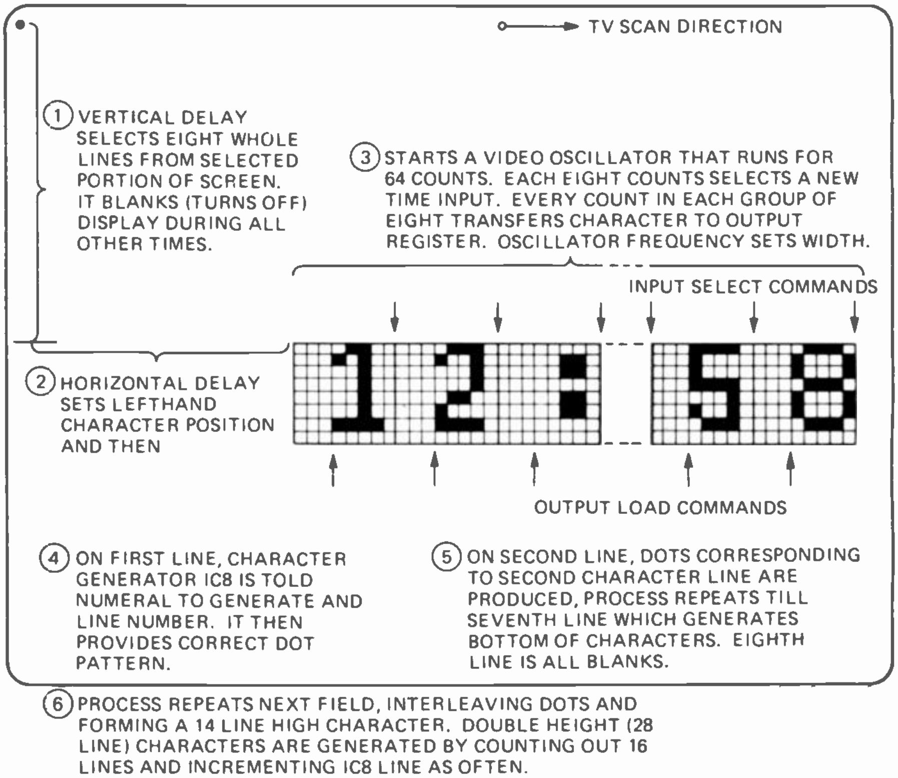



**FIG. 2—TIMING OF A SINGLE FIELD**

## Choosing a character

We could get by with a numeral 3 dots wide by 5 dots high, but it wouldn't be very pretty, and there's no standard IC that will do the job. Instead, we use a computer standard 5-dot-high number or letter that we can ge out of a standard ASCII alphanumeric character generator IC. To keep the timing simple and to still allow enough circuit setup time, we use three blank "udots" between each character. We also let the timing run for an eighth line at the bottom, generating all blank undots. This gets us by with a standard divide-by-eight counter.

While a seven-line-high character would do the job, it would be very small. It would also mean that you would have all sorts of interlace problems. So, we go to 14 lines of character height, putting identical information on both fields and solving both problems at once. Now, if you want the same thing to seven *pairs* of lines on *each* field, and end up with a 28-line-high character. Thus you have a choice of two possible character heights.

Now, we somehow have to get the right part of each numeral in the right place at the right time. This is what the Revideo unit is all about.

At the beginning of a field, a vertical trigger pulse trips a monostable delay that sets the vertical position of the numeral display. (Step 1, Fig. 2). Since the monostable could end up anywhere on the screen, it tells a *synchronizing* circuit to pick up the *next* eight *whole* horizontal lines and to allow a video output only during those lines. We use the first seven lines for numeric output; the final line is a blank. If, instead, we are using the double height characters, the *next* sixteen *whole* horizontal lines are picked, presenting 14 lines of numeral and 2 lines of blanks.

As we adjust the vertical position, the entire display moves up or down the screen to where we want it. Since the line counter is always working on *whole* horizontal lines, the vertical position control does not affect the side-to-side numeral positions, and the start of each numeral takes place on each field exactly the same distance from the side of the screen.

So much for the vertical action. Now (Step 2, Fig. 2) once each horizontal line, we start a delay monostable that tells us how far over to the right the display is going to be —this is our horizontal position control. After the delay is complete, a *video oscillator* is started and counts out exactly 64 counts and then shuts down. The *frequency* of the video oscillator determines the spacing between counts, and thus determines the horizontal size of each numeral. The 64 counts are grouped into eight groups of eight counts each. The first group is for the ten hours, the second for the hours, the third for a colon, and so on, out to the final eight, which are for the seconds information. The first three counts of each group is for the three blank-between-numeral undots and for settling time. The numeral undots and for settling time. The final five counts of each group are for the five possible numeral dots in each line.

The read-only memory computer character generator is the heart of the circuit. It has three input lines that tell it what line of the numeral it is working on, and six input lines that tell in which of 64 possible letters, numbers punctuation, or blanks to work on. When it is told which line of what character to generate, it outputs a group of five dots or undots that are needed for that part of that character. These five bits of information are then loaded into a shift register and marched out as video, nicely putting the right thing in the right place at the right time.

An eight-position selector switch precedes the character generator and picks the right input for each of the eight slots across the screen. The character generator combines this with an input from the line counter to decide what pattern of dots to produce. A three-count delay is allowed between the time we change the input to the character generator and load its output—this lets things settle down and gives the character generator a chance to operate. Thus, the output of the character generator is loaded into the shift register on the falling edge of the *third* count in each group of eight video oscillator pulses; the input selector is changed on the beginning of the *first* count in each group.

The character generator starts with the tops of all eight numerals on the first horizontal line. On the next line, its line counting input changes, and it puts the second row of dots down for each numeral. It continues this way down to the seventh line when it puts down the bottoms of all the numerals. The next lineis a bunch of blanks, and after that, the circuit shuts down till the next field.

## The ASCII character code

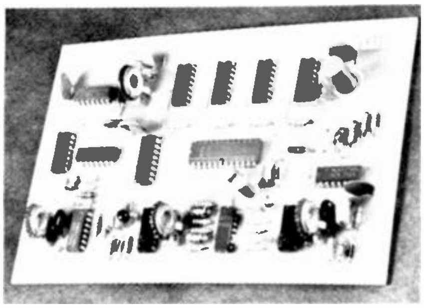
The input code for the character generator is shown in Fig. 3. The 64 possible inputs are represented by six lines. For numerals, the bottom four lines are simply the BCD or binary coded decimal representation of the numbers, exactly the same code used in the Superclock and the majority of digital clocks. If we wanted to have all the letters and numbers, we'd need a six-pole input selector. But for just numbers, we can hard-wire 1's (+5 volts) to the two most significant inputs, and we get by with only four poles worth of input selector. A colon is necely a BCD "ten," or 1010.

If we brought all the leads out, there would be 32 of them on the input. It turns out we can save on input wires by hardwiring what we aren't going to change or don't need. For instance, we can put the colons in permanently in positions three and six. We don't need the 80 hours and 40 hours inputs, so we can made these permanently zero or ground. We don't need the 20 hours input if we are using only a 12-hour display, but we do need it for the 24-hour version. Similarly, we don't need the 80 minutes and 80 seconds inputs; these can also be zeros. This reduces the input leads to 19 or 20. These can be a small flat cable (or two) a foot long

| ASCII CHARACTER CODE | | | |
|---|---|---|---|
| fedcba | | fedcba | |
| 000000 | @ | 100000 | BLANK |
| 000001 | A | 100001 | ! |
| 000010 | B | 100010 | " |
| 000011 | C | 100011 | # |
| 000100 | D | 100100 | $ |
| 000101 | E | 100101 | % |
| 000110 | F | 100110 | & |
| 000111 | G | 100111 | ' |
| 001000 | H | 101000 | ( |
| 001001 | I | 101001 | ) |
| 001010 | J | 101010 | * |
| 001011 | K | 101011 | + |
| 001100 | L | 101100 | COMMA |
| 001101 | M | 101101 | DASH |
| 001110 | N | 101110 | PERIOD |
| 001111 | O | 101111 | / |
| 010000 | P | 110000 | 0 |
| 010001 | Q | 110001 | 1 |
| 010010 | R | 110010 | 2 |
| 010011 | S | 110011 | 3 |
| 010100 | T | 110100 | 4 |
| 010101 | U | 110101 | 5 |
| 010110 | V | 110110 | 6 |
| 010111 | W | 110111 | 7 |
| 011000 | X | 111000 | 8 |
| 011001 | Y | 111001 | 9 |
| 011010 | Z | 111010 | : |
| 011011 | [ | 111011 | ; |
| 011100 | \ | 111100 | < |
| 011101 | ] | 111101 | = |
| 011110 | ^ | 111110 | > |
| 011111 | UNDERLINE | 111111 | ? |

$a = a_0$ = WEIGHT "1" = PIN 17 OF IC8 (FIG. 1)
$b = a_1$ = WEIGHT "2" = PIN 18 OF IC8
$c = a_2$ = WEIGHT "4" = PIN 19 OF IC8
$d = a_3$ = WEIGHT "8" = PIN 20 OF IC8
$e = a_4$ = WEIGHT "16" = PIN 21 OF IC8
$f = a_5$ = WEIGHT "32" = PIN 22 OF IC8
"1" = +3 TO +5 VOLTS
"0" = GROUND

**FIG. 3—ASCII CODE (The American Standard Code for information Interchange).**



**THE REVIDEO UNIT, carefully constructed, works as well as it looks.**

that plugs directly into the readout sockets on the Superclock.

## The circuit

With these operating principles in mind, let's turn to the actual circuit and parts lists of Figs. 4 and 5. The H and V inputs are conditioned with Q1-D4 and Q2-D5 respectively and then fed to monostables IC3 and IC1 for the horizontal and vertical position delays. At the end of their delay times, the pair of latches in IC2 are respectively set. The vertical latch (pins 8-12) releases the clear on a divide-by-eight or a divide-by-sixteen counter IC7 that counts out the horizontal lines used for the active portion of the display. The V size control jumper lets you pick a normal or double height character.

Once each horizontal line, the horizontal latch (pins 1 to 16 on IC2) releases a clearing clamp on the video oscillator IC4, the divide-by-eight video counter (IC5) and the cascaded divide-by-eight character counter (IC6). The video oscillator is a free running astable multivibrator when it is not being clamped by IC2. Its frequency is coarsely controlled by C11 and finely adjusted by R24, the horizontal size control. After exactly 64 counts, the H latch is cleared, the counters are clamped to 0000 and the video oscillator is stopped to await the next horizontal line.

The video counter goes around eight times and controls the output loading and spacing. It changes the input selector address just before its *first* count, and provides a shift register IC9 (Fig. 5) load count on the falling edge of its *third* count. This automaticially transfers the contents of the character generator IC8 to the output register after a three-count settling delay. Three undots, or the space between numerals is generated during the three-count settling time. The final five counts of each numeral sequence are for the actual numeral video.

The character counter goes around only once per line, stepping a four-pole, eight-position input data selector IC10-13 once around as needed, routing the report inputs to the character generator in the right time slots. Character generator IC8 receives this data, along with a what-line-is-it? command from the line counter IC7. The character generator then outputs the proper dot combination to the output register IC9 which in turn marches the dots out as video.

## Building it

PC boards are commercially available for this project, as are parts kits—see the parts list. If you are building and etching your own board instead, a full size replica appears in Fig. 6. Components are loacted as shown in Fig. 7.

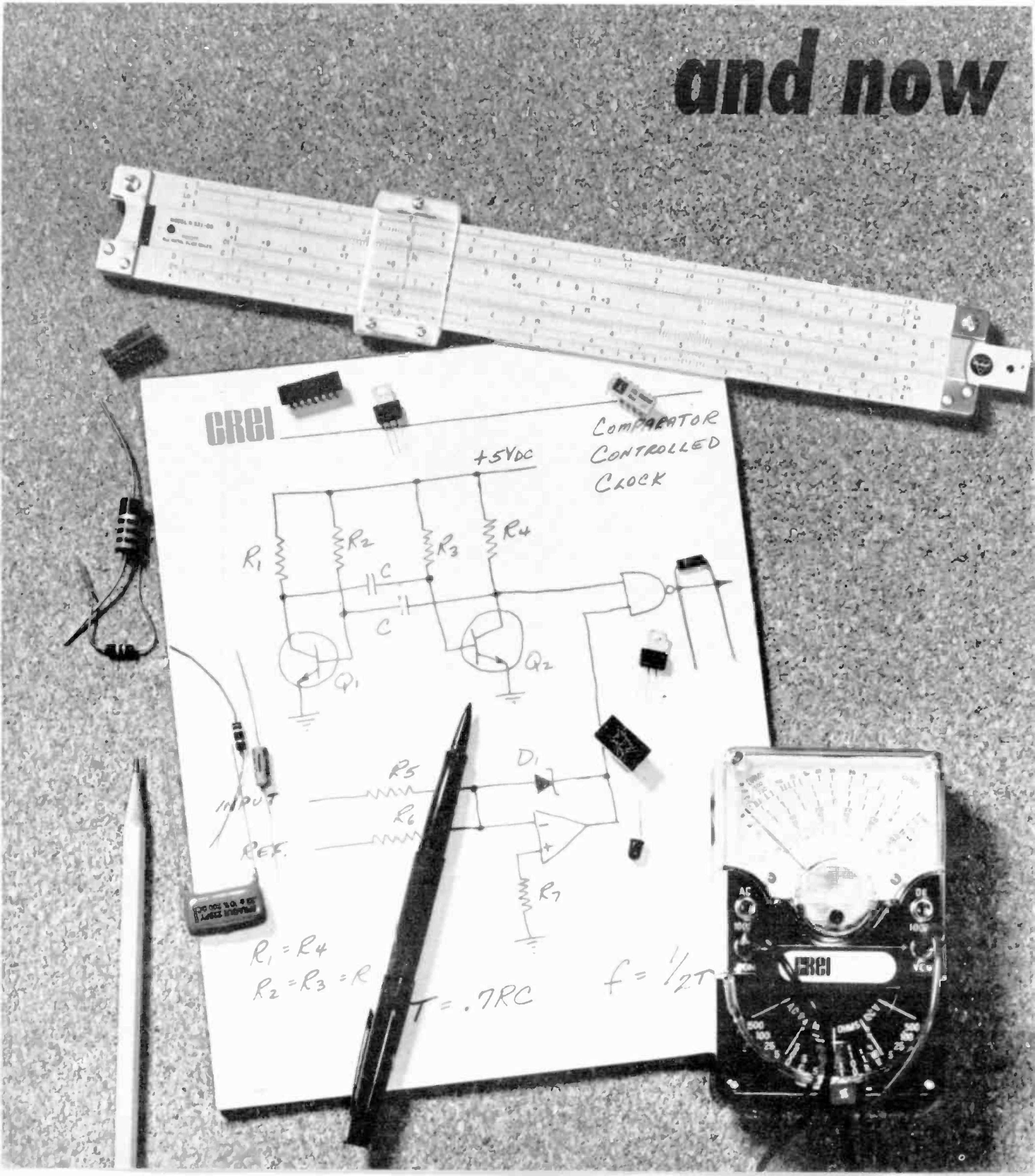
Start assembly with the jumpers and the smaller components, followed up by the IC's and finally the control pots. Use a small iron and fine solder and be sure to observe which IC goes where and the code notch and dot on each one. Also, watch out for diode and electrolytic capacitor polarities. Chances are you'll want to start with the larger character size, so jumpers the two upper "28" holes in the V SIZE box. Do not unwrap IC8 or remove it from its protective foam until you have modified the TV suitable and have *completely* tested the rest of your circuit.

## Modifying your television

You'll need three modifications on your TV. One is to provide a new video input to sum the time on top of the existing program. One is to derive a narrow, positive-going, vertical sync pulse of 3 to 5 volts amplitude across a 10,000-ohm resistor. Finally, you have to derive a suitable narrow positive horizontal sync pulse of 3-5 volts across a 10,000-ohm resistor. *Any* method you use that doesn't obviously affect the TV operation and still gets the job done is acceptable, and the best way varies from brand to brand and model to model.

Before you modify your television, sit down carefully with a complete schematic or *PhotoFact* set and locate suitable tie-in

# CREI—the only home-study college-level training



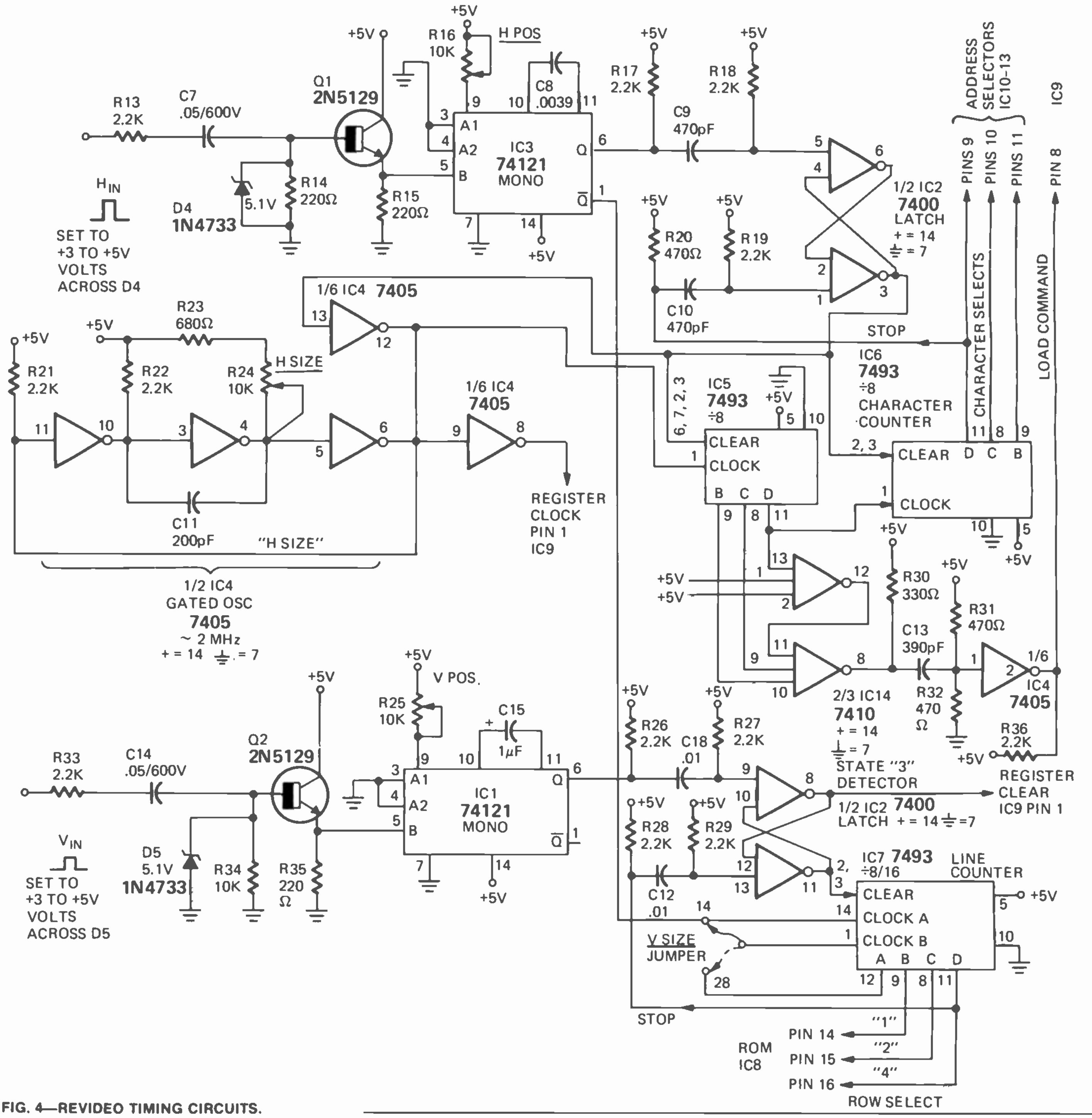



**FIG. 4—REVIDEO TIMING CIRCUITS.**

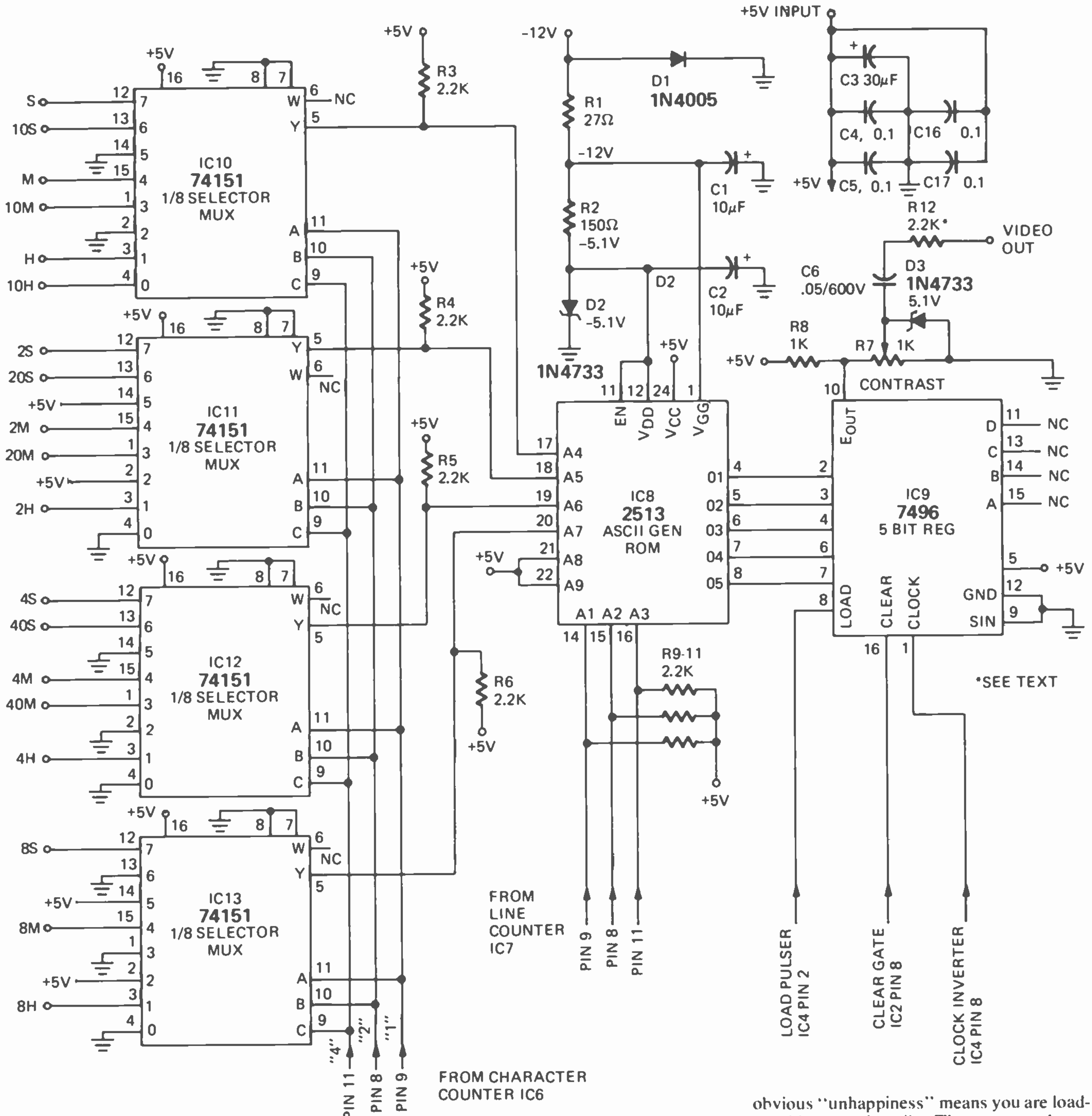
points. An oscilloscope is almost essential for this, even if you have extensive electronics experience. Fig. 8 suggets some possible interface points.

Let's start with the video. This can usually be injected into the grid or base of the first video amplifier stage, most likely through a 3,300-ohm series resitor and 0.1-μF coupling capacitor. The optimum network here is one that doesn't degrade the normal picture response, yet at the same time provides enough numeral contrast. Be sure to pick a point that gives you *white* numerals. This means a point in the circuit where more positive means *whiter*. Adjust the value of R12 for the desired numeral contrast.

On a tube TV, a whole bunch of attenuation will be required to bring the trigger signals down to size. One good place to et the vertical triger signal is the plate or col-

**COMPLETE**

C1, C2—10-μF, 15-volt electrolytic
C3—30-μF, 6-volt electrolytic
C4, C5, C16, C17, C18—0.1-μF, 10-volt disc ceramic
C6, C7, C14—0.05-μF, 600-volt mylar
C8—.0039-μF polystyrene
C9, C10—470-pF poly, mica, or disc
C11—200-pF polystyrene or mica
C12, C16—0.01-μF, 10-volt disc ceramic
C13—390-pF polystyrene or mica
C15—1-μF, 15-volt tantalum electrolytic
D1—1N4001 or equivalent silicon power diode
D2, D3, D4, D5—5.1-volt, 1-watt Zener diode, 1N4733 or equivalent
IC1, IC3—72121 TTL monostable
IC2—7400 TTL quad two-input gate
IC4—7405 TTL open collector hex inverter
IC5, IC6, IC7—7493 TTL divide by sixteen
IC8—2513 ASCII character generator (Signetics)
IC9—7496 TTL five-bit shift register
IC10 to IC 13—74151 TTL one-of-eight selector
IC14—7410 TTL triple three-input gate
Q1, Q2—2N5129 transistor
R1—27-ohm, carbon
R2—150-ohm ½-watt carbon
R3, R6, R9, R13, R17, R22, R,26, R29, R33, R36—2.2K, carbon
R7—1K upright mounting PC potentiometer
R8—1K, carbon
R14, R34—10K, carbon
R16, R24, R25—10K upright mounting PC potentiometer
R23—680-ohm carbon




**PARTS LIST**

R29—4.7K, carbon
R30—330-ohm, carbon
R20, R26, R31, R32—470-ohm, carbon
R15, R35—220-ohm, carbon

**All resisters ¼-watt unless noted**

**Miscellaneous**

**PC Board,** 4×6½ inches; PC terminals, optional (25); No. 24 wire jumpers and sleeving; mounting hardware; Flat 16-conductor input cable (2 lengths); solder; TV interface connector and lead kit (optional); gating switch (optional);

NOTE: The following is available from Southwest Technical Products, 219 West Rhapsody, San Antonio, Texas, 78216; Circuit Board, etched and drilled No. RV-1, $2.85 (IC's are considerably cheaper from surplus and volume suppliers listed in **Radio-Electronics** ads than could be offered as part of a kit—the kit is thus split to give the **Radio-Electronics** reader the lowest possible unit price.)

lector of the vertical output stage. This will be several hundred volts high and a suitable narrow, positive going spike. Cut it down to size with two series 470K, 1-watt resistors and a .005-µF, 600-volt coupling capacitor. Use two series capacitors if the voltage is higher. When the network is added to the TV, nothing drastic should happen. A slight change in picture height or hold setting might occur, but any tearing, breakup, or obvious "unhappiness" means you are loading things too heavily. The attenuated output has to drive a TTL monostable. It should stay below 0.8 volts most of the time; the narrow positive portion of the output should be 3 to 5 volts high with the Revideo unit connected. Unconnected, the signal should be *twice* as great (6-10 volts).

Don't try using the horizontal output stage as a trigger point—besides being lethal we coulddetune the flyback and cause all sorts of problems. So, look around for another, tamer narrow horizontal trigger pulse. On older tube TV's the plate of the agc keyer should have a several-hundred-volt narrow positive pulse suitable for our needs. Attenuate it down to the same size as the vertical trigger is—mostly below 0.8 volts except for a narrow, 3 to 5-volt positive pulse with the Revideo unit connected, 6-10 volts on open circuit.

Which transistor TV's, the voltages generally will be lower and somewhat less attenuation (lower value resitors) will be

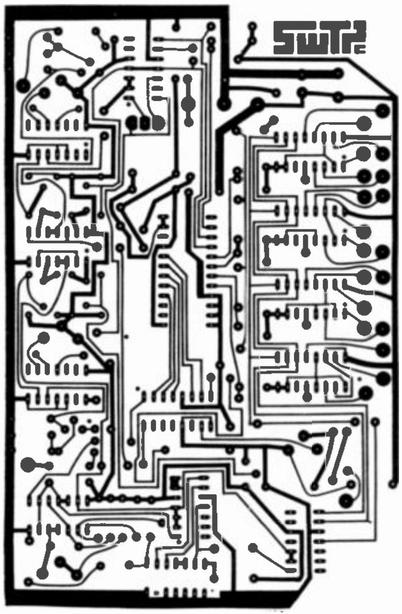


**FIG. 6—LAYOUT OF THE PRINTED CIRCUIT BOARD, one-half actual size.**

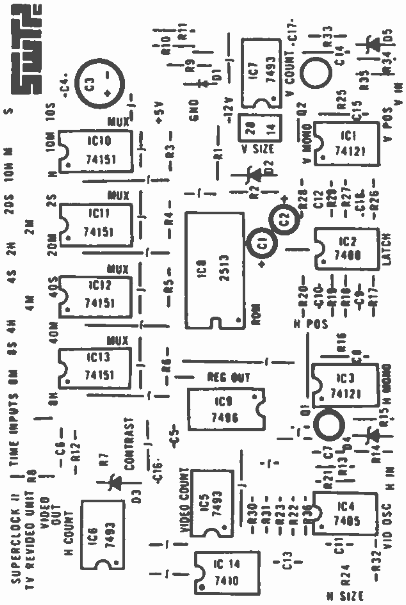



**FIG. 7—THE COMPONENTS LAYOUT.**

needed. Since the total energy you need for triggering is negligible compared to the normal circuit needs of the TV, you should have no problem after a try or two. Above all, work with the schematic and the scope when you're modifying the TV and don't connect the Revideo unit up until you are *sure* you have safe and reasonable trigger signals. Remember that connecting the Revideo unit will cut the trigger amplitude in half—from 6-10 volts to between 3 and 5 volts.

## Preliminary checkout

You'll also need a ground lead between the TV and the Revideo unit. A complete set of system interconnections is shown in Fig. 8. *Remember that if the TV has a hot chassis you'll have to use an isolation transformer or live with a completely "hands off" system!*

Leave IC8 uninstalled and the clock unconnected for the initial checkout. Apply suitable supply power and complete the television set to Revideo unit connections.

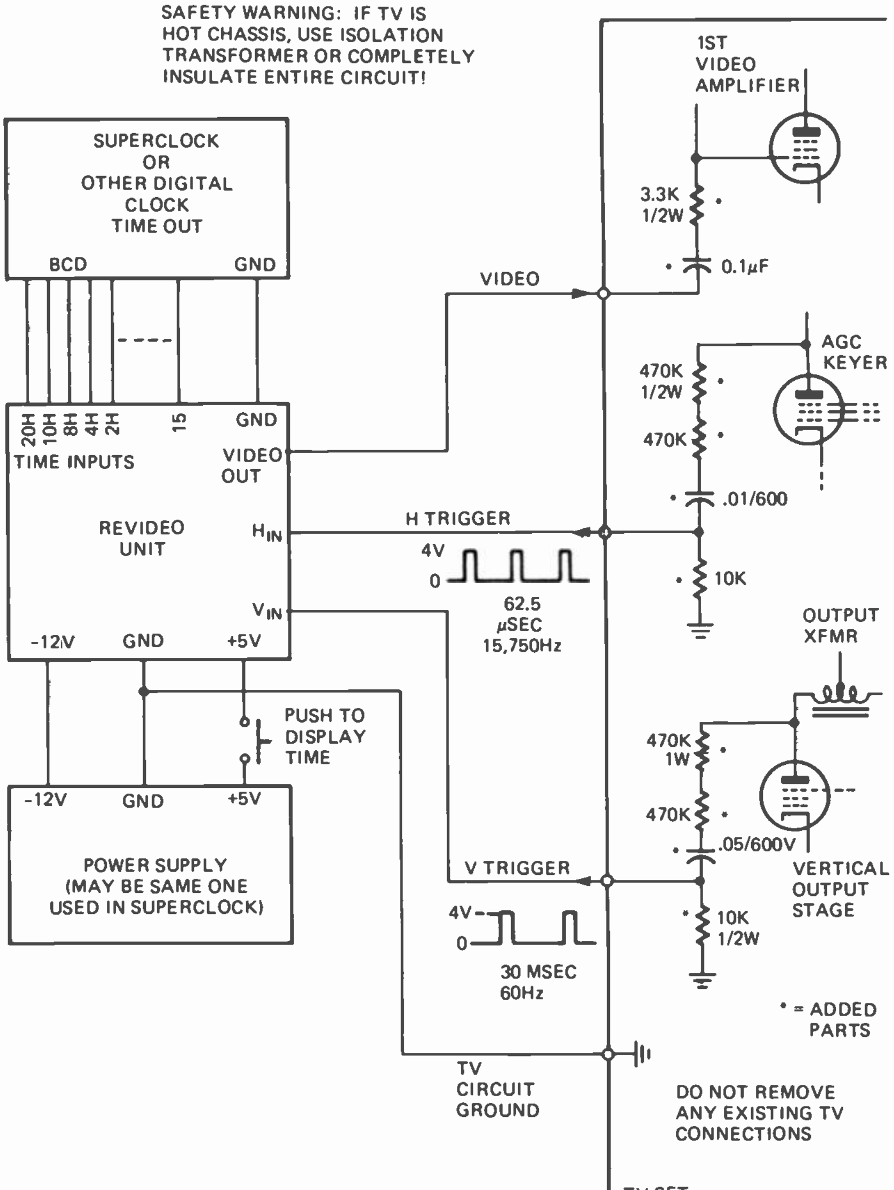



**FIG. 8—TV MODIFICATIONS NEEDED.**

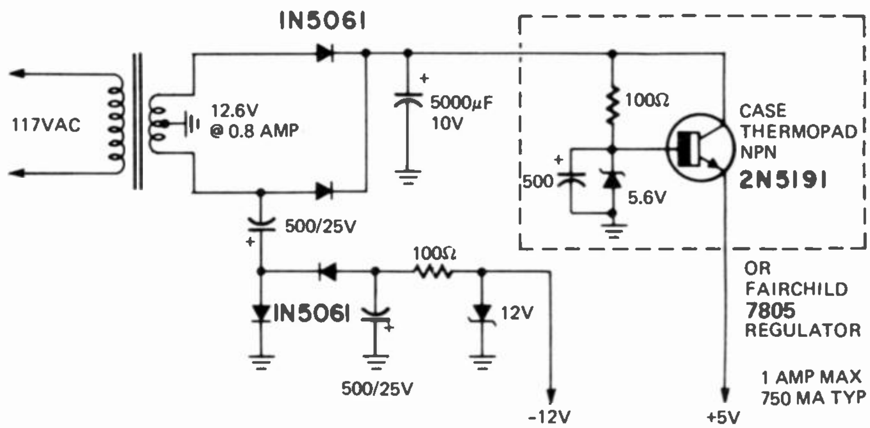



**FIG. 9 — OPTIONAL POWER SUPPLY**

(An optional power supply is shown in Fig 9; use it only if you can't get power from the clock, the TV or a handy bench supply.)

If everything is working right, you should have eight white boxes where the numerals are to go, and you can move them around and change their size as you want to.

If you don't have the boxes, use a scope to debug. Check first for proper trigger pulses on IC1 and IC3, followed by proper operation of the video oscillator and the three counters, finishing up with the output register and the stage-three decoder IC14. Usually trouble is caused by the input networks being wrong or crossed to the wrong inputs. *(continued on page 94)*

# SPECIAL REPORT

# *New Opportunities for the Service Technician*

*There's much more than just TV's and radios that require the services of today's technician. He can and shculd also be repairing electronic ovens, calculators, hi-fi gear, PA systems, burglar and fire alarms, videotape and electronic controls*

**by LARRY STECKLER**
**EDITOR**

FOR THE PAST SEVERAL YEARS, I HAVE HAD THE GOOD fortune to meet with and talk to electronic service technicians from all parts of the United States. And to me, the most remarkable thing is how much alike they are. For whether they come from New York City; Des Moines, Iowa; Bath, Maine; Houston, Texas or Hot Springs, Arkansas they are all performing the same kinds of tasks and they all have the same kinds of problems, the same needs, the same aims and the same pressing desire to earn a better living this year than they did last year.

