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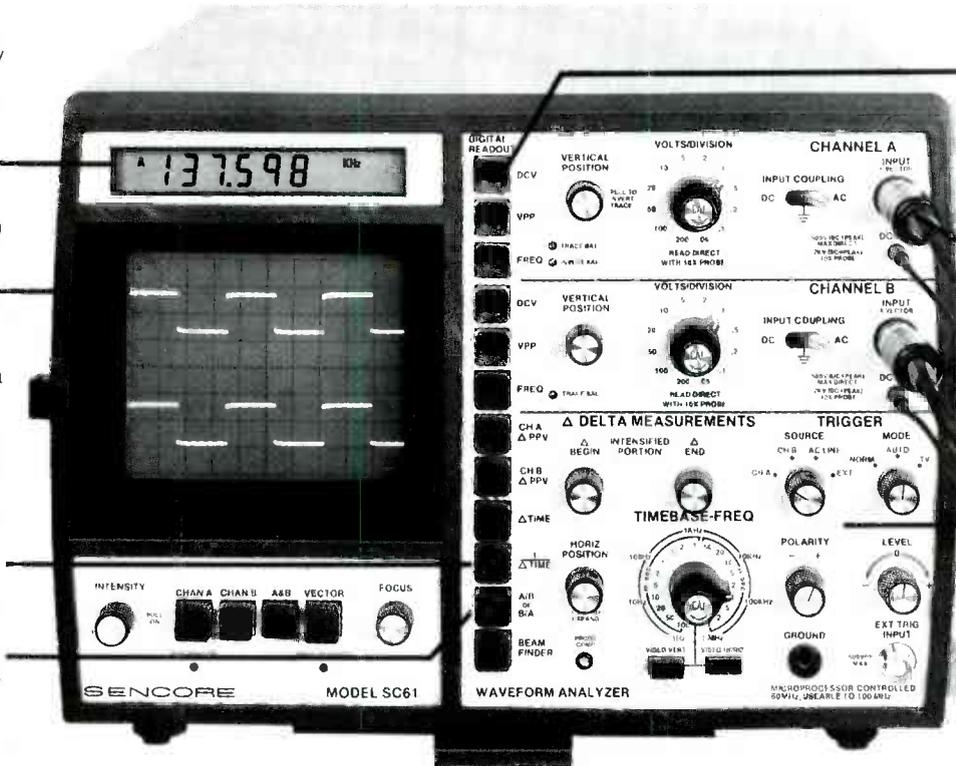
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DSQD = Double Sided Quad Density; TPI = Tracks per inch.

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To get the fastest delivery from CE of your Wabash computer products, send or phone your order directly to our Computer Products Division. Be sure to calculate your price using the CE prices in this ad. Michigan residents please add 4% sales tax or supply your tax I.D. number. Written purchase orders are accepted from approved government agencies and most well rated firms at a 30% surcharge for net 30 billing. All sales are subject to availability, acceptance and verification. All sales are final. Prices, terms and specifications are subject to change without notice. All prices are in U.S. dollars. Out of stock items will be placed on backorder automatically unless CE is instructed differently. Minimum *prepaid* order \$50.00. Minimum *purchase order* \$200.00. International orders are invited with a \$20.00 surcharge for special handling in addition to shipping charges. All shipments are F.O.B. Ann Arbor, Michigan. No COD's please. Non-certified and foreign checks require bank clearance.

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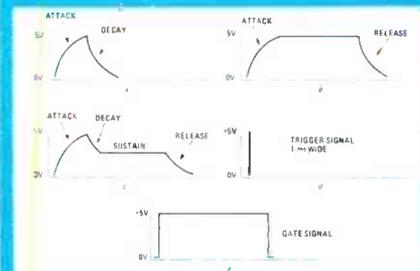
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## ON THE COVER

Timepieces have come a tremendous way in the past few years—from wind-up and electric clocks to those with LED and LCD displays and—now—to clocks with no display at all! The talking alarm clock featured in this issue will announce the time either automatically or on request, and can also be set to *tell* you when it's time to get up. Modern speech-synthesis IC's make it extremely easy to build, as you'll find out starting on page 57.



**THE MAINSTAY** of today's popular music is the synthesizer. Once incredibly difficult and expensive to design and build, its current popularity is due in part to the versatility built into the LSI IC's that are found at its heart. The story of those IC's can be found on page 65.

## COMING NEXT MONTH On Sale May 19

- **Special Videogames Section:** What's new for 1983...and what's in store for the future.
- **Add-on RAM.** A non-volatile 8K memory expansion you can build for your Timex/Sinclair 1000.
- **LF Loop Antennas.** The next installment on our continuing series on VLF-LF receiving techniques.
- **And lots more!**

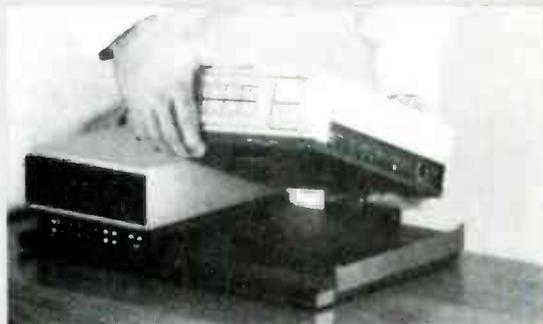
Radio-Electronics, (ISSN 0033-7862) Published monthly by Gernsback Publications, Inc., 200 Park Avenue South, New York, NY 10003. Second-Class Postage Paid at New York, N.Y. and additional mailing offices. One-year subscription rate: U.S.A. and U.S. possessions, \$14.97, Canada, \$17.97. Other countries, \$22.47 (cash orders only, payable in U.S.A. currency.) Single copies \$1.50. © 1983 by Gernsback Publications, Inc. All rights reserved. Printed in U.S.A.

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# VIDEO ELECTRONICS

DAVID LACHENBRUCH  
CONTRIBUTING EDITOR



## CONVERTIBLE VCR

A new approach to portable VCR's is RCA's ultra-deluxe model 900 "convertible," (see photo above) the first product to be offered under the new contract in which Hitachi replaced Matsushita as the company's prime source of video recorders. The recorder resembles a normal high-end VCR when in home use. But for use as a portable, the hinged control drawer at the front is lowered and the deck unit slides out. When replaced for playback, the 7.9-pound portable automatically "docks" into a connector at the rear, eliminating cable connections.

The new VHS recorder has five heads, the fifth used for noiseless special effects exclusively. It has all high-end features, plus a few new ones, including a complete wireless remote control, 8-event 21-day programmability, liquid-crystal display showing elapsed recording time, sound-on-sound recording, "video dub" for insert edits, monitor earphone, digital keypad tuning, and a jack for a pay-TV cable converter.