But the one thing that does not seem to make too much sense is the vast number of shops that repair only TV or only TV and radio. With the huge amount of consumer electronic equipment that is in every home these days, it seems to me that the technician who limits himself to servicing only TV or only TV and radio is letting a tremendous amount of other business go to someone else. Because you can be sure that someone is making money repairing calculators; someone is making money working on hi-fi equipment; someone is putting dollars into the bank from work he did on alarm systems. So let's take a look as these other products and see how and where they might fit into the service technician's capabilities and work patterns.

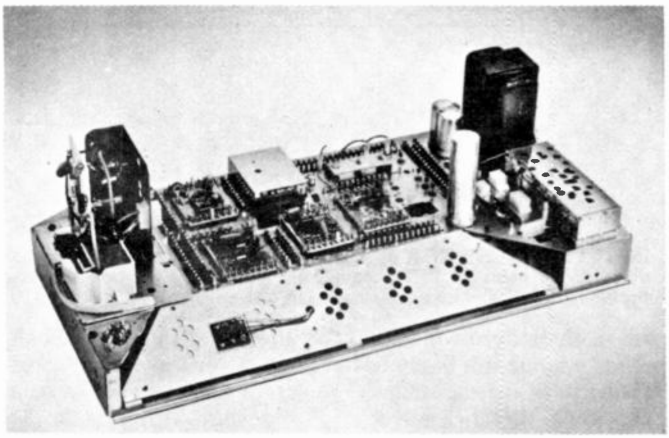
### Hi-fi components and systems

Next to the TV set, you will probably find more hi-fi equipment in your customer's home than any other product. And if he's an average person, he's spent from $250 to $1000 or more for it. And when it isn't working properly he'd like to get it fixed. And you can fix it for him! We all know there was a day when you could repair a simple phono amplifier with little more than a voltmeter and perhaps, in an extremely difficult case, an audio oscillator. Well, those days are gone. If you are serious about doing hi-fi repair work you're going to have to invest in some $2000 worth of test gear. Because today when a hi-fi amplifier stops working, the consumer wants you to do more than just restore the sound. He wants you to restore the original performance levels the manufacturer built into that equipment.

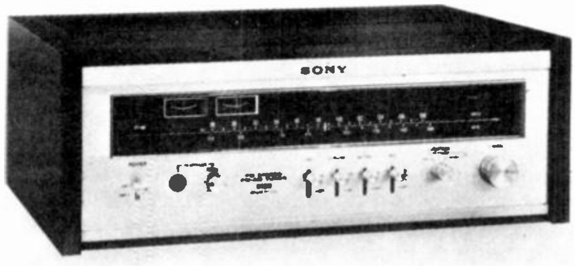
What does that really mean? It means that he wants the full 20, 40 or 60-watts per channel that the amplifier delivered when it was new. He wants that less than 0.5% distortion. He wants the original high sensitivity and selectivity of his tuner restored. You just can't do this kind of job with a voltmeter and audio oscillator. If you want to see what kind of equipment you really need for hi-fi service turn to Len Feldman's article in this issue (page 61) and find out.

### Take a look at calculators

One of the hottest new electronic products on the market today is the electronic calculator. Ranging in price from as little as $19.95 to as much as $800 and more, they seem to be

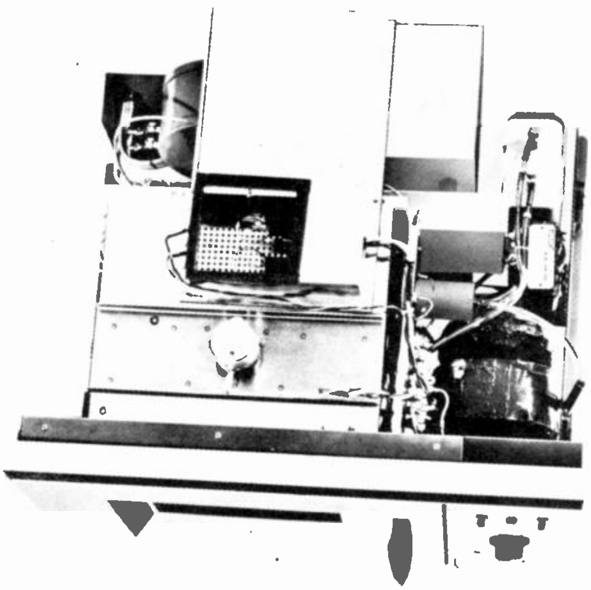


MODULAR TV CHASSIS IS WHAT MOST TECHNICIANS are servicing today. But it represents only a small portion of the total number of consumer electronic devices in use today.




TYPICAL HI-FI COMPONENTS LIKE THIS ONE need service too. It takes some special test equipment and some additional service literature, but is a natural "extra" to try.

## ELECTRONIC OVENS



Foods are heated in the microwave oven by the absorption of microwave power. All food is constructed of many millions of molecules per cubic inch. These molecules react to the microwave field in much the same manner as a compass needle reacts to a magnet. If you place a magnet to one side of the compass, the needle will then point to the magnet. If you then move the magnet to the other side of the compass, the needle will turn and again point to the magnet. When this process is repeated quickly and many times, eventually the friction in the bearing that supports the needle will heat the bearing.

The molecules in food react in a very similar manner to the changing microwave field; that is, the molecules tend to align themselves with the field. The molecules that make up the food which is cooked in the microwave oven are rotated from their starting position to 180° from their starting position and back to their starting position 2,450 million times a second. This rate depends upon the operating frequency of the oven and can vary from oven-to-oven. This constant and rapid rotation causes the food to get hot. As the microwaves penetrate the food, power is lost to each successive layer of molecules. The center molecules, therefore are not rotated a full 180° and less heat is generated towards the center of the food than at the outside of the food.

Contrary to popular belief, food prepared in a microwave oven is not cooked from the inside out, but is cooked all the way through at the same time with more cooking being performed on the exterior of the food. It is, therefore, possible to prepare a rare, medium or well done roast in a microwave oven.

The fact that food is heated throughout makes it possible for the microwave oven to cook food fast. Time required to cook an item in the microwave oven is solely dependent upon how much heat is required, and in turn the amount of heat required of the food and the weight of the food. In conventional cooking, only the surface of the food is heated directly by the oven or grille. The heat required to cook the inside portion has to be conducted from the surface.

everywhere these days. Now obviously, you are not going to find too many people who want their $19.95 machine repaired, but if they have $150 or more invested and that machine breaks down, they are not going to run out and buy a replacement. And there is no reason why you can't get in on those repairs.

You don't need any special equipment. You do need some special knowledge. The technical end you can get from an article that has already appeared in **Radio-Electronics**. It's "How to Keep Electronic Calculators Running" and it appeared in the August 1973 issue. You will also have to do a bit of homework—find out who makes calculators, get the necessary service data, find out where to get the special parts you will need, and then let your customers know that you repair calculators.

### Electronic ovens

The electronic oven (microwave oven, radar oven, etc.) is really an electronic device. Yes it is an appliance. But basically it is electronic and compared to a TV set or hi-fi equipment or even a calculator it is a simple device. The only special equipment you will need, if you intend to service this equipment is a leakage detector. Your regular vom will take care of everything else. Again, some special briefing is needed, schematics are a must, and a look into sources of replacement parts must precede any announcement that you accepting these devices for repair. For a little more information on electronic ovens see the story on page 44.

### Don't overlook PA

Public-address systems go sour too; and when they do, the customer's usual concern is how soon can I get it back? So the prime service you must be able to offer your PA customer is speed. Fortunately, PA systems are not difficult to troubleshoot. For the most part you face a relatively ordinary amplifier, some elaborate speaker wiring and systems, plus a microphone. Again, no special techniques or equipment are needed. Even most of the replacement parts you are likely to need will already be in your inventory. The only items you are not likely to have are the line-matching transformers. But these seldom require replacement so you can pick them up when needed. By the way, a PA system is a great item to cover on an annual maintenance contract. It can not only bring you some income without having to do any repairs—you may have years without having to do any

**VIDEOTAPE RECORDERS MAY SOON BECOME everyday fixture as common as color TV in the home. Are you ready to start servicing them? Do you know how they work and how to repair them?**

repairs—you may have years with no service requirements at all—but it locks the customer into your shop for service.

### Alarm systems

Here's an electronic system that suffers more from mechanical problems than electronic ones. The most common failures turn out to be window switches that don't work, a broken foil or a gap in the wiring somewhere. Yes, there are electronic faults that develop too but they are rare.

A good stock of normally open and normally closed switches plus a variety of transducers for special purposes will probably complete your extra parts inventory. One special word of warning however, before you run out and start repairing burglar or fire alarms. In some communities a special license is required. If you need one in your area, get it before you start repairing alarm systems.

### MATV and CATV

You are probably already installing master antenna systems right now. If you are, why don't you go on to the next section of this article. If you aren't, you really should be. How many customers do you now have, who own two or more TV's plus a hi-fi system, and *do not have* a MATV system in their homes? You're right! More than 90% of them.

By installing a MATV system you not only earn some extra dollars for yourself, you make it possible for your customer to have the best possible TV and FM reception. You can minimize interference between sets and insufficient signal strength to drive two or more sets simultaneously, etc.

And once you've done several home installations you may want to look at hotel and motel work. For a complete breakdown of what this kind of job entails, see "What's New In MATV", by Forest H. Belt, in the May 1974 issue of **Radio-Electronics**.

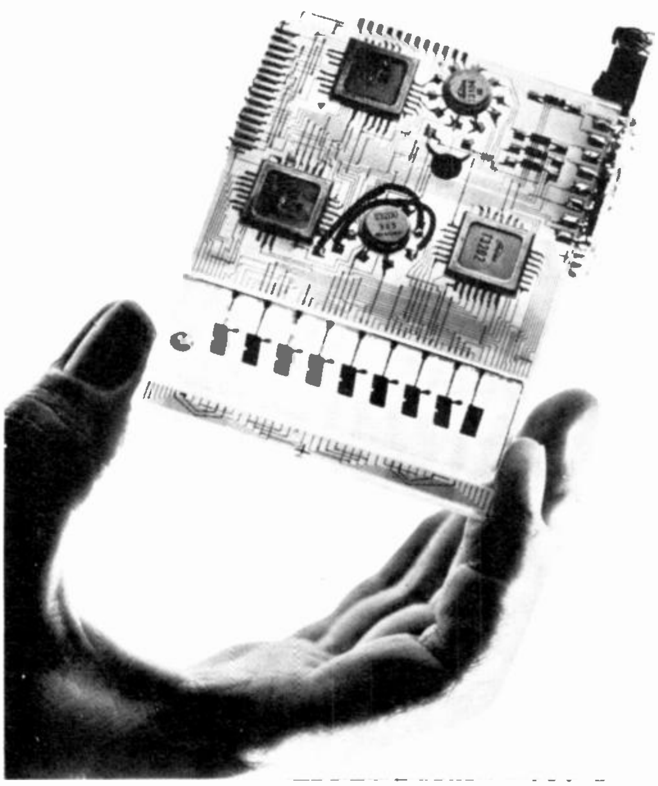
Cable television another story. In most instances the cable company uses its own personnel to handle all installations. However, if you could subcontract the installations, you might be able to get some new customers for the repair TV work out of it. You could also offer to install an MATV system in your customer's home that he could then hook up to the cable TV incoming line. If you are going to do very much of this work you'll need a truck equipped with a "cherry picker" to reach to the top of the utility poles. Also, watch out for power lines.


**MODERN DIGITAL TEST EQUIPMENT will be a big help if you move into new servicing areas. Improved accuracy and easy reading are just two of the advantages.**

### TV tape recorders

Here's an area of electronic equipment that is practically untouched. It is still so new that there is very little equipment in the consumer's home. The reason is simple—it costs too much. But the price is coming down and there are definite signs that the TV disc player is close at hand too (see "Here Come The Videodiscs" by David Lachenbruch,

## NEW SHARP CALCULATOR



Here's a calculator that has a special feature in its construction that rates being called a technological innovation. As you can see on the cover of this issue of **Radio-Electronics** and in the photograph above the calculator is built on a glass substrate. On this substrate are all the LSI IC's, capacitors, liquid-crystal display and wiring for the main calculator section. One small circuit board with some additional components clips onto one side of the board. The result is a neat efficiently built unit with the extra bonus of very low power consumption. A single 1.5-volt penlight cell provides operating power for 100 hours of use.

The shirt-pocket calculator is 3⅛ inches wide, 4¾ inches high on 1¹/₁₆ inches deep. It has an 8-digit floating decimal display with leading zero suppression.

As the circuit board is a sheet of glass and not an epoxy-fiberglass compound, it is not as easy to work with. Bonding componnents and soldering wiring must be done at low temperatures to keep from distorting the glass panel. Also high temperatures could damage the liquid crystal display which is an integral part of the board. So special technology was developed to make the construction possible.

How important is the result? That depends on how important the cost of operating a calculator is. Compared to some calculators, the savings in battery cost could make it possible for this calculator to pay for itself in a five year period. How important is that feature to you?

**Radio-Electronics** August 1974 and "Videotape-Videodisc" by Fred Petras **Radio-Electronics** June 1974).

The circuitry in these new devices is very much like that of a TV receiver with some added complications thrown in. Again manuals and parts supply sources are first, but as this equipment has not saturated the consumer market yet, there's time to develop sources.

A training course in VTR repair might be a wise move. Work it in now if you can, before the rush begins and open classes become hard to find.

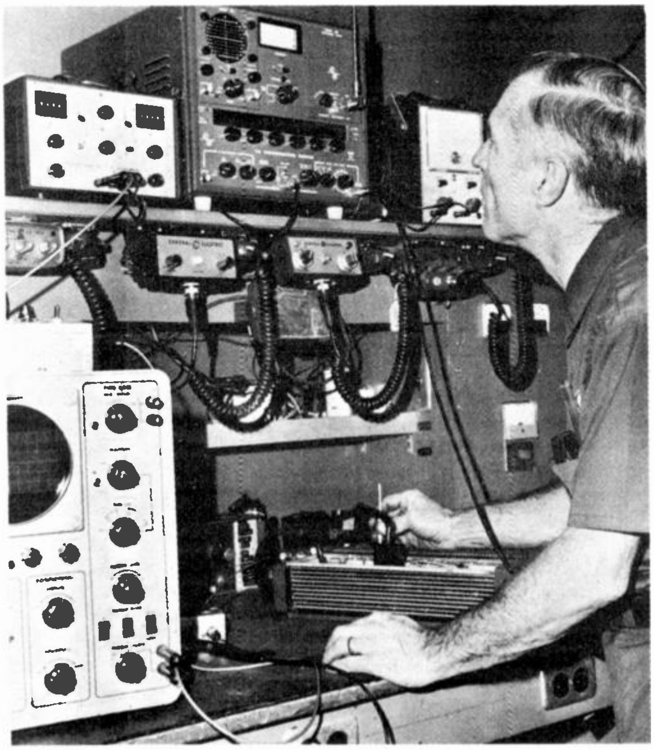
## Electronic musical instruments

This too sounds like a natural. In practice you'll find that it isn't. The special requirements of the musician are not for you and you will probably do best to leave this kind of repair work to the specialist.

## Industrial controls

Here's a place you can really shine. While large plants usually have their own electronic maintenance staffs, the smaller industrial plants usually rely on their regular plant maintenance people for this kind of work. The run-of-the mill stuff they can handle but real troubleshooting is often beyond their capabilities.

One way to get some of this work is to visit local plants, find out what kind of electronic gear they have that needs maintenance and let them know that you can handle it. Then you can start off by suggesting that they call you the next time a problem comes up and eventually lead them into an annual maintenance contract.



**COMMUNICATIONS TEST BENCH could look like this one. You'll note that much of the test gear is familiar and only a few unfamiliar instruments are to be seen.**

In industrial work, there is one vital point to remember, speed of repair is pressing. Every minute equipment is down, out of service, is a minute of lost production. So if you plan on trying to do industrial work, it must be done on a rush basis.

## Communications equipment

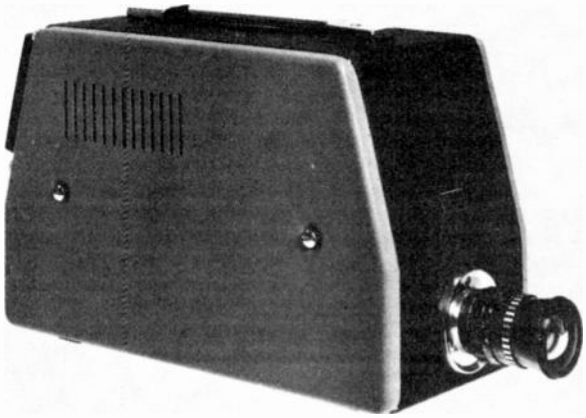
Here's another growing market. The numbers of CB gear as well as commercial communications equipment is growing rapidly. You do need some special equipment here, but in particular, you will need an FCC second class license. Without one you are not permitted to adjust frequency determining sections of this gear.

Here again, speed of service is important. If a person or a company depends upon radio communications they won't like being without equipment for long periods. And lest we forget there's lots of marine communications gear around too.

## Car stereo

As more and more people add FM and FM stereo radios to their car and as still others add 2 and 4-channel tape players and sometimes even recorders (both add-on and factory installed) more and more of them look for service once the warantee is over. This is a natural. Again you will need some special equipment—a 12-volt power supply to operate the unit on your bench and some acquired knowledge on how to get these things out of the car. By the way, the removal and reinstallation are likely to be the major problems. The electronics just isn't that difficult. One other requirement especially in cold climates, is a warm, indoor place to work while removing or installing equipment.

Installing tape decks in cars that don't have one can be profitable too. You can either make arrangements with a dealer that sells them to do his installation work or you might even consider carrying a line of your own that you could sell and install.



**CLOSED-CIRCUIT TV CAMERAS ARE GROWING MORE COMMON too. You'll see them as a part of VTR systems as well as part of surveillance systems. And they do break down too.**

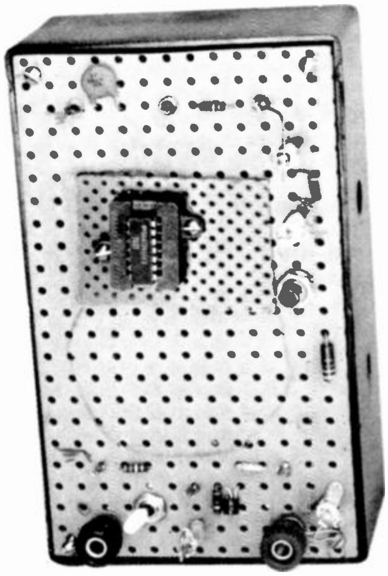
## TV cameras

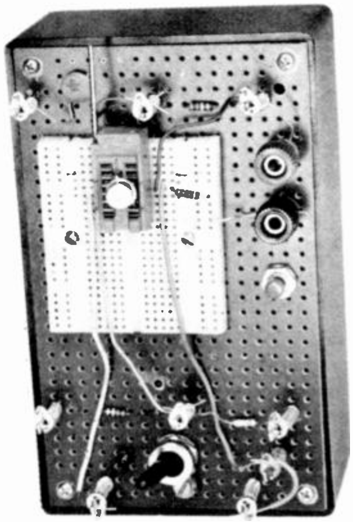
More and more low-cost units are appearing. You find them in catalogs of just about every electronics mail-order house. They are used with video tape recorders of course, to see who's at the front door, as a check on shoplifters and in dozens of other applications. But this means that there are plenty of TV camera repair jobs around too. How much of this work are you getting?

## Wrapup

In this article we've only tried to touch upon the more common possibilities that are open to the technician. We are certain that many readers are already doing these kinds of electronic service as well as others that we have not mentioned. In this direction you can help. If you've come across another area of electronic service that can be profitable, drop us a line and let us know. We'd like to pass it along. Address your letters to Editor, Radio Electronics, 200 Park Avenue South, New York, N.Y. 10003. And please accept our thanks in advance. **R-E**

# BUILD THIS OP-AMP TESTER





*The knowledge that you are using a good IC is essential as you begin to work or experiment with op-amps. This go-no-go tester will give the assurance that you need.*

**by SOL D. PRENSKY***

A SIMPLE AND PRACTICAL METHOD for rapidly testing the condition of integrated-circuit operational amplifiers (op-amps) is especially desirable now that these versatile devices are becoming more and more available. "Standardized" type numbers (such as the 709, 741, 101A and others) have emerged as low-cost, general-purpose op-amps that are attractive for all sorts of experimental construction projects. Moreover, they now can be conveniently obtained from retail stores and often, in untested condition, from surplus houses.

A major drawback for the experimenter, however, is the lack of any practical way of testing them inexpensively. There are formidable obstacles against arriving at even a fairly complete test for these useful devices. **When dealing with these popular op-amps, the experimenter is confronted first by a variety of packages, [e.g., the 8-pin types in metal-can (TO-5) form, or the dual-in-line packages (DIP) in both 8-pin and 14-pin configurations]. Additionally, he is faced with a long list of refined specifications on the data sheet—all making it seem that it is necessary to use very special equipment, to perform a valid functional test—even if the experimenter is only interested in quickly finding out whether the op-amp in question is in good operating condition or not.

The test method described here gets around these complications, and quickly answers the "Go-No-Go" question for all three common packages of the popular op-amp series from the various manufacturers. It uses a unique arrangement for quick-and-easy insertion and extraction of the unit in question. Then, *by concentrating only on the ability of the op-amp to function satisfactorily*, this test method rapidly determines the operating condition of the op-amp by just two strategic readings on a multimeter; (preferably a FET-VM, but also usable with a vtvm or even an ordinary vom).

* Fairleigh Dickinson Univ.; adapted by the author from his "Manual of Linear Integrated Circuits" (in press), Reston Publishing Co., Reston, VA.

** See "Text IC's 11 Ways With Your VTVM," which analyzes the internal components of only a single IC transistor array, (HEP590); **Radio- Electronics** (June 1973 issue).

## Theory of test operation

The test circuit of Fig. 1 shows the device under test (DUT) arranged in an oscillator (or multivibrator) configuration that produces a square-wave output for practically any of the widely-used "standard-type" op-amps. With the battery power turned on (S1); the multimeter set to read ac volts and connected across the output, *first read the value of this square-wave output, with the op-amp in a nominally unloaded condition*, (with the frequency-determining RC values set for a frequency around 1 kHz, and with a nominal 2K across the output, as specified for typical operation). Then, on pressing push-button switch S2, the circuit is loaded by the built-in miniature loudspeaker (in series with) the 330-ohm current-limiting resistor), and thus gives the *second output-voltage reading, under the more heavily-loaded loudspeaker combination*. The resulting audible output, plus the two readings of the voltmeter, provide the indications for the satisfactory working condition of the op-amp under both the nominally-unloaded condition; as well as with the op-amp delivering current to the load, (roughly here, around ± 10 mA). Thus, these two readings, accompanied by the audible tone, establish these two essential conditions:

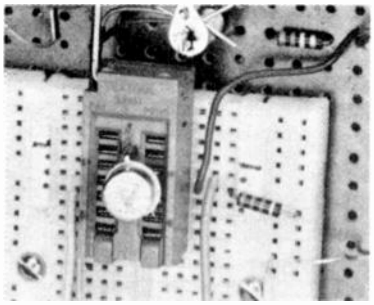
1. The ability of the op-amp to provide a *satisfactory oscillator-voltage output* (and consequently sufficient *voltage amplification)*, and,

2. The ability to deliver *sufficient current output*.

(*Note:* The interpretation of "Go-No-Go" values can be made either by comparison with a device of that type known to be good, or alternatively, from the summary of test results given in a later paragraph).

## Build your own

A choice of two breadboard arrangements for the tester is shown in the photos. One arrangement uses the unique "ZIP-DIP" (zero-insertion-pressure" DIP) adapter, which allows blissfully-easy insertion and extraction of the IC to be tested without any of the ordinary nuisance of straightening or aligning the pins of any of the three packages. The op-amp is simply dropped into the *Textool adapter* in its open (lever-up) condition, and the multiple leads of the unit are then firmly clamped into their proper contact by turning the closing lever down to its horizontal position.



**THE TEXTOOL DIP SOCKET for testing IC's. See text for details on how it works.**

The choice of sockets is given between the ordinary, inexpensive DIP socket version which requires soldering the DIP pins to respective "flea-clips" on a *Vector* perf-board, and a slightly more expensive *"universal" breadboard arrangement* that is made from a strip of the *EL SK-10 socket that requires no soldering*. Here, the connections to the multiple pins of the DUT are made by simply inserting the bare end of the connecting wire (No. 20 or No. 22) into any one of the four receptacle holes that are already wired in parallel with each of the pins of the unit.

When these connecting wires are connected to the Vector spring clips (which also require no soldering), the rest of the components required for the circuit can be externally connected to the spring clips. As a result, since none of the connections are soldered, components can be clipped and unclipped to change the circuit at will, resulting in a truly "universal" breadboard. (More of this "universal" arrangement later.)

In any case, whichever form of breadboard is chosen, the test arrangement is greatly simplified by the fact that the *circuit requires only five active leads for its operation*—and these five leads are fortunately all *in the same (or equivalent position in all of the three packages*. Because of the fortunate "standardization" of practically all of the most-popular op-amp types, this comes about in the following way:

The 8-pin arrangement is shown in Fig. 2-a for the Mini-DIP package, and in Fig. 2-c for metal-can (TO-5) type with "formed leads" (as can easily be formed by hand in accordance with the "DIL-can" form used by RCA units). For either of these 8-pin arrangements, we use only the two input leads (numbered 2 and 3, the number 6 output lead, and the two split power-supply leads: 7 as V+ and 4 as V−.

The *pin numbers for the 8-pin packages align identically with the corresponding active leads of the 14-pin package*, by the simple expedient of *inserting the 8-pin package two holes down* from the index point of the 14-pin socket as shown in dotted lines of Fig. 2-b. Since the top two pins (on either side of the 14-pin socket) are NC (no connection), as is the lowest-pin on either side, we find that remaining 8 pins in the middle of the 14-pin socket have identically the same function as in the 8-pin arrangement. Thus as seen in Fig. 2-b corresponding DIP pins are as follows:

| | 14-pin | | 8-pin |
|---|---|---|---|
| Input leads | 4 | corresponds to | two = INV (−) |
| | 5 | corresponds to | three = NON-INV (+) |
| Neg. Supply | 6 | corresponds to | four = V− |
| Output | 10 | corresponds to | six = Output |
| Pos. Supply | 11 | corresponds to | seven = V+ |

As a result, the identical connections are made, either when we insert the first pin of the 8-pin package into the third hole of the 14-pin socket, or, as obtained from inserting the 14-pin package into its socket in the usual way—and thus all three packages can be accomodated in the one simple 14-pin socket. The Textool adapter, as previously stated will plug into either the conventional, relatively-inexpensive 14-pin DIP socket, or the *EL socket strip*. (The recently announced SK-20 socket — also with solderless receptacles — is similar to the long SK-10 but is made to accomodate only a single 14/16-pin DIP. This SK-20 is convenient for a more compact tester, and at $12.75, is much less expensive. Depending on your needs, you may prefer to use one-third of a SK-10 which will accomodate two 14/16-pin DIP's or four 8-pin mini-DIP's. However, the SK-20 will suffice for testing or using a single op-amp IC. This new device is the basis for a simplified EL Starter Kit, see parts list.)

Whichever socket you chose, the main point is that the plug-in Textool adapter makes it extraordinarily convenient to drop in any one of dozens of different types of "standardized" Op Amps for this test — and, in the case of the EL socket, with the *added advantage* of being able to quickly set up any other desired op-amp circuit by simply changing components between the Vector spring clips.

In the arrangement used here some soldered connections were made for convenience in this test (but without necessarily destroying the "universal" aspect of the unit using the EL socket. The miniature (2 or 2¼ inch), 8-ohm loudspeaker is cemented to the board, and just a few soldered connections are made for the switch, LED pilot light, and the common-ground connections. The two square-bottommed (NEDA 1602) 9-volt batteries are easily fitted into the bottom of the plastic box as a ±9 volt split-supply; (these are used for extended life, although the common transistor-type 9-volt batteries can also be used to provide the limited current used by the tester). An extra Vector spring-clip is mounted next to and strapped to the V+ terminal; this strap can be removed if it is desired to monitor the current drawn from V+ by the op-amp in both the loudspeaker-load and the nominally-loaded conditions. Adding an LED as pilot indicator is optional, and its 10-20 mA current should not be an excessive drain on the batteries.

## Test results

A number of popular makes of op-amps were tried on the tester, including both good and inoperative units. The tester found every defective op-amp. Of course, where a good op-amp of a particular type is available, it is a simple matter of compare its readings with that of the unknown unit of the same type. Otherwise, as a starting point, a rough "rule-of-thumb" range is given below, to illustrate the general order of magnitude of values that might be expected.

## Rule of thumb limits

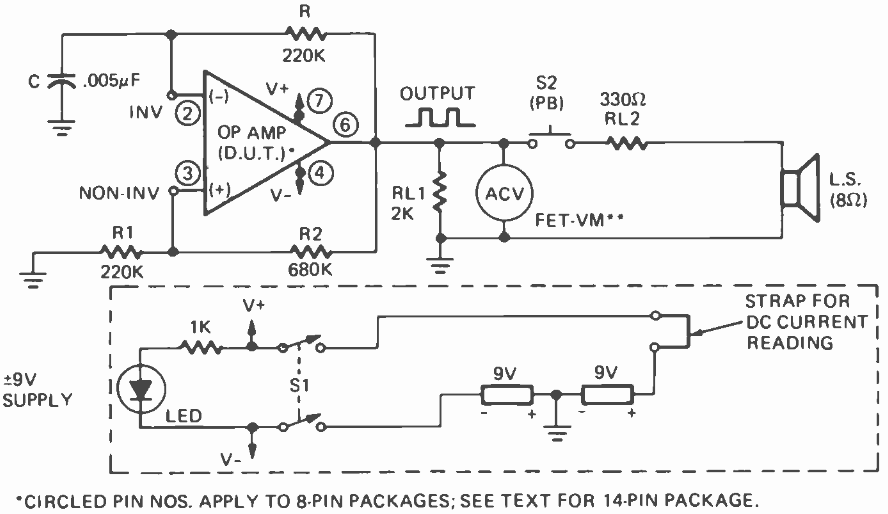
In general, the p-p value of the nominal-loaded suare-wave output should roughly approach the value of the ±9-volt supply. Then, taking into account design variations of different makes of general-purpose op-amps, and figuring on the safe side, we can set a range of p-p values to exceed *2/3 of the total 18-volt dc supply, or, in this case, from 12 volts p-p up, to indicate a good unit for the first reading*. When delivering current to the loudspeaker, we should expect at least half of the first reading, or *greater than 6 volts (p-p) for the second indication*.

## Using the meter

The peak-to-peak readings given here are all based on using an FET-VM or a vtvm. It is also possible to use a non-electronic vom on its ac range, but because of the different rectifier arrangement in the vom, its values for a square-wave output will not agree with the p-p values of the FET-VM. When using a vom on its ac range, *a rough but workable correction factor* can be used by doubling the so-called "rms" vom reading (instead of the usual 2.8 for sine-waves), to approximate the equivalent p-p value of the FET-VM, for the square-wave output.

## Sample results

Without attempting to discuss the many



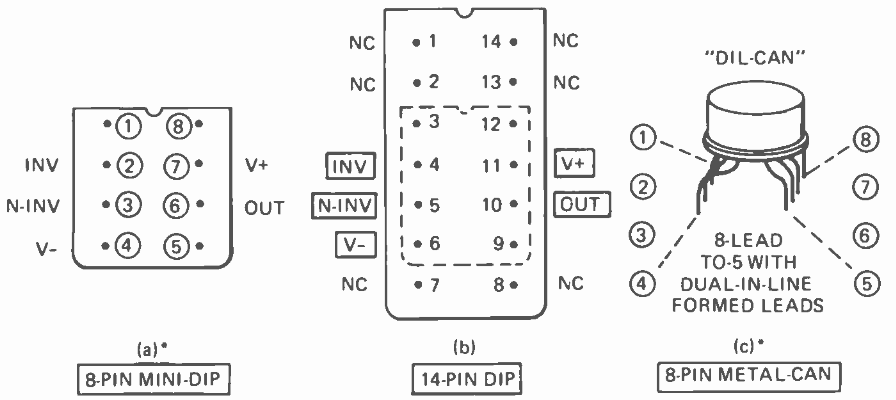

*CIRCLED PIN NOS. APPLY TO 8-PIN PACKAGES; SEE TEXT FOR 14-PIN PACKAGE.
**FET-VM PREFERRED FOR P-P READINGS; SEE TEXT FOR USE OF VOM.

**FIG. 1—OP-AMP TESTER schematic. The instrument has spring clips so wiring and components can be changed as needed. Jacks are provided for plugging in a multimeter.**

**PARTS LIST**

*All resistors ½ watt*
R, R1—220,000 ohms
R2—680,000 ohms
RL1—2000 ohms
C—.005 μF
BATT 1, BATT 2—9 volts each (for long life I suggest Eveready 246, Burgess 2N6 or equal NEDA 1602 type)
S1—dpst or dpdt
S2—push button, normally open
SPEAKER—2 or 2¼-inch, 4, 8 or 16 ohms
Perf board—with .093 holes, 3½×6 in.
Socket—standard type (requires soldering) dip. 14-pin (Cinch, Cambion, Barnes, GC Electronics or equal). Universal type (solderless) EL SK-10 (1/3 strip) or SK-20see text. (Available from EL Instruments, 61 First St., Derby, CT 06418
JACKS—to fit meter test leads

**OPTIONAL**
IC TEST SOCKET—Zip-Dip. 14-pin polycarbonate (available from Textool Products Inc.) 1410 W. Pioneer Dr., Irving, TX 75061)
LED pilot lamp—1.6 V, 20 mA and 1000-ohm series resistor
Case, plastic, to fit board.
A kit containing all the breadboard and all necessary parts for the tester except batteries and S1 is available from EL Instruments, 61 First St., Derby, CT 06148. Order as EL Starter Kit. $10.95 plus 50¢ for postage and handling.




*CIRCLED NOS. APPLY TO BOTH 8-PIN PACKAGES (a) AND (c).

**FIG. 2—THE TEST SOCKET is a 14-pin DIL type that can be used for 8-pin mini-DIP and TO-5 can 8-pin DIL devices. Drawing (b) shows how 8-pin devices are inserted.**

types of op amps that are available for special purposes, here is a brief sampling of the results obtained from op amps I had on hand at the time. These samples include both *internally and externally compensate types*. Both types can be tested in this types of open-loop circuit without bothering with frequency-compensation. As a third class of "standardized" op amps, samples of the FET-input type are included. (The "standardized" type number, which also reappears in "second-sourced" models by other manufacturers — is shown in italics). The following op-amps, (with standardized pin-numbers) all produced a clear tone and easily exceeded the arbitrary limits (12 volts p-p unloaded and 6-volts p-p loaded), as "good" units on an FET-VM for the peak-to-peak readings:

*Internally-compensated units:*

| | |
|---|---|
| CA3100S (RCA) | MC*1556* (Motorola) |
| LM*107* (National) | SN52771 T.I.) |
| µA*741* (Fairchild) | HEP, C6052P, similar to MC*1741*; |

*Externally-compensated units* used without compensation):

| | |
|---|---|
| LM*101A* | SN52770 |
| µA*709* | HEP, C6053P, similar to MC*1539* |
| µA*748* | |

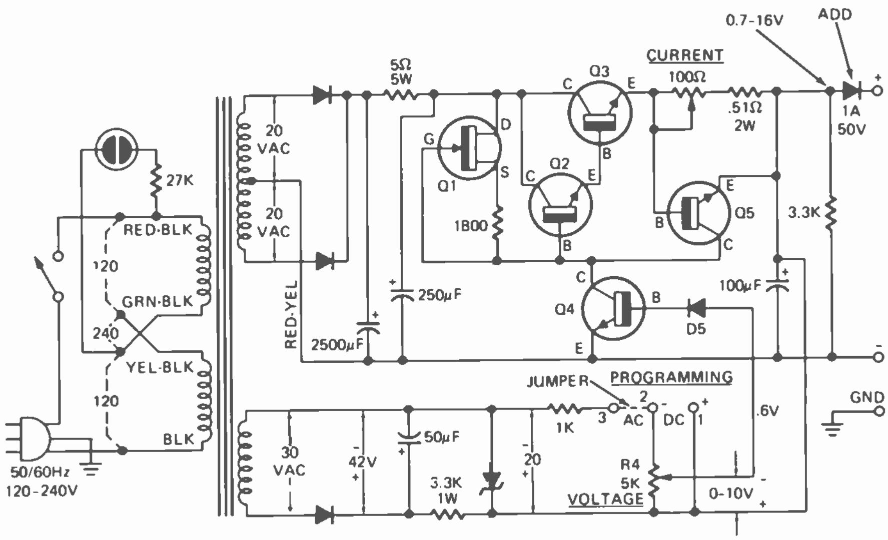
*FET-input units:*

| | |
|---|---|
| µA*740* (Fairchild) | NE536 (Signetics) |
| ICL8007 (Intersil) | AD503 (Analog Devices) |

This list could be broadened to include op amps that do not have the "standardized" pin numbers by the use of the solderless "universal" form of breadboard. In that case, it is a simple task of only minutes to change the pin connections to the Vector spring clips, and thus be able to accomodate dual op amps (such as the 747 type) and many other special types, as desired. **R-E**

## HEATHKIT IP-18 POWER SUPPLY

This type of power supply is extremely susceptible to damage from reverse voltage applied to its output. If voltage control R4 is turned down when a Ni-Cad battery is connected, for example, excessive current may flow through D5 and Q4. Depending upon the failure mode of Q4 and the length of time power is left on, Q2 and Q5 may also fail. The solution is to connect a 1-ampere silicon diode at the output as shown. Simply remove the blue wire from the "+" terminal on the circuit board and connect it instead to the cathode of the new diode. Solder the anode of the diode into the "+" terminal of the board and the job is complete. — *Donald R. Hicke*




## POOR MAN'S BINDING POSTS

Binding posts are expensive these days and they take up lots of space, particularly when you are working with small components like IC sockets.

Here is how you can make your own binding posts for an IC test socket. Drill holes to pass 4-40 screws where you want a binding post. Fig. 1 shows

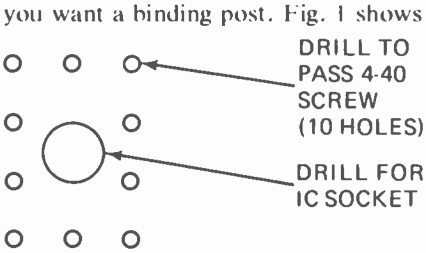



FIG. 1

the square pattern I use for a round 10-pin IC socket. It is easier to start with perforated board and simply widen existing small holes. Also, you will need a larger hole at the center (S) into which the IC socket fits. Cement the socket in place.

Now *cement* a 4-40 nut under each hole as in Fig. 2. Use any good epoxy.

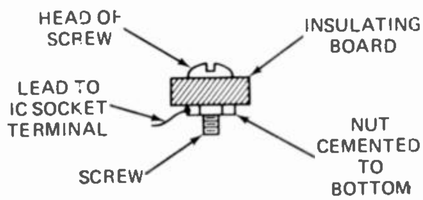



FIG. 2

When the glue is tacky enough to hold the nut fairly well, insert the screw from the *top* and tighten it. This holds the nut in the correct spot under pressure until the epoxy hardens. Make sure the screw is free to turn within the nut; don't let glue get *inside* the nut.

When finished, solder a lead between the nut and a terminal of the IC socket.

To use the binding posts, simply raise the screw, insert a lead under the head and tighten. If desired, you may use an open type *lug* instead of just a *wire*. This method is far more convenient than soldering and unsoldering wire during an experiment. — *I. Queen*


*"Not me lady–I'm just here to fix the TV."*

# What's a RAM?

*The vocabulary of engineers or experimenters working with computers, synthesizers, electronic calculators and similar digital devices is replete with acronyms you should know. RAM is one, read on to find out what it is and how it's used.*

**by DON LANCASTER**

ANY MEMORY IS A STORAGE DEVICE THAT is given some information at some time and hopefully will return that identical information at a later date for reuse at least once. The most elemental unit of a memory storage system is the *cell* which can store one *bit* consisting of a "1-0" or "Yes-No" simple decision. Memory cells are often grouped into *words* of several bits each. These words can represent the number in a calculator, an instruction command in a computer, a tone and its duration in an electronic music composer, an alphanumeric character in a TV Typewriter and so on.

Memories can range from one bit to many billions of bits. The equivalent of the human memory is sometimes suggested as 10 billion bits while the longest memory you can buy in a single off-the-shelf integrated circuit is 4096 bits.

There are several different types of memories. You usually classify them by when, how and how often you put information in them. A *Read Only Memory* (See "What is a Read Only Memory?", **Radio-Electronics**, February 1974) has information put into it only *once*. It keeps the information inside it more or less permanently. Read only memories are often used for such things as square root, log and trig instruction *microprograms* in a calculator, for time-zone conversion in a digital clock and for many other situations where you always want the same response to your system. Some read-only-memory systems are called "table lookup" systems, for they provide an "answer" in the same way you would get it from a math handbook. A few read-only-memory systems *can* be altered, but not rapidly. This is done by erasing them with intense ultraviolet light and reprogramming them; others are altered with special voltage or current pulses. Sometimes these are called *Read Mostly Memories*.

We could also theoretically have a *write only memory* that would accept information but never return it. Contrary to some misguided and uninformed industry jokes about WOM's, these DO exist and have a very specialized use in computer programming, particularly in data stripping and formating. Still, nobody really manufactures WOM's. When you want a WOM function, you use one location of a read-write memory over and over again instead, never bothering to read it.

The most versatile memory is one that you can *write* (put information into) and *read* (receive information from) rapidly and in any sequence. Magnetic cores are typically this type of memory, although by eliminating or not using the write current generators, we can also obtain a read only function. Most cores are *destructively* read out, meaning that the information is lost the first time you use it. You then have to perform a *rewrite after read* operation and then put the information *back* into the memory cells if you are going to use the information again.

Most semiconductor memories are *non-destructively* read out in that you can accept information without physically altering the memory contents.

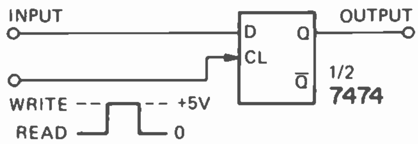
If you *must* put the information in and get it back in one specified sequence, you have a *sequential* memory. Long MOS shift registers can make a sequential memory. These have traditionally been lower in cost than true read-write memories, but have disadvantages of being noisier and having to wait a long time for the information you need to come out.

The more versatile read-write memory is one that you can read or write in any location at any time. This is called a *Random Access Memory*, or RAM for short. RAM's can be made sequential simply by deciding that you want to access or *address* things in order.

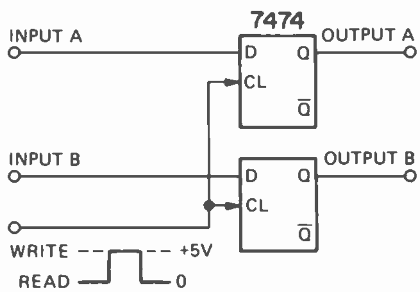
A memory is *non-volatile* if you can remove the supply power or stop moving the data around inside the memory and still hold the information. Magnetic core is usually non-volatile. Semiconductor read only memories are, of course, non-volatile. Most reasonable or available semiconductor RAM's are volatile and you must keep the supply power up or you will lose information. Many RAM's offer a reduced power mode where you can keep information for long times on battery power. In a few years, we can expect true non-volatile semiconductor RAM's, but for now, you have to design your memory application in such a way that the information is either no longer needed or stored somewhere else than in a semiconductor RAM during power down times. This really isn't nearly as bad as it seems for usually you can easily get around the problem one way or another. Often a mixture of ROM's and RAM's in a single system does the job.

There are two basic types of semiconductor RAM's. These are the *static* RAM and the *dynamic* RAM. *Both* of these are volatile and will lose information during power down times. The difference is that static RAM's will keep their information so long as power is applied without reshuffling or *refreshing* the data while a dynamic RAM has to have its internal storage moved around occasionally, often at a 500-hertz rate or faster. Static RAM's usually have a flip-flop cell for data storage. Once set or reset, it will stay in that state until power is removed or it is relr tten. Dynamic RAM's usually use a capacitor for data storage. The capacitor will eventually discharge and thus the data must be moved or *refreshed* before it is lost. Dynamic RAM's are normally far cheaper as you can pack a lot more bits onto a given size chip, but they add to the external circuit complexity and may take some elaborate timing to reliably get them to work. Thus, dynamic RAM's are more suited for very large memory systems, those over 50,000 bits or so.

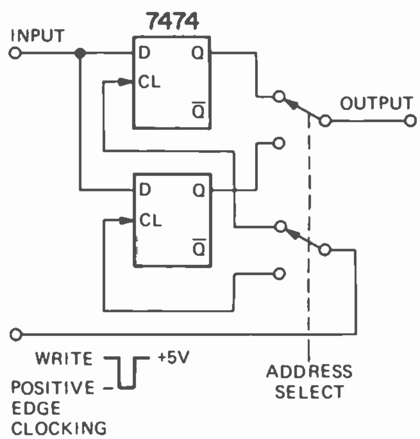
Today, you can buy a 256-bit surplus static RAM for $2.56 and get the same thing new for under $6.00. A 1024-bit dynamic




*a* ONE-BIT MEMORY

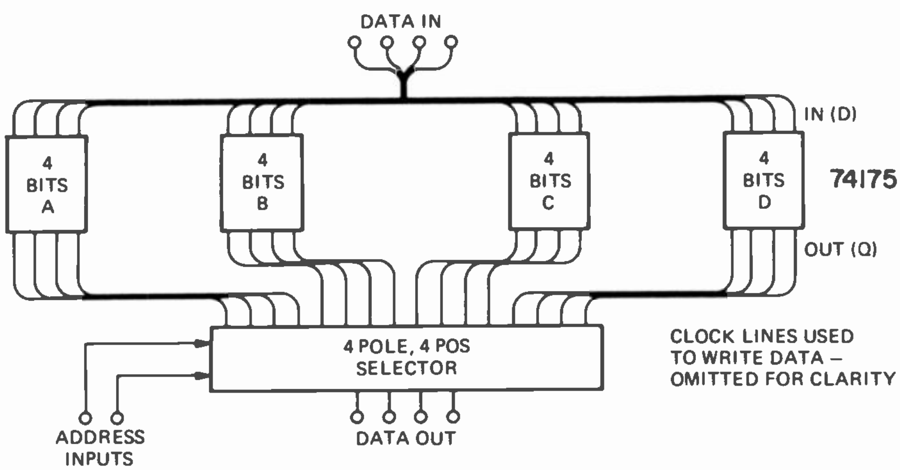



*b* TWO-BIT MEMORY,
ONE WORD OF TWO BITS (1 X 2)




*c* TWO-BIT MEMORY,
TWO WORDS OF ONE BIT EACH (2 X 1)

**FIG. 1—SOME VERY SIMPLE RAM circuits using the TTL 7474 dual-D flip-flop.**




a 4-WORD, 4-BIT-PER-WORD MEMORY USING FOUR 74175's

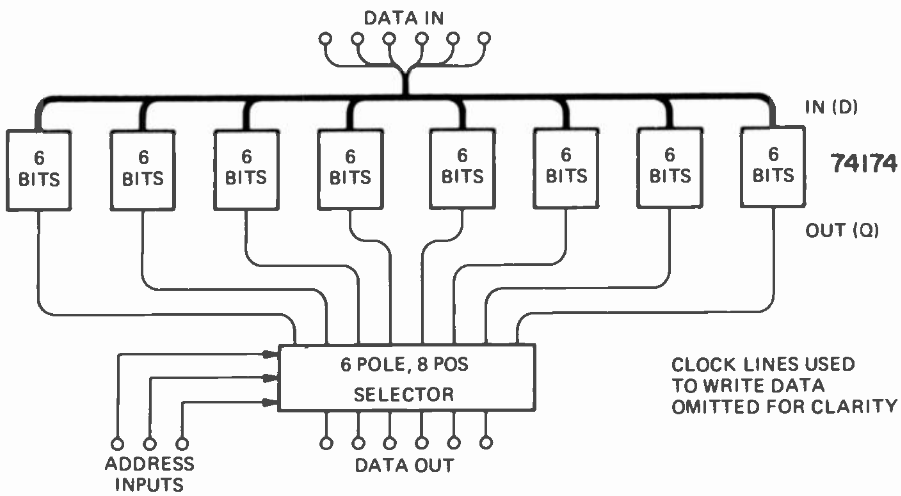



**FIG. 2—TTL RAM CIRCUITS using quad and hex latches as memory IC's.**

RAM runs around $5.00 surplus and under $12.00 new. Thus, we are talking prices *right now* of a penny per bit and under and projected pricing runs as low as *one-tenth* of a penny per bit. At this projected pricing, a minicomputer computer memory big enough to speak Basic or Fortran could be built for a memory component cost of $64.00 for 64,000 bits, perhaps arranged as 4000 words of 16 bits each. Simpler memory systems for things like terminals, electronic locks, music composers and a whole bunch of things nobody has thought up yet today should cost well under $20.00 and eventually should come down to $2.00. So, now is the time to start becoming familiar with these exciting new devices.

## A simple semiconductor RAM

Let's start with a rather small RAM and see what we can do with it. We'll use the 7474 TTL dual type D flip-flop as shown in Fig. 1. We'll start with a one-bit memory and then double it to two bits by using both halves of the package.

In Fig. 1-a, we use half the 7474. This stage can store a "1" (often a high state around 3.3 volts) or a "0" (usually a low state around 0.5 volt). The stored value appears at the "Q" output. The opposite or *compliment* of the stored value appears at the Q output. We have a data or D input and a clock or CL input. Information present on the D line gets loaded into our memory at the time the clock goes from ground to a positive value. To enter information into our memory, we put the information on the D line. At that time, it does NOT go into the cell. At the instant we bring the clock line from ground to a positive level or from a TTL positive logic 0 to a positive logic 1, we actually load or write the information into our flip-flop cell. Whatever was on D at the instant of positive edge clocking gets loaded into the memory and appears at the Q output.

This is a random access memory as we always can get to the memory cell (trivial, as we only have one cell) anytime we want. It is static as it will keep the loaded information for as long as we apply power. It is volatile as the information will go away if we ever shut off the +5-volt power supply. And our simple memory is *organized* as "one word of one bit each."

We can watch or *read* our memory any time we like, but since a change may be produced during clocking, we shouldn't be using or reading at that particular instant. We call the clocking interval the *write cycle*. Time spent looking at this particular cell's output is called the *read cycle*. Normally, you don't read and write simultaneously. You either *execute* a read cycle where you monitor and use the output of the memory cell or you execute a write cycle where you place new information into the cell. The 7474 will do a write or a read cycle in under 50 ns. Since nothing physically changes internal to the 7474 during reading, the readout is non-destructive and we can reuse the stored information hundreds or even millions of times if we like.

A one-bit, one-word memory by itself isn't too useful, although you can think of an alarm system as a one-bit memory and there are numerous other trivial applications. To do any really useful function, we most often need quite a few more bits of storage.

Figure 1-b shows how you can use both halves of a 7474 to build a memory of one word of two bits. This is done by simultaneously clocking each half of the package and using both outputs at once. Thus we have two data input lines, two output lines and one write line. This organization is *one word of two bits*. In 1-c, we have the opposite, a memory of *two words of one bit each*. Now something new has been added. We have to *combine* or *select* which of the two memory bits is going to appear as an output. We also have to decide which of the two cells is going to have data written into it at any given time. This decision is called *addressing*. We now have to address cell A (a 0 on the address line) or cell B (a 1 on the address line). By controlling the address line, we select which memory cell is to be acted upon or read.

The more cells we have, the more complicated the addressing will become. Note that we needn't alternate memory cells if you don't want to. You can address either cell in any sequence you want. Hence the name *random access*.

## Adding more bits

We could use as many 7474's as we like to build up any memory, but even at surplus prices, the 25¢ or so per bit and the large supply power and size will eventually get to us. The next step up is to use packages with more than two D flip-flops. Quad and hex latches, the 74175 and 74174 are a good choice. Figure 2 shows some memory circuits using these components.

In Fig. 2-a, we have a 16-cell memory arranged as four words of four bits each. We have four data lines, four output lines and *two* address lines. These two address lines are binarily decoded (00, 01, 10 and 11) to get at the *four* possible memory cell locations. We might use this memory to store four BCD numbers as part of a computer or calculator.

In Fig. 2-b, we use eight 74174's to build a 48-bit memory organized as eight words of six bits each. This time, we have six data input lines, six output lines, and *three* address lines. The three address lines are decoded (000, 001, 010, 011, 100, 101, 110 and 111) to get at the *eight* possible locations of six cell groups. Since we can represent a letter, number, space or punctuation with six bits of the standard ASCII code, this memory could be used to store an eight character message.

## Which organization?

Suppose we had a 64-cell memory. How could we group the cells to obtain different combinations of bits-per-word and numbers of words? Figure 3 shows some possibilities. While each of these memories is 64 bits total capacity, the *organization* of each is different.

In Fig. 3-a, we have one word of 64 bits each. We need zero address lines since we are always looking at the same word, but we need 64 input lines and 64 output lines. In Fig. 3-b, we have two words of 32-bits each. We now need *one* address line to select which half of the memory is to be written into or read from. There are 32 input leads and 32 output leads. The next combination of Fig. 3-c would be four words of 16 bits each. Here we need *two* address lines binarily decoded to select which quarter of the memory is to be active and there would be 16 input leads and 16 output leads.

You can rapidly run down the other organizations. Figure 3-d gives us eight words of eight bits each. There are three address lines needed that are decoded one-of-eight to pick one-eighth of the memory for use and we have eight input lines and eight output lines. In Fig. 3-e, we have four words of 16 bits each. Four address lines decode one of sixteen and there are four input and output lines. Two words of 32 bits each take two input lines, two output lines and five address lines, the latter decoded one- of -32 as shown in Fig. 3-f. Finally, in Fig. 3-g, we have 64 words of one bit each. There is one input line, one output line and six address lines which are binarily decoded one-of-64 to pick which of the individual memory cells is to be interrogated.

So, we have a wide choice of organizations to any memory. The more the bits, the more the choices. Which do we use?

This depends on you if you are working with a large system and depends on the integrated circuit manufacturer if you are trying to get the job done with only one or two stock integrated circuits. Obviously, you organize the memory to suit the information you are trying to put into it. Four-bit words are common for BCD (binary coded decimal) number storage in calculators. Six-bit words are often used to store ASCII characters. If the full ASCII code, including transparent control commands and lower case and error detection is to be used, we have to up to eight bits per word. Or, we might like to use the remaining two bits to select a color on a color display. We could get one of four with two bits. Minicomputers tend to use 8-, 9-, 12-, 13-, 16-, 17-, 18-, 24- or 25-bit words depending on the manufacturer and the task the computer is aimed at. So, for system's use, you pick the number of bits needed to do the job.

On the other hand, if you are a integrated circuit manufacturer, you want to have the most reasonable package in your system. The majority of semiconductor memories only have ONE input line and ONE output line and address lines for one-of-N decoding, giving you organizations such as 256 one-bit words 1024 one-bit words, 4096 one-bit words, and so on. Occasionally a smaller memory may have four bits per word, to make working with BCD numbers easier. Other arrangements are rarely used and you usually add packages to pick up the total number of bits you want.

## Decoding

All organizations in Fig. 3 have binary to one-of-N decoders on the address lines. If this decoder is internally provided in the integrated circuit as it almost always is, we have an *internally decoded* memory. If we must provide external address decoding as is common with magnetic cores, we need *external decoding*. External decoding is also needed when you have several memory packages that you are combining for a total storage. In this case, you use *output enable* or *chip select* lines to pick which package is to be used. Once selected, each individual package then goes on to provide internal decoding. For instance, with two IC's we could simply tie their inputs and outputs together and drive the first memory's chip select as an address line and drive the second memory's chip select from the *compliment* of that line. Thus, we pick one-of-two memory IC's and the chip selects give us a new form of addressing. If we tie four memories together, we use two new address lines, one-of-four decode them and then chip select only one memory at a time. Figure 4 shows how you can expand memories using the chip select system.

Unlike magnetic cores and many older memory systems, the data input and output lines are completely separate with most new semiconductor RAM's. This eliminates amplifier recovery problems, steering networks, "single port" problems and things like this.

## Who makes what?

Figure 5 is a list of my choice of the best

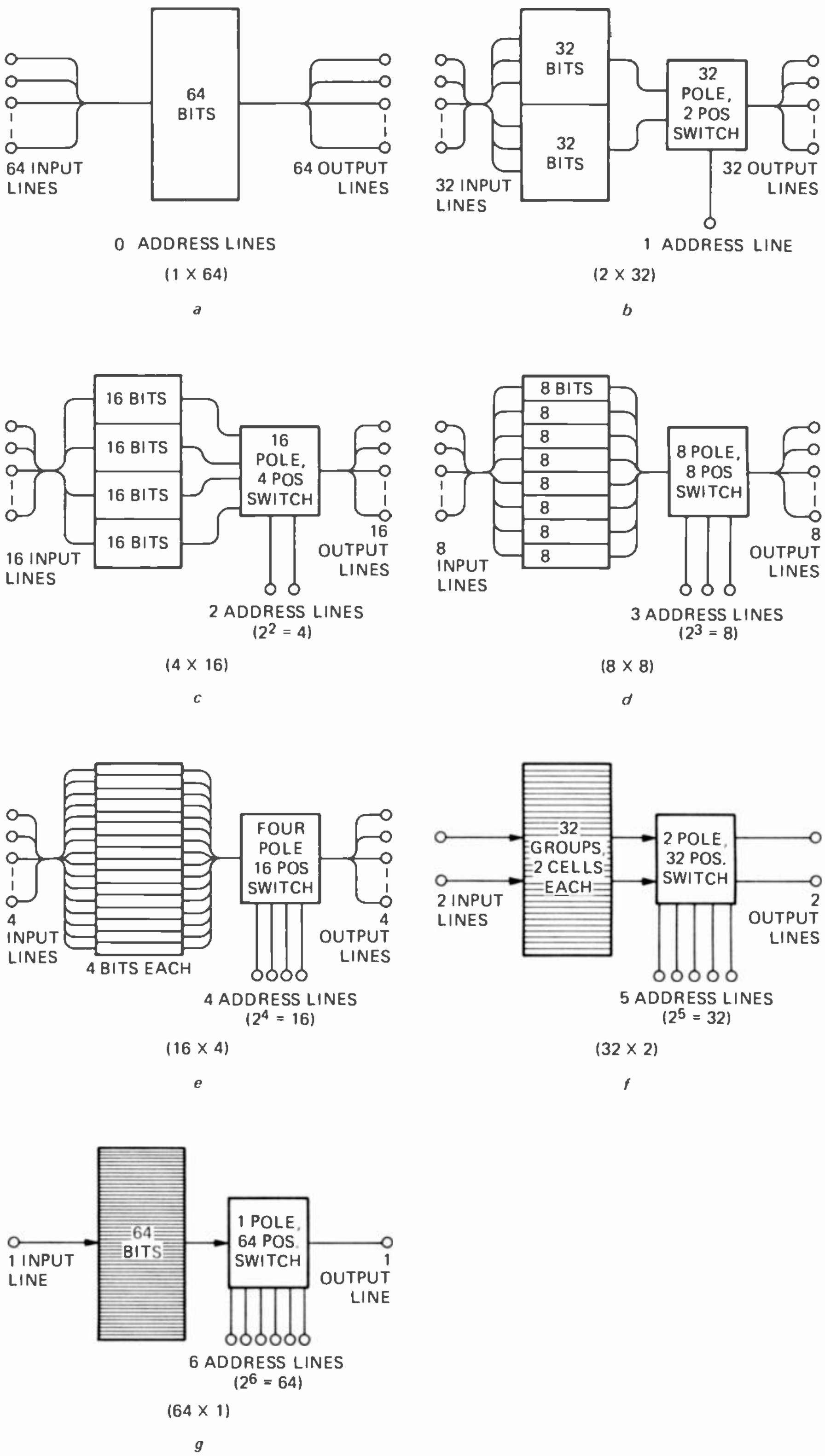


**FIG. 3—WAYS OF ARRANGING or organizing a 64-bit memory.**

HERE WE USE A NEW ADDRESS LINE AND AN INVERTER TO SELECT ONE OF TWO MEMORY IC'S. IF A AND B ARE ORGANIZED AS 64 x 1, NEW MEMORY IS 128 x 1.

WITH TWO NEW ADDRESS LINES AND A ONE-OF FOUR DECODER, WE CAN QUADRUPLE A MEMORY BY USING FOUR IC'S. ONLY ONE MEMORY IS ENABLED AT A TIME. IF A, B, C, AND D ARE 64 x 1 MEMORIES, SYSTEM IS A 256 x 1 MEMORY.

ANY NUMBER OF IC'S CAN BE USED BY ADDING NEW ADDRESS INPUTS AND 1-OF N DECODING THEM.

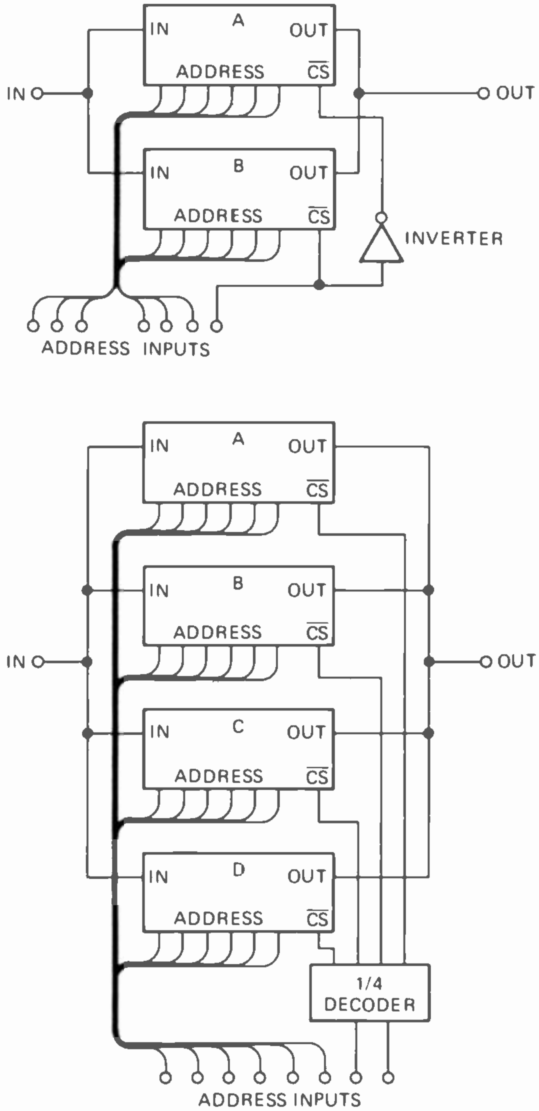



**FIG. 4—MORE THAN ONE IC can be used in a memory by using the chip-select as a new address input. Everything is connected in parallel, but only one IC is enabled at any time.**

| NUMBER | BITS | TECHNOLOGY | ORGANIZATION | SUPPLY | MANUFACTURER* |
|---|---|---|---|---|---|
| 7474 | 2 | TTL | 2x1 OR 1x2 | +5,0 | TEXAS INSTS. |
| 74175 | 4 | TTL | 1x4 | +5,0 | TEXAS INSTS. |
| 74174 | 6 | TTL | 1x6 | +5,0 | TEXAS INSTS. |
| 7489 | 64 | TTL | 64x4 | +5,0 | TEXAS INSTS. |
| 25L01 | 256 | P MOS | 256x1 | +5,-12 | SIGNETICS |
| 2102 | 1024 | N MOS | 1024x1 | +5,0 | INTEL |

*PARENT COMPANY—MANY SECOND SOURCES
FIRST NUMBER IN ORGAINZATION IS NUMBER OF WORDS; SECOND IS NUMBER OF BITS PER WORD.

**FIG. 5—SIX IC's and their basic specifications.**

ADVANCED MEMORY SYSTEMS
1276 Hammerwood Avenue
Sunnyvale, California, 94086

AMERICAN MICROSYSTEMS INC.
3800 Homestead Road
Santa Clara, California, 95051

ELECTRONIC ARRAYS
501 Ellis Street
Mountain View, California, 94040

INTEL CORPORATION
3065 Bowers Avenue
Santa Clara, California, 95051

INTERSIL MEMORY CORPORATION
10900 North Tantau Avenue
Cupertino, California, 95014

MICROSYSTEMS INTERNATIONAL
Box 3529-C
Ottowa, Canada, K1Y4J1

MOSTEK
1215 West Crosby Road
Carrolton, Texas, 75006

MOTOROLA SEMICONDUCTOR
Box 20912
Phoenix, Arizona, 85036

NATIONAL SEMICONDUCTOR
2900 Semiconductor Drive
Santa Clara, California, 95051

SIGNETICS
811 East Arques Avenue
Sunnyvale, California, 94086

TEXAS INSTRUMENTS
Box 5012
Dallas, Texas, 75222

**FIG. 6—IC MEMORY MAKERS. Write for information you need.**

current bets for experimental memory use. These are easy to use, widely available and low in cost. Leading memory manufacturers are shown in Fig. 6. As with any semiconductor work, always have the exact data sheet and as much as you can get in the way of applications information before you begin any work with semiconductor RAM's.

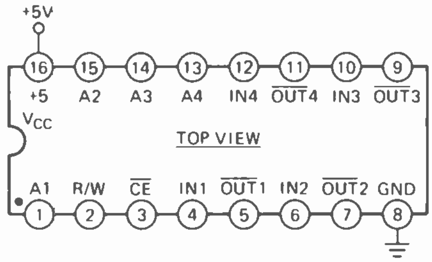
There are lots of different ways to classify semiconductor RAM's. One grouping is based on the process used. *Bipolar* RAM's include TTL and ECL logic. MOS versions include P-channel, (metal and silicon gate), N-channel, and CMOS types. In the past, MOS devices have almost always been slower and much cheaper. Some MOS memories are now as fast as TTL and most MOS devices will continue to be cheaper than bipolar for some time to come.

MOS memories are further broken down into *static* and *dynamic* versions. Dynamic versions are much cheaper and much harder to use, particularly in experimental or very small system applications.

Let's take a closer look at some specific IC's:

## 7489

The 7489 is a good choice for initial experiments with RAM's. It is TTL and works off a single 5-volt supply. Organization is 16 words of four bits each as shown in Fig. 7.




CHIP ENABLE LOW ENABLES MEMORY
CHIP ENABLE HIGH INHIBITS MEMORY
R/W LOW WRITES
R/W HIGH READS

**FIG. 7—THE 7489 IS A 64-BIT TTL memory organized as 16 x 4 or 16 words of 4 bits each (16 4-bit words). It needs a single +5-volt supply. Output information is a compliment of the input.**

There are four data inputs and four data outputs along with four address lines. The address lines are four-line-to-one-of-sixteen decoded internally. Internal circuitry is arranged so that you store and read out the *compliment* of the input information.

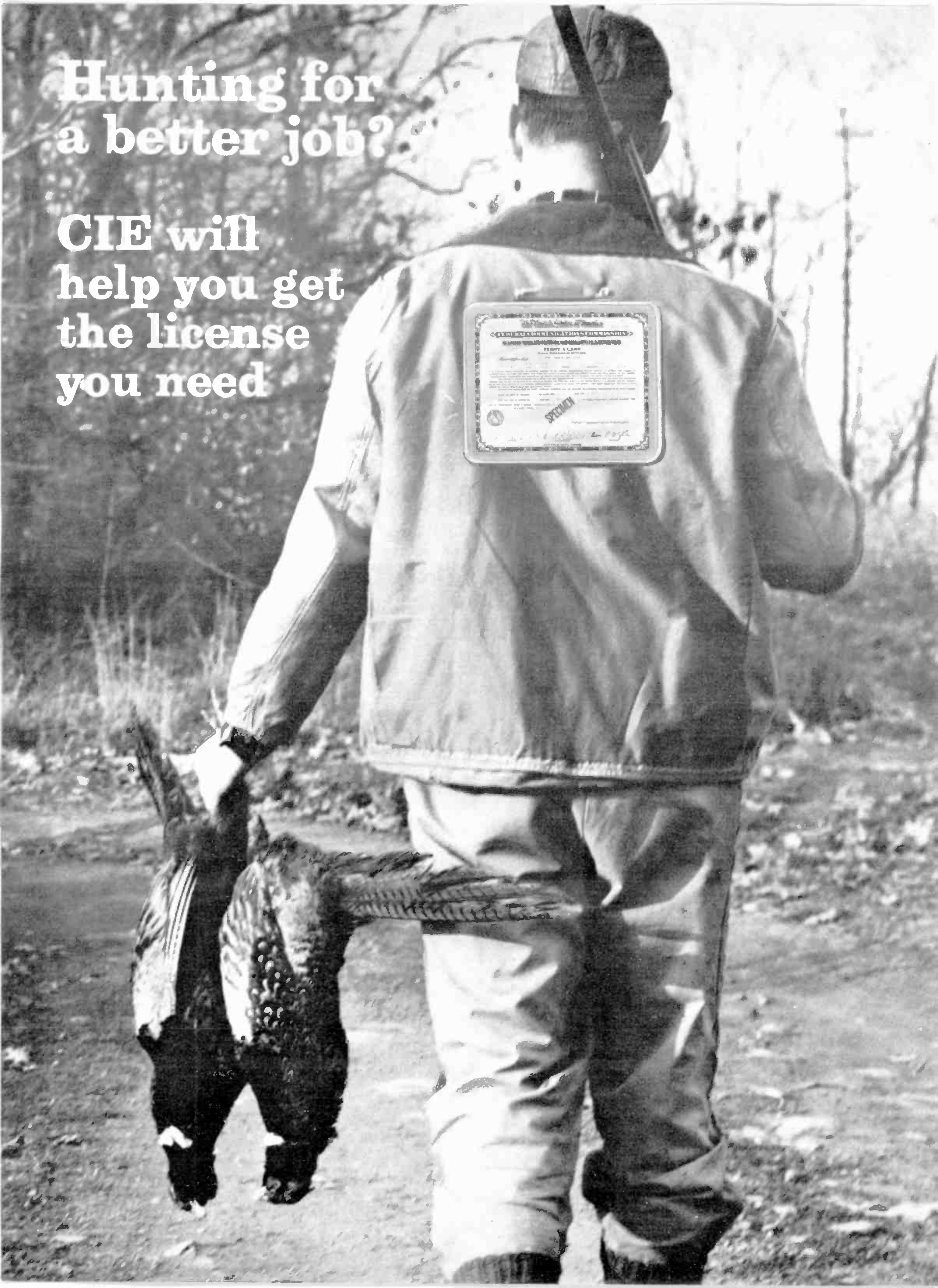
To read this memory, you apply a four-bit address to pick the slot you want to look at and then bring the memory enable line low. For instance, address 0101 selects the *fifth* group of four cells. Data appears at the output shortly after the address is stable.

To write into the 7489, pick an address, input the compliment of the data you want to store and then briefly bring the write enable low. This loads the memory.

One thing you have to watch very carefully in any semiconductor memory is that the address cannot be changed immediately before, during or immediately after a write command. (The definition of "immediately" varies with the IC—carefully consult the data sheets!) As a memory address changes, certain locations are "flashed" by in the decoding process. It is possible to write, erase or physically move data around if you aren't careful. ALWAYS *PULSE* THE WRITE COMMAND ON ANY SEMICONDUCTOR MEMORY. *NEVER* CHANGE ADDRESSES DURING WRITE PULSING! Put another way, always leave the memory in a disable or a read mode. Don't put into write mode until after the address is stable.