## UNIVERSAL REMOTE

One of the annoyances of the video age is the profusion of controls and buttons to push. The owner of a TV, videodisc player, VCR, and stereo may be required to sit with four remote-control keypads on his lap in order to use the advantages of all the latest conveniences. Presumably that is about to change. Sony has already announced two *Unicontrol* systems, designed to work with both its TV sets and Betamax recorders, hinting that in the future they may control Sony stereos as well. This spring, RCA is expected to unveil its own universal remote control, which will operate its TV sets, VCR's, and videodisc players. Those devices will work only with equipment of the given brand. If you have, say, a Sony TV, an RCA VCR, and a Pioneer videodisc player, you'll presumably still need three remote controls. Is it possibly time for an allocation of the infrared-command frequencies for standardization of remote-control systems so that in the future any remote unit will work with any equipment?

## NEW BETA

The Beta group of VCR manufacturers, seeking to improve their lagging market share, can be expected to introduce several innovations in the next few months. The imminence of the New Beta Hi-Fi sound system has already gained Beta three new adherents in the United States. Audio manufacturers Aiwa, Pioneer, and Nakamichi plan to introduce Beta Hi-Fi recorders, using the breathtaking new sound system being adopted for Beta recorders. As described in this column last September, Beta machines to be introduced this spring will feature high-fidelity stereo audio recording and playback via a frequency-modulated pair of soundtracks on the helical video track between the chrominance and luminance signals.

Compatible recorded programs—both musical tapes and movies—are already becoming available. They're playable on existing Beta VCR's because they have sound on both the longitudinal and helical tracks. The new recorders have no additional recording or playback heads, the standard video heads being used for the audio material; the sound is separated from the video in the machines' circuitry. Although Aiwa (owned by Sony) and Pioneer have long been Beta licensees, they plan to enter the American VCR market for the first time this year. Nakamichi is completely new to the video market and hopes to manufacture a video recorder compatible with its reputation for excellence in audio. It is considering adding video monitors as well. Although members of the VHS group have demonstrated audio systems similar to Beta Hi-Fi, they are undecided about marketing plans.

R-E

# Tek's most successful scope series ever: At \$1200-\$1450, it's easy to see why!

**Wide-range vertical sensitivity:** Scale factors from 100 V/div (10X probe) to 2 mV/div (1X probe). Accurate to  $\pm 3\%$ . Ac or dc coupling.

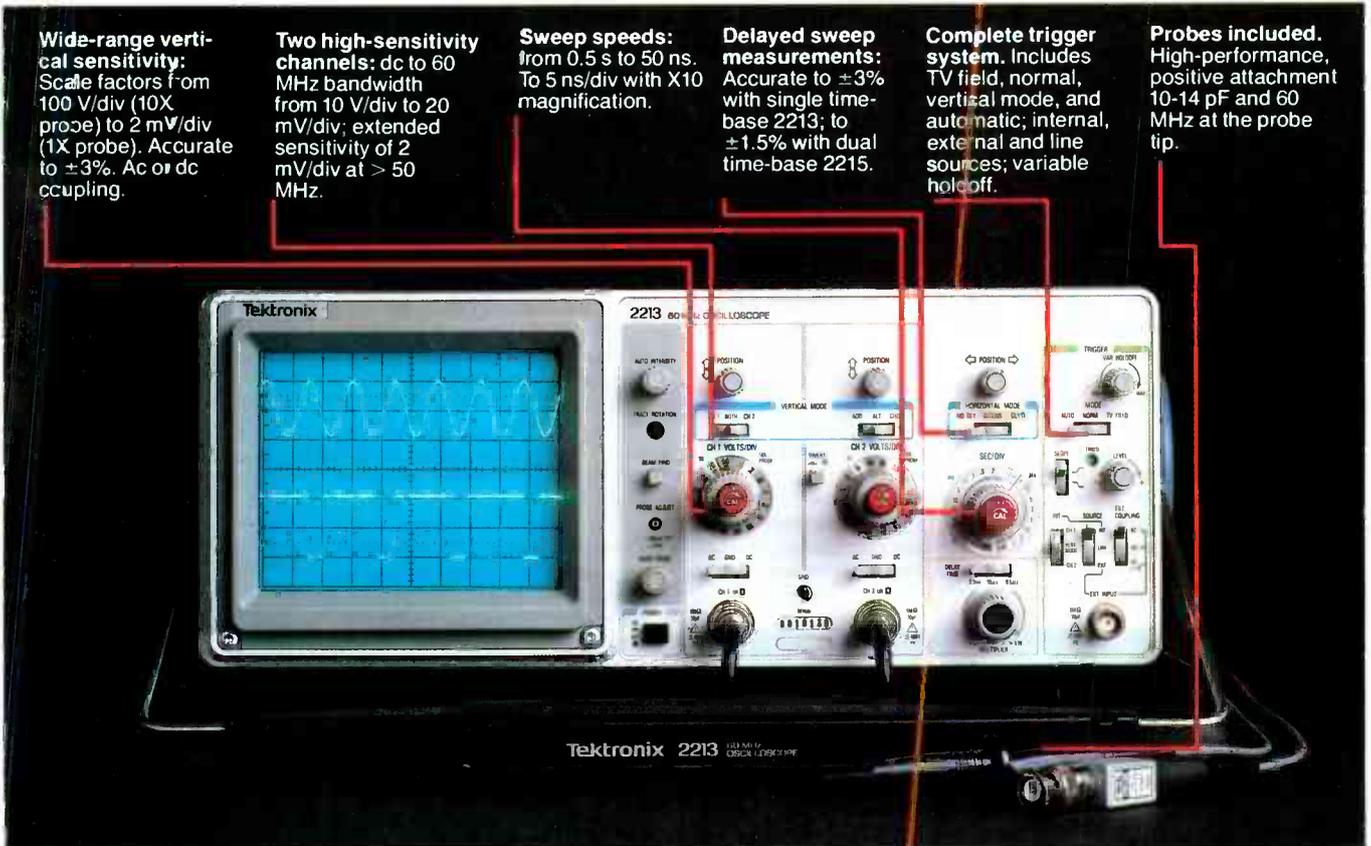
**Two high-sensitivity channels:** dc to 60 MHz bandwidth from 10 V/div to 20 mV/div; extended sensitivity of 2 mV/div at  $> 50$  MHz.

**Sweep speeds:** from 0.5 s to 50 ns. To 5 ns/div with X10 magnification.

**Delayed sweep measurements:** Accurate to  $\pm 3\%$  with single time-base 2213; to  $\pm 1.5\%$  with dual time-base 2215.

**Complete trigger system.** Includes TV field, normal, vertical mode, and automatic; internal, external and line sources; variable holdoff.

**Probes included.** High-performance, positive attachment 10-14 pF and 60 MHz at the probe tip.



**In 30 years of Tektronix oscilloscope leadership, no other scopes have recorded the immediate popular appeal of the Tek 2200 Series.** The Tek 2213 and 2215 are unapproachable for the performance and reliability they offer at a surprisingly affordable price.

There's no compromise with Tektronix quality: The low cost is the result of a new design concept that cut mechanical parts by 65%. Cut cabling by 90%. Virtually eliminated board electrical connectors. And eliminated the need for a cooling fan.

Yet performance is written all over the front panels. There's the bandwidth for digital and analog circuits. The sensitivity for low signal measurements. The sweep speeds for fast logic families. And delayed sweep for fast, accurate timing measurements.