This particular memory cycles in under 50

*(continued on page 78)*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Richard Kihn, Anahuac, Texas, worked in the engine room of a tugboat when he started his CIE training. He reports, "Before finishing, I got my FCC License and landed a job as broadcast engineer at KFDM-TV in Beaumont, Texas. I was able to work, complete my CIE course and get two raises . . . all in the first year of my new career in broadcasting."

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# 40 PROJECTS Using COSMOS

*Are you up on COSMOS, the latest in solid-state technology?*

DIGITAL INTEGRATED CIRCUITS HAVE BEEN available for a good many years now and most readers will be familiar with common family logic names like RTL (*R*esistor-*T*ransistor *L*ogic), DTL (*D*iode-*T*ransistor *L*ogic), TTL (*T*ransistor-*T*ransistor *L*ogic) and ECL (*E*mitter-*C*oupled *L*ogic). Each of these families offers its own particular advantages when compared to the other types, but all the families share a number of common disadvantages.

The chief disadvantages of the more common logic families are, (1), high quiescent current requirements (typically 5 mA per gate), (2), tight power supply requirements (power supplies typically have to be regulated to ± 10%), (3), low input impedances (typically a few hundred ohms per gate) and (4), poor noise immunity (meaning that gates can be easily triggered by spikes on the supply lines).

Recently, a new and rather amazing type of digital IC has appeared on the scene and seems set to push all the other families into rapid obsolescence in low- to medium-speed applications. This new family of devices are known as COSMOS or CMOS (*C*omplimentary *M*etal *O*xide *S*ilicon) digital IC's and suffer from none of the disadvantages of the earlier families.

Typically, COSMOS draws the incredibly low quiescent current of only 0.001 μA per gate and can be used with unstabilized power supplies giving voltages anywhere in the range 5 to 15 volts (special versions of COSMOS can operate as low as 1.3 volts). Each COSMOS logic gate has an input impedance of about a million megohms, but is fully protected against damage by static charges via built-in safety circuitry.

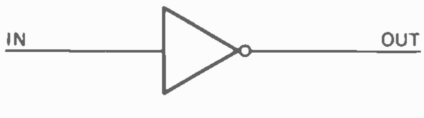
COSMOS has inherently good noise immunity and can safely tolerate input spikes up to nearly 50% of the supply voltage without being upset. Finally, COSMOS has excellent thermal characteristics: low-cost "commercial" types of COSMOS are designed to operate over the temperature range −40°C to +85°C, while the more expensive military versions can operate from −55°C to +125°C.

The performance of COSMOS is so unbelievable that we have decided, in this series of articles, to PROVE just how good it really is by presenting forty practical projects that you, the reader, can build around a single low-cost COSMOS digital IC. These projects range from simple pulse inverters to high-output multi-input burglar alarms, etc. The IC that forms the basis of these forty circuits is a quad 2-input NOR gate and is available from a number of advertisers in this magazine at a cost of less than one dollar.

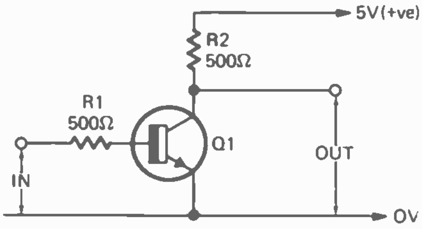
Before going on to look at the first of these practical projects, however, let's digress a little and find out just why COSMOS is so good. You might also check the article "All About CMOS" by Don Lancaster in **Radio-Electronics** December 1973.

## Understanding COSMOS IC's

The simplest type of digital circuit that you get in any logic family is the inverter or NOT gate. The symbol for a NOT gate is in Fig. 1-a and its resistor-transistor equivalent is in Fig. 1-b. Circuit operation is quite sim-




*a*




*b*

**FIG. 1-a—THE SYMBOL OF a digital inverter or NOT gate. b—RESISTOR-TRANSISTOR equivalent circuit.**

ple. Input and output are always either low (grounded or at logic 0) or high (at positive supply voltage or logic 1). Suppose that the input to the circuit is at logic 0. In this case, zero base drive is applied to transistor Q1, so the transistor is cut off and the output is at logic level 1. In this case, the quiescent current of the circuit is equal to the leakage current of the transistor and is virtually zero.

Suppose now that the input to the Fig. 1 circuit is set to the high or logic 1 level. In this case, heavy base drive is applied to Q1 via R1, so the transistor is driven to saturation and the output falls to logic level 0. Under this condition, the quiescent current of the circuit rises to about 10 mA. Also note that the output of this simple circuit is always inverted relative to the input.

A simple manually-triggered 'memory' circuit can be made up from two NOT gates by cross-coupling them as shown in Fig 2. If we press S1, we set the input of Q2 to logic 0 so the output of Q2 goes to logic 1 and drives Q1 on and thus reduces the Q1 output to logic 0. Because of the cross-coupling, the circuit stays locked in this state once S1

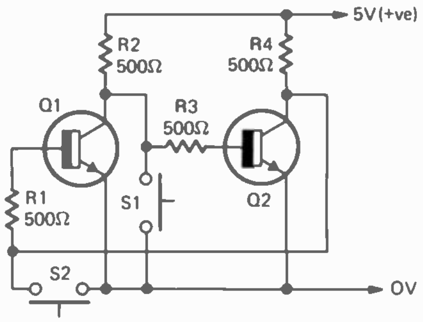



**FIG. 2—SIMPLE MANUALLY TRIGGERED resistor-transistor "memory" circuit draws a quiescent current of 10 mA.**

is released so the circuit acts as a simple memory. The state of the memory can be changed, if required, by momentarily closing S2, in which case the output of Q1 goes to logic 1 and the output of Q2 goes to logic 0. The important point to note here is that one or other of the transistor NOT gates is switched hard on (saturated) at all times, irrespective of the state of the memory, so the circuit draws a constant quiescent current of 10 mA.

So much for resistor-transistor logic. Let's now go on and see what happens in its COSMOS equivalent.

Figure 3 shows the basic circuit of a COSMOS inverter or NOT gate. The circuit

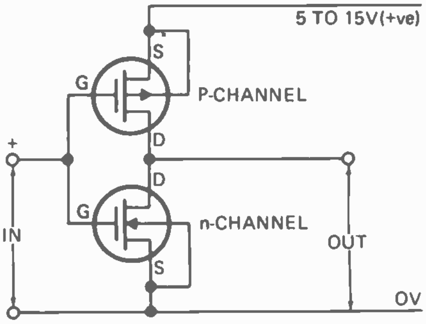



**FIG. 3—BASIC COSMOS digital inverter or NOT gate.**

consists simply of one p-channel and one n-channel insulated-gate field-effect transistor (IGFET), wired in series between the two supply lines, with the IGFET gates tied together at the input terminal and with the output taken from the junction of the two devices.

Essentially, an IGFET can be regarded as a 3-terminal voltage-controlled variable resistance. The variable resistance appears between the two terminals known as the source and the drain, and the control voltage is applied between the source and the third

# Digital IC's

*If not, learn what its about with these simple circuits.*

terminal, known as the gate. The gate typically presents an impedance of about a million megohms to incoming voltages or signals, so the IGFET can be regarded as a voltage (rather than current) controlled device.

When a very low (near-zero) voltage is applied to the IGFET gate, the drain-to-source path of the device acts like an open-circuit resistance and typically presents an impedance in the order of thousands of megohms. Near-zero current thus flows through the device under this condition. If the gate voltage is steadily increased, a point is reached where the drain-to-source resistance just starts to fall: this point is known as the THRESHOLD and threshold voltages are usually between 2 and 3 volts in COSMOS IGFET's.

As the gate voltage is increased beyond the threshold, the drain-to-source resistance falls further and eventually falls to a minimum effective value of about 400 ohms: the resistance cannot fall below this value no matter how much further the gate voltage is increased, so a safe limit is automatically set on the maximum current that can flow through the device.

Let's go back to our Fig. 3 circuit in which we are concerned mainly with input signals that are *low* (below the threshold of the n-channel IGFET but above that of the p-channel device) or *high* (above the threshold of the n-channel IGFET but below that of the p-channel device.

Suppose first that we have a logic 0 (low) input to the circuit. In this case, the n-channel (lower) IGFET is cut off and is acting like a virtual open-circuit resistor with an impedance of about 10,000 megohms, but the p-channel (upper) IGFET is biased hard on and acts like an impedance of only 400 ohms.

This situation is clearly illustrated in the

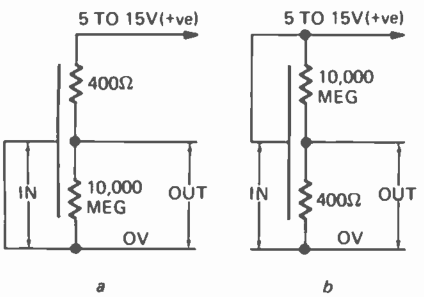



**FIG. 4—EQUIVALENT CIRCUIT OF COSMOS NOT gate circuit with (a) logic 0 input and (b) logic 1 input.**

equivalent circuit of Fig. 4-a where it can be seen that the two IGFET's act like a resistive voltage divider in which the output is high (at logic 1) and is essentially strapped to the positive supply line via the 400-ohm resistance and in which the quiescent current of the divider is limited to the nanoamp region by the high value of the 10,000-megohm resistor.

Suppose now that the input voltage is slowly increased in a positive direction. The device current is virtually zero until the input voltage exceeds the threshold of the n-channel IGFET, at which point the effective resistance of the n-channel device starts to decrease and that of the p-channel IGFET starts to increase. Under this condition, the device current is dictated by the larger of the two resistances and is of measurable proportions.

When the input voltage is appreciably *less* than half of the supply volts, the resistance of the n-channel IGFET is much greater than that of the p-channel device, so the output of the circuit is high or at logic level 1: when the input voltage is appreciably *more* than half of the supply volts, the resistance of the n-channel IGFET is much less than that of the p-channel device, so the output of the circuit is low or at logic level 0.

When the input voltage is at approximately half-supply volts, a point is reached where both IGFET's attain the same value and at this point the output voltage starts to switch from one logic level to the other and a current of several milliamps may flow through the circuit: in practice, a semi-regenerative switching action takes place at this point and the output switches abruptly from one state to the other.

The value of input voltage needed to initiate this switching action is known as the TRANSITION voltage and is usually specified as a percentage of the supply voltage. Transition voltages vary between 30% and 70% of the supply voltage in COSMOS devices.

Finally, consider the case where the input to the Fig. 3 circuit is high or at logic 1. In this case, the p-channel IGFET is cut off and acting like a virtual open circuit while the n-channel IGFET is biased hard on and is acting like a 400-ohm resistor. This situation is shown in Fig. 4-b where it can be seen that the two IGFET's again act like a voltage divider, but in this case the 400-ohm resistor is at the low end, so the output is low (at logic 0) and is essentially strapped to ground via 400 ohms. The quiescent current of the network is again limited to the nanoamp region by the larger of the two resistors.

Thus, the Fig. 3 circuit acts as a conventional digital inverter or NOT gate, but has the following unique properties:

1. **An exceptionally high input impedance** (about a million megohms).
2. **It draws negligible quiescent current** from the supplies (about one nanoamp), irrespective of its logic state.
3. **It can be operated** from a wide range of supply voltages (typically 5 to 15 volts), since its minimum voltage requirement is limited only by the threshold characteristics of its IGFET's and the maximum is limited only by the breakdown characteristics of the devices.
4. **Its output can swing** from zero to the full positive supply rail voltage since no potentials are lost in the circuit as a result of saturation voltages or forward biased junction voltages.
5. **The device cannot be damaged** by shorts at its output since the maximum current of the device is automatically limited by the 400 ohms minimum impedance of its ON IGFET.

Figure 5 shows how two COSMOS NOT

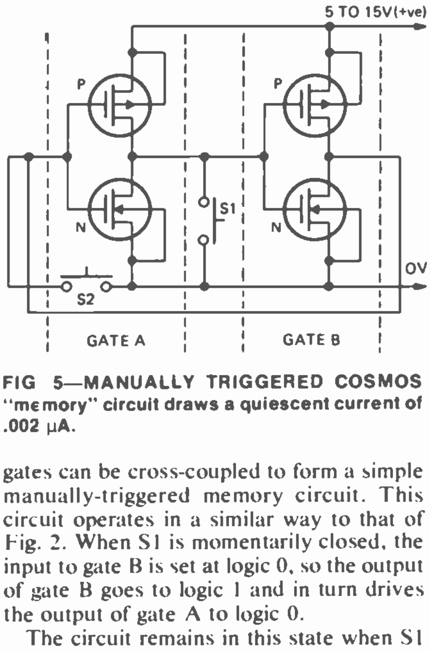



**FIG 5—MANUALLY TRIGGERED COSMOS "memory" circuit draws a quiescent current of .002 μA.**

gates can be cross-coupled to form a simple manually-triggered memory circuit. This circuit operates in a similar way to that of Fig. 2. When S1 is momentarily closed, the input to gate B is set at logic 0, so the output of gate B goes to logic 1 and in turn drives the output of gate A to logic 0.

The circuit remains in this state when S1 is released due to the cross-coupling between the two gates, so the circuit acts as a simple memory. The state of the memory can be changed by momentarily closing S2, in which case the output of gate A goes to logic 1 and the output of gate B goes to logic 0.

The most important practical difference between the resistor-transistor memory circuit of Fig. 2 and the COSMOS circuit of Fig. 5 is that the resistor-transistor circuit draws a quiescent current of 10 mA while the COSMOS version draws a quiescent current of only 0.002 μA. Thus, the resistor-transistor version draws five million times more quiescent current than its COSMOS equivalent.

The reader may at this stage be thinking that this notion of a logic circuit drawing virtually zero supply current sounds too good to be true and that there must be a catch in this COSMOS business somewhere. The simple answer to that is that a COSMOS circuit does in fact draw a significant current, but only as it is going through the actual motion of changing logic states and not when it is in the quiescent condition.

Each time COSMOS changes state, it draws a pulse of current from the supply. The more often it changes state in a given time, the greater are the number of current pulses that it takes from the supply and the greater is the MEAN current that it consumes. Thus, the mean current that it takes is directly proportional to the frequency of its operation.

At frequencies of 5 MHz, COSMOS logic draws roughly the same current as its TTL equivalent: at 5 kHz, it draws only one-thousandth of the current of TTL. Consequently, COSMOS is best suited to low- or medium-speed applications, although it is capable of operating as high as 10 MHz when needed.

Having cleared up these basic points, let's go on and look at a practical COSMOS digital IC.

## The CD4001

Several manufacturers produce ranges of COSMOS digital IC's. Leaders in the field are RCA, and one of the most useful and versatile IC's in their range is a quad 2-input NOR gate which is known as the CD4001: Motorola produces an identical device under the coding of MC14001.

Figure 6 shows the logic circuit and pin

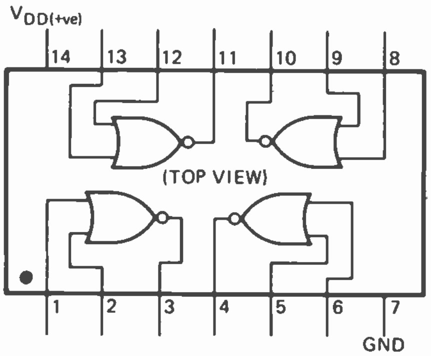



**FIG. 6—LOGIC DIAGRAM and pin connections of the CD4001 quad 2-input NOR gate.**

connections of the CD4001 IC which is encapsulated in a 14-pin dual-in-line plastic or ceramic package. As you can see, two of the pins are used for supply connections (pin 7 goes to ground and pin 14 goes to the positive supply line) and the rest of the pins connect to the input or output terminals of the NOR logic gates. There are four identical 2-input NOR logic gates in each IC package.

Figure 7-a shows the actual circuit that is used in each of the 2-input NOR gates. Here, two series-connected p-channel IGFET's are wired in series with two parallel-connected n-channel IGFET's: each of the two input terminals is connected to the gates of one of the p- and n-channel IGFET pairs. Circuit operation is as follows.

Suppose first that both input terminals are grounded or at logic level 0. In this case, both of the n-channel IGFET's are biased

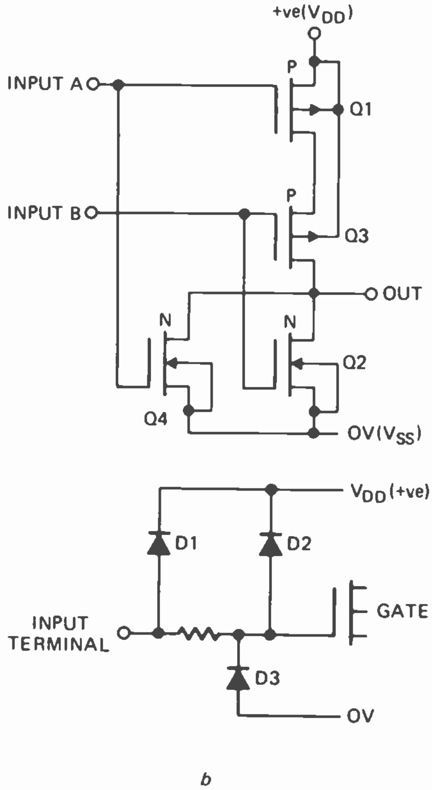



**FIG. 7-a—CIRCUIT OF EACH of the four gates of the CD4001. b—COSMOS GATE INPUT protection circuit that is connected to each of the eight input terminals of the CD4001.**

below their threshold points and act like open-circuit resistors and both of the p-channel IGFET's are saturated and act like 400-ohm resistors. The output of the circuit is thus high and at logic level 1 under this condition. The output is thus inverted relative to the inputs.

Suppose now that input A is at logic level 1 and that input B is at logic 0. Now Q2 acts like an open-circuit resistor and Q3 acts like 400 ohms due to the 0 input on terminal B, but Q1 acts like an open-circuit resistor and Q4 acts like 400 ohms due to the 1 input on terminal A. Since Q1 is in series with Q3 and Q2 is in parallel with Q4, the result is that the top half of the circuit acts like an open circuit and the lower half acts like 400 ohms. Consequently, the output of the circuit is low and at logic 0 under this condition.

Suppose next that input A is at logic level 0 and input B is at logic 1. This situation is similar to that outlined above except that in this case, Q3 and Q4 act like open circuits and Q1 and Q2 act like 400-ohm resistors. The net result is the same, however, and the top half of the circuit acts like an open circuit and the lower half acts like 400 ohms, so the output of the circuit is again at logic 0 under this condition.

Finally, suppose that both inputs are at logic level 1. In this case, both upper IGFET's act like open circuits and both lower IGFET's act like 400-ohm resistors, so the output is again low at logic level 0.

Thus, the output of the NOR gate goes to logic 1 only when both inputs are at logic 0. Note that the circuit can be made to function as a simple logic inverter or NOT gate by shorting inputs A and B together.

All input terminals of the CD4001 NOR gate IC (and all other digital IC's in the COSMOS family) have input impedances of about a million megohms, but are fully protected against damage from static charges via the input safety circuit shown in Fig. 7-b. Each of the eight input terminals of the CD4001 are protected by one of these diode-resistor safety circuits.

The CD4001, like all COSMOS digital IC's, is an extremely rugged device and can withstand considerable abuse without suffering permanent damage. Its output, for example, is fully short-circuit proof. There are in fact only three ways in which you can damage a COSMOS circuit and one of these is to connect the supply lines in the wrong polarity, in which case heavy current will flow through the D2 and D3 protection diodes and damage the substrate.

One other way you can damage the device is to connect a very low impedance input signal to it when its power supplies are switched off and the remaining way is to connect the device to a very low impedance input signal that has such a large amplitude that it goes above the positive supply line voltage. In either case, a heavy current will flow through protection diode D1 and the substrate will again be damaged. Both of these potential sources of damage can be eliminated by simply wiring a 1000-ohm resistor in series with each input terminal so that any current that does flow is limited to a safe value of a few milliamps.

## Using the CD4001

The CD4001, like all other COSMOS digital IC's, is a very easy device to use, providing you obey the following basic rules.

**1. Always make sure** that power lines are in the correct polarity before you apply power to the IC.

**2. Never connect** very low impedance energy sources (including storage capacitors) directly to the device input terminals: always connect them via a 1000-ohm or greater current-limiting resistor.

**3. Always tie unused input** terminals directly to ground or to the positive supply line, depending on the logic requirements.

**4. Never let used inputs float:** always take them to ground or to the positive line via a high value resistance.

When you buy your first CD4001 IC, you'll find that it has a one-or-two-letter suffix added at the end of its basic code number. This suffix relates to the style of packaging of the device and to its voltage and temperature operating ranges. Details of the meanings of the five available suffix codes are shown in Table 1. Thus, the CD4001AD is a quad 2-input NOR gate housed in a ceramic dual-in-line package and can operate over the supply range 3 to 15 volts and the temperature range −55°C to +125°C, while the CD4001E is in a plastic DIL package and can only operate over the supply range 5 to 15 volts and the temperature range −40°C to +85°C.

Most of the forty practical projects described in the remaining sections of this series of articles are designed to operate with supply voltages in the range 5 to 15 volts and can thus be used with any types of CD4001 IC. In most cases, however, the circuits can be made to operate with supply voltages as low as 3 volts by simply using them with CD4001 IC's that have suffix numbers AD, AE or AK.

Next month we will go on and look at the first of our 40 IC projects. **RE**

HOW TO

# Measure HI-FI Amplifier Performance

*Checking hi-fi component performance is a job that requires precise measurements with lab-grade test equipment. Our audio consultant describes his test gear and how it's used.*

**by LEN FELDMAN**
CONTRIBUTING HIGH-FIDELITY EDITOR

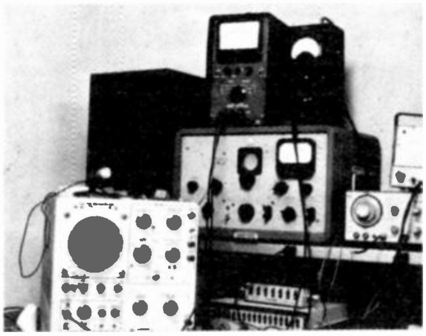
HIGH-FIDELITY COMPONENTS HAVE reached a level of perfection which would have seemed impossible even for so-called professional sound equipment just a few years ago. Frequency response of audio amplifiers extends well below and above human audibility. Recognized forms of distortion such as IM and harmonic have been reduced in modern solid-state amplifiers to percentages so low as to defy measurement using the very best test equipment available just a few years ago. Power output of solid-state amplifiers is fast approaching kilowatt levels.

Whether or not you agree that these last orders of refinement are worth the money the consumer pays for them is secondary. Admittedly, there are experts in the field who steadfastly maintain that harmonic distortion of less then 0.5% contributes no further improvement to audible fidelity and that the ability of an amplifier to reproduce frequencies below 20 Hz or above 20 kHz is equally academic. Still, in the real world of the knowledgeable audiophile, there *are* consumers who are willing to pay for the ultimately low distortion figures and the wideband response. More important, these same consumers want continued assurances that their equipment is performing as well as when it was purchased. The fully equipped audio service center or laboratory of a few years ago is just not capable of accurately measuring and reporting on the important audio parameters of a modern hi-fi amplifier or preamplifier, however heavy the initial investment in test equipment many have been.

Take my own case. In addition to engaging in fundamental audio and rf design from time to time, I regularly test and report on a variety of audio products and occasionally am commissioned to confirm the performance of new prototype products which manufacturers submit to my laboratories.

## Distortion measurements

Up until recently, the measurement of harmonic distortion or power output capability of an amplifier on my lab bench involved the use of at least four



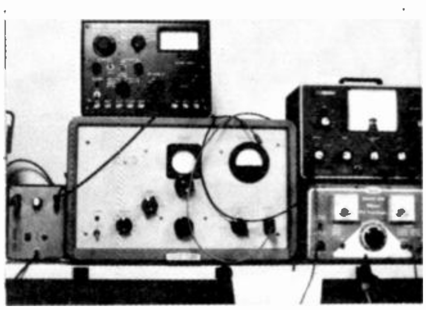


**FIG. 1—PHOTOS SHOW MAJOR pieces of equipment used to check audio amplifier performance.**

separate pieces of equipment, arrayed in the photo of Fig. 1. These included a Hewlett-Packard 650A signal generator, an HP 330A harmonic distortion analyzer, a Tektronix dual trace wideband oscilloscope, model 533, a pair of Ballantine ac vtvm's and, of course, suitable non-inductive loads of proper 8-ohm or 4-ohm impedances. The block diagram of Fig. 2 illustrates the usual setup. Since line voltage invariably affects power output capability of an audio amplifier, a variable voltage transformer and an accurately calibrated ac line voltmeter are also part of this elaborate measurement setup.

Since a fully equipped high-fidelity laboratory must also be capable of measuring the performance of FM tuner sections, a variety of additional equipment is arrayed across the test bench as shown in Fig. 3 and additional items are detailed in Figs. 4, 5 and 6. The inherent distortion of the HP 650A audio generator was known to be just under 0.1%, but there are amplifiers on the market today which boast THD figures of 0.02% and even lower at nominal power output levels. In addition, to perform a series of THD measurements over the entire audio spectrum involved tedious repeated voltage readings, resetting of frequency at both generator and distortion analyzer and repeated nulling and balancing of the null filter in the analyzer. At best, readings were subject to errors based upon meter and load accuracies. Particularly at maximum power output of an amplifier where an error of 3% in voltage can result in significant power errors, it was difficult to get two successive readings to agree. Suppose for example that a given amplifier is rated at 50 watts, driving 8-ohm loads, for less than 0.5% distortion. The amplifier output voltge should be set to 20 volts for this measurement.

$(W=E^2/Z = 20^2/8 = \frac{400}{8} = 50$ watts).

If the ac vtvm reads 3% too low, a reading of 20 volts would really correspond to an actual output of 20.6 volts which would correspond to an actual power output of 53.05 watts at which output the distortion produced by the amplifier might well exceed several percent. To compound the error, if the loads are on the low side of 8 ohms by 3%, actual power produced would be $(20.6)^2/7.76 = 54.69$ watts with an even higher distortion reading. Conversely, a high reading meter and a "plus" discrepancy in load resistors would result in an overly optimistic THD reading since the amplifier would then not be driven to its actual full rated output.

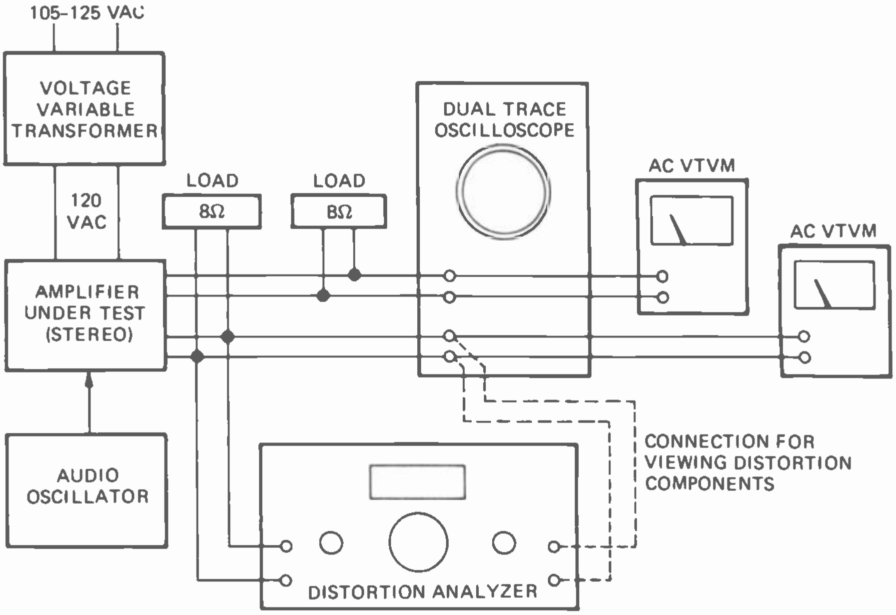


FIG. 2—BLOCK DIAGRAM OF SOME OF THE EQUIPMENT used to check audio amplifier performance specifications.


FIG. 3—OVERALL VIEW OF PORTION OF LAB TEST BENCH suggests amount of test gear required for audio equipment testing.

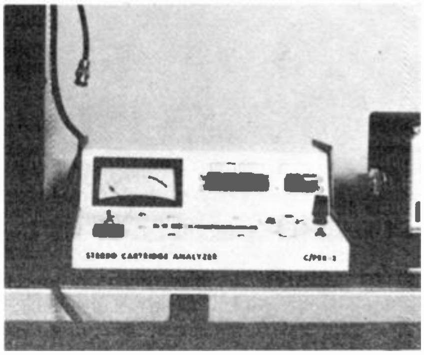


FIG. 4—SHURE CARTRIDGE ANALYZER is helpful in evaluating phono cartridge tracking and performance.

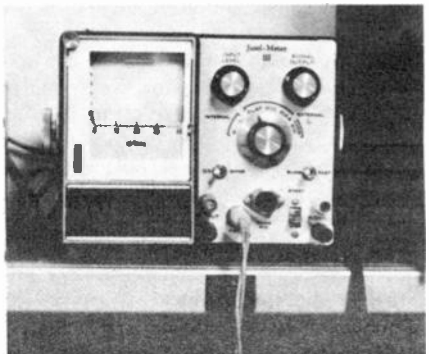


FIG. 5—AUDIO TECHNICA MARKETS COMBINATION graphic recorder useful in making frequency-response plots.

### The McAdam audio analyzer

McAdam Electronics of San Diego, California has assembled an "audio lab in a single box" known as their model 2000A, a front view of which is shown in Fig. 7. The most important innovation of this combination instrument is its digital readout circuitry. In use, even the power line voltage can be monitored digitally and set, by means of the self-contained variable voltage transformer to precisely 120 volts.

In addition to a triggered sweep oscilloscope with maximum vertical sensitivity of .02 volts/cm., a series of high-power Dale load resistors are affixed to the back of the cabinet and are switchable to provide four channel loads at 4, 8 or 16 ohms. Loads of 600 ohms or open circuit are also available from a front panel switch. One of the high-power load resistors can be seen in the photo of Fig. 8. The three major modules developed by McAdam Electronics include the digital readout module (Fig. 9), the distortion analyzer module (Fig. 10) and the audio oscillator module (Fig. 11). This last module produces signals at selected frequencies from 20 Hz to 100 kHz and, in addition to the low-distortion sine waveform (less than .02% THD), square wave signals at each frequency can be generated as well as the 4:1 combination of 60 Hz and 7000 Hz required for IM distortion testing.

The signal is distributed to four jacks, each with its own amplitude trim pot so that quadriphonic amplifiers may be driven uniformly through all four channels. A master volume control permits varying the audio signal from less than 1 mV (for phono or microphone preamplifier input testing) to over 3 volts. Exact amplitude is read on the digital display. Outputs from the amplifier under test are connected by means of supplied cables to the output terminals on the analyzer. All other connections and interconnections to scope, etc. are accomplished internally and by means of front panel switches. For example, when the selector switch is set to "source," the 'scope face displays the input and its amplitude is digitally displayed. When "amp" is selected, the output waveform is displayed on the scope and its value may be read directly in watts on the digital readout.

When THD is read, not only does the digital display indicate its value in percent (after 100% reference has been established) but the harmonic distor-

FIG. 6—WOW AND FLUTTER METER used for checking tape decks and turntables shown mounted above a second FM-AM generator.

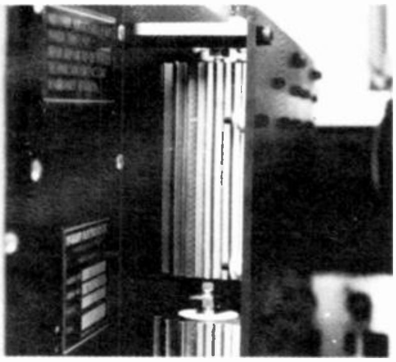


FIG. 8—ONE OF EIGHT high-power precision load resistors mounted on rear of McAdam analyzer.

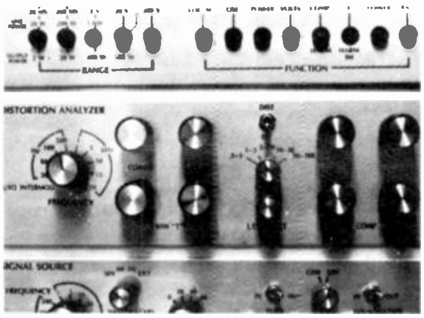
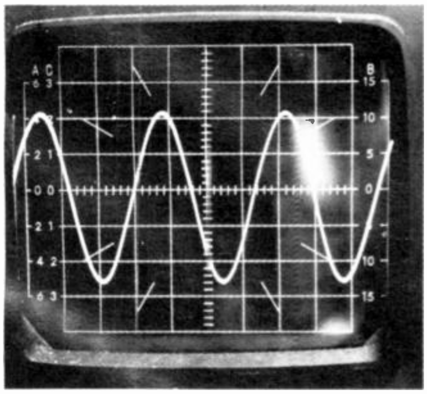


FIG. 10—DISTORTION ANALYZER SECTION has fixed frequency selection which simplifies nulling procedure.



tion content of the waveform being analyzed is shown on the scope as well. Because fixed frequencies are available from the generator, corresponding fixed frequency settings on the distortion analyzer make filter nulling much more rapid than would be the case with continuously variable oscillators and separate distortion analyzers. Two types of nulling are available for making THD readings. The first uses a

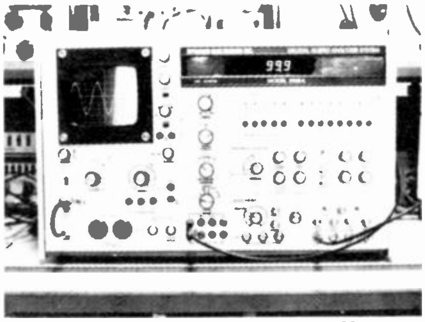


FIG. 7—OVERALL VIEW OF McADAM digital audio analyzer system.

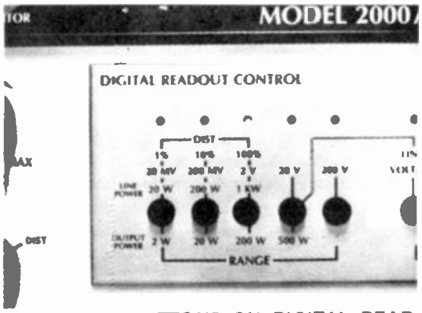



FIG. 9—PUSHBUTTONS ON DIGITAL READOUT control module determine readout range for all digital funtions.

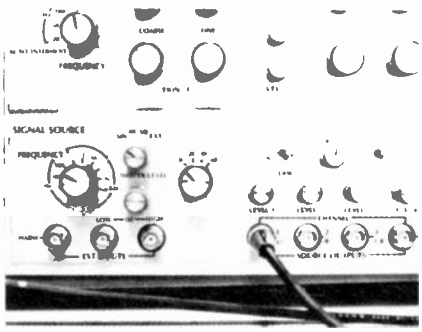


FIG. 11—FIXED FREQUENCIES of oscillator section range from 20 Hz to 100 kHz.

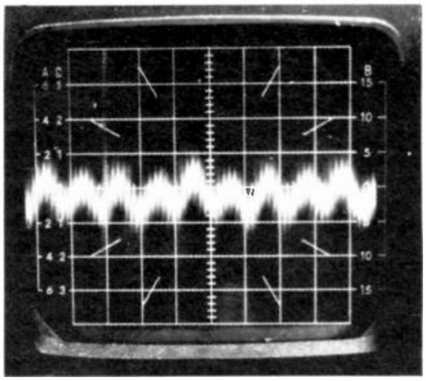


FIG. 12—BUILT-IN SCOPE is switched to view signal source preamplifier output (a, left) or to view actual distortion content of output waveform (b, above).

sharp twin-T nulling network and is nulled in a matter of seconds by means of the four adjustments knobs on the front panel. This filter will permit THD readings down to .02% or better. A more critical-to-adjust nulling system which cancels the signal source's own minute distortion permits readings down to as low as .002% or better and is intended for use with "super spec" equipment under test.

IM distortion readings are almost instantaneous and require no nulling. Percentages are read directly on the digital display module. The makeup of the IM distortion component is also displayed on the scope face when these measurements are made. An example of two scope displays is shown in Fig. 12. Figure 12-a is the output waveform from a high quality amplifier under test at a power output well below clipping. Figure 12-b displays the harmonic distortion of this waveform which, in this case, was just about 0.02% and consisted primarily of 3rd harmonic distortion with lesser amounts of higher order harmonics clearly in evidence despite their virtually unmeasurable amplitude. The presence of the visual display of total harmonic distortion on the scope makes nulling extremely rapid since one can quickly adjust the nulling controls for the smallest amplitude display.

### Other audio measurements

Input sensitivities, residual hum and signal-to-noise capability of an amplifier product are all easily and directly readable on the digital module. There is even provision for converting the input signal to an RIAA equalized recording curve by means of a switch which hardily attenuates the input signal by 43 dB and also proportions the amplitude of the spot frequencies in accordance with prescribed RIAA bass attentuation and treble emphasis. Thus, when checking a playback preamplifier circuit, flat output response automatically corresponds to correct RIAA equalization while deviation from flat response denotes deviation from RIAA directly.

### dB's and percentages

The digital readout facility of the analyzer is, of course, strictly an amplitude form of readout. Thus, such readings as involve dB ratios, such as signal-to-noise, hum and even frequency response must be translated from voltage or power amplitudes to decibel notations, if desired. Happily, our lab is equipped with a Hewlett-Packard model 45 pocket calculator which makes these transformations almost instantaneously, but we have also found that by calibrating any reference reading in terms of 100%, as if we were going to make a distortion measurement, it is simpler to "read down" on the digital scales in terms of percentage and translate the residual noise and hum readings to dB from a 100% reference. Thus, 1% equals −40 dB, 0.1% equals −60 dB, etc. Since the lowest or most sensitive scale will read down to 0.001% in this manner, that gives the instrument a potential reading capability down to −100 dB.

*(continued on page 94)*

# Step-by-step TV Troubleshooters Guide

*SCR's have replaced transistors as the horizontal output device in some TV sets. Here is an approach to use when servicing these circuits.*

**by STAN PRENTISS**

THE THYRISTOR FAMILY OF SCR'S IS A GROUP of bistable semiconductors with four p-n layers and a trio of terminals, gate, anode, and cathode. They are turned on by current pulses to their gates. Originally designed to operate at low frequencies, they have been used with outstanding success during the past few years as 15,734-Hz color television horizontal deflection outputs (drivers). Such deflection sub-systems, with their novel SCR's, unique magnetics, and especially saturable reactors—expensive though efficient, and 7 amps powerful—have been a mite difficult to troubleshoot by the uninitiated.

RCA, in its XL-100 series, has SCR's designed in for more than three years, and Philco, in the 3CS90-91 and 3CY90-91 receivers, has been operating a somewhat similar sub-system. So, these SCR horizontal deflection circuits are worth more than just casual attention—they'll be around in thousands of receivers for the remainder of the '70's at least.

## Common faults

Usual problems are basic opens and shorts, but these thyristors and their damping-control diodes can generate a number of faults, many of which are visible only on weak signals—a condition that's well worth a page or two in your trouble book:

1. Foldover on left of screen—retrace diode open.
2. Center foldover with narrow raster—trace diode open.
3. Straight line on left of pix—retrace diode.
4. Straight line in center of pix—trace diode.
5. Wide band to right of raster center—trace diode.
6. Straight line at right side of raster—trace SCR.

And in the same category of raster disturbers, but from different causes:

7. Straight line of interference near right side of raster—MAH horizontal deflection module.
8. Left tilted curve around raster middle—regulator clamp diode.
9. Partial double-banding on left side of raster—quadrupler fault.
10. Interference (dots and dashes) on lower left side of pix with incoming signal —diode oscillating in one of MAD color-drive modules.
11. Poor or no horizontal sync—horizontal oscillator disable circuit on PW400.
12. Popping circuit breaker—shorted diode or SCR.

Now that's an even dozen faults that can occur in and around any of these SCR deflection circuits. To find most of them —especially the frequency problems— you'll need a good oscilloscope.

## Troubleshooting chart

The Mitchell-inspired trouble solution chart (due credits to RCA) is worth looking at, beginning on the basis of NO RASTER—NO HIGH VOLTAGE; then

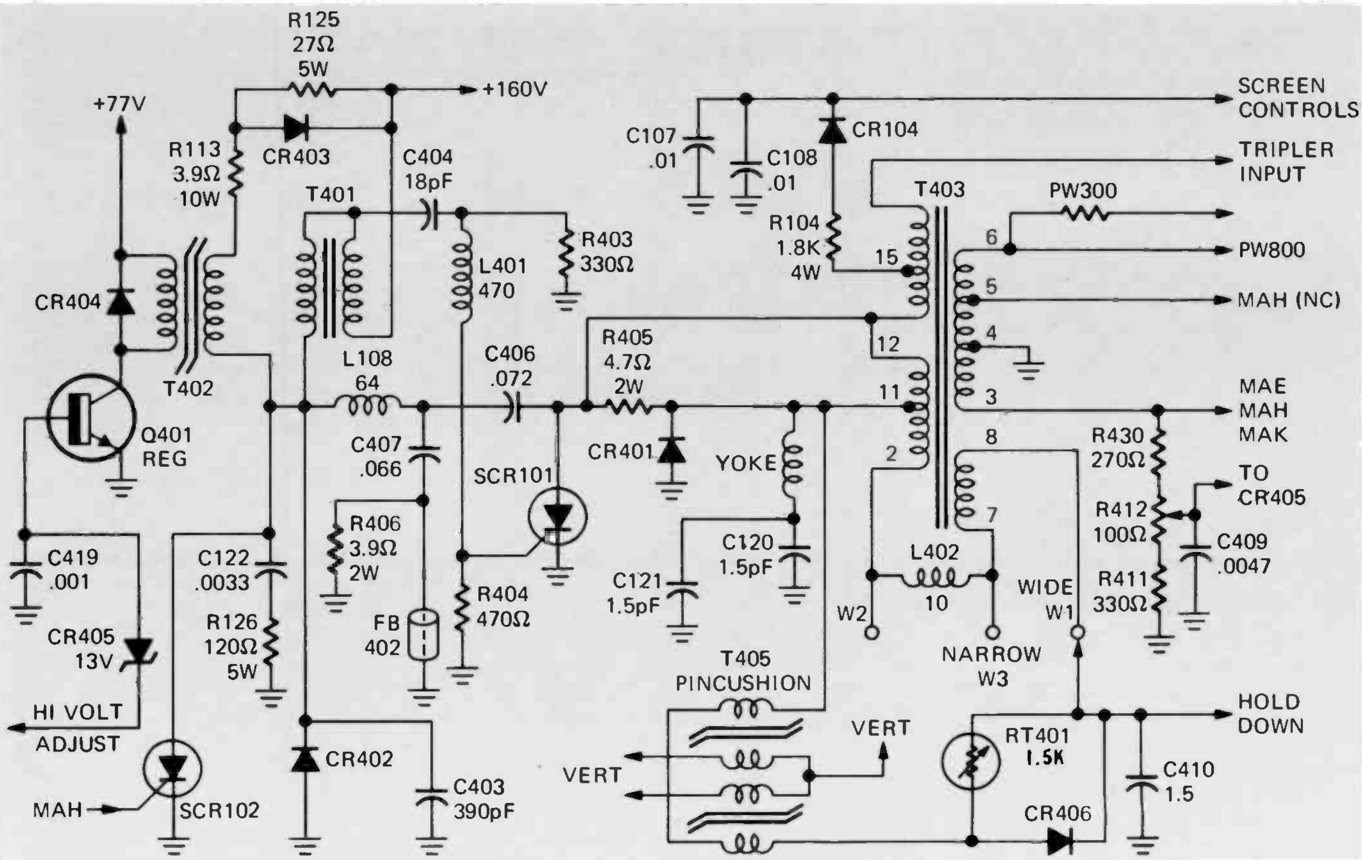
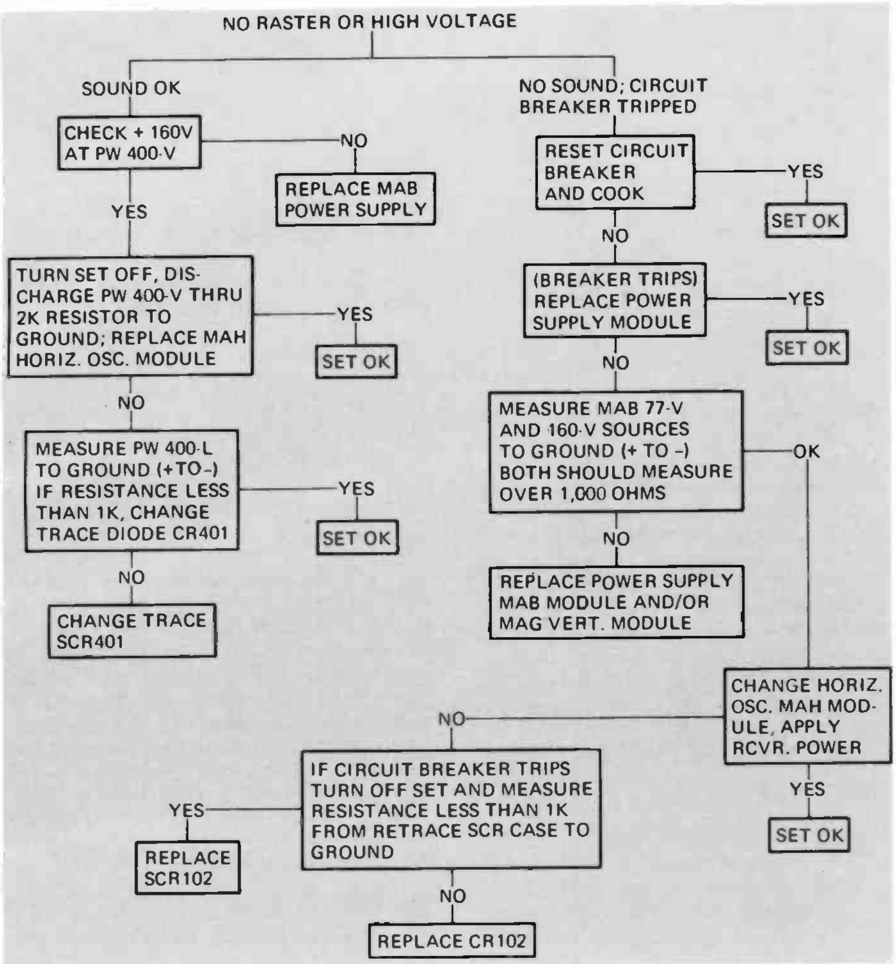



**FIG. 1—RCA CTC 48 HORIZONTAL DEFLECTION CIRCUIT. Pincushion transformer is in flyback parallel. C410 is a width capacitor.**




**TROUBLESHOOTING CHART (Horizontal Deflection Circuits)**

following the sequenced procedure, with and without sound. For if there is sound, the i.f. strip is obviously operating to some extent, even though there may not be adequate because of nonexistent flyback keying. Without sound, a good OFF/ON switch, and a tripped cricuit breaker, both 160-volt and 77-volt power supplies are suspect, as well as certain modules. In any event, simply follow directions. The chart and its terminal designations apply to all XL-100 receivers, including the CTC 46, 48, 49, 54, & 59 chassis. The only exception is that PW400-U turns out to be numbered PW400-X on the portable RCA CTC 49 and 59 color television chassis.

Note that in making the resistance measurements indicated on the chart, that the positive ohmmeter test probe is always contacted to the test point and the meter adjustment is always on the R×1 scale. Negative test lead is grounded.

## Other facets

There is also an oscillator hold-down circuited in the later CTC 46 and regular CTC 54 and 48 chassis that can be serviced with this chart method, although the procedure's too short to require a formal drawing. If the horizontal oscillator is out of sync, short TP-2 to ground and adjust the horizontal hold so the oscillator can be brought momentarily into sync—but not held. If this can be done, the sync problem is actually excessive high voltage, and must be remedied by repairing the high-voltage circuit. When TP-1 and TP-2 are shorted together with the oscillator in sync, it should fall out of sync, and the number of diagonal lines on the screens should change slightly with variations of the brightness control. These are the immediate problems of the moment, and will be illustrated with an oscilloscope following the usual theory of operation.

## How SCR deflection operates

The *trace* portion of this SCR horizontal deflection sub-system (Fig. 1) includes the yoke, C120 and C121 in parallel, T405 pincushion transformer, primary turns of flyback T403, and SCR101 or CR401, depending on which is conducting. The retrace portion consists mainly of flyback windings, yoke, pincushion transformer, C120, C121, C406, C403, L108, C122 and R126, and SCR102–CR402. The resonant frequency of the trace circuit is about 10 kHz, and so a 20-kHz half cycle (T=1/F) roundly equals the 52.4-$\mu$s forward scan time. Retrace, then must typically have a resonance of 45 kHz so that its 90-kHz half cycle can equal the 11.1-$\mu$s recovery time. Power input circuit is then composed of T402, T401, CR403, C404, R403, and SCR101, CR401. The voltage at the junction of L108 and T402 must then rise to maximum during the scan period and even begin decay, depending on the action of the voltage regulator, which senses the high-voltage output and increases or decreases its collector current, saturating or unsaturating T402. This action increases or decreases T402's resonance, causing retrace SCR102 to operate faster or slower and compensate for variations in high voltage. Output from the retrace SCR, of course, is coupled through T401 and L401 to the gate input of trace SCR101, and turns it on after SCR102 completes conduction.

The two SCR's and their twin diodes are actually bidirectional switches in parallel, but inverse connections. During trace, diode CR401 actually conducts when yoke current is *most* negative. As this current passes through zero from negative to positive, CR401 (CR101 on some receivers) turns off and SCR101 draws current, discharging capacitors C120 and C121 and supplying energy to the yoke in the second half of forward trace, linearly deflecting the trace to the right edge of the CRT. As this period comes to an end, commutating (retrace) SCR102 gates ON from horizontal oscillator pulses and C406 discharges through L108. Discharge current increases until yoke current is exceeded, turning on CR401 which back-biases trace SCR101 so it can turn off. As the discharge pulse decreases below yoke current, CR401 opens and the yoke now has the current to charge C406 and C407, plus C122 during the initial half of retrace. In the second portion of retrace (or ringing period), CR402 (CR102 in other receivers) conducts, allowing the retrace SCR to turn off, and so begins a new cycle. CR104 is the screen control voltage supply positive rectfier, while CR403 will conduct when voltages on its anode exceed dc or rms 160 volts.

## Problems & waveforms

The problem RCA technicians can have is not with the SCR circuit itself, but with shotgun parts substitutions by people who are careless. For instance, begin disturbing time constants in this circuit by swapping C406 for C404, and you'll have a slower CR401 turn off, a quicker pulse couple for SCR101, and the circuit begins to see all sorts of problems.

The waveform, at a time base of 20 $\mu$s per divisor, illustrates approximately three cycles of conduction and non-conduction of these trace and commutator retrace SCR deflection units. In dealing with a pnpn semiconductor switch, its ON time is inevitably the point of lowest resistance. Consequently, the trace dc period at 20 $\mu$s begins at the second vertical line and continues just past line 4, for a total time of about 50 $\mu$s—52.4 × $10^{-6}$ is normal line trace time. For the better part of trace conduction, the retrace (commutator) SCR is off, Y2(W1), and comes on for 25$\mu$s—11.1 × $10^{-6}$ is standard retrace time.

Now when test points TP-1 and TP-2 in the horizontal oscillator disable circuit are shorted together, the 10 volts potential difference between them across a 2% resistor is nullified, the disable transistor has full forward bias potential applied and conducts, drawing current from the oscillator and kicking it off frequency. Instead of 50 $\mu$s for trace time as in W1, the conduction period of the trace SCR now amounts to 56 $\mu$s, Y1'(W1') (Fig.3), and the resonant frequency drops from 20 kHz to 17.9 kHz, as the oscillator slows down and falls out of sync. The commutator portion, Y2'(W1') also reacts with a jittery shift around 25 $\mu$s that really defies precise counting, although it, too, should be greater in time but less in frequency. If you're overly analytical and wonder about the 12.5 $\mu$s that results from

*(continued on page 66)*

# equipment report

## *Lafayette SQ-W 4-Channel Decoder*

THE BASIC SQ MATRIX DECODER HAS little inherent center-front to center-rear separation. The separation that does exist is dependent on psycho-acoustic effects. The center-front (mono) program information appears in both rear outputs 180° out of phase with each other. If the listener is precisely positioned in relation to the speakers, the rear spill from the center-front information cancels in the listener's brain. Obviously, this idea does not work out in practice too often.

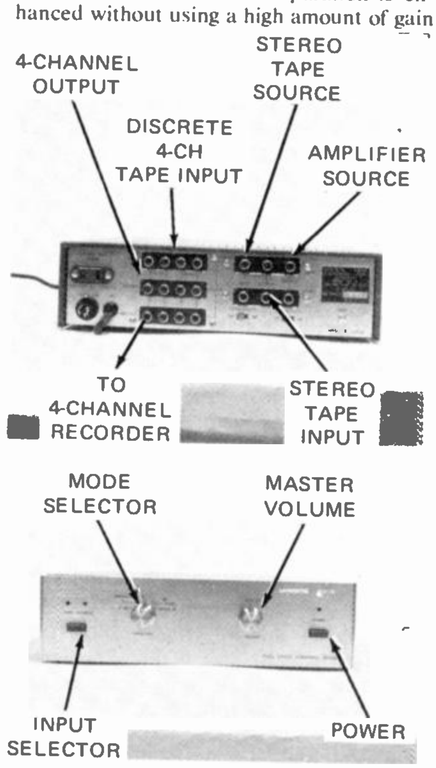
Several techniques have been used to increase the apparent center-front–center-rear (CF/CR) separation. One inexpensive method is to electrically blend some of the out-of-phase rear signals so part of the common rear output is cancelled before it gets to the speakers. Generally, 6 to 8 dB of blend is used for minimum reasonable degree of separation. Unfortunately, blending reduces the left-to-right separation, with 8-dB blend giving the most practical total surround separation. (Not great, but reasonably good.)

To achieve even greater separation, later SQ decoders used something termed "logic," actually a gain riding of either the center-front information, or the center-front and center-rear, depending on the decoder's complexity. When predominant center information was detected, the decoder's gain was increased (unbalanced) accordingly to expand the apparent CF/CR separation.

Something termed "wavematching" was added to the gain riding technique to expand the corner information. When predominant corner information was sensed, the corner gain was increased to enhance the spatial effect.

The wavematching full-logic decoder produced almost optimum results, characterized by many critics as "close to discrete." Depending on the type of program material, however, it was sometimes possible to actually sense the gain-riding, which appeared as a mild "pumping"—similar to the "pumping" heard on older movie sound tracks.

To eliminate "pumping of the full logic decoder—which some users found objectionable—Lafayette's SQ-W decoder features a Variblend in addition to the wavematching full-logic. When the decoder senses primarily corner information—front or rear—the separation is expanded through the wavematching circuits. But the spill from the center-front into the rear outputs appears equally in both rear channels, though out of phase. The Variblend senses this equal but out of phase information, and automatically increases the rear channels blend factor to electrically attenuate the signals before they get to the speakers. In this manner, the CF/CR separation is enhanced without using a high amount of gain riding and without noticeable loss of left-to-right separation.




**THOUGH THE SQ-W DECODER will normally use an amplifier's tape jacks, the recoder connections are not "lost" because they are available on the decoder. A stereo recorder can be used to record the stereo signal from the amplifier; a discrete 4-channel recorder connection(s) is handled directly by the decoder.**

Since the blend factor is constantly changing in relation to the program information, the circuit was logically termed Variblend.

The Lafayette SQ-W decoder is an add-on accessory intended for 4-channel amplifiers and receivers which might or might not have a built-in matrix decoder. Its signal

*(continued on page 100)*



**STEP-BY-STEP**
*(continued from page 65)*

halving the commutator's 25-μs retrace period, instead of the usual 11.1-μs interval, this is just a slight time constant change from the original circuit. The proof that it works can be evaluated from the half power 3-dB down point of the OFF 400-volt trace pulse, Y1(W1), which measures just about 11 μs on the button. Logically, then, if good trace, then sufficient retrace.

To aid service technicians, RCA in the CTC 48 series has now connected its pincushion transformer across the primary of the flyback instead of in series with the yoke so that an open in the yoke circuit is not as likely to occur and blow SCR101 or CR401. When checking one of these sub-systems after repairs, Variac the ac line current supply up to about 40 or 45 volts and see if the high voltage (it must be metered) is still increasing. If it is, there are probably no SCR or diode shorts, and you may continue to apply additional potential up to the normal 120 volts. If high voltage rise stops abnormally or decreases at some point below regular input voltage, check your circuits again for shorts. In this way, you'll save lots of SCR's—both yours and RCA's. **R-E**

## *R-E's Substitution guide for replacement transistors*
## *PART XIX*

**compiled by**
**ROBERT & ELIZABETH SCOTT**

**ARCH**—Indicates the Archer brand of semiconductors sold only by Radio Shack and Allied Radio stores Allied Radio Shack, 2725 W 7th St . Ft Worth, Texas 76107
**DM**—D M Semiconductor Co , P O Box 131, Melrose, Mass 02176
**G-E**—General Electric Co., Tube Product Div , Owensboro, Ky 42301
**ICC**—International Components, 10 Daniel Street, Farmingdale, N Y 11735
**IR**—International Rectifier, Semiconductor Div , 233 Kansas St . El Segundo, Calif 90245
**MAL**—Mallory Distributor Products Co , 101 S Parker, Indianapolis, Ind 46201
**MOT**—Motorola Semiconductors, Box 2963, Phoenix, Ariz 85036
**RCA**—RCA Electronic Components, Harrison, N.J 07029
**SPR**—Sprague Products Co , 65 Marshall St , North Adams, Mass 01247
**SYL**—Sylvania Electric Corp , 100 1st Ave , Waltham, Mass. 02154
**WOR**—Workman Electronic Products, Inc., Box 3828, Sarasota, Fla. 33578
**ZEN**—Zenith Sales Co , 5600 W. Jarvis Ave., Chicago, Ill. 60648

Radio-Electronics has done its utmost to insure that the listings in this directory are as accurate and reliable as possible, however, no responsibility is assumed by Radio-Electronics for its use We have used the latest manufacturers material available to us and have asked each manufacturer covered in the listing to check its accuracy. Where we have been supplied with corrections, we have updated the listing to include them. The first part of this Guide appeared in March 1973.

| | ARCH | DM | G-E | ICC | IR | MAL | MOT | RCA | SPR | SYL | WOR | ZEN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2N3939 | NA | SR-1245 | NA | ICC-R1245 | NA | NA | HEP-R1245 | NA | NA | NA | NA | NA |
| 2N3940 | NA | SR-1246 | NA | ICC-R1246 | NA | NA | HEP-R1246 | NA | NA | NA | NA | NA |
| 2N3945 | NA | TS-3010 | NA | ICC-S3010 | NA | PTC 144 | HEP-S3010 | NA | NA | NA | NA | ZEN 207 |
| 2N3946 | NA | T-713 | GE-20 | ICC-713 | NA | PTC 136 | HEP-713 | NA | NA | NA | NA | NA |
| 2N3947 | NA | T-713 | GE-20 | ICC-713 | NA | PTC 136 | HEP-713 | NA | NA | NA | NA | NA |
| 2N3948 | RS276-2009 | T-75 | GE-28 | ICC-75 | IRTR-87 | NA | HEP-75 | SK 3024 | RT-114 | ECG 128 | WEP 243 | NA |
| 2N3953 | NA | T-709 | NA | ICC-709 | NA | NA | HEP-709 | NA | NA | NA | NA | ZEN 105 |
| 2N3959 | RS276-2013 | T-730 | NA | ICC-730 | NA | NA | HEP-730 | NA | NA | NA | NA | ZEN 116 |
| 2N3961 | NA | NA | GE-28 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2N3962 | NA | T-708 | GE-67 | ICC-708 | NA | NA | HEP-708 | SK 3114 | RT-115 | ECG 159 | WEP 717 | NA |
| 2N3963 | NA | T-708 | GE-21 | NA | NA | NA | NA | SK 3114 | RT-115 | ECG 159 | WEP 717 | NA |
| 2N3964 | NA | T-715 | GE-21 | ICC-715 | NA | NA | HEP-715 | SK 3114 | RT-115 | ECG 159 | WEP 717 | ZEN 106 |
| 2N3965 | NA | T-715 | GE-21 | ICC-715 | NA | NA | HEP-715 | SK 3114 | RT-115 | ECG 159 | WEP 717 | ZEN 106 |
| 2N3966 | NA | T-801 | GE-FET-1 | ICC-801 | NA | PTC 152 | HEP-801 | NA | NA | NA | NA | NA |
| 2N3967 | NA | T-801 | GE-FET-1 | ICC-801 | NA | PTC 152 | HEP-801 | SK 3112 | NA | ECG 133 | NA | NA |
| 2N3968 | NA | T-801 | GE-FET-1 | ICC-801 | NA | PTC-152 | HEP-801 | SK 3112 | NA | ECG 133 | NA | NA |
| 2N3969 | NA | T-801 | GE-FET-1 | ICC-801 | NA | PTC 152 | HEP-801 | SK 3112 | NA | ECG 133 | NA | NA |
| 2N3973 | NA | TS-0004 | GE-20 | ICC-S0004 | IRTR-64 | PTC 123 | HEP-S0004 | SK 3122 | RT-102 | ECG 123A | WEP 735 | ZEN 127 |
| 2N3974 | NA | TS-0004 | GE-20 | ICC-S0004 | IRTR-64 | PTC 123 | HEP-S0004 | SK 3122 | RT-102 | ECG 123A | WEP 735 | ZEN 127 |
| 2N3975 | NA | TS-0004 | GE-20 | ICC-S0004 | IRTR-64 | PTC 123 | HEP-S0004 | SK 3122 | RT-102 | ECG 123A | WEP 735 | ZEN 127 |
| 2N3976 | RS276-2009 | T-736 | GE-20 | ICC-736 | IRTR-64 | PTC 123 | HEP-736 | SK 3024 | RT-102 | ECG 123A | WEP 735 | ZEN 120 |
| 2N3977 | NA | T-739 | GE-22 | ICC-739 | NA | PTC 103 | HEP-739 | SK 3114 | RT-115 | ECG 159 | WEP 717 | ZEN 122 |
| 2N3978 | NA | T-739 | GE-22 | ICC-739 | TR-20 | PTC 103 | HEP-739 | SK 3114 | RT-115 | ECG 159 | WEP 717 | ZEN 122 |
| 2N3979 | NA | T-739 | GE-21 | ICC-739 | TR-28 | PTC 103 | HEP-739 | SK 3114 | RT-115 | ECG 159 | WEP 717 | ZEN 122 |
| 2N3980 | NA | T-310 | NA | ICC-310 | NA | NA | HEP-310 | NA | NA | NA | NA | ZEN 129 |
| 2N3981 | NA | NA | GE-63 | NA | TR-25 | PTC 144 | NA | NA | NA | NA | NA | NA |
| 2N3982 | NA | NA | GE-63 | NA | TR-25 | PTC 144 | NA | NA | NA | NA | NA | NA |
| 2N3983 | RS276-2011 | T-56 | GE-60 | ICC-56 | NA | PTC 121 | HEP-56 | SK 3039 | RT-113 | ECG 108 | WEP 56 | ZEN 104 |
| 2N3984 | RS276-2011 | T-56 | GE-60 | ICC-56 | NA | PTC 115 | HEP-56 | SK 3018 | RT-113 | ECG 108 | WEP 56 | ZEN 104 |
| 2N3985 | RS276-2011 | T-56 | GE-60 | ICC-56 | NA | PTC 115 | HEP-56 | SK 3018 | RT-113 | ECG 108 | WEP 56 | ZEN 104 |
| 2N3993 | NA | T-803 | NA | ICC-803 | NA | NA | HEP-803 | NA | NA | NA | NA | NA |
| 2N3994 | NA | T-803 | NA | ICC-803 | NA | NA | HEP-803 | NA | NA | NA | NA | NA |
| 2N3995 | NA | T-2 | NA | ICC-2 | TR-17 | NA | HEP-2 | NA | NA | ECG 160 | WEP 637 | ZEN 300 |
| 2N4000 | NA | T-714 | GE-18 | ICC-714 | NA | PTC 144 | HEP-714 | NA | NA | NA | NA | NA |
| 2N4001 | NA | T-714 | GE-18 | ICC-714 | NA | PTC 144 | HEP-714 | NA | NA | NA | NA | NA |
| 2N4006 | NA | NA | GE-22 | NA | TR-20 | PTC 103 | NA | NA | NA | NA | NA | NA |
| 2N4007 | NA | NA | GE-22 | NA | TR-20 | PTC 103 | NA | NA | NA | NA | NA | NA |
| 2N4008 | NA | NA | GE-21 | NA | TR-28 | PTC 103 | NA | NA | NA | NA | NA | NA |
| 2N4012 | NA | NA | GE-28 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2N4013 | NA | T-736 | GE-20 | ICC-736 | NA | NA | HEP-736 | SK 3122 | RT-102 | ECG 123A | WEP 735 | ZEN 120 |
| 2N4014 | NA | TS-0005 | GE-20 | ICC-S0005 | NA | NA | HEP-S0005 | SK 3122 | RT-102 | ECG 123A | WEP 735 | NA |
| 2N4015* | NA | T-716 | NA | NA | NA | NA | NA | NA | NA | NA | NA | ZEN 107 |
| 2N4016* | NA | T-716 | NA | ICC-716 | NA | NA | HEP-716 | NA | NA | NA | NA | ZEN 107 |
| 2N4017* | NA | T-716 | NA | ICC-715 | NA | NA | HEP-715 | NA | NA | NA | NA | ZEN 106 |
| 2N4019* | NA | T-715 | NA | ICC-715 | NA | NA | HEP-715 | NA | NA | NA | NA | ZEN 106 |
| 2N4020* | NA | T-715 | NA | ICC-715 | NA | NA | HEP-715 | NA | NA | NA | NA | ZEN 106 |
| 2N4021* | NA | T-715 | NA | ICC-715 | NA | NA | HEP-715 | NA | NA | NA | NA | ZEN 106 |
| 2N4022* | NA | T-715 | NA | ICC-715 | NA | NA | HEP-715 | NA | NA | NA | NA | ZEN 106 |
| 2N4023* | NA | T-715 | NA | ICC-715 | NA | NA | HEP-715 | NA | NA | NA | NA | ZEN 106 |
| 2N4024* | NA | T-715 | NA | ICC-715 | NA | NA | HEP-715 | NA | NA | NA | NA | ZEN 106 |
| 2N4025* | NA | T-715 | NA | ICC-715 | NA | NA | HEP-715 | NA | NA | NA | NA | ZEN 106 |
| 2N4026 | NA | T-708 | GE-67 | ICC-708 | IRTR-88 | NA | HEP-708 | SK 3025 | RT-115 | ECG 129 | WEP 242 | NA |
| 2N4027 | NA | TS-3003 | NA | ICC-S0003 | IRTR-88 | NA | HEP-S0003 | SK 3025 | RT-115 | ECG 129 | WEP 242 | NA |
| 2N4028 | NA | T-708 | GE-67 | ICC-708 | IRTR-88 | NA | HEP-708 | SK 3025 | RT-115 | ECG 129 | WEP 242 | NA |
| 2N4029 | NA | TS-3031 | NA | ICC-S3031 | IRTR-88 | NA | HEP-S3031 | SK 3025 | RT-115 | ECG 129 | WEP 242 | NA |
| 2N4030 | NA | TS-3001 | GE-67 | ICC-S3001 | IRTR-88 | PTC 141 | HEP-S3001 | SK 3025 | RT-115 | ECG 129 | WEP 242 | NA |
| 2N4031 | NA | TS-3003 | NA | ICC-S3003 | IRTR-88 | NA | HEP-S3003 | SK 3025 | RT-115 | ECG 129 | WEP 242 | NA |
| 2N4032 | NA | TS-3001 | GE-67 | ICC-S3031 | IRTR-88 | NA | HEP-S3031 | SK 3025 | RT-115 | ECG 129 | WEP 242 | NA |
| 2N4033 | NA | TS-3031 | NA | ICC-S3031 | IRTR-88 | NA | HEP-S3031 | SK 3025 | RT-115 | ECG 129 | WEP 242 | NA |
| 2N4034 | NA | T-52 | GE-21 | ICC-52 | NA | NA | HEP-52 | NA | RT-126 | ECG 106 | WEP 52 | NA |
| 2N4035 | NA | T-715 | GE-21 | ICC-715 | NA | NA | HEP-715 | NA | RT-126 | ECG 106 | WEP 52 | ZEN 106 |
| 2N4036 | NA | TS-3031 | GE-29 | ICC-S3031 | NA | PTC 141 | HEP-S3031 | SK 3025 | NA | ECG 129 | NA | NA |
| 2N4037 | RS276-2025 | TS-3012 | GE-67 | ICC-S3012 | NA | PTC 141 | HEP-S3012 | SK 3025 | NA | ECG 129 | NA | NA |
| 2N4040 | NA | TS-3005 | GE-28 | ICC-S3005 | NA | NA | HEP-S3005 | NA | NA | NA | NA | NA |
| 2N4041 | NA | TS-3005 | GE-28 | ICC-S3005 | NA | NA | HEP-S3005 | NA | NA | NA | NA | NA |
| 2N4046 | NA | TS-3008 | NA | ICC-S3008 | NA | NA | HEP-S3008 | NA | NA | NA | NA | NA |
| 2N4047 | NA | TS-0005 | NA | ICC-S0005 | NA | NA | HEP-S0005 | NA | NA | NA | NA | NA |
| 2N4048 | NA | NA | NA | ICC-G6002 | NA | NA | HEP-G6002 | NA | NA | NA | NA | NA |
| 2N4051 | NA | NA | NA | ICC-G6002 | NA | NA | HEP-G6002 | NA | NA | NA | NA | NA |
| 2N4054 | NA | T-244 | GE-27 | ICC-244 | NA | PTC 104 | HEP-244 | SK 3103 | NA | ECG 157 | WEP 244 | ZEN 201 |
| 2N4055 | NA | T-244 | GE-27 | ICC-244 | NA | PTC 104 | HEP-244 | SK 3103 | RT-135 | ECG 157 | WEP 244 | ZEN 201 |
| 2N4056 | NA | T-244 | GE-27 | ICC-244 | NA | PTC 104 | HEP-244 | SK 3103 | RT-135 | ECG 157 | WEP 244 | ZEN 201 |
| 2N4057 | NA | T-244 | GE-27 | ICC-244 | NA | PTC 104 | HEP-244 | SK 3103 | RT-135 | ECG 157 | WEP 244 | ZEN 201 |
| 2N4058 | RS276-2023 | T-52 | GE-67 | ICC-52 | IRTR-52 | PTC 127 | HEP-52 | SK 3118 | RT-126 | ECG 106 | WEP 52 | NA |
| 2N4059 | RS276-2023 | T-52 | GE-67 | ICC-52 | IRTR-52 | PTC 127 | HEP-52 | SK 3118 | RT-126 | ECG 106 | WEP 52 | NA |