**The cost: \$1200\* for the 2213. \$1450\* for the dual time base 2215.**

You can order, or obtain more information, through the Tektronix National Marketing Center, where technical personnel can answer your questions and expedite delivery. Your direct order includes

probes, operating manuals, 15-day return policy and full Tektronix warranty.

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# WHAT'S NEWS

## "Home computer/robot" is shown at Las Vegas

A robot especially designed for the home-computer enthusiast was exhibited at the International Winter Consumer Electronics Show in Las Vegas last January. The home robot was described by its manufacturer, Robotics International Corp. of Jackson, MI, as not only an adjunct to existing home computers, but also as a totally self-contained computerized system, with robotic hardware and software compatible with existing home microprocessors. It can be equipped for vacuuming, entertaining, or providing security, without human monitoring, says its developer.

The robot stands 4½-feet high and weighs about 120 pounds. Two 7-inch drive wheels and two casters allow it to negotiate hardwood floors or thick-pile carpets. It

is powered by two 12-volt, 20 ampere-hour batteries. One charge is good for about four hours. When the battery is low, the robot can identify its own location, then go and connect to its personal recharging unit.

When the robot is first put into operation, it "walks" around the home, chirping ultrasonically as it maps wall distances and furniture location. It recalls that map each time it re-enters a room. Thus, it can vacuum a room full of furniture without damaging anything. Infrared obstacle-avoidance keeps it from bumping into pets, children, or new obstacles.

The head contains a cathode-ray tube that displays normal alphanumeric information, and has a pre-programmed video "mouth" with lips that mimic lip motion when it is synthesizing speech. The CRT operates normally when linked to

the home computer, or to an optional computer package and software that eliminates the need for an external computer.

The robot can be equipped optionally with a security package, one or two arms, a vacuuming unit, a computer with keyboard and 48K or more of memory, and state-of-the-art voice recognition.

## IBM joins Japanese in research effort

International Business Machines (IBM) has informed the Japanese government that it would like to join a research project to develop a "fifth generation computer" that Japan started early in 1982. The proposed computer would think like a human being.

The Japanese Ministry of International Trade and Industry is subsidizing the project with an initial grant of 423 million yen (about 1.7 million dollars) for preliminary research.

Fujitsu, Hitachi, NEC, and five other Japanese companies are already taking part in the project. Several European computer makers have also shown interest. Thus, the 10-year project is on its way to become the world's largest international research effort in computer history.

## New GE GaAs FET's improve power handling

General Electric Research and Development scientists have developed a novel high-voltage power field-effect transistor (FET) with switching speeds of less than five billionths of a second, and with resistance about one-tenth that of comparable silicon devices. The new FET's can block up to 150 volts—the best previous gallium arsenide FET's would not go beyond 85 volts.

Breaking with conventional horizontal layout (with the source, gate and drain closely aligned on the top of the chip), the new FET's have a large source contact on the top and a large drain contact on the bottom of the chip, with the fine gate regions running through the center.

By avoiding the close arrangement of tiny details on the surface of the wafer, the GE layout increases current-handling capability



GE'S NOVEL VERTICAL-CHANNEL gallium arsenide field-effect transistor that blocks up to 150 volts and switches in less than 5 billionths of a second. This photomicrograph shows its unusual construction. Most gallium-arsenide devices are horizontal, with the fine lines that form the source, gate, and drain closely aligned at the top of the chip. The GE design places a large source contact on top of the chip and a large drain contact on the bottom, with fine gate regions running through the center.

ity and reduces the possibility that a crystalline defect in the material can result in lines that touch, causing the devices to short out. That buried-gate design yields high quality and few defective chips.

## Larger-than-life video shown at Las Vegas

General Electric demonstrated a consumer-oriented system that projects bright, clear, color video images up to 25 feet wide at the Consumer Electronics Show at Las Vegas last January.

The *Talaria* Technology uses a single-gun, single-optical-path system and can accept video signals from off-the-air tuners, live TV cameras, tapes and discs, and computer terminals with standard video output. The system is already in use for industrial applications such as background display on TV weather broadcasts, magnification of minute details for display in large lecture halls, and large-screen CCTV broadcasts.

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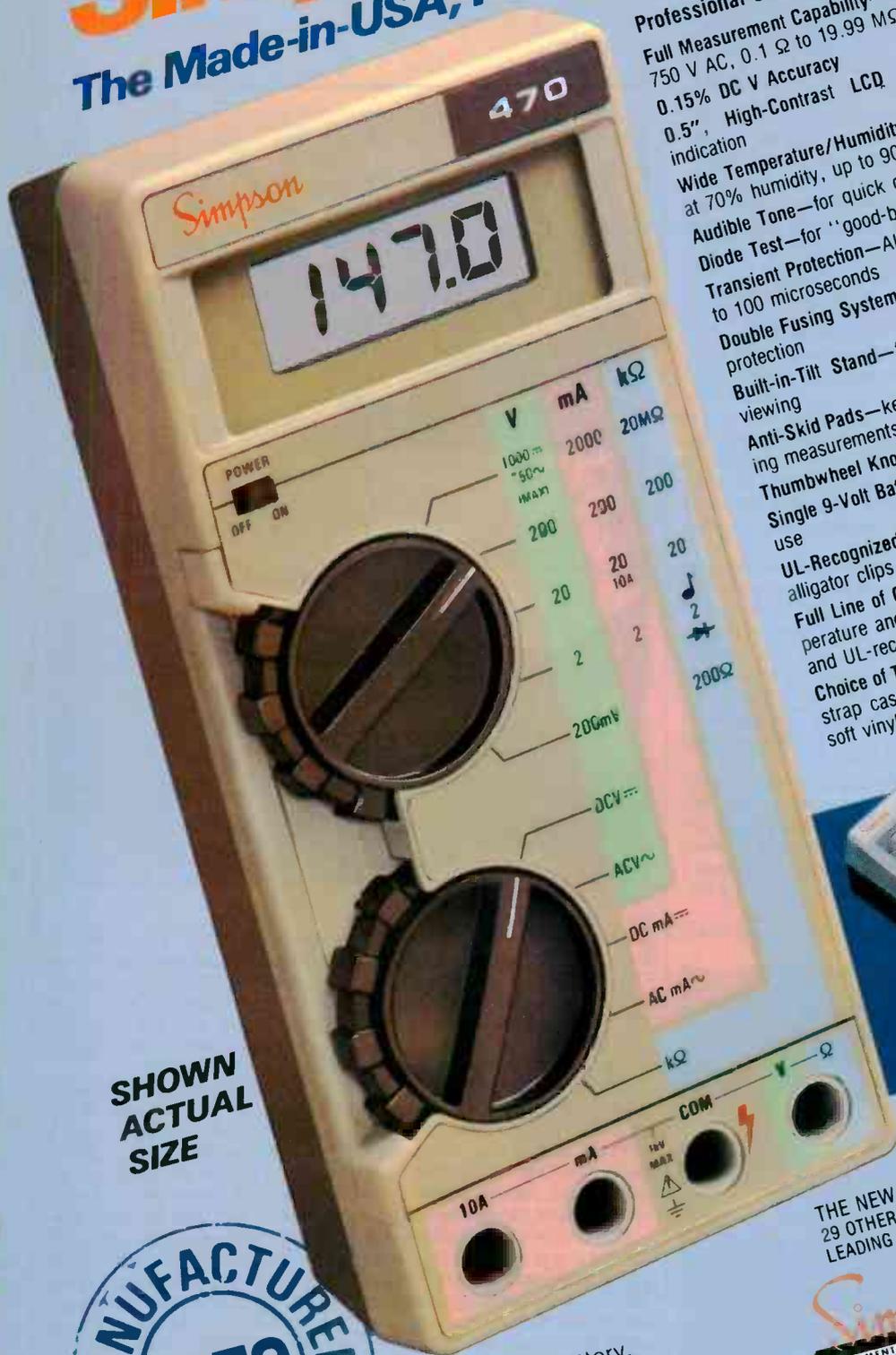


A FORMIDABLE SENTRY, THE ROBOT security monitor stands guard over the home. For that purpose it is equipped with microwave, passive infrared, and audio discrimination detectors. The robot is made by Robotics International Corp. of Jackson, MI.