NA=NOT AVAILABLE

*(turn page)*

| | ARCH | DM | G-E | ICC | IR | MAL | MOT | RCA | SPR | SYL | WOR | ZEN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2N4060 | RS276-2023 | T-52 | GE-21 | ICC-52 | IRTR-52 | PTC 103 | HEP-52 | SK 3118 | RT-126 | ECG 106 | WEP 52 | NA |
| 2N4061 | RS276-2023 | T-52 | GE-67 | ICC-52 | IRTR-52 | PTC 127 | HEP-52 | SK 3118 | RT-126 | ECG 106 | WEP 52 | NA |
| 2N4062 | RS276-2023 | T-52 | GE-21 | ICC-52 | IRTR-52 | NA | HEP-52 | SK 3118 | RT-126 | ECG 106 | WEP 52 | NA |
| 2N4063 | NA | NA | NA | NA | NA | NA | NA | SK 3045 | NA | ECG 123A | NA | NA |
| 2N4064 | NA | NA | GE-32 | NA | NA | NA | NA | SK 3045 | NA | ECG 123A | NA | NA |
| 2N4068 | NA | TS-0005 | GE-18 | ICC-S0005 | NA | PTC 125 | HEP-S0005 | SK 3045 | RT-110 | ECG 154 | WEP 712 | NA |
| 2N4069 | NA | T-714 | GE-32 | ICC-714 | NA | NA | HEP-714 | NA | NA | NA | WEP 56 | NA |
| 2N4070 | NA | TS-5004 | NA | ICC-S5004 | NA | NA | HEP-S5004 | NA | NA | NA | NA | NA |
| 2N4071 | NA | T-707 | NA | ICC-707 | NA | NA | HEP-707 | NA | NA | NA | NA | ZEN 204 |
| 2N4072 | RS276-2011 | T-718 | GE-17 | ICC-718 | NA | PTC 121 | HEP-718 | SK 3018 | RT-113 | ECG 108 | WEP 56 | NA |
| 2N4073 | RS276-2009 | T-75 | GE-18 | ICC-75 | NA | NA | HEP-75 | SK 3018 | RT-113 | ECG 108 | WEP 56 | NA |
| 2N4074 | RS276-2009 | T-55 | GE-64 | ICC-55 | NA | PTC 123 | HEP-55 | SK 3122 | RT-102 | ECG 123A | WEP 735 | ZEN 103 |
| 2N4077 | NA | NA | NA | NA | NA | NA | NA | NA | NA | ECG 155 | NA | NA |
| 2N4078 | RS276-2006 | T-643 | GE-30 | ICC-643 | TR-50 | NA | HEP-643 | SK 3052 | RT-127 | ECG 131 | WEP 642 | NA |
| 2N4079 | NA | NA | NA | NA | NA | NA | NA | NA | RT-127 | ECG 131,155(CP) | WEP 6742 | NA |
| 2N4080 | NA | T-752 | GE-21 | NA | NA | NA | NA | SK 3118 | RT-126 | NA | WEP 52 | NA |
| 2N4081 | NA | NA | GE-60 | NA | NA | NA | NA | NA | NA | NA | NA | ZEN 127 |
| 2N4086 | RS276-2009 | T-55 | GE-62 | ICC-55 | NA | PTC 139 | HEP-55 | SK 3124 | RT-102 | NA | WEP 735 | ZEN 103 |
| 2N4087 | RS276-2009 | T-55 | GE-62 | ICC-55 | NA | PTC 139 | HEP-55 | SK 3124 | RT-102 | NA | WEP 735 | ZEN 103 |
| 2N4088 | NA | TF-1035 | NA | ICC-F1035 | NA | NA | HEP-F1035 | NA | NA | NA | NA | NA |
| 2N4089 | NA | TF-1035 | NA | ICC-F1035 | NA | NA | HEP-F1035 | NA | NA | NA | NA | NA |
| 2N4090 | NA | TF-1035 | NA | ICC-F1035 | NA | NA | HEP-F1035 | NA | NA | NA | NA | NA |
| 2N4096 | NA | SR-1002 | NA | ICC-R1002 | NA | NA | HEP-R1002 | NA | NA | NA | NA | NA |
| 2N4097 | NA | SR-1003 | NA | ICC-R1003 | NA | NA | HEP-R1003 | NA | NA | NA | NA | NA |
| 2N4098 | NA | SR-1005 | NA | ICC-R1005 | NA | NA | HEP-R1005 | NA | NA | NA | NA | NA |
| 2N4100* | NA | TS-0007 | GE-63 | ICC-S0007 | NA | PTC 121 | HEP-S007 | NA | NA | NA | NA | NA |
| 2N4101 | NA | NA | NA | NA | NA | NA | NA | SK 3502 | NA | NA | NA | NA |
| 2N4103 | NA | SR-1223 | NA | ICC-R1223 | NA | NA | HEP-R1223 | NA | NA | NA | NA | NA |
| 2N4104 | NA | NA | GE-20 | NA | NA | NA | NA | SK 3124 | NA | NA | NA | NA |
| 2N4105 | NA | NA | GE-8 | NA | TR-08 | NA | NA | SK 3010 | RT-122 | NA | WEP 724 | NA |
| 2N4106 | RS276-2006 | T-238 | GE-2 | ICC-238 | TR-05 | NA | HEP-238 | SK 3010 | NA | NA | WEP 630 | ZEN 329 |
| 2N4107 | NA | NA | GE-54 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2N4108 | NA | SR-1002 | NA | ICC-R1002 | NA | NA | HEP-R1002 | NA | NA | NA | NA | NA |
| 2N4109 | NA | SR-1003 | NA | ICC-R1003 | NA | NA | HEP-R1003 | NA | NA | NA | NA | NA |
| 2N4110 | NA | SR-1005 | NA | ICC-R1005 | NA | NA | HEP-R1005 | NA | NA | NA | NA | NA |
| 2N4111 | NA | T-704 | GE-19 | ICC-704 | NA | NA | HEP-704 | NA | NA | NA | NA | NA |
| 2N4112 | NA | NA | GE-19 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2N4113 | NA | T-704 | GE-19 | ICC-704 | NA | NA | HEP-704 | NA | NA | NA | NA | NA |
| 2N4114 | NA | NA | GE-19 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2N4117 | NA | NA | GE-FET-1 | NA | NA | NA | NA | SK 3112 | NA | ECG 133 | NA | NA |
| 2N4118 | NA | NA | GE-FET-1 | NA | NA | NA | NA | SK 3112 | NA | ECG 133 | NA | NA |
| 2N4119 | NA | NA | GE-FET-1 | NA | NA | NA | NA | SK 3112 | NA | ECG 133 | NA | NA |
| 2N4121 | RS276-2023 | T-52 | NA | ICC-52 | TR-30 | NA | HEP-52 | SK 3118 | RT-126 | NA | WEP 52 | NA |
| 2N4122 | RS276-2021 | T-715 | GE-21 | ICC-715 | NA | NA | HEP-715 | SK 3118 | RT-126 | NA | WEP 52 | ZEN 106 |
| 2N4123 | RS276-2009 | T-724 | GE-20 | ICC-724 | IRTR-53 | PTC-136 | HEP-724 | SK 3124 | RT-102 | NA | WEP 735 | ZEN 106 |
| 2N4124 | RS276-2009 | T-53 | GE-20 | ICC-53 | IRTR-53 | PTC 136 | HEP-53 | SK 3124 | RT-102 | NA | WEP 735 | ZEN 112 |
| 2N4125 | RS276-2023 | T-52 | GE-21 | ICC-52 | IRTR-54 | PTC-103 | HEP-52 | SK 3114 | RT-115 | NA | WEP 717 | ZEN 102 |
| 2N4126 | RS276-2024 | T-57 | GE-67 | ICC-57 | NA | NA | HEP-57 | SK 3114 | RT-115 | NA | WEP 717 | NA |
| 2N4127 | NA | NA | GE-66 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2N4128 | NA | NA | GE-66 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2N4130 | NA | T-247 | GE-14 | ICC-247 | NA | NA | HEP-247 | SK 3036 | NA | NA | NA | NA |
| 2N4131 | NA | TS-5004 | NA | ICC-S5004 | NA | NA | HEP-S5004 | NA | NA | NA | NA | NA |
| 2N4133 | NA | T-714 | NA | ICC-714 | NA | NA | HEP-714 | NA | NA | NA | NA | NA |
| 2N4134 | NA | T-709 | GE-60 | ICC-709 | NA | PTC 121 | HEP-709 | SK 3039 | NA | ECG 108 | WEP 56 | ZEN 105 |
| 2N4135 | NA | T-709 | GE-60 | ICC-709 | IRTR-64 | PTC 121 | HEP-709 | NA | NA | NA | NA | ZEN 105 |
| 2N4136 | NA | NA | GE-54 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2N4137 | NA | TS-0004 | NA | ICC-S0004 | NA | NA | HEP-S0004 | NA | NA | NA | NA | ZEN 127 |
| 2N4138 | NA | T-733 | GE-61 | ICC-733 | IRTR-51 | PTC 139 | HEP-733 | NA | NA | NA | NA | NA |
| 2N4140 | RS276-2009 | T-50 | GE-20 | ICC-50 | IRTR-53 | PTC 136 | HEP-50 | SK 3122 | RT-102 | NA | WEP 735 | ZEN 100 |
| 2N4141 | RS276-2009 | T-55 | GE-20 | ICC-55 | IRTR-53 | PTC 136 | HEP-55 | SK 3122 | RT-102 | NA | WEP 735 | ZEN 103 |
| 2N4142 | RS276-2023 | T-52 | GE-21 | ICC-52 | NA | PTC 103 | HEP-52 | SK 3114 | RT-115 | NA | WEP 717 | NA |
| 2N4143 | RS276-2024 | T-57 | GE-67 | ICC-57 | NA | PTC 127 | HEP-57 | SK 3114 | RT-115 | NA | WEP 717 | NA |
| 2N4144 | NA | SR-1001 | NA | ICC-R1001 | NA | NA | HEP-R1001 | NA | NA | NA | NA | NA |
| 2N4145 | NA | SR-1001 | NA | ICC-R1001 | NA | NA | HEP-R1001 | NA | NA | ECG 5400 | NA | NA |
| 2N4146 | NA | SR-1002 | NA | ICC-R1002 | NA | NA | HEP-R1002 | NA | NA | NA | NA | NA |
| 2N4147 | NA | SR-1003 | NA | ICC-R1003 | NA | NA | HEP-R1003 | NA | NA | NA | NA | NA |
| 2N4148 | NA | SR-1004 | NA | ICC-R1004 | NA | NA | HEP-R1004 | NA | NA | NA | NA | NA |
| 2N4149 | NA | SR-1005 | NA | ICC-R1005 | NA | NA | HEP-R1005 | NA | NA | ECG 159 | NA | NA |
| 2N4150 | NA | TS-3002 | GEMR-4 | ICC-S3002 | NA | NA | HEP-S3002 | NA | NA | NA | NA | NA |
| 2N4151 | NA | S-620 | GEMR-4 | ICC-620 | NA | NA | HEP-620 | NA | NA | NA | NA | NA |

*Indicates a dual transistor for high-speed switching, diff amplifier etc. Likely to be a matched pair. Use two of the type specified, matching when necessary, on a curve tracer or lab-type transistor checker.

NA=NOT AVAILABLE

*(continued next month)*

# R-E's Service Clinic

## The transistor — that imprecise device!

*How to select replacements for hard-to-find types.*

by JACK DARR
SERVICE EDITOR

THE INVENTION OF THE TRANSISTOR, 25 years ago, started something. For one thing, it opened the floodgates for a simply tremendous stream of literature written about it. The mathematicians had a field day! They happily poured out a flood of formulas and then developed more, and more, and more—the h-parameters (hybrid parameters), the y-parameters (admittance parameters) in addition to the few *simple* formulas that we need to determine the performance of the thing in a given circuit.

Besides this, they came up with the incomprehensible concept of "holes." This may be valid, but it served mainly to bring about a state of total and utter confusion in the minds of those of us who must work with the things. I can attest to this, not only from my own personal experience, but from thousands of letters we get at **Radio-Electronics** in the Service Clinic mailbag.

Unfortunately, this kind of math is based on the premise that these devices are precision instruments! In other words, they're all alike. Later thinking contradicts this. In the words of one authority, "The system of stability factors is too complex to be used easily in practical design situations without computer aid or an impractical amount of human effort!"*

To be practical (meaning to work as predicted), transistors would have to be capable of precision reproduction. In plain English, this means that every device of a certain number would have precisely the same characteristics; gain, leakage, current-rating, and on and on. This is simply untrue. A group of 6CG7's all have identical characteristics; a group of 2Nxxxx's do not.

You *can* get a group of transistors with almost identical characteristics. You can *not* build them that way, though. You make them, and then you *select* those with almost identical characteristics. All you have to do to verify this statement is to read the spec sheet on any transistor. You'll find that they show a minimum, maximum and typical value for every parameter of the device. For beta, as an example, you may find it varying from 50 to 150. This is called "parameter spread," as well as other names, some not nearly so polite. Even these must be read at a fixed temperature, 25°C. All parameters vary wildly with temperature; leakage, beta, breakdown voltage, and on and on.

In a large transistor factory which I visited some time ago, the final-test machine was a monster almost 100 feet long. The transistors were plugged into little adapters, and traveled down a track on the top. At each stop, they were tested. The first few were for shorts, opens, etc. Later, they were checked for all other parameters. I asked the friendly soul who was giving me the guided tour "What's that last station, the one on the very end?" He grinned and said "When they get there, we raise the price three dollars and mark 'em MIL-SPEC!"

The transistors that were kicked out into bins in the middle of the machine were those that weren't precisely on spec, but within a given percentage *variation*. For example, if the bogey value of beta was 100, the machine could be set to kick out all that fell within a variation of +50 to −50 (except for those that read *precisely* 100; these went on to the Last Stop).

You can verify this, too. Just buy 100 commercial transistors and check them for beta. One of my friends has shown me this. Out of 100 identical transistors, 50 will be right on the typical, 25 above, and 25 below.

The wide tolerance of these things is amazing. When we were in radio school, we worked things out to four decimal places (which I always thought a bit unnecessary.) When we got out into actual service work, we found tolerances of 10% and even 20%, and felt that this was being a little slack. Normal tolerances in transistors are really something; one authority gives the figure of +100%;−50% for the beta alone.

From the preceding gloomy statements, you may begin to wonder how they could *ever* build anything with such inconstant devices. (So do they, at times.) However, there is a way. Later thinking has worked out means of compensating for the variations. To make a practical transistor circuit (one that works), the design engineer simply *designs the transistor out of the circuit.*

He does this by choosing his circuit constants so that the variation in parameters is simply *swamped out.* If this transistor has a normal leakage current of 500 μA, he sets his normal resting current at say, 2.0 mA. This is so much greater than 50 μA that the leakage-current variation won't cause too much change.

The next step in this process is the liberal use of feedback, both current-mode and voltage-mode. By doing this, he can swamp out the effects of any beta variation, and hold the overall gain of the circuit constant under worst-case conditions.

The final step is "derating." (Remember this.) This is simple; we've been doing it for years; we called it "safety factor." Example; if he needs a transistor with a maximum collector voltage breakdown of 50 volts, he uses one with a breakdown rating of 100 volts, or even 200 volts (if Production Control will let him). By derating voltage and

*J.R. Pierce: "Transistor Circuit Theory and Design" Chas. E. Merrill Books, Columbus, Ohio 1963

**This column is for your service problems—TV, radio, audio or general and industrial electronics. We answer all questions individually by mail, free of charge and the more interesting ones will be printed here.**

**If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. If return postage is not included, we cannot process your question. Write: Service Editor, Radio-Electronics, 200 Park Ave. South, New York 10003.**

current ratings, the junction will run as cool as possible. This eliminates the worst single cause of parameter variation: a rise in the *junction temperature*. This makes every parameter of the transistor vary tremendously.

Right about now, most of you are probably saying "What's this all got to do with *me*? I'm not designing the stuff: I just fix it." That's the point, brethren. To make *practical* repairs on this stuff, we have to know how it works, and above all, the working *limits* of the devices. If you understand these, you can make substitutions and in most cases come up with a circuit that works better than it did before it failed. All you need to do this is a copy of any one of the Transistor Replacement Guides, which give the ratings for the whole line of general replacement transistors. I have six of these on my desk now, and there are several others. They're the most consulted reference books I have. All of the data you need is there.

You know that one of our worst problems is locating replacement transistors. We never open up a piece of equipment that we don't see a whole new set of numbers, if the things have any numbers at all on 'em. The makers of general replacement transistors claim that only 50-60 of their transistors will replace thousands of OEM numbers. This is quite true.

There simply isn't all that much *difference* in transistors. For example, if you need an i.f. or tuner transistor in a TV set, one general replacement transistor, such as RCA's SK-3018 or Motorola's HEP-728, can be used to replace any one of literally thousands of OEM types. There are several others, of course, in other lines; I just picked those at random.

All common transistors could be lumped into a very few classes, with a very small set of the really important parameters. The *least* important to us is the beta. (More on this later.) The most important, in my mind, is the collector breakdown voltage and maximum collector current rating.

A properly designed transistor stage will be amply derated, as I said before. My pet authority on the subject recommends that a transistor should never be used at a collector current that is more than 40% of its maximum current rating. The same thing would apply to the collector voltage breakdown, though I like to double this, at least, and have used a factor of four.

The most controversial statement that I've made so far is probably the one about the beta being the least important parameter. Like everything else in our business, this isn't unqualified. I did say that in a *properly designed* circuit, it wasn't too critical! This is due to the fact that the beta of all transistors is far from being a constant thing. It will vary wildly with temperature, current, applied voltage, leakage, and you name it. In the properly designed circuit, these variations will be swamped out so that wide variations of voltage, current and even junction temperature will have only a small effect on the overall *gain* of the stage. (For a full discussion of this, read Gerald Williams' "Practical Transistor Circuit Design and Analysis," McGraw-Hill 07-070398-1.)

Besides these things, we have the wide parameter spread; often as high as 75% ± the bogey value. So, even if you are using an Exact Factory Replacement, it's possible to get one with a beta that differs quite a bit from the original. (You may get one that's precisely the same, but then you may not. I've checked a few "matched pairs," and found them highly un-matched!)

In actual service work, and in a long series of experiments using general replacement transistors, I've found that this will work. I have substituted as many as five different GR types into TV sets, and found no trouble at all. In most cases, if you can "get in the ball-park," OK. If you can find a number on the thing, and it's listed in the Replacement Guide, the chances are it will work very well. The only time I've ever run into trouble is with the occasional typographical error.

There is one case where you may run into some problems. This is in the multi-stage direct-coupled audio amplifiers. If you replace an output transistor, and the resting current is incorrect, try replacing the driver transistor. The original driver may not have precisely the correct beta. (Although, as said before, if the designer swamped the circuit out, this won't upset it.) Try using types with either a higher or lower beta, and see. Sound like K&T? (Kut and Try.) It is. It may be the way the stage was designed in the first place! To check, read the resting current of the output transistors.

You can make your own experiments. The next time you get a TV set with plug-in transistors, try a few from your general replacement stock. Try picking one that *looks* as if it would work. The chances are that it will. **R-E**

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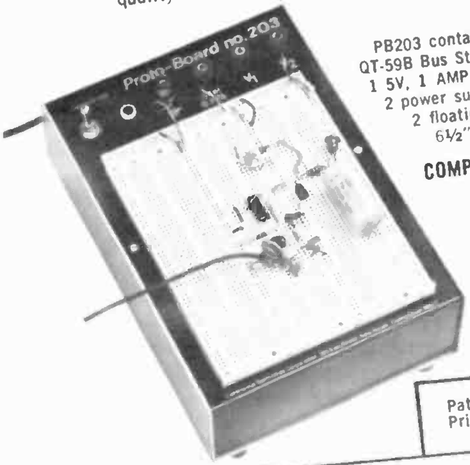


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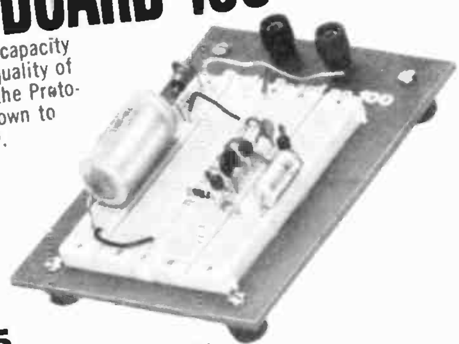

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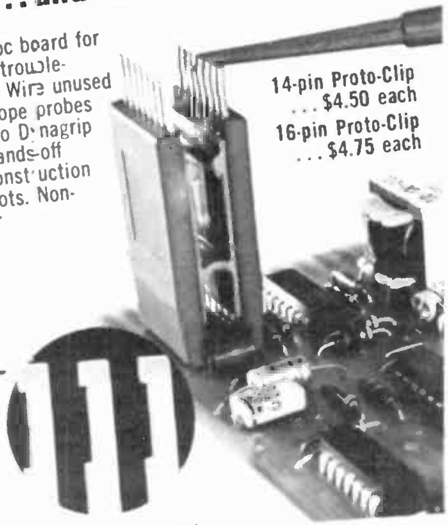

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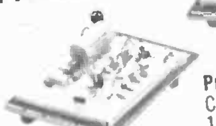

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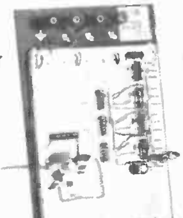

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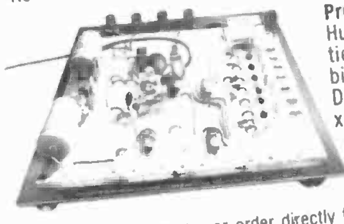

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# reader questions

### HUM-BARS FROM TRANSLATOR???

*"In regard to the 'Hum-Bars in The Color' question, in the August 1973 issue, if the reader is getting his signal from a translator station, this is normal! I've seen this on about 20 sets in my area, on translators!"—R.J., Franklin, N.C.*

Excuse me for differing with you, but hum-bars in translator signals are definitely *NOT* normal! (In color, or anything else.) Not if the translator station is operating up to FCC standards. If you see them on more than one set, this should be reported to the Chief Engineer of the TV station using the translator. If this doesn't get action, write to your nearest FCC office.

### LOCAL STATION "BLOCKS" RADIO

*Here's a problem! In a small clock radio, it'll get the local station, 50 kW, 540 kHz, about a mile away, and that's it. From about 590 on the dial, nothing. All transistors check out.—L.F. Watrous, Sask, Canada.*

You *do* have a problem. And when I get through you'll probably still have it. This is common. The signal from a 50-kilowatter at only a mile is tremendous, and I'm afraid that it's simply blocking the mixer-oscillator stage. The field strength is so great that the transistor is cut off.

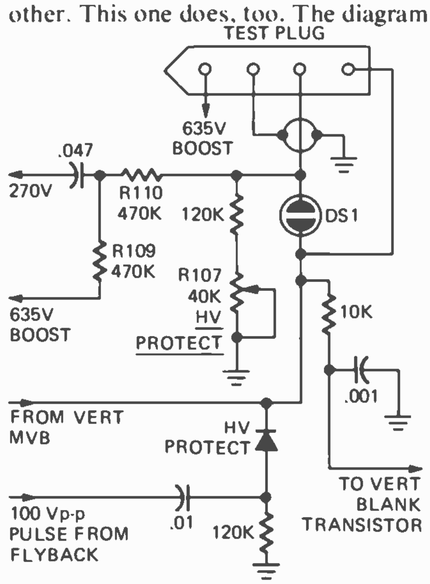
About the only thing you could do is try a "suckout" trap tuned to the frequency of the local.

### HV PROTECTION CIRCUIT

*Hey; I'm in hot water again. This time it's an almost new RCA CTC-63XC with brightness problems. If I turn the brightness control or contrast control down, the raster will cut off. Won't come on again until I turn the set off and on. Everything I check seems normal; waveforms, etc. HALP!—C.C., Baton Rouge, La.*

Well, you know what they say; stay in hot water long enough and you get pretty hard-boiled. Let's see. This sounds familiar.

Many late model sets have "protection circuits" built into them, to comply with some HEW regulation or other. This one does, too. The diagram




shows the high-voltage circuitry. RCA's service data says "With a synced picture, connect a 5-megohm precision resistor across R109-R110. The neon bulb DS1 should fire, and produce a blank or no-raster condition." The variable resistor, R107, is the control for this circuit, I'm almost certain. Seems to be able to set the threshold for the cutoff action (which cuts off the raster by biasing the video, through the vertical blanker).

Check this; if the neon lamp *is* firing, the circuit is getting just a little too eager about protecting you! You should be able to adjust it, with R107, to a point where it won't trigger on normal brightness or contrast changes. If not, the neon lamp may be defective; some of these will get erratic and fire at different voltages. Replace it. **R-E**

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#215 Stereo Amplifier Kit $69.50 PPD

The first of the super low distortion amplifiers, our famous "Tiger .01". The first amplifier to be designed with our complementary differential input system. Rated at 60 Watts continuous sine wave output into either 4.0 or 8.0 Ohms, "Tiger .01" is 3.0 dB down at 0.1 Hz and 250 KHz. Power bandwidth is 10 Hz to 75 KHz; and IM distortion is of course less than .01% up to rated output. The circuit is housed in a bronze annodized chassis and has an output meter, overheat indicator lamp and power switch on the front panel. Parts are our usual name brand first quality stuff. In this kit you will find things like RCA, and Motorola transistors, Sprague capacitors and like that. The kit comes with the usual pictorial wiring diagrams, wiring tables and step-by-step instructions.

#207 Amplifier Kit $77.50 PPD

New–#275 Tiger B

Our latest version of the amplifier that started it all, the faithful old "Universal Tiger". We have switched to our new complementary differential input circuit and put him in a fancy new chassis, but this is still the most economical, low distortion power you can get. Rated at 75 Watt with an 8.0 Ohm load, or 90 Watts with a 4.0 Ohm load with IM distortion less than 0.1% up to rated output. Typically less than .02% at low power levels. Frequency response is -3.0 dB at 0.1 Hz and 250 KHz and rise time is less than 1.0 microsecond. "Tiger B" is the ideal BASIC amplifier for all type of applications Hi-Fi system, public address, instrument amplifier; you name it. As in all of our amplifiers, we have provided all of the protection that we know how to put into a circuit. The outputs stages have volt-amp limiting systems, there are two supply fuses, a line fuse, a speaker fuse and a thermal cutout. "Tiger B" comes in the same chassis as our #207, but the finish is alodine instead of annodize. For those of you who insist on guilding the lilly, we will have an accessory kit to add an output level meter, input level control, etc.

#275 Amplifier Kit $64.50 PPD


Tigersaurus is our answer to those who want, or need tremendous amounts of power, but insist on it being clean. This amplifier uses the same basic circuit as "Tiger .01", but uses stacked parallel output devices and of course a higher supply voltage. This amplifier can supply 200 Watts continuous sine wave power into 8.0 Ohms and 250 Watts into 4.0 Ohms at less than .05% distortion. Below 100 Watts distortion is typically less than .01%. Output at clipping is typically 300 Watts. Bandwidth is the same as our other amplifiers. The eight output transistors are mounted on over 500 square inches of heat sink for cool reliable operation even at these power levels. There is a large illuminated meter to indicate power output on the front panel and the entire case is finished in a bronze annodized finish for durability and scratch resistance. If you need "beastly" amounts of power this is the amplifier for you.

#210 Tigersaurus Amplifier Kit $154.50 PPD

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*(continued from page 53)*

ns. If you are running any memory very fast, times will occur when the old information or wrong information will be put out until the answers settle down. If this "garbage" time is too great for your application, you can add a latch to the output (perhaps a 74174) to sample the output only during instants when you know the data is good. A very few new memory IC's include internal latches and eliminate this problem.

By the same token, if you are running fast, the ripple and gate times on address changes may cut into your cycle time significantly. Again, if you are running fast, it pays to either use fully synchronous timing or else latch the addresses to get them all changing at once. Some semiconductor mainframes get around the problem by using emitter coupled logic (ECL) and its very high speeds for addressing.

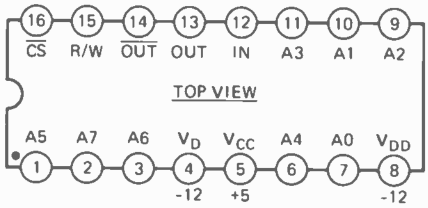
The 7489 has a few obvious and apparently untapped electronic music applications. For instance, you can use sixteen four-bit words to completely specify one cycle of a music waveform, the attack-sustain-decay envelope of a note or a melodic sequence. These run around $3.50 surplus and under $11.00 new.

### Other TTL memories

There's quite a few other TTL memories available, some as long as 1024 bits. The 7481 is a very old design arranged as sixteen words of one bit each. The 74170 is called a 4 × 4 file, meaning it is a 16-bit memory arranged as four words of four bits each. The 74200 and faster 74S200 are a 256 × 1 memory or 256 words of one bit each. There's also a bunch of "non-7400" TTL memories. The *Signetics* 8225 is a pin-for-pin replacement for the 7489.

### 1101

The 1101 is a MOS static memory arranged as 256 words on one bit each. It's shown in Fig. 8. MOS memories are gener-




CHIP ENABLE LOW ENABLES OUTPUT
CHIP ENABLE HIGH DISABLES OUTPUT
R/W HIGH WRITES
R/W LOW READS

**FIG. 8—256-BIT MOS MEMORY takes +5 and −12-volt supplies. Typical devices are Signetics 25L01 and Mostek MK4007-4P. Older 1101 devices use same pinout but run hotter and take −9-volt supplies.**

ally much cheaper and often much slower than TTL ones. The 1101 works on +5, −9 supplies and runs quite hot. There is TTL compatibility on inputs, addresses and outputs. There are seven address lines, internally decoded to pick one of the 256 bits. There is one input line and two output lines, a normal one and its compliment.

To read, you make the chip select low and the read/write low after applying the selected address. The output data will be valid within a microsecond or so afterward.

To write, you select your address, wait 300 ns, bring the read/write line high for at least 400 ns and then wait at least 100 ns after the write line goes low before changing addresses. As usual, NEVER change the address during, before or immediately after writing.

The 1101 is widely available and costs as little as $2.56 for probably good surplus units and as little as 50¢ for questionable surplus units. New cost is under $6.00. One possible application would to be using six of them in a data terminal or programmable calculator to store a 256-word message using the ASCII code.

### Improved 1101's

The original 1101's were rather slow and could take as long as 1.5 ms to read. They are very hot running and the −9 supply is usually a rather wierd thing to have to provide. Improved devices are now available. An 1101A1 cycles in one microsecond maximum. The *Signetics* 25L01 and the *Mostek* MK4007-4P are second-generation, pin-identical, versions that cycle in under a microsecond, consume much less supply power and work on standard +5, −12 supplies.

### CMOS RAM's

One new type of 1101 replacement is the CD4061, a CMOS device made by RCA. This is a pin-for-pin replacement, but being CMOS, it takes only one supply and draws utterly negligible supply power if you aren't writing or changing the address. Thus, you can use this with a very small battery for power down storage and still hold the information. You can also run on incredibly lower currents than the 1101 style devices and much faster as well—several hundred nanoseconds. This makes the 4061 ideal for hand-held data equipment and calculators, as well as meter readers and things like this. The only hitch—it's a new device and still costs $40.00. Maybe next year.

Other CMOS memories include the *Motorola* 14505 (64 × 1), the *Solid State Scientific* SCL5554 (256 × 1) and the *Inselek* A5503 (256 × 1).

### 1103

The main reason we include the 1103 here is as a warning NOT to try and use it—unless you have lots of fancy equipment and considerable experience. This is especially true of surplus 1103's.

The 1103 is a 1024-word x 1-bit dynamic shift register. It is very low in cost. It ranks as the all time most successful single integrated circuit and it toppled "king core" from the computer world. The device trades a very simple and very dense internal circuit for quite a bit in the way of outside support circuitry. This IC needs critically controlled clocks, usually needs an output sense amplifier, and has a complex timing sequence so elaborate that a 30-ns overlap error in the wrong place will cause information dropout. The 1103 is eminently suited for large memories of at least 50,000 bits (this is tiny by mainframe computer standards) or so, where all the critical support circuitry is easily worked with and may be offset by the savings you get by cramming 1000 bits in each package.

The 1103 uses capacitors for internal data storage. The data must be moved around or *refreshed* at least 500 times per second.

*(continued on page 98)*

USING THE VOM AROUND THE CAR

by JACK DARR
SERVICE EDITOR

HERE ARE A FEW HANDY TRICKS AND TESTS you can make with a standard volt-ohmmeter (vom), around a car, boat, motorhome or anything with a dc power supply system. The primary source of power here is a storage battery with a recharging system. These systems are about as simple as you'll get, electrically speaking. There will be a hot wire from the battery to all devices, and the frame of the vehicle itself serves as the return or ground. When the engine is running, the battery is being recharged by a generator or alternator. That's all she wrote.

Whenever you have any kind of electrical trouble, you need some way to get a handle on the problem. The first thing to check is the condition of the battery. Using the 0 to 15 or 0 to 20-volt dc range of the vom, check this at any convenient point, usually at the battery itself. Normal voltage of a fully charged battery should be 12.6 volts. Simple test for condition of charge; switch on a medium load, like the headlights. The voltage shouldn't drop more than a fraction of a volt. If it goes down to 8 to 10 volts, the battery needs recharging.

For the simplest check on whether the recharging system is working, start the engine and then read the voltage across the battery. Of course, if the battery won't turn the engine over, that answers your question. If it does start, the voltage should go up to about 14.5 volts.This shows that the generator or alternator is trying to charge the battery, anyhow. Unfortunately, this won't tell you whether the battery will take a charge or not. The voltage regulation of the system is very good, and it won't let the voltage go higher than 14.5 volts, even on a battery with a bad cell.

You can start the engine with jumper cables from another car. There is a right and wrong way to do this, too. WATCH the POLARITY! All US made cars, and a great many foreign cars,have a negative ground connection.

Connect the black cable from ground to ground on each car. Any good clean bolt, etc. makes a good contact. Now hook the red cable to the positive battery post of the good one, and to the positive battery post of the dead one. Start the engine of the helper car. NOW try to start the engine of the dead one. This lets the generator of the helper car carry the load. (In some British cars, such as MGB's, if you raise the bonnet, which is the tin thing covering the motor, you'll see a little label saying "This vehicle wired negative earth." Same thing.)

### Cable testing

If the car starts slowly, there may be other things wrong besides a low battery. Bad contact between the battery cable terminals and the battery posts is one. To check for this, put one prod of the vom on the end of the battery post itself, and the other on the cable terminal. Push hard to make a good contact, and then hit the starter. If you see any *voltage reading* at all, this contact is dirty. Use the lowest scale on the vom for this, for accuracy. If you see even 1.0-volt reading on this test, take the terminal off, and clean both post and inside of the terminal, and bolt it back on very tightly. Recheck.

Second check: put one prod of the vom on each post of the battery (not on the terminals; the post itself). Note the reading, then crank the car. The voltage should not drop below about 9 or 10 volts. If it does, the battery may be low.

If you don't get much voltage drop on the battery itself, take the same reading from the terminals. A drop here indicates a dirty contact between post and terminal; clean it up. If the voltage stays up at this point, but the starter cranks slowly, put one prod on the negative terminal of the battery and the other on a good clean bolt on the engine itself. Hit the starter. If you get any voltage reading, even on the lowest scale, the battery's ground cable isn't making good contact somewhere. You're reading a voltage drop across what should be practically a zero resistance. Loading it with the heavy current of the starter will show it up instantly.

### Dim lamps

In some cases, lamps on the car or motorhome will be mysteriously dim, though the battery checks good. This is usually due to corrosion or a dirty contact at the lamp socket. Take the bulb out, and scrape the terminals and shell clean. Check the socket for dirt or foreign matter.

If it's still dim, connect the negative vom lead to the frame, and check the voltage on the hot wire at the lamp socket. If this reads the full normal voltage, take another reading, this time from the negative (shell) of the lamp socket to the nearest ground. This, of course, should be zero, if the ground connection is good. If you see a 2 to 3-volt reading here, connect a jumper wire

*(continued on page 90)*

# If you can use any of these tools...

**You could build this Bell & Howell 25-inch diagonal color TV with digital features!**

Electro-Lab is a registered trademark of the Bell & Howell Company.