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# WHAT'S NEWS

(continued from page 6)

## Sharp supplies "office in an attache case"

With three compact new pieces of equipment, Sharp claims: "Today's businessman can carry most of his office needs right in his attache case and still have room left for lunch."

The new *EL-6200* Planning Calculator ( $6\frac{5}{16} \times 1\frac{3}{16} \times 3\frac{3}{8}$  inches) acts as an ever-present secretary. It reminds him of all appointments, including business meetings and lunch dates, who and when to call, and the phone numbers. An interesting feature is the use of symbols in the display—a dinner date might be indicated by a knife and fork, for example. When it's not being used as a reminder of specific appointments, it serves as a standard clock and calendar.

The *EL-7100* Memowriter ( $7\frac{1}{32} \times 1\frac{5}{16} \times 3\frac{3}{4}$  inches) provides a miniature typewriter keyboard, a complete display, and a printer that makes hard copy on paper. (The memo may be written on the display and then immediately erased, or by pushing a PRINT button, turned into hard copy. The Memowriter has a memory of up to 40 words.)

The *7050* Graph Generator ( $10\frac{7}{16} \times 1\frac{31}{32} \times 5\frac{3}{4}$  inches) is designed for the sales engineer in the field. It generates a number of line or bar charts and ribbon or circle graphs—in four colors, com-

plete with shading. It can make one drawing on top of another to compare the effects of different inputs, or enlarge or reduce any segment of a chart. (Both effects can be very useful in competitive sales situations.)

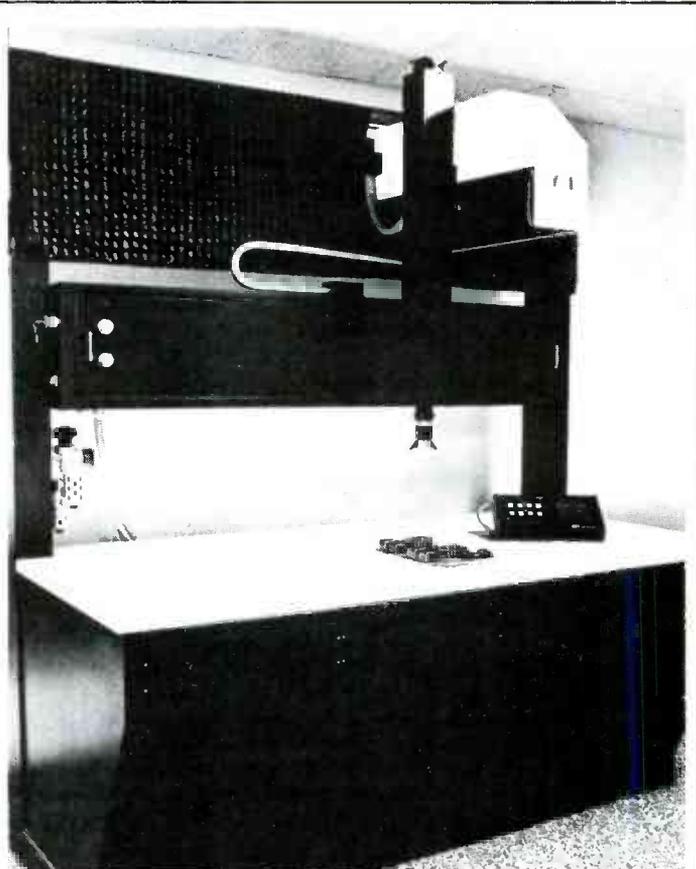
## Three-armed robot makes printed-circuit boards

A new high-precision, microprocessor-controlled robot for use in printed-circuit manufacture is claimed to be the first robot on the market able to place non-standard parts automatically at high speed. Called the *Sembler* model *CAR-1000*, it is made by Control Automation, Inc. of Princeton, NJ.

The *Sembler* is available with one, two, or three arms, and is precise to 0.001 inch. Each arm is capable of coordinated motion in X, Y, or Z axes, plus wrist rotation (theta axis). The work envelope is 56 inches long, 20 inches deep, and 20 inches high. The robot wrist can rotate up to 180 degrees. Load capacity is 10 pounds.

The robot picks up the appropriate part (transformer, relay, IC, etc.) and places it precisely in the desired position on the printed-circuit board. Its precision allows it to handle odd-shaped components.

With appropriate procedures,



MODEL CAR-1000 SEMBLER MICROPROCESSOR-CONTROLLED ROBOT.



SHARP MEMOWRITER, PLANNER, AND GRAPH GENERATOR (clockwise from upper left) can indeed fit in an attache case, with room for some extra memo paper.

the *Sembler* can be controlled by any computer, in any language. The standard system includes an external computer (*SC 1000*) that the user programs in BASIC. That makes the robot literally plug-compatible with other assembly components.

All of the robot's motions are actuated by DC servo motors through lead screws with zero backlash. That eliminates belts and pulleys and results in a relatively maintenance-free robot.

The robot's chief application is assembling printed-circuit boards. Other applications include material handling and assembling computer peripherals (keyboards, etc.) and small electronic and automotive subassemblies.

## Computer tracks down hit-and-run drivers

Tokyo police are now using a computer to catch drivers who

leave the scene of an accident. In 1983 over 93 percent of the drivers in over 1,000 hit-and-run accidents in the metropolitan area were apprehended, and the police believe it possible to raise the figure to nearly 100 percent.

The computer analyzes paint particles left at the scene of the accident. A bit of paint as small as 0.2 mm (smaller than a pencil point) is all that the computer requires. The computer compares the paint with data on more than 10,000 finishes in its memory. It then tells the make, model, and year of all cars on which the finish was used. That information reduces tremendously the number of cars that might have been involved.

The work is done in five minutes, compared to the half day required for visual checking. Further, the older method requires a particle of 2 mm—ten times the size of the computer sample. **R-E**

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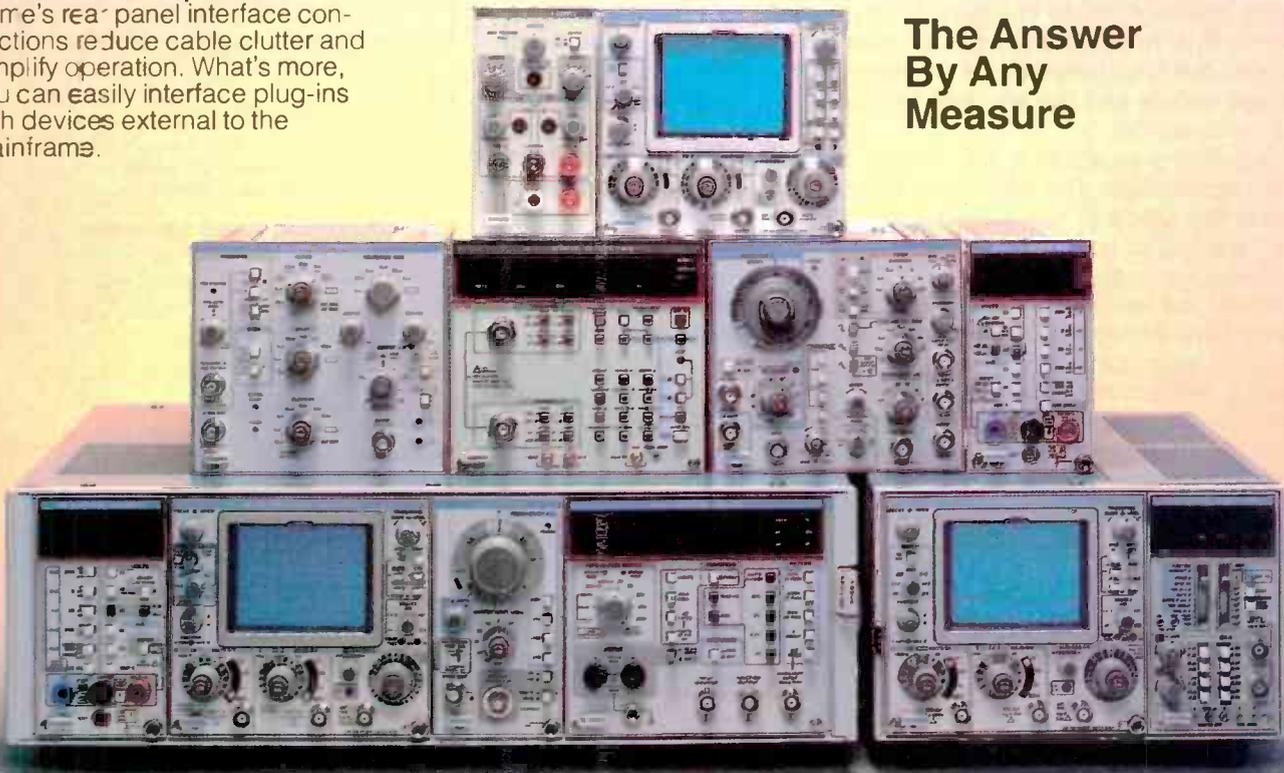
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# EDITORIAL

## Becoming An Author

Every year or two, I write an editorial devoted to our readers who yearn to become authors and write for **Radio-Electronics**. Based on the number of inquiries I've received on this subject lately, I've decided to repeat an editorial that was published almost two years ago:

Wherever I go, the most often asked question is: "How do I go about writing an article for **Radio-Electronics**?" I do not dismiss that question lightly. Our readers represent a vast untapped reservoir of knowledge. Each and every one of you has developed a special expertise in at least one particular area. Many of you have unique ideas and knowledge that is not widely known. The drive to acquire knowledge and share knowledge and ideas with others is immense. In fact, that is the main function of **Radio-Electronics**. It is a vehicle for the exchange of knowledge and ideas. For those reasons we encourage our readers to write articles.

What do you get out of writing an article? Aside from the extra income and recognition of having your name in print, there's the satisfaction of sharing your knowledge with others. In fact, you have advanced the knowledge of the members of this industry and have helped people just like yourself. Indeed, it is a rewarding and satisfying achievement.

Submitting an article is not difficult. It is simply a matter of sending it to my attention. The best first step, however, is to send me an outline of the article to see if we're interested in the subject. If we are, we'll tell you to go ahead and perhaps even make a few suggestions regarding your outline.

There are far too many steps involved in writing an article for us to cover here. However, we do have an Author's Guide that will answer many of your questions. If we've managed to stir your curiosity, then send a self-addressed stamped envelope to Author's Guide, **Radio-Electronics**, 200 Park Avenue South, New York, NY 10003, and we'll send you one.

Now what's your excuse for not writing an article?



**ART KLEIMAN**  
Editor

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Cover photo by Robert Lewis

**Radio-Electronics** is indexed in *Applied Science & Technology Index* and *Readers Guide to Periodical Literature*.

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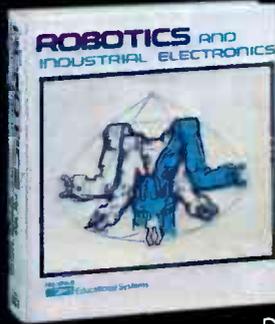
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Capable of seven axes of mo-

tion, the robot can be programmed to pick up small objects with its arm. It will also speak in complete sentences, using its voice synthesizer.

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# SATELLITE/TELETEXT NEWS

GARY ARLEN

CONTRIBUTING EDITOR

## LOW-FLYING "SPACE MIRROR" COULD SUPPLEMENT SATELLITES

"Space Mirrors," which could bounce TV, audio, and data communications from orbiting positions about 100 miles high, are being developed by a University-of-Oregon professor in cooperation with Stanford Research Institute. The reflectors, two to five meters in diameter, would be made of ultra-fine wire and held stationary above Earth by the pressure of electronic radiation. Although the space mirrors would be passive reflectors, they could be adapted to transmit signals. The big attraction is that they could cost as little as \$10 million—less than 20% of the price of a conventional communications satellite—and there would be lower launch costs.

Prof. Paul Csonka, who developed the space-mirror concept, foresees use of the low-flying dishes as particularly attractive in parts of the world which don't have the need or finances for full-scale satellite services. The reflective dishes could bounce signals between points up to 1000 miles apart—which is far less than the footprint covered by today's geostationary orbiting satellites. The space-mirror study was underwritten by equipment-maker EMCEE, which holds the patent rights to it. Further research, expected to continue through early 1984, is now under way to iron out some technical problems with the orbiting reflector.

## SATELLITE TV CORP. OKAYED FOR DBS; 1986 TARGET DATE REMAINS

Satellite Television Corp. has received FCC approval to begin its first phase of construction for a national direct-broadcast satellite system. The FCC action gives STC a slight head start on the other eight companies which have received preliminary FCC approval to begin developing DBS services. If all goes according to plan, STC could put up its first DBS bird by early 1986, ready to serve viewers in the eastern time zone. The FCC was expected to begin action on the other DBS applications within a few weeks after okaying STC's plan. The DBS systems operate in the 12/14-GHz band.

The FCC authorization doesn't include launch go-ahead, frequency allocations or orbital slots for STC's direct broadcast birds. Those matters will be addressed after the June 1983 western hemisphere Regional Administrative Radio Conference, which will sort out DBS assignments for North and South American nations.