# It's just part of a fascinating learn-at-home program in electronics from Bell & Howell Schools!

Simulated TV picture


If you're handy with a set of tools, you may already have some of the skills you'll need to build Bell & Howell's color TV . . . the TV with digital features! This program is the perfect way to discover the exciting field of digital electronics . . . and best of all, you can do it all at home, in your spare time. Get free information now about this first-of-a-kind learn-at-home program prepared for you by skilled instructors at Bell & Howell Schools.

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Once you complete this learn-at-home program, you'll have the specialized skills to service color TV's plus the knowledge that you can apply to repair a variety of home electronic equipment. And because this Bell & Howell Schools' program includes the study of digital circuitry, you'll be among the first with professional home training in digital electronics, a field that's growing in importance every day.

**No electronics background necessary**

We start you off with the basics. You'll receive a special Lab Starter Kit with your first lesson so that you can get immediate "hands on" experience to help you better understand newly-learned electronics principles. Later, you'll use your knowledge and learn valuable skills as you build the color TV. You can take full advantage of our toll-free phone-in assistance service throughout the program and also our in-person "help sessions" held in 50 cities at various times throughout the year where you can "talk shop" with your instructors and fellow students. You learn valuable skills in electronics through experiments and testing as you build this advanced-design color TV.

**You build and work with a revolutionary color TV**

Discover the technology behind such extraordinary features as channel numbers that flash on the screen, an on-screen digital clock that flashes the time in easy-to-read numbers, and an automatic pre-set channel selector that allows intermixing of VHF and UHF channels in any sequence. You'll enjoy probing into advanced performance features like silent all-electronic tuning, Black Matrix picture tube, "state of the art" integrated circuitry, and the 100% solid-state chassis that makes possible a brighter sharper picture with long life and dependability.

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While many of our students do not ask for employment assistance, it is available. We will help you look for a job in a field of electronics that best fits your interests and abilities. Of course, no assurance of income opportunities can be offered. One thing you can be certain of: no better or more practical at-home training in electronics is available anywhere.

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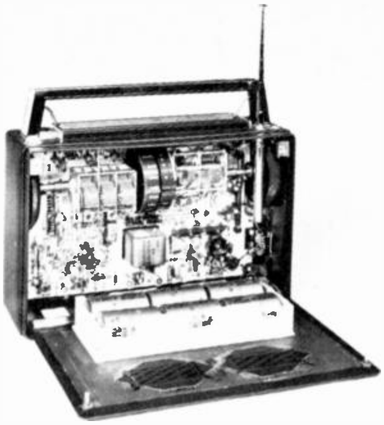
# new products

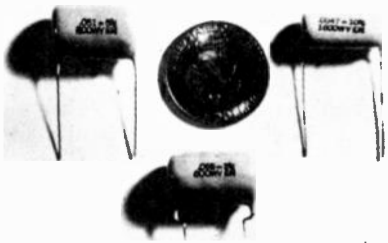
*More information on new products is available from the manufacturers of items identified by a Reader Service number. Use the Reader Service Card inside the back cover.*

**PORTABLE SHORTWAVE RECEIVER,** *model XCR-30.* All solid-state set features direct frequency readout. Uses multiple heterodyne circuit (interpolation and crystal oscillators); provides precision no-gap tunning from 500 kHz to 30 MHz. A 1-MHz crystal — in conjunction with the Wadley Loop circuit (Racal) — stabilizes received frequency and eliminates drift. Tuned frequency is displayed mechanically as a composite function of two dials; the whole number (in MHz) shown on one dial drum and the decimal portion (in kHz) shown on the second. Reception modes include AM, CW and switchable (LSB or USB) single sideband. There are provisions for an external 9-12 volt dc supply, earphone reception and an external antenna (there is a built-in collapsible whip antenna). 11-½ x 7-½ x 3-⅞ in.; 9 lbs. 2 oz.; about $260.00—**Gilfer Associates, Inc.,** 52 Park Avenue, P.O. Box 239, Park Ridge NJ 07656.



*Circle 31 on reader service card*

**CAPACITORS.** *El-Menco* polypropylene dielectric capacitors are used in the audio to ultrasonic frequency range. Dissipation factor at 1 kHz is not greater than 0.1 percent and insulation resistance is greater than 10 gigohms. Capacitance drift after a temperature cycle from −55°C to +85°C is less than 0.5 percent.



Temperature coefficient is −200±150 ppm/ degree C. Features: film and extended foil construction, radial leads securely attached and fire retardent encased.

Type *PPD* series covers range of values from .0018 to .47 μF at dc rated voltages of 200, 400 and 600. Type *PPDS* series covers range of values from .001 to .1 μF at 600, 1000 and 1600 volts dc. Tolerances for both types are ±2, ±5, ±10 and ±20%. — **International Electronics Corp./El Menco,** 316 South Service Road, Melville, N.Y. 11746.

*Circle 32 on reader service card*

**QUADRIPHONIC RECEIVER,** *model 434* features 64 watts (4 x 16) rms continuous, all channels driven into 8 ohms at rated power bandwidth (28—22,000 Hz). FM sensitivity: 1.8 mV. Has front/rear SQ logic circuitry; CD-4 demodulator; "joystick" channel balance control.

Amplifier strapping combines power output of all channels for stereo operation.

There are two tuning meters — center-of-channel, signal strength; loudness contour with automatic shut-off when level is raised; illuminated mode indicators; Baxandall-type bass and treble controls; FM muting, jacks for 2- or 4-channel headphones; 4-channel recorder output jacks and tape monitor circuit.—**Fisher Radio,** 11-40 45th Road, Long Island City, NY 11101.

*Circle 33 on reader service card*

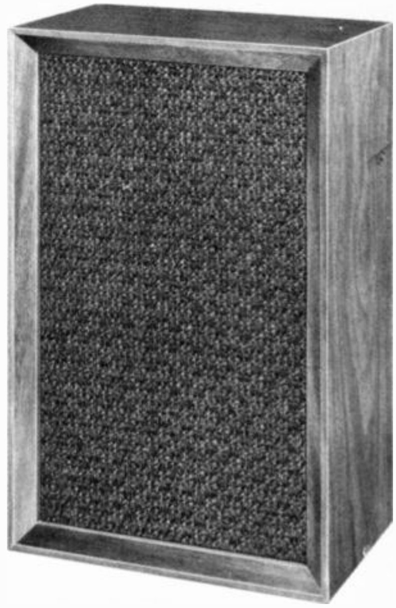
**MIXER POWER AMPLIFIERS** feature low distortion, extended and linear frequency response, low noise content and continuous wattage output. Model *UPD-120T* offers 120 watts ±1.5 dB at less than two percent THD from 50 to 15,000 Hz. Model *UPD-60T* provides 60 watts and UPD-*30T* has 30-watt power output

with same specifications. All three models incorporate straight-line fader controls for mixing, equalization and mastering.

Master bass and treble controls, ±10 dB at 80 Hz (bass control) and ±10 dB at 8000 Hz. Master gain control provides simultaneous regulation of all six input channels. Other features: preinstalled transformers for balanced 150-ohm mic level inputs; input and output jacks for signal processing from external equalizer or compressor, tape/booser output that produces maximum of plus 30 dBm for use with tape recorders or bridging additional power amps; signal-to-noise is 75 dB — **University Sound,** 1515 South Manchester, Anaheim, Calif. 92803.

*Circle 34 on reader service card*

**3-WAY LOUDSPEAKER SYSTEM,** *model AS-5.* Features a 10-inch high-compliance woofer that uses a 4-layer high temperature copper voice coil and 35-Hz resonance; 6-inch mid-range driver that uses damped cloth suspension and



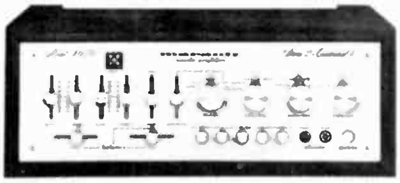
sealed chassis; 3-½-inch direct radiator tweeter. Electrical crossovers provide frequency division within the system's range of 40 Hz to 18 kHz. Power capacity is 25 watts program, 50 watts peak. Nominal impedance is 8 ohms. 12-½ × 22 × 9 in.; 27 lbs.; finished in deep walnut with brown-and-black tweed grille fabrics; $69.95—**Utah Electronics,** 1124 East Franklin Street, Huntington, Ind. 46750.

*Circle 35 on reader service card*

**MARINE CB ANTENNA,** *Lancer style 4039* requires no ground plane—works equally well on fiberglass, wood or metal boats. Features end-fed half-wave design and impedance-matching cable with thread base for ratchet folding mount (style 366). All antenna fittings are corrosion-proof nickel-chrome plated brass. 10-½ feet; complete with harness $33.95.—**Shakespeare Co.,** Industrial FiberglassDiv., P.O.Box5806, Columbia, S.C. 29250.

*Circle 36 on reader service card*

**AMPLIFIER,** *model 4070* is rated at 70 watts total continuous power. Unit produces more than 15 watts per channel in *Quadradial* mode. Compatible with stereo with bridging circuits producing full stereo power of more than 35 watts per channel. Total harmonic distortion at rated power is 0.5%. Pre-out/main-in facilities are provided on rear panel, allowing preamplifier section and output amplifiers to be used independently. Four-channel facilities include



decoder pocket on bottom panel that accommodates optional SQ-decoder or any advance in 4-channel matrix technology.

Built into amplifier is exclusive Vari-Matrix, a synthesizer that derives 4-channel sound from both stereo and matrix-encoded sources. A dimension control is provided for fine tuning 4-channel effect. Unit incorporates facilities to accommodate discrete demodulator for reproducing 4-channel sound from CD-4 discs and discrete tape sources. Other features include separate slide-type front-to-rear and left-to-right balance controls, separate professional slide-type bass and treble controls, loudness compensation, low and high filters and tape/source monitoring. $299.95 — **Marantz Co., Inc.**, P.O. Box 99, Sun Valley, Calif. 91352.

*Circle 37 on reader service card*

**PROGRAMMER** can program any MITS desktop calculator to do long or often used calculator operations. Instead of repeatedly entering into calculator a formula in which only certain variables change, a formula can be entered once into programmer and then be stored at will. Automatically executes all steps of program until it sees a location within the formula where a variable is to be entered. It then halts execution, but once the variable is entered into



*Circle 62 on reader service card*



*Circle 64 on reader service card*



*Circle 63 on reader service card*

calculator, the continue key is pressed again and all remaining steps of formula are executed

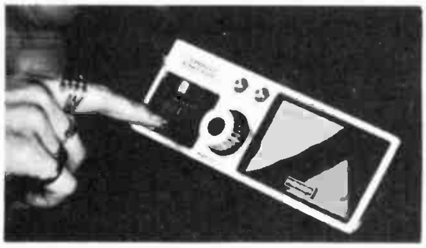
until programmer sees another variable entry or end of program command.

Each key of calculator is represented by special alphanumeric programmer code. Code is entered into programmer by depressing appropriate programmer keys associated with each code. Once a complete program has been entered, user can return to beginning address and either run program from start to finish or step through each instruction, executing them one at a time. Features 256 programming steps with optional expandability to 512 steps, constant power to RAM's to preclude destruction of stored programs, 16-key array to enter the address or instruction in hexadecimal. Kit form $199.95; assembled unit $299.95 — **MITS Inc.**, 6328 Linn, N.E., P.O. Box 8636, Albuquerque, N.M. 87108.

*Circle 38 on reader service card*

**CAR STEREOS & SPEAKER SYSTEMS,** *Chameleons.* Three models feature a removable, exchangeable front panel that can be modified, mixed or matched to suit the consumer's mood and the car's intereo. Sound from the stereo speakers emanates from both around and through the fabric or graphics display panel. All panels have the tilt-up look.

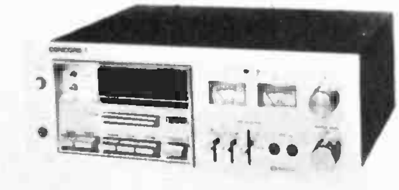
6½ inch speakers fit into a variety of locations



three 8-track under-dash units: *TP801* features an AM/FM radio; *TP800* has an FM radio and *TP828* is the 8-track unit alone. — **Pioneer Electronics of America**, 1555 East Del Amo Blvd., Carson, Calif. 90746.

*Circle 39 on reader service card*

**CASSETTE DECK,** *model CD-1000* is designed as a stereo component with front loading. Front panel contains headphone jacks, two VU meters, microphone jacks and tape counter with



memory rewind. Tape motion and direction is visually indicated.

Features solenoid assisted piano key controls for play, stop, rewind and fast forward; Dolby noise reduction system which eliminates tape noise and hiss; tape selector switch for regular, low-noise and chromium dioxide tapes; built-in illumination for head cleaning. Also contains a locking pause control, separate clutch-coupled



*Circle 65 on reader service card*



*Circle 66 on reader service card*

rotary record and output controls and an input line/mic selector switch. $299.95. — **Benjamin Electronic Sound Co.,** 40 Smith Street, Farmingdale, N.Y. 11735.

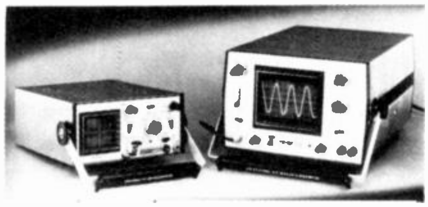
*Circle 40 on reader service card*

**MICROPHONE,** *Trucker model 555.* Noise-cancelling power microphone for CB application has been field tested on actual hauls by truckers. Sound waves of speech about 1/4 inch from lips are curved and accepted by special microphone cartridge and diaphragm. After traveling from distances beyond 1/2 inch, sound waves start to flatten out and microphone cartridge is insensitive to waves in this flat form.


Has high impact charcoal grey Cycolac case, three-conductor (one shielded) coiled cable that extends to eight feet, press-to-talk switch that springs to off position when released and a mounting bracket for vertical or horizontal mounting. Solid-state amplifier and piezo electric ceramic element resist temperature and humidity extremes. Factory wired for electronic type operation, it converts if relay type switching is required. Output is adjustable over 40 dB range with control knob furnished or with small screwdriver. Output impedance is under 5000 ohms and recommended load is 100 ohms and up to open circuit. 3-3/8 x 2-3/8 x 1-19/32 in.; 10-3/4 oz with cable. — **Astatic Corp.,** Box 120, Conneaut, Ohio 44030.

*Circle 41 on reader service card*

**OSCILLOSCOPES,** *models 37 & 27.* Model 37 is a 3-inch scope, that operates over a bandwidth from 5 Hz to 2.5 MHz; in either 110-120 V or 220-240 V models for either 50 or 60 Hz. Input impedance: 1 meg-ohm shunted by 30 pF; maximum input: 400 V; synchronization: internal plus or minus and external; external band-

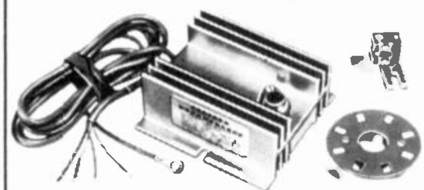


width: 5 Hz to 300 kHz; draws 25 watts; 4 x 8-1/4 x 10-3/4 in.; 11 lbs.; $165.00.

Model Systems 27 is a 5-inch scope, has 5-inch CRT and operates over bandwidth from dc to 2.5 MHz; in either 110-120 V or 220-240 V models for either 50 or 60 Hz. Additional application is television line and field synchronization. Input impedance: 1 megohm shunted by 30 pF; maximum input: 400 V; synchronization: internal plus or minus, external, TV line and field; external bandwidth; dc to 300 kHz; 7 x 10-1/2 x 17 in.; 15 lbs.; $280.00.—**Systems Electronics, Inc.,** 9727 Inglewood Avenue, Inglewood, CA 90301. R-E

*Circle 42 on reader service card*

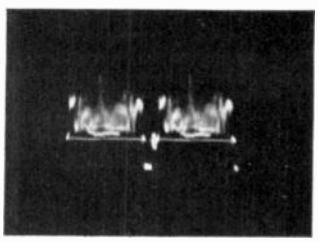




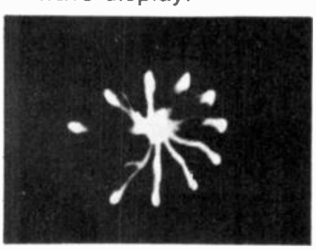


*Circle 67 on reader service card*

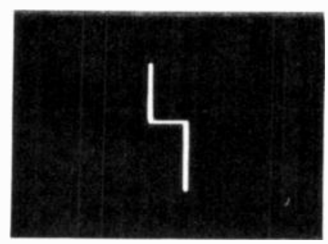




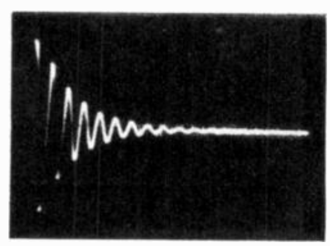














*Circle 68 on reader service card*

## APPLIANCE CLINIC
*(continued from page 81)*

from the socket to a ground. If this brings the lamp to normal brightness, take the original ground connection off and clean it. These are generally pigtails from the socket to a nearby bolt on the frame. Many tail-lamps, etc. on modern cars are mounted in plastic. So, they must have a pigtail to ground to make the lamp light.

If you get a low voltage under load, at the lamp socket, take the lamp out and repeat the test. If you now get the full battery voltage, the chances are that you have a wire somewhere with almost all of the strands broken. The low loading of the vom will show you the full battery voltage, while the load current of the lamp causes a high voltage drop in the wire. Cure; trace the wire, looking for a place where it has been almost cut in two, or bent very sharply. In some cases, such as tail or stop-lights inside the trunk, you can run another wire from the bad socket to a good one; tape the new wire to the cable, and that's all you need.

### Leaks

One of the most annoying things in the world is to go out on a cold morning and find your battery so dead that it won't even grunt. If there is a small current leakage anywhere in the system, it will drain the battery overnight. If you get it going, the next morning it could be dead again. This *can* be the battery itself; the only way to tell is with a "load-tester" at the service station. If the battery checks good, then you have a leakage.

If your vom has a dc amperes scale, preferably up to 10.0 amps, you can use it for the next test directly. If you have only a dc volts scale, get a 1.0-ohm wirewound resistor, and connect the vom prods across this, on a low dc volts scale. You'll read 1.0 volt dc for each 1.0A of current flowing through the resistor. Now you're ready to find the leakage.

Take one of the battery terminals off the post (either one). Connect the vom on the dc amps scale, or the 1.0-ohm resistor, *between* battery post and cable. Be sure that every normal load on the car is turned off, and the doors closed to turn off the dome lights. You should see zero current. If there is any leakage current, you'll read it on the meter. In my own car, some years ago, I had a steady reading of about 2.0 A. This may not sound like too much, but it pulled a perfectly good battery down so far that it wouldn't even pull in the starter solenoid!

The locate the leaky device, just start disconnecting things. When you pull the wire off the guilty part, you will see the leakage current disappear. In my car, it was the stop-light switch. A new one fixed it up. The push-on terminals used in so many places in modern cars makes this a lot easier. **R-E**

# new lit

*All booklets, catalogs, charts, data sheets and other literature listed here with a Reader Service number are free. Use the Reader Service Card inside the back cover.*

**INTRODUCTION TO MATV.** 22-page booklet contains chapters on television signal, antennas, ghosting, cable preamplifiers, main power amplifier, splitters (combiners), tapoff (TV outlets), matching transformer, special applications, overall system, cost factors and a glossary of terms. Includes many diagrams. — **Blonder-Tongue Laboratories, Inc.**, 1 Jake Brown Road, Old Bridge, NJ 08857.

*Circle 43 on reader service card*

**TEST & MEASUREMENT INSTRUMENTS CATALOG.** 10-page catalog describes the TM 500 series which includes counters, power supplies, multimeters, signal sources, signal processors and CRT monitors. Contains many illustrations. — **Tektronix, Inc.**, P.O. Box 500, Beaverton, OR 97005.

*Circle 44 on reader service card*

**1974 ELECTRONIC TEST ACCESSORIES CATALOG.** 68-page catalog contains more than 500 products, 17 or which are new. Products introduced in this edition include a "Grabber" test probe fitted with 6-32 threads, a 36 kV test probe, seven adapters, three banana jacks with wire wrap terminals, four patch cords and one molded breakout. Provided illustrations and complete engineering information on all products—including dimension drawings, schematics, specifications, features and operating ranges.—**Pomona Electronics**, 1500 East Ninth Street, Pomona, CA 91766.

*Circle 45 on reader service card*

**SYSTEMS EQUIPMENT CATALOG** contains 75-ohm installations, 300-ohm installations, MATV systems diagrams, antennas, splitters, matching transformers, couplers, attenuators, tap-on wall plates, tap-off wall plates, hook-up cables, coaxial cables, uhf connectors, cable connectors, cable clips and clamps grounding blocks, tools, stapling equipment, parts master and how to sketch and plan a system. The second half of the catalog contains 19 systems project worksheets.—**RMS Electronics**, Inc., 50 Antin Place, Bronx, NY 10462.

*Circle 46 on reader service card*

**TOOL KITS CATALOG.** 12-page catalog describes 18 different stock, fully equipped tool kits and shows 13 tool cases that can be ordered empty or custom filled with a choice of tools, meters, parts containers, etc. Tool kits are designed for maintenance, assembly and repair in the electronic, electrical, vending, computer, relay, appliance, office machine and similar industries. Catalog also provides listing of all tools that are most useful to installers, technicians and maintenance personnel. —**Electronic Tool Co.**, 15 Bertel Avenue, Mt. Vernon, NY 10550.

*Circle 47 on reader service card*

**AEROSOL PRODUCTS CATALOG.** 6-page catalog includes the company's aerosols available and also depicts, with line drawings, their application. Describes high-purity cleaners, special cleaners and solvents, mold releases, protective materials and aerosol accessories for special applications. Also includes a "Typical Maintenance Problems" chart that lists the equipment to be maintained, the cleaning problem, remedy and aerosol product that will solve the problem. —**Miller-Stephenson Chemical Co.**, P.O. Box 628, Danbury, CT 06810.

*Circle 48 on reader service card*

**STEREO SOUND SHEET** demonstrates PAIA's line of electronic music synthesizer kits. The record features the synthesizers at work in live performances and studio environments with pieces ranging from structured melodic works to "Sound Collages." Included with the record is a booklet that shows the patching connections for each piece and musical scores where applicable. A second booklet, "A Schematic Symbology for Synthesizer Patching Arrangements" is also included. Record and booklets as a set **$1.00—PAIA Electronics, Inc.**, 1020 West Wilshire Blvd., Oklahoma City, OK 73114. R-E

**EQUIPMENT REPORT**
*(continued from page 30)*

source is usually taken from the amplifier's tape output jacks or directly from a stereo recorder, as determined by a front panel switch. Discrete 4-channel inputs (such as for a quad recorder) are also provided. There are front and rear (quad) outputs at line level for the amplifier and a tape recorder. A front panel selector determines either matrix decoding or direct feed from the 4-channel discrete tape input.

Three decoders are built into the SQ-W. In addition to the wavematching full-logic Variblend SQ decoder, there is also a basic SQ decoder with a moderate degree of blend (for A/B comparisons) and a "composer," Lafayette's term for a decoder that extracts "ambient sounds" from a standard stereo record or tape.

Two front panel controls are provided: one selects the decoder and discrete tape modes, the other serves as a master volume control for the quad system. Two switches serve for the power and amplifier/tape sound source.

The measured (not manufacturer's specs) level of performance of the Variblend decoder proved excellent, somewhat exceeding Lafayette's claims. The corner-to-corner separation was nominally 20 dB, while the CF/CR separation was 18 dB. This contrasts to the basic (blended) SQ decoder's CF/CR separation of 6 dB. The amplifier's frequency response was within 1 dB from 20 to 20 kHz, at a distortion no higher than 0.1% THD at any frequency.

Most important, using several different types of programs, no trace of gain-riding pumping was evident, yet the degree of separation was so high it was possible to hear musical effects moving from corner to corner, as originally orchestrated. A listener would be hard pressed to tell the difference between the SQ-W and a discrete system.

# next month

## OCTOBER 1974

**It's hi-fi time again, and here's the chance to get completely up-to-date on the latest developments in the world of high-fidelity sound.**

- **Build A Full-Logic IC SQ Decoder**
  Latest circuitry includes wave-matching. Three new IC's make construction easy. This is probably the first time this circuit has been made available to the constructor.

- **CD-4 — How It Works**
  Take a look at what's behind the way discrete 4-channel records work. It's an up-to-the-minute report of where this system stands today.

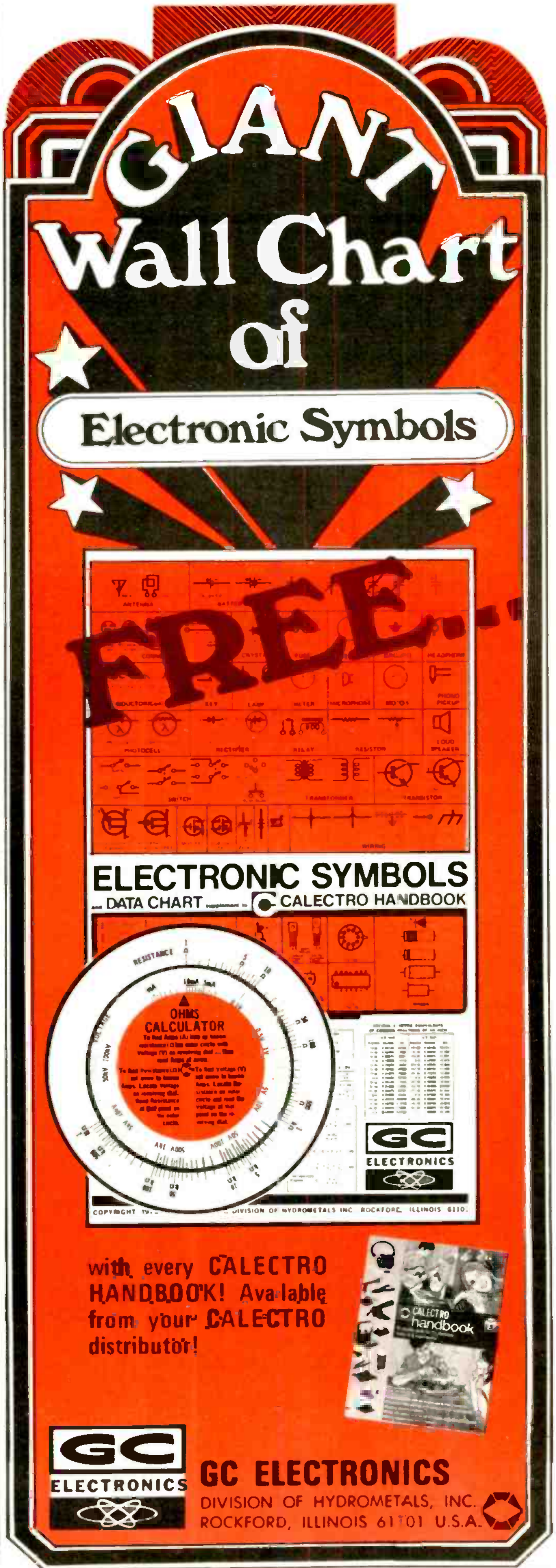
- **Many Roads To Four Channel**
  Don't be afraid to buy new stereo gear now. It all can be used for 4-channel later.

- **4-Channel Record Reviews**
  Radio-Electronics' editorial staff rates the 4-channel effectiveness of recent 4-channel record releases.

- **More COSMOS IC Projects**
  Part II of this series presents a group of circuits that are practical to build with COSMOS IC's.

**PLUS:**
**Step-By-Step Troubleshooting Charts**
**Radio-Electronics' Replacement Transistor Guide**
**Jack Darr's Service Clinic**
**Appliance Clinic**

**October issue on sale September 19**




Circle 75 on reader service card

**TIME ON TV SCREEN**

*(continued from page 42)*

Once you have the eight white boxes, carefully measure the voltages where IC8 is to go—+5 on pin 24; −5 on 11 and 12; and finally −12 on pin 1. *Reverse supply voltage will instantly ruin IC13*, so even with the idiot-proofing network D1, R1 *be careful!*

IC8 is a MOS integrated circuit, and exceptionally careless handling could damage it. Leave it in the case and protective foam till you are ready to use it, then quickly solder it in place with a small soldering iron, watching to get the code dot and notch correct. After it is soldered in place, the circuit will protect the IC from most damage.

Reapply supply power, and the eight boxes should now read 1?:7?:7? if you have a 12-hour system and 3?:7?:7? if you have a 2400-hour one. The unconnected inputs are "read" as digital "1"s, as are +5 signals. Only a ground is read as "0". Do not connect anything to your clock until you have the exact display called for above. Once you are certain all is well, connect up the multiconductor cable to the proper place in your Superclock (either the inputs to the readouts or the 1-2-4-8 outputs of the various counters). Keep these short, preferably under 15 inches. The TV interconnects can be reasonably long, but avoid running across the room with them. When the clock is connected, you should have the correct time to your TV set and the project is complete.

## Using it

Remember, you can turn the time display off and on by applying or removing the +5, by breaking the video line, or by breaking the vertical trigger line. If you experience some character breakup at the minimum horizontal width settings of the display, you can increase the −12V supply by a volt to −13, or, if you're real brave, you can short out R1. Should you want a bigger than the largest available time display, increase C11. For a very small display, decrease C11 and you can go down to the breakup point. With the circuit we've shown you, the *minimum* display size will be slightly *wider* than shown in the lead photo. You should be able to use the available controls to move the display most anywhere you want to place it on the screen and almost any size, within reasonable limits.

If you want to display something besides the time, you can rework the input data selectors and perhaps add two more to pick up the total alphanumeric capability of this circuit.

Should you want lots more than 8 numerals at a time and want internal storage as well, a much more elaborate TV ALPHABETIZER system is in the works here at RADIO-ELECTRONICS. We'll be telling you about it shortly. In the meantime, good luck on this project. **R-E**

**MEASURE HI-FI PERFORMANCE**

*(continued from page 63)*

## Additional measurements

Another convenient pushbutton on the analyzer permits the user to directly measure and read the wattage consumed by any audio product from the power line source. There is also an eternal input to the digital readout module which lets you read the amplitude of any sinusoidal waveform up to 250 volts rms.

External inputs are provided through which signals may be fed into the instrument in the event that audio frequencies other than those built in are required for any reason. Such signals will, of course, have their amplitudes read directly by the digital module and are fully controllable by the switches and multiturn attenuation poteniometers of the analyzer.

The acquisition of the McAdam audio analyzer has, of course, simplified many of the audio measurements which I am called upon to make almost daily and I have found that it is relatively easy to interface this equipment with the rf equipment which is used for AM and FM measurements. For example, the Sound Technology FM generator model 1000A, shown standing atop my now displaced audio generator in Fig. 1, has provisions for external modulation. By modulating it with the available audio tones from the McAdam analyzer and connecting tuner or receiver under test to the output terminals of the analyzer, full use can be made of the distortion measurement facilities of the analyzer and THD as well as S/N readings can be made digitally as well. By continuing to use the internally supplied stereo composite signal generating facilities of the FM generator, separation measurements can also easily be made using the generator in combination with the McAdam analyzer.

The McAdam analyzer is not inexpensive, retailing for $3450.00, but even in the short time we have had an opportunity to use it in our daily lab work it has begun to pay off in terms of time saved and increased accuracy and reliability of measured results. **R-E**

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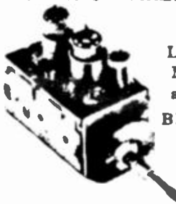
**41mc**



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*Circle 79 on reader service card*

# circuits

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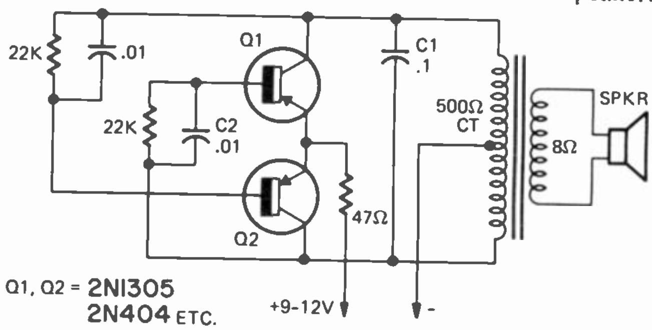
If you are like most of us there must be many times when you need some sort of an alarm for a project, yet a decent buzzer or alarm isn't handy. Well here's an answer to your problems! Our Beeper is super simple, yet packs an audio wallop! It puts out almost 300 mW of power at a frequency that is certain to grab your attention! The circuit is simple, but yet it outperforms buzzers and alerts costing many times as much. You should be able to get the parts from your junkbox—see if you can find an old transistor radio: most radios can supply all the parts. But if you prefer to buy everything, there's no problem. All of the parts are available and they won't set you back but a few dollars. So let's get busy and build it! I constructed mine around a 2½" speaker.




First I cut a doughnut of perforated board to fit over the speaker magnet and then I mounted all the parts on the board, wired them up, and slipped the board back over the speaker magnet, securing it with epoxy. I just finished up by connecting the speaker, and bringing out long wires for the power. To test it out I connected it up to a 9-volt transistor battery—voila', it worked! You get an ear splitting beep of about 5 kHz, but if you want a different frequency, change the value of C1. Current drain is on the order of 50mA, so use a heavy-duty battery if you plan to use it much. By the way our beeper makes a terrific continuity checker, burglar alarm, and car seatbelt alarm. What sort of applications can you find? — *Gary McClellan* **R-E**

## EASY-TO-HANDLE EPOXY

Epoxy cement is generally sold in tubes. Invariably it seems, they leak after several applications. They become so sticky that they may have to be discarded after 5 or 6 times of use.

Recently, a new brand of epoxy made its appearance. It is sold in small jelly-bean size containers that come in 2 colors, red and yellow. The directions call for cutting off the ends of one yellow and one red container, emptying their contents onto a flat surface, blending thoroughly for maximum strength and then using.

For my arts-and-crafts, and probably for your radio repairs, only a few drops of epoxy may be needed. I pierce the ends of the containers, squeeze out a few drops of each (equal quantity, of course) mix and use. I find that the "jelly bean" containers seal themselves at once, and you can use them over again. You must pierce them each time you use them, so keep a pin handy.

No fuss, no waste, no sticky fingers. — *Lillian Queen* **R-E**





# try this

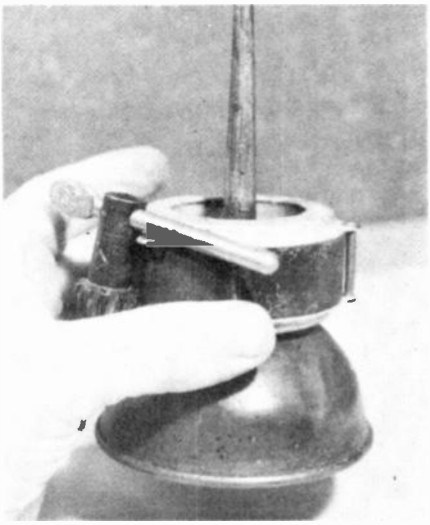
## ICE CUBE TRAYS FOR HARDWARE STORAGE

Inexpensive plastic ice cube trays may be used in your work area to keep nuts, bolts, washers and other hardware organized. These trays are also handy to keep small parts from getting lost during construction of electronic kits. These

trays are often purchased by the happy homemaker in search for a tray that readily releases ice cubes . . . and when they do not, are usually found in or getting near the trash pile waiting to be rescued for use in your shop.—*Kent Mitchell, W3WTO*

## MAGNET FROM TV RECEIVER

If you salvage parts from an old TV set; don't fail to save the heavy-duty ring magnet that encircles the picture tube neck. This type of collar — called a focus ring — is a powerful permanent magnet that will hold large hand tools firmly. Fasten it to the wall or at any convenient spot and use it to



hold an assortment of metal items. It is especially useful to hold squirt cans — usually made of copper-plated sheet iron — since the spout of the can may be inserted through the center of the ring from the bottom where it will be held securely until needed. For greater security spring-mount the magnet in some way to resist shock and vibration. —*Glen F. Stillwell*

## WHAT'S A RAM?

*(continued from page 79)*

The 1103 is obsolete today. There are some significantly improved devices available today that are much easier to use, but they still are a rather tough design problem if you do not have elaborate equipment and considerable digital know-how. Improved versions include the *Intel* 1103-A, the *Mostek* MK4006 and MK4008, the *Electronic Arrays* EA1500 1501 and 1502 and the *American Microsystems* S3103.