STC, a wholly owned subsidiary of Comsat, has already begun to make plans for its DBS service, which the company predicts will cost \$680 million to build. By the end of the first year of operation, about 650,000 subscribers should be buying the service (for about \$20 per month) which will offer three channels of pay-TV, education, and other programming.

In an unrelated development, Oak Industries has delayed its DBS plans. The company had hoped to get an early start on DBS sometime in 1984, using a Canadian satellite until its own bird could be launched in 1986. But further tests showed that the Canadian satellite wouldn't be strong enough to cover Oak's target audience, even using a higher-powered transmitter like those that are currently available on U.S. birds. Oak is still proceeding with its 1986 DBS plans.

## PROMISING PREDICTIONS ABOUT SATELLITE USE, LOWER PRICES

Fearless forecasters continue to envision a bright future for satellite services, including lower prices for many facilities. For example, SPACE (The Society for Private and Commercial Earth Stations) foresees another \$1,000 drop in prices for a typical earth station this year; SPACE estimates that the average home-satellite user now spends about \$4,500 to set up equipment, which itself is a dramatic drop from a year ago when the typical start-up costs ran as high as \$7,000. In all, that means a sophisticated 4/6-GHz private receiving system will cost about \$3,500 by the end of 1983—and, of course, many systems will be built for far less. Meanwhile, SPACE is also estimating that about 4000 new dishes are being installed each month, adding to the 60,000 or so units now in place. Moreover, another 250,000 homes are seeing bird-fed programming via Satellite Master Antenna TV systems (SMATV) in apartments, condos and other multi-home dwelling units.

If the rapid growth of current satellite-reception technology seems staggering, there's an even bigger explosion ahead when Direct Broadcast Satellites are in full swing. By 1990, more than 15 million rooftop DBS receivers will be installed, according to a report from International Resource Development. The DBS facilities will make the present backyard terminals all but obsolete, IRD says. They also predict that the business of building and installing the small DBS dishes will be almost totally controlled by large satellite-industry firms such as Hughes, Harris, Scientific-Atlanta, and RCA.

R-E

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# VIDEOGAMES

## A tale of two synthesizers

DANNY GOODMAN, CONTRIBUTING EDITOR

MATTEL AND ODYSSEY HAVE INTRODUCED us to a new technology that will add new excitement to home videogames: electronic speech synthesis. Both voice boxes are complementary add-ons to their respective consoles. They are attached to the game system through the cartridge slot, and game cartridges, in turn, plug into the voice add-ons. Both synthesizers use the same high quality speech technique from Texas Instruments, called Linear Predictive Coding (LPC). LPC allows different voices and accents to be stored digitally in ROM (Read-Only Memory) IC's that are packed inside the game cartridges.

Despite the similarities, the two companies have entirely different philosophies on how to approach videogames using voice. That diversity is not so much in hardware (although *Intellivoice* plays through the TV speaker and the *Odyssey 2* voice module, shown in Fig. 1, has its own built-in speaker) but in the specially coded software cartridges that make the modules move their electronic lips.

*Odyssey's* voice cartridges are initially aimed at educational applications, although one popular action cartridge, *UFO*, is reportedly being re-designed to incorporate voice. One of the educational

cartridges, *Type and Tell*, lets the "player" type in any word, name, or jumble of letters, and the synthesizer attempts to speak the word—expletives not deleted.

But most of the *Odyssey 2* voice cartridges for action games will be compatible with the same console without the voice module. That is, the cartridge will be playable without the module. That way, *Odyssey* believes, those without *The Voice* will still have the opportunity to play all the cartridges.

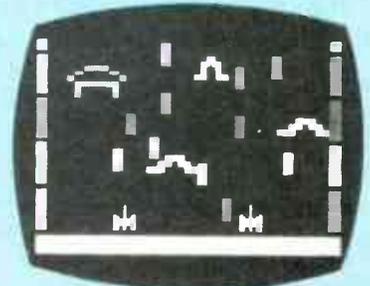
Mattel, on the other hand, seems to take the position that voice should be an integral part of the game play. In its voice cartridge *B-17*, for example, you're busy watching for ground targets below the plane when the plane's co-pilot alerts you that there are bandits at 3 o'clock. With that verbal alert, you know how to change your screen view to get the bandits in your gunsight. Some of the voices on that cartridge, however, are purely for decoration, like when the bombardier shouts "Bombs away!"

My initial reaction is that the Mattel approach will appeal to more *Intellivision* owners than the *Odyssey* idea will attract *Odyssey 2* owners. While it's "neat" to have a talking game, there is more incentive to go the voice route if the voice is

integrated into the game play, instead of being put on only for extra trimming. One driving force behind all videogame development is the player's demand for more—more detailed graphics, greater strategic realism, and more challenges. If an electronic voice adds to those dimensions of the game, then there is a real incentive to invest in the voice add-on.

Atari is forecasting a speech add-on for the *5200* for 1983. I hope the software designers are doing more than just adding a Howard Cosell voice coming from the press box of a football game.

### Fox Video Game's Worm War I for Atari 2600



CIRCLE 101 ON FREE INFORMATION CARD

Fox Video Games	Worm War I									
GRAPHICS	█	█	█	█	█	█	█	█	█	█
SOUND	█	█	█	█	█	█	█	█	█	█
EASE OF LEARNING	█	█	█	█	█	█	█	█	█	█
CHALLENGE	█	█	█	█	█	█	█	█	█	█
VALUE	█	█	█	█	█	█	█	█	█	█
	1	2	3	4	5	6	7	8	9	10
	Poor		Fair		Good		Excellent			

You might expect games coming from Twentieth Century Fox to bear titles licensed from Fox's motion pictures. Not just yet, they tell me. In the meantime, Fox Video Games has jumped into the scene with four Atari VCS-compatible games designed by a respected personal-computer-software developer, Sirius Software. *Worm War I* is a

(continued on page 2)



FIG. 1

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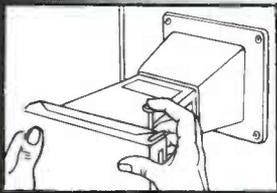


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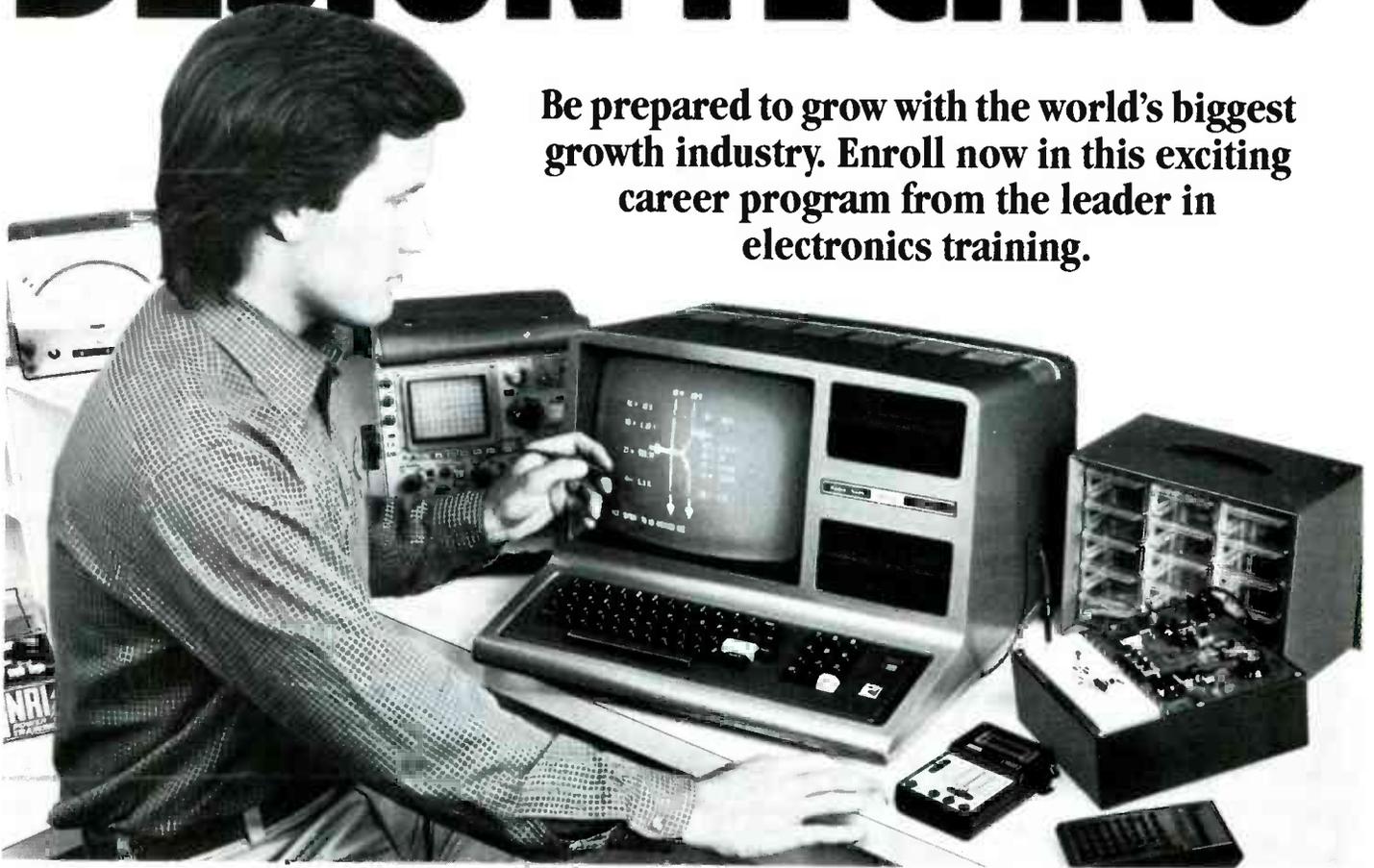
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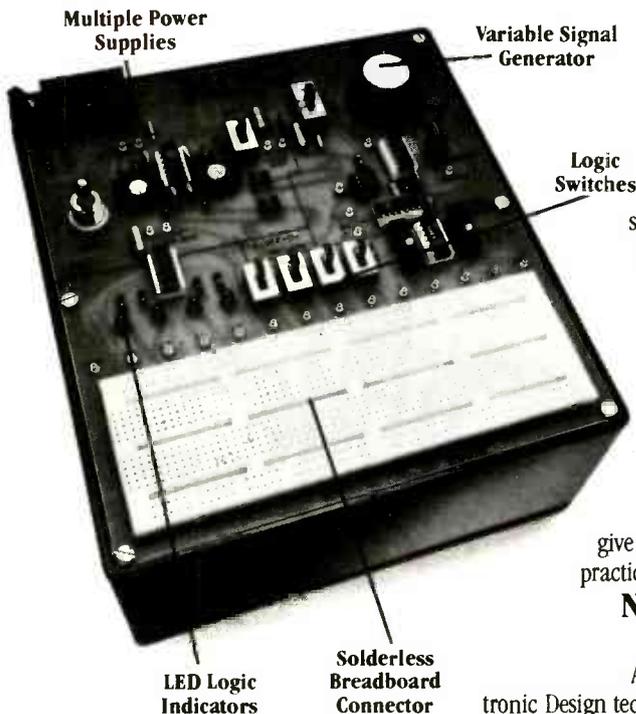
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# BECKMAN

CIRCLE 41 ON FREE INFORMATION CARD

# VIDEOGAMES

continued from page 14

unusual creation that pits a conventional tank against a horde of not-so-conventional giant worms that wiggle back and forth across the screen. The worms, plus other wall-like obstacles on higher levels, scroll from top to bottom, giving you the illusion of tank motion down a wide avenue. You control left-right movement of the tank and the scrolling speed.

The object is to clear off each successive wave of wriggly worms. If one scrolls off the bottom, it "wraps around" and re-appears at the top for another chance. Each wave materializes on the screen, along with an occasional gas station.

Gas station? Yes, your tank's fuel supply is limited, so you've got to pass through a station (more like a garage door) as quickly and as squarely in the center as possible to pick up the most fuel. As you soon learn, it's not so easy to hit a moving worm in the right spot on purpose, but it's all too easy to blast away a garage by accident.

The worm graphics are not greatly detailed, but the worms are unique in their movement. To some players, a fresh wave of worms will look like an oscilloscope pattern run amok. The sound consists of blaring barrages similar to the *Yar's Revenge* sequence after hitting the elusive *Qoite*.

*Worm War I* may not rank among the all-time great VCS cartridges, and inexperienced players may find the difficulty progression rather fast, but the original scenario and game play make it a worthy addition to larger libraries.

## Parker Brothers' Frogger Jumps to the Atari 2600

*Frogger* was one of those non-combatant arcade games that helped draw quarters from the female audience once *Pac-Man* had whetted their appetites. The game's scenario was cute and simple: get the frog across a busy highway and a river in 30 seconds. Controlling the frog meant simply moving him forward, backward, left or right—just like a maze game. In spite of its simple scenario, and ease in picking up how the game works, the game advances rapidly into harrowing experiences for that homebound frog.

There is a lot going on on a *Frogger*



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	Parker Brothers					Frogger				
GRAPHICS	1	2	3	4	5	6	7	8	9	10
SOUND	1	2	3	4	5	6	7	8	9	10
EASE OF LEARNING	1	2	3	4	5	6	7	8	9	10
CHALLENGE	1	2	3	4	5	6	7	8	9	10
VALUE	1	2	3	4	5	6	7	8	9	10
	Poor		Fair			Good			Excellent	

screen, especially in the river. That includes things like moving logs, turtles that dive (disappear) into the water, alligators, snakes, lady frogs, and flies (the last two account for bonus points). When Parker Bros. announced it had purchased the rights to *Frogger* from Sega/Gremlin, I had some doubts as to how much of the original could be convincingly transferred to an Atari VCS cartridge, given that system's limited memory and graphics-addressing capabilities. However, I was pleasantly surprised when I finally saw Parker's rendition. With the exception of one hazard (the otters), Parker's *Frogger*

manages to capture most of the subtleties of the original graphics. More importantly, the game play is at least as challenging as the arcade version, with the difficulty increasing at a brisk but not frustrating pace.