### 4096 bits

The big race today is to build an improved 1103-style integrated circuit with 4096 bits. At least one has been announced by TI at a 100-lot price of $26.00, or around 0.6¢c per bit. The other manufacturers aren't taking this sitting down and the race is on. Pinouts have pretty much been standardized and some should be available as you read this. Competitive products include the *Electronic Arrays* 1504, the *Intel* 2107A, *Standard Microsystems* 4412, *Texas Instruments* 4030, *Microsystems International* 7112, *Mostek* 4096, *Motorola* 6605 and probably a bunch more. Only eight of these integrated circuits are needed to build a decent minicomputer main memory.

### +5-volt, single supply MOS memories

A number of new, very easy to use and interchangeable MOS memories are now available that use an n-channel static technology. They have no clocks and are entirely and absolutely TTL compatible. There are no clocks or sense amplifiers needed. These include the *Signetics* 2602, the *Intel* 2102, *Intersil* 1M7552, *Motorola* MCM6602 and the *Microsystems International* MF 2102. Cost in single quantities is around 2¢ per bit as of this writing. They are far too new to crop up surplus. Organization is 1024 × 1, or 1024 words of one bit each.

These integrated circuits cycle in a microsecond and screened 0.5-ms devices are also available. There are ten input address lines, a data in and a data out. Figure 9 shows the pinouts.

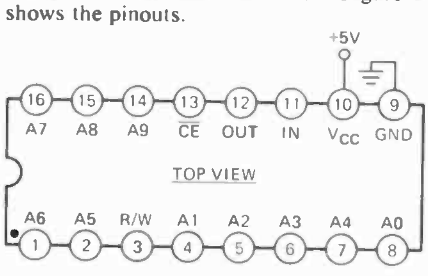



**FIG. 9—1024-BIT N-CHANNEL memory works off a single +5-volt supply and is very easy to use. Typical devices include Intel 2102, Signetics 2602, Motorola MCM6612, Intersil IM7552 and Microsystems International MM2102.**

To read, you pick your address with the chip select low and the read-write high. The output data appears within a microsecond or so of an address change. To write, apply your input data, select your address, wait 400 ns, bring the write line low for at least 500 ns, send it back high again and wait at least 100 ns before changing the address. Once again, don't change the address immediately before, during or immediately after the write line is active low. The chip select can be used to expand the memory by several IC's. Six of these in parallel are ideal for a data terminal or TV typewriter memory. Prices should drop well under a penny per bit by next year.

What good are semiconductor memories? Calculators, programmable computers, teaching machines, terminals, TV typewriters, electronic games, minicomputers, full-blown computers, electronic music and hundreds of other applications exist now. What can *you* do with them? Let us know. **R-E**



# new books

**RADIO COLLECTOR'S GUIDE by Ralph H. Langley. Edited and expanded by Morgan E. McMahon. Vintage Radio, Box 2045, Palos Verdes Peninsula, CA. 90274. 8 1/4 x 5 1/4 in. 264 pp. Softcover $3.95.**

This book fills the need for information on radio sets made from 1929 through 1932. It is an ideal aid to the collector, historian and dealer. It lists key information on over 9000 radio receivers made by some 1200 companies. It lists the manufacturer, year introduced, original price, cabinet type and technical notes for each of the sets listed.

**WORLD RADIO & TV HANDBOOK — 1974 Distributed in U.S.A by Gilfer Associates Inc., Box 239, Park Ridge, NJ 07656 6 x 9 in. 408 pp. soft cover $7.50.**

This is the 28th annual edition of this world-famous directory of short-wave, medium-wave, and long-wave radio broadcasting stations of the world. It also includes callsigns, schedules, languages used, station power, etc.

In addition to radio station listings, the Handbook also includes world TV FM stations by frequency and power.

If you are a SWL or medium-wave DX'er, you will surely want this book.

**QUESTIONS & ANSWERS ABOUT TAPE RECORDINGS, by Herman Burstein. TAB Books, Blue Ridge Summit, PA 17214. 264 pp. 8-½ x 5-¼ in. Hardcover $8.95; Softcover $5.95.**

Whether it's head alignment, bias adjustment or selection of the right tape, this book has all the answers plus all the circuits, sketches and wiring diagrams a tape recorder enthusiast is ever likely to need. Of importance to everyone who owns or services tape recorders or players, this book covers just about any problem that one might ever encounter or servicing recording playback equipment.

**TRANSISTOR CIRCUITS & APPLICATIONS, Second Edition, by Laurence G. Cowles Prentice Hall, Inc., Englewood Cliffs, NJ 07632. 365 pp. 9 x 6 in. Hardcover $17.25.**

An updated second edition of a highly practical description of junction and field effect transistor circuits. By using only those parameters that are truly important, the author succeeds in simplifying circuit calculations. The new edition has more examples of single- and multi-stage gain calculations. The explanations of feedback have been expanded to include loop feedback and the control of amplifier stability and there are new sections on an improved single stage amplifier, integrated circuits, CMOS switching and memory circuit, computers and memory control.

**SOLID-STATE DEVICES: ANALYSIS AND APPLICATION, by William D. Cooper. Reston Publishing Co., Inc., Box 547, Reston, VA 22090. 453 pp. 9 x 6 in. Hardcover $14.50.**

Here is a logically organized treatment of all major solid-state devices. It includes integrated circuits and thoroughly describes and analyzes solid-state devices as circuit elements. The behavior of solid-state devices and practical circuit applications is well covered using both graphic and mathematic methods of circuit analysis. Many detailed and practical circuit examples including amplifiers, power supplies, oscillators and industrial circuits are provided in this book. Problems and questions at the end of each chapter assist in the retention of the material.

**ROLLING STONE GUIDE TO HIGH-FIDELITY SOUND, by Len Feldman. Straight Arrow Books, 625 Third St. San Francisco, CA 94107. 159 pp. 7-¾ x 4-¾ in. Softcover $4.95.**

Ever since Tom Edison bellowed "Mary had a little lamb" into his first wax cylinder record-making machine back in 1877, people have been explaining and extolling the virtues of good sound reproduction in the home. Time and technology have improved the quality of reproduced sound, but most books on the subject have followed a rather dreary pattern of trying to make audio engineers out of the readers. This book is designed to rescue the audio neophyte from the mire of technical jargon, hard-to-understand specifications, myths and hi-fi folklore. Instead, it concentrates on how to put together a fine hi-fi system. This guide will help hi-fi enthusiasts make the distinction between a good hi-fi component product and a piece of junk parading itself as hi-fi equipment. The author begins with an introduction into audio dynamics, moves into the debate over components and then goes into further nuts and bolts considerations: turntables, speakers, amplifiers, receivers — including your room as a part of the sound system. From mono to stereo to quadriphonic, it's all here — including a comprehensive glossary of hi-fi terms, many useful diagrams, schematic drawings as well as vintage turn-of-the-century illustrations. R-E

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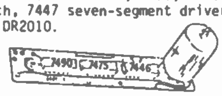


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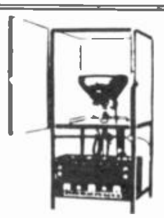

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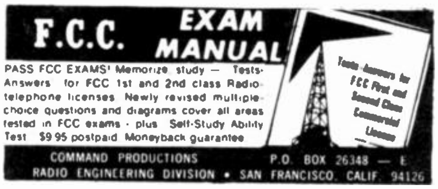



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- ☐ 30 pcs. **HEAT SHRINK**, for protecting connecting wires. 100 uses $1
- ☐ 75 **MOLEX SOCKETS**, most pop connectors for integrated circuits $1
- ☐ 15 **LAMPS**, for ac sets, flashlights, includes 2.25v, 2.3v, & 6 v $1
- ☐ 10 **RESISTOR NETWORKS**, for 100's of electronic ckt use ..... $1
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- ☐ 25 **VITAMIN Q CAPACITORS**, .01mf to .1mf up 600v ..... $1
- ☐ 4-**TRANSISTOR TRANSFORMERS** 500 to 3.2 ohms, ⅝ x ⅝ x ½ $1
- ☐ 100 **FEET SPAGHETTI TUBING**, #16 for bare wire and fiber optics $1

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- ☐ 5-**SCRs 7-AMP TO220**, 6-12-24 prv, power tab ..... $1.
- ☐ 10-**MOS FETS**, 3N187, 3N200, 3N128, TO-18, Fairchild* ..... $1.
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- ☐ 50 – **GERMANIUM**, glass rectifiers, signal, axial leads* ..... $1.
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- ☐ 2 – **PHOTO TRANSISTORS**, with darlington amp, 2N5777, GE. . $1
- ☐ 4 – **PHOTO CELLS**, Clairex, pancake, 30K-70 ohms ..... $1

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- ☐ 2 – **6 AMP TRIAC 200 PRV**, TO-5 ..... $1.
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- ☐ 5 – **PLASTIC 35W** powers, npn, silicon, hobby 2N6121 ..... $1.
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- ☐ 2 – **MOS FETS, DUAL GATE**, N chan. 3N187, TO-18, RCA ..... $1.
- ☐ 2 – **MOS FETS, DUAL GATE**, N chan. 3N140, TO-18, RCA ..... $1.
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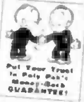
- ☐ 2 — **MPF-1000**, Motorola MOS dual gate "The Claw" ..... $1.
- ☐ 2 — **2N5655** 200 hfe, 250 vceo, power tab $1.

## I.C. & LED HOBBY-ONICS




- ☐ 4-**DUAL 709**, dip pak, op amps, untested ..... $1.
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- ☐ 10 – **LINEAR AMPS**, 709, 710, 711, 741, TO-5 ..... $1.
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- ☐ 10-**"C" MOS IC's**, 74C and CD4000 series, DIP pak* ..... $1.
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- ☐ 1 -**2516 CHARACTER GENERATORS**, hobby, for MAN 2* ..... $1.
- ☐ 1. **2513 CHARACTER GENERATOR, Hobby for MAN-2** ..... $1.
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- ☐ 1-**AM RADIO-ON-A-CHIP**, by Sprague, DIP, u test 'em ..... $1.
- ☐ 1-**DUAL 2-WATT "Stereo-Amp-On-A-Chip"**, fallout/Sprague, u test $1.
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- ☐ 1-**OPCOA SLA-3H***, 0.7 charac. readout, 1-or-more segs missing. $1.
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- ☐ 2-**OPCOA SLA-1***, **MAN-1**, red, .33" charac. 1-or-more segs gon $1.
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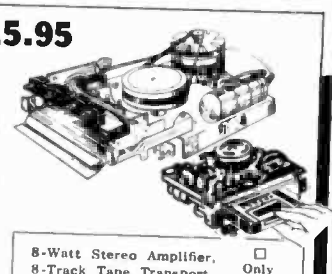
- ☐ 2 — **3-DIGIT NATIONAL READOUTS**, some digits good ..... $1.
- ☐ 10-**SPRAGUE DIPS, LINEAR OP AMPS**, 2111 series, 2120 series . $1.
- ☐ 1-**MAN-3, "THE CLAW"**, one dot missing, 100% perfect ..... $1.
- ☐ 2 —**MMS736** 6-Digit Calculator on a Chip, hobby ..... $1.
- ☐ 10—**FAIRCHILD-NATIONAL**, 9000 Series ICs, dips, hobby . . . $1.

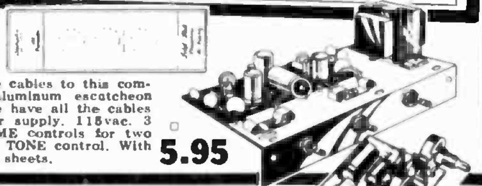
## 8-TRACK PROFESSIONAL TAPE TRANSPORT FOR HOME USE $15.95 ☐



Same type unit found in the most expensive home tape players. It's a complete 8-track player system with BUILT-IN PREAMP — just plug into any stereo amplifier (see some of our low-priced units). Excellent replacement unit, or you can design your own high-quality stereo tape system. It's the type you insert a cartridge to turn-on deck, then enjoy up to 80 minutes of non-stop, non-repeat stereo. Remove cartridge and player "shuts off" automatically. Built-in output controls in preamp. Features: 4 PROGRAM INDICATOR LIGHTS, automatic or manual program change, plays your car tapes at home. WOW-FREE precision fan-cooled motor, which operates off 115Vac. Requires external 12Vdc supply, for the electronics. With diagrams.

8-Watt Stereo Amplifier, 8-Track Tape Transport and hook-ups both. ☐ Only **$19.95**

## 8 WATT STEREO AUDIO AMP



The factory "snipped" most of the cables to this compact 8 watt stereo unit with aluminum escatcheon plate. It's easy to use because we have all the cables marked ready to use. With power supply. 115vac. 3 controls, LEFT and RIGHT VOLUME controls for two speakers for balancing and center TONE control. With knobs. 7 x 3½ x 3½. Hookup spec sheets.

☐ **5.95**

## 4 WATT GUITAR AMP AMPEREX

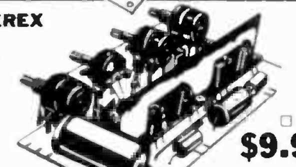
Musical instrument amplifier at low, low price! Peak power output 10 watts. Two input circuits are equalized for normal or solo guitar. The four controls are VOLUME, TONE, TREMOLO INTENSITY and TREMOLO SPEED. There are terminals on board for normally open foot switch connection. Supply voltage 18vdc. Output to 8 ohm hi-quality speaker. Input impedance ≈3,000 ohms. Current drain 20 mils. External power supply required. Wt. 1 lb. With instructions, hookups and diagrams. Size 8 x 2⅝ x 3.

• SOLID STATE

**With Tremolo**

☐ **$7.95**

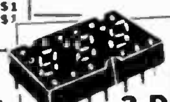
## 8 WATT STEREO AMP AMPEREX



Type PCA-3C-18. Provides 4 watts per channel. May be used as stereo tuner too! Unit has 4 controls ..... VOLUME, BALANCE, BASS and TREBLE. Circuit has 3 stage DC coupled power amplifier with thermistor for temperature stabilization. Each channel has separate PREAMP. Input imp 1 meg, for use with ceramic or crystal cartridges. Requires external power supply. Supply voltage 18VDC. Outputs to 8 ohm speakers. Freq. response 40 hz to 30 kHZ. Current per channel 340 mils. Size 7 x 3½ x 3½ x 3. **SOLID STATE**

☐ **$9.95**

## GIANT SALE ON 3-DIGIT READOUTS

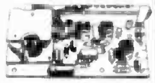


☐ **$2.50** 9 DIGITS FOR $6.

Made by National, their Type NSN-33. With red lens filter. Properly multiplexed. Three digits size of MAN-3. Driver SN7448, 10 mils. Case only 9/16 x 3/8 x 1/16"; 12-pins. For pc boards, or fits into standard IC socket. For calculators, DCMS, DVM, Clocks and 1000's of indicating devices. Price is lowest we have seen! 100% perfect. Buy all good digits, not rejects as the Hewlett Packard's advertised by others.

## 2 TRANSISTOR AM TUNER

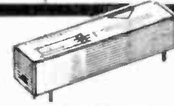
AMPEREX



☐ **Only $3.50**

Includes carefully matched transistors, A high Q litz wire loopstick matches the autodyne converter in stage #1 followed with and IF stage with agc control. Audio output comes from transformer coupled detector thru and rf filter. Matches any audio amp with 50 mv sens. With 2 gang variable capacitor. Covers 530 to 1620 KHz. Power requirements 9V @ 6 ma. 2 x 4½ x 2¼. Use with our Sanken amplifiers. Wt. 8 oz.

## CLARE REED SEALED CAN RELAYS*



**$1.49**

*All 6 VDC 250 ohm coil
**1¼ x ½ x 5/16"
***when energized 2 pole sets normally open, 2 poles N.C. Reverse the voltage polarity the opposite takes effect thru built-in "magnet bias".

| Type | Description |
| --- | --- |
| ☐ MR2MF-1006 | DPST Normally open** |
| ☐ MR3MF-1006 | 3PST Normally open** |
| ☐ MR4MF-1006 | 4PST*** |

## "AEROSPACE" BABCOCK & LEACH CRYSTAL CAN RELAYS

All hermetically sealed Submini, 1/6, half, and full crystal can types in 6-12-24V in asst contacts up to 4PDT, 1 amp up 10 amps. Such types as BR40, 41, 10, 44, 16, 24, etc.

**12 for ☐ $3.50**

Sorry, no choosing voltages or types. From factory mixtures . . . to you! Good asst, if you are space-minded, at low prices.

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- COLORFUL
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First multi-level 115 VAC fiber optic lamp display — in kit form for less than $10. Colorful acrylic designed base structure. Versatile multi-color disc control changes 125 "white lighted" fiber tips to a splashing optical array of color. New design eliminates messy adhesives. 12" high. Kit includes: 125 pre-shaped 20-mil plastic fibers, black acrylic base, inter-locking designed colorful cylinder, 6-ft. 115 VAC lamp cord, booklet, color disc control, all accessories.

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- 1400 multi-color fibers
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- Cordless light source
- Variable color control
- Variable Level Control
- Blinks, Winks, Twinks

Advanced version! SELF-POWERED, multi-tiered fiber optic Kit displaying colorful marvels, splashing, shimmering "sprays" of light from 1400 magical fibers, 18" high, includes **"BLINKY"** variable color control (3-pc. kit). Telescopic stem gives instant level control (3 stems). Safe! Educational! Fun! Easy! **RE-DO PROCESS** to re-make your **LIGHTS** over again. 16-page booklet. Accessories include: "O" rings, adhesive, 1400 optically perfect glass fibers, 12" long.

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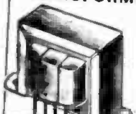
Input all 115/60 cycles. Open frame and metal encased.



| | Output | | | Sale |
| --- | --- | --- | --- | --- |
| ☐ | 5.0V | @ | .120A | $1.00 |
| ☐ | 6.3V | @ | 3A | 2.95 |
| ☐ | 12.0VCT | @ | 3A | 2.95 |
| ☐ | 18.0VCT | @ | 2A | 2.50 |
| ☐ | 150.0V | @ | 50MA. | |
| | 7.0V | @ | 1A* | 2.95 |

*Nixie tube transf.

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**WITH GLASS ESCUTCHEON**

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Has the following controls on front panel. PHONO-STEREO-AM-FM, MONO, FM STEREO, TAPE, master control switch. LOUDNESS, BALANCE, TREBLE, BASS controls, with power ON-OFF rocker switch. Designed for all audio-philes to use as wall unit in DEN or FAMILY ROOM, or control unit by easy chair in family room, or for those who wish to design their own console or modular system. With 6 ft. 115 VAC cord and plug. Only 13 x 7 x 3½. plus diagram. Shpg. wt. 3 lbs. With knobs.

Only **$39.95**

## 20-WATT STEREO AM-FM-MULTIPLEX

**60-WATT AM-FM-MULTIPLEX**
☐ Same as above except amplifier heavy-duty stereo 60 watt unit. $59.95 ☐ **$59.95**

**2 for $19.95**
☐ Same as item #1 except reject, parts may be missing.

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| SN7426 | .33 |
| SN7430 | .24 |
| SN7432 | .35 |
| SN7437 | .49 |
| SN7438 | .52 |
| SN7440 | .24 |
| SN7441 | 1.19 |
| SN7442 | 1.12 |
| SN7443 | 1.12 |
| SN7444 | 1.25 |
| SN7445 | 1.19 |
| SN7446 | 1.29 |
| SN7447 | 1.29 |
| SN7448 | 1.35 |
| SN7450 | .27 |
| SN7451 | .31 |
| SN7453 | .31 |
| SN7455 | .31 |
| SN7462 | .35 |
| SN7464 | .43 |
| SN7465 | .43 |
| SN7471 | .55 |
| SN7472 | .41 |
| SN7473 | .49 |
| SN7474 | .49 |
| SN7475 | .85 |
| SN7476 | .53 |
| SN7478 | .85 |
| SN7480 | .65 |
| SN7481 | 1.25 |
| SN7482 | .99 |
| SN7483 | 1.15 |
| SN7486 | .49 |
| SN7489 | 3.10 |
| SN7490 | .85 |
| SN7491 | 1.35 |
| SN7492 | .85 |
| SN7493 | .85 |
| SN7494 | 1.05 |
| SN7495 | 1.00 |
| SN7496 | 1.00 |
| SN74100 | 1.65 |
| SN74107 | .51 |
| SN74108 | .95 |
| SN74112 | .95 |
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| SN74114 | .95 |
| SN74121 | .61 |
| SN74122 | .69 |
| SN74123 | 1.05 |
| SN74125 | 1.45 |
| SN74126 | 1.45 |
| SN74140 | 2.50 |
| SN74141 | 1.95 |
| SN74145 | 1.19 |
| SN74148 | 4.50 |
| SN74150 | 1.19 |
| SN74151 | 1.00 |
| SN74153 | 1.39 |
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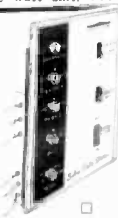
| SN74156 | 1.45 |
| SN74157 | 1.45 |
| SN74158 | 1.45 |
| SN74160 | 1.85 |
| SN74161 | 1.59 |
| SN74163 | 1.75 |
| SN74164 | 2.10 |
| SN74165 | 2.10 |
| SN74166 | 1.85 |
| SN74173 | 1.85 |
| SN74175 | 2.60 |
| SN74176 | 1.85 |
| SN74177 | 1.85 |
| SN74180 | 1.10 |
| SN74181 | 4.10 |
| SN74182 | 1.05 |
| SN74185 | 2.50 |
| SN74192 | 1.55 |
| SN74193 | 1.50 |
| SN74194 | 1.55 |
| SN74195 | 1.10 |
| SN74196 | 1.25 |
| SN74197 | 1.10 |
| SN74198 | 2.35 |
| SN74200 | 9.95 |

* "DIP" Packages



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- Wall "Slim-Line" Type!
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| SN7442 | 5 for $1. |
| SN7444 | 5 for $1. |
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| SN7446 | 5 for $1. |
| SN7447 | 5 for $1. |
| SN7448 | 5 for $1. |
| SN7472 | 10 for $1. |
| SN7473 | 10 for $1. |
| SN7474 | 10 for $1. |
| SN7475 | 5 for $1. |
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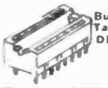
| SN74154 | 5 for $1. |
| SN74181 | 5 for $1. |
| SN74189 | 5 for $1. |
| SN74192 | 5 for $1. |
| SN74193 | 5 for $1. |
| SN74199 | 3 for $1. |

Includes factory-good, rejects & defects, who knows at these prices!

## INTEGRATED CIRCUIT SOCKETS



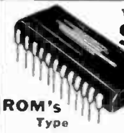
Buy Any 3 Take 10% Discount!

| | |
|---|---|
| ☐ 14-Pin, DIP | $.45 |
| ☐ 14-Pin, Side Mount | 1.00 |
| ☐ 16-Pin, DIP | .50 |
| ☐ TO-5, 8 or 10-Pins | .29 |
| ☐ 14-Pin, Wire Wrap | .69¢ |
| ☐ 16-Pin, Wire Wrap | .89¢ |

## EXPERIMENTAL op amps

Money Back Guarantee!

| Type | Sale |
|---|---|
| 300 | 5 for $1. |
| 301 | 10 for $1. |
| 307 | 10 for $1. |
| 308 | 5 for $1. |
| 309K | 4 for $1. |
| 380 | 3 for $1. |
| 381 | 3 for $1. |
| 516 | 5 for $1. |
| 556 | 4 for $1. |
| 558 | 4 for $1. |
| 565 | 4 for $1. |
| 567 | 4 for $1. |
| 592 | 5 for $1. |
| 703 | 5 for $1. |
| 709 | 10 for $1. |
| 710 | 10 for $1. |
| 711 | 10 for $1. |
| 723 | 5 for $1. |
| 733 | 5 for $1. |
| 741 | 5 for $1. |



Your Choice **$3.95** Any Type

## NATIONAL READ ONLY MEMORIES

Buy 3 take 10%
Order by type number

ROM's

| Type | Description | Sale |
|---|---|---|
| MM3501 | 1024 bit static ROM | $3.95 |
| MM4213 | 1024 bit ROM | 3.95 |
| MM4220 | 1024 bit static ROM | 3.95 |
| MM4230 | 2048 bit static ROM | 3.95 |
| MM4231 | 2048 bit static ROM | 3.95 |
| MM4232 | 4096 bit static ROM | 3.95 |
| MM4233 | 4096 bit static ROM | 3.95 |
| MM4241 | 3072 static charac. gen ROM | 3.95 |

THREE-QUARTER INCH
## 4-DIGIT KRONOS
Using OPCOA SLA-3H
Choose: ☐ Red ☐ Green **$54.**

## NATIONAL LINEAR OP AMPS

Buy any 3 — Take 10%
(A) TO-5, Dip or mini Dip

| | | |
|---|---|---|
| LM-300 | POS V.R. (super 723) TO-5 | $ .91 |
| LM-301 | Hi-performance op amp (A) | .41 |
| LM-302 | Voltage follower TO-5 | .91 |
| LM-305 | Pos. Voltage Reg. TO-5 | 1.19 |
| LM-307 | Super 741 op amp (A) | .41 |
| LM-308 | Hi-Q fet type op amp TO-5 | 1.19 |
| LM-309H | 5V Volt-Regulator TO-5 | 1.19 |
| LM-309K | 5V Volt.-Reg. 1 Amp TO-3 | 1.85 |
| LM-310 | Voltage-Follower TO-5 | 1.25 |
| LM-311 | Hi-perf. Volt. Comp.(A) | 1.19 |
| LM-319 | Hi-speed Dual Comp. DIP | 1.50 |
| LM-320 | MINUS 5, 12 or 24V V.R. TO-3 | 1.50 |
| LM-339 | Quad Comparator. DIP | 2.50 |
| LM-324 | Quad (4-741's in DIP) | 2.50 |
| LM-350 | Dual peripheral driver | .41 |
| LM-370 | AGC Squelch op amp, TO-5 | 1.19 |
| LM-371 | R-F, I-F, op amp | 1.25 |
| LM-373 | AM-FM SSB I.A.D, TO-5 | 3.50 |
| LM-374 | AM-FM SS IVAD TO-5 | 3.50 |
| LM-377 | Dual 2-watt audio amp | 3.00 |
| LM-380 | 2-watt audio amplifier TO-5 | 1.69 |
| LM-381 | Low noise dual pre amp DIP | 1.95 |
| LM-382 | Low noise dual pre amp DIP | 1.95 |
| LM-703 | RF-IF amp, TO-5 | .55 |
| LM-709 | Operational amplifier (A) | .36 |
| LM-710 | Differential amplifier (A) | .45 |
| LM-711 | Dual Differential Amp (A) | .36 |
| LM-723 | Voltage Regulator (A) | .69 |
| LM-725 | Instrument Op Amp | .95 |
| LM-733 | Differential Video | 1.75 |
| LM-741 | Freq. Comp. 709 (A) | .41 |
| LM-741CV | Mini DIP 741C | .45 |
| LM-747 | Dual 741 (A) | .89 |
| LM-748 | Freq. adjustable 741C (A) | .44 |
| LM-1303 | Stereo pre amp DIP | .95 |
| LM-1304 | FM Stereo Multiplexer | 1.25 |
| LM-1307 | FM Multi. Stereo Dem. DIP | .91 |
| LM-3028 | Differential RF/IF amp | 1.50 |
| LM-3900 | Quad "current mirror" amp | .95 |
| LM-4250C | Programable op amp | 2.50 |
| LM-75451 | Dual peripheral driver | .44 |
| LM-75453 | Dual peripheral driver | .44 |
| LM-75491 | Quad seg. driver, LED (DIP) | 1.85 |
| LM-75492 | Hex digit driver, 250ma, DIP | 1.85 |

## LINEAR Op Amps

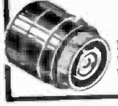
• FACTORY GUARANTEED  FACTORY TESTED  FACTORY MARKED

| | | |
|---|---|---|
| 531 | Hi slew rate op-amp (TO-5) | $2.50 |
| 532 | Micro power 741 (TO-5) | 2.50 |
| 533 | Micro power 709 (TO-5) | 2.50 |
| 536 | FET input op amp (TO-5) | 2.95 |
| 550 | Precision 723 voltage reg. (DIP) | 1.17 |
| 555 | Timer 2 u Seconds to 1-hr. (A) | 1.25 |
| 556 | 5 Times faster than 741C | 2.10 |
| 558 | Dual 741 (DIP) | 1.00 |
| 560 | Phase lock loops (DIP) | 2.95 |
| 561 | Phase lock loops (DIP) | 2.95 |
| 562 | Phase lock loops (DIP) | 2.95 |
| 565 | Phase lock loops (A) | 2.95 |
| 567 | Tone decoder (A) | 2.95 |
| 702C | Hi-grain, DC amp (TO-5) | .49 |
| 704 | TV sound IF system | 1.50 |
| 711C | Dual diff. comp (A) | .33 |
| 723C | Voltage regulator (A) | .69 |
| 741CV | Freq. comp 709 (Mini DIP) | .44 |
| 748C | Freq. adj. 741C (A) | .44 |
| 753 | Gain Block | 1.75 |
| 739-739 | Dual stereo preamp | 1.98 |
| 741-741 | Dual 741C (TO-5) | .89 |
| PA265 | 5-Watt voltage regulator | 1.00 |
| ULN2300M | Op amp with SCR | 1.00 |
| CA3065 | Video Audio system | 1.00 |
| RC4195 | Dual 15V Tracking V.R. | 2.50 |
| 4136 | Quad 741's (DIP) | 2.50 |
| RC-2556 | Dual 555's | 2.25 |
| TVR-2000 | Super 723, TO-5 | $1. |

(A) TO-5 or DIP BUY ANY 3 — TAKE 10%

BRAND NEW LOWEST PRICES

## MALLORY SOLID STATE ALARM 'SONARLERT'

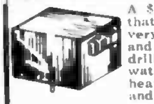


☐ Only **$4.50**
3 for $12

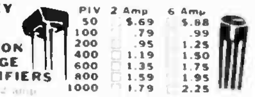
1000's of circuits where the voltage is 6 to 28 VDC. Responds to 3 mils with a sound output of 70 db. Mounts in 1-9/64" holes in panels up to ¼" thick. Type SC628 with color-coded leads. 2.9KHz. minus 40° to 85°C. Size: 1¼" x 1¼".

Never before offered at these low prices. This unique intrusion alarm device may be used for

## INDUSTRIAL SPEED CONTROL $4.95



A $30 item from G.E. Model 533A (made for Xerox) that controls home, shop and industrial lighting too! A very elaborate circuit for controlling many electrical and electronic devices. Easily controls speeds of electric drills, brush type motors, etc. 115vac, rated at 1100 watts. With variable speed or dimming control in heavy-duty aluminum case. 3 x 2¾ x 2. With diagram and hookups.



**EPOXY FULL WAVE SILICON BRIDGE RECTIFIERS**

| PIV | 2 Amp | 6 Amp |
|---|---|---|
| 50 | $.69 | $.88 |
| 100 | .79 | .99 |
| 200 | .95 | 1.25 |
| 400 | 1.19 | 1.50 |
| 600 | 1.35 | 1.75 |
| 800 | 1.59 | 1.95 |
| 1000 | 1.79 | 2.25 |

**LOWEST PRICES EPOXY SILICON RECTIFIERS**
*Submini

| PIV | 2Amp* | 2Amp | 3Amp |
|---|---|---|---|
| 50 | $.05 | $.05 | $.08 |
| 100 | .06 | .06 | .12 |
| 200 | .07 | .07 | .15 |
| 400 | .09 | .09 | .22 |
| 600 | .12 | .12 | .28 |
| 800 | .15 | .15 | .39 |
| 1000 | .18 | .18 | .45 |

## SCRS! TRIACS! QUADRACS!

10-Amp Power Tab Plastic Units

| PRV | Sale |
|---|---|
| 50 | $ .75 |
| 100 | .95 |
| 200 | 1.25 |
| 300 | 1.50 |
| 400 | 1.98 |
| 500 | 2.25 |
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SAME PRICE SALE!

## 20-WATT STEREO AMP

Featuring solid state circuitry throughout, with printed circuit construction. 10 watts "peak" audio power per channel. Handsome walnut veneer grain with chrome trim escutcheon. With provisions for separate escutcheon mounting items as STEREO HEADPHONES, TREBLE, BASS, BALANCE, VOLUME controls, separate PHONO AND AUXILLIARY with separate OFF-ON POWER switches. Chassis size 11½ x 3 x 2". Separate rear plate has right and left speaker phono type jacks, with convenience power outlet for tape of phono and Auxilliary inputs, for using amplifier with tape decks, and other equipment. Separate external cables for stereo phono connections, 6-ft. power cord, separate ON-OFF light indicator, and automatic turntable power plug with handsome set of knobs. Wt. 2 lbs.

☐ **16.95**


## NEW! TO-3 NATIONAL LM-340 VR's

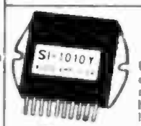
☐ Your Choice **$2.95**

- TO-3 Case • 1 Amp
- POSITIVE VOLTAGE

| Type | Volts |
|---|---|
| LM-340-05 | 5 v |
| LM-340-06 | 6 v |
| LM-340-08 | 8 v |
| LM-340-12 | 12 v |
| LM-340-15 | 15 v |
| LM-340-18 | 18 v |
| LM-340-24 | 24 v |

**GENERAL ELECTRIC 3-WATT AUDIO AMP** 3 FOR $6.00 ☐ **$2.50**

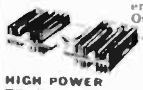
Delivers 3.5 watts continuous, 10 watts peak. With heat sinks: micro-mini size: ¾x½x½", 9 to 30V supply. High sensitivity. 8 to 16 ohms.



## SANKEN HYBRID AUDIO POWER AMPS

| Mfgr's Type | Watts | Sale |
|---|---|---|
| SI-1010Y | 10 | $ 8.88 |
| SI-1025E | 25 | 18.88 |
| SI-1050E | 50 | 29.95 |

Used extensively in hi-fi systems, tape decks, FM tuners, record players, stereo components, musical instruments, P.A., etc. All amplifiers, flat within ½ db from hz to 100,000. Each unit properly heat-sinked, with heavy-duty connecting tie lug connections. Single-ended pushpull output. Power supply required 24VDC. Output to 8 ohms. Order by Stock No.

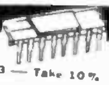


**HIGH POWER TRANSISTOR WITH HEAT SINK**

3 for $3 ☐ **$1.49**

Removed from new equipment! Includes popular 2N174 'doorknob' transistor for TO-36, germanium. PNP, 150 watts, VCBO 80V, 15 amps, 40 hfe. For ignition, high power transmitters, etc. Mounted on heat sink 5 x 2½ x 1¼".

## "MEMORY LANE"



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| | | |
|---|---|---|
| 1101 | 256 Bit RAM MOS | $2.50 |
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| 2513 | Character Gen. ROM | 12.50 |
| 2516 | Character Gen. ROM | 12.50 |
| 7489 | 64 Bit RAM TTL | 2.95 |
| 8223 | Programmable ROM | 2.95 |
| 8225 | 64 bit read & write RAM | 6.50 |
| MM5220 | Pre-Programmable ROM | 2.95 |
| MM5260 | 1024 Bit RAM | 6.50 |
| MM5262 | 2048 Bit RAM | 9.95 |

## PLASTIC VOLTAGE REGULATORS

| | | | | |
|---|---|---|---|---|
| ☐ L-129 | 5V | 600ma | $2.10 | *TO-136 Package |
| ☐ L-130 | 12V | 500ma | 2.10 | |
| ☐ L-131 | 15V | 450ma | 2.10 | Buy 3 – Take 10% |

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