One advantage of the home game over the arcade version is the number of game levels available. The cartridge contains 6 variations, three each for one and two players, called "easiest" (not that easy), "more difficult," and "speedy." In "speedy," *Frogger* continues to jump in one direction as long as you push the joystick that way. In other games, it's one push of the joystick per jump. VCS difficulty-switches also give you the option of letting the frog scroll around the screen on turtles or logs, instead of biting the algae when it reaches the screen edge. That's highly recommended for novice players.

Scoring is one-tenth that of the arcade version (e.g., 100 points for getting all five frogs home vs. 1000 at the arcade). Extra frogs are earned for every 1000 points, up to a maximum of four reserve frogs at any time. That may sound more generous than the arcade game (only one extra *Frogger* at 2,000 equivalent points), but it indicates the greater challenge that the Parker *Frogger* cartridge offers.

Players get a brief *Frogger* musical interlude between levels and the theme music at the game's outset. If you're intent on replaying the game, that intro music seems to take forever, but unlike Parker's *Empire Strikes Back*, you've got to wait for the music to stop before *Frogger* can start.

Even if you've never played the arcade original, you'll enjoy *Frogger*, as will the young and novice game players in your home.

R-E



"Would you like to hear my secretary in stereo?"

# LETTERS

Address your comments to: Letters, Radio-Electronics,  
200 Park Avenue South, New York, NY 10003

## DMM ADD-ON

In reference to the "DMM Add-On" ("New Ideas," October 1982 issue), I must admit that, for me, the article does not compute. There was no rationale given for the "divide 4000 by the meter reading."

By my logic, I would consider the simplified circuit to be as you see it in Fig. 1.

Consider Rx to be 100 megs; then R total = 100 + 0.5025 = 100.5025 megs. Total current =

$$\frac{E}{R} = \frac{8}{100,502,500} =$$

0.0000000796 amperes.

The DMM should read the voltage drop across 0.5025 megs.  $E = IR = 0.0000000796 \times 502,500 = 0.039999005$  volts; that rounds out to 0.04 volts (meter reading).

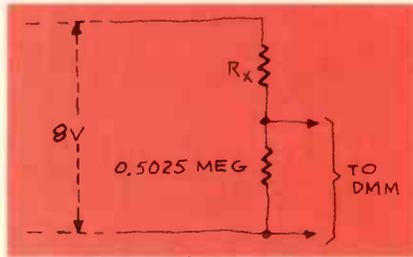


FIG. 1

According to the article,

$$R_x = \frac{4000}{0.04} = 100,000 \Omega$$

That is not 100 megohms!

100 megohms can be derived by first determining the voltage drop across  $R_x = 8V - 0.040V = 7.96V$ . Then

$$R = \frac{E}{I} = \frac{7.96}{0.0000000796} = 100,000,000$$

or 100 megohms. Or the formula could be used:

$$R_x = \frac{E_{RX}}{E_{DMM}} \times \frac{0.5025 \text{ megs}}{1}$$

JOSEPH S. RIZK  
Jacksonville, FL

In the 200-millivolt range, the meter reading is 40—not 0.04. To obtain the correct resistance in megohms, divide 4000 by the actual meter reading—not the voltage value.—Editor.

## AGREEMENT

I agree with Mr. Joseph W. Miller's suggestion in the "Letters" section of the January

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11305	20	99	90	75
11306	22	1.12	1.02	.85
11307	24	1.25	1.14	.95
11308	28	1.52	1.38	1.15
11309	40	2.05	1.86	1.55

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11203	16	16	15	14
11204	18	18	17	15
11205	20	20	18	16
11206	22	22	20	18
11207	24	24	22	20
11208	28	28	26	25
11209	40	40	37	33

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1.5 W TYPE:

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13825-1 DATA SHEET FOR DC/DC CONVERTERS ..... 25

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13812	SOLV30-24	24	2.0A	5-5/8x4-7/8x3-3/16	OVP-4	59.95

13802-1 Data Sheet for SOLV Series ..... 25

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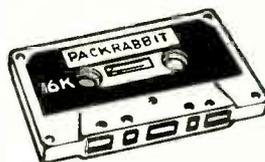
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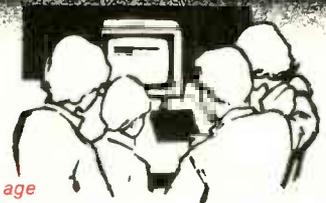
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RE5

1983 **Radio-Electronics** that you ease off computer articles.

I am not a subscriber, but the newsstand saves me a copy every month, and I have a **Radio-Electronics** file of several years' standing. I am a "hobbyist," retired (age 74), and have been in electronics and radio since 1923.

I have just refused to renew my subscription to another electronics magazine because they devote too much space to computers. There is not a single magazine (to my knowledge) that is for the hobbyist; all have gone to computers. There are still a lot of us, believe it or not, who are *not* interested in computers, *per se*.

GERALD HASSELL  
Brookhaven, NY

### FASTER THAN LIGHT

In your January 1983 issue, Dr. Harold W. Milnes presents three experiments. He interprets the first two (and particularly the second) as "leading to one conclusion: An electrical signal in a conductor, under suitable conditions of very low L and C values, can be made to pass through that conductor at a velocity considerably greater than that of light." He estimates it to be "greater than one hundred times the speed of light."

The problem with the experimental setup is that the wire is not a *straight* wire. In both experiments, the wire forms *loops* (a multitude of loops in the first experiment, and one in the second). Those loops allow for inductive magnetic coupling—or rather magnetic short-circuiting—of early parts of the wire with late parts of the wire.

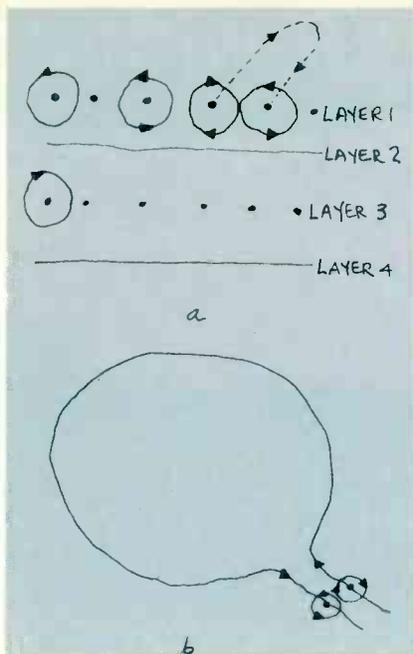


FIG. 2

Although the wire length is 400 meters, the magnetic length is only of the order of one meter or less (depending on the connecting wires). That can be seen in Figs. 2-a and 2-b below, which correspond respectively to the experiments. The magnetic lines show how the mutual magnetic inductive coupling occurs, and how a magnetic short-circuiting of the ends of the wire ensues. (Another way to examine that short-circuiting consists of

considering the stepwise EMF induced in one end of the wire by the stepwise magnetic field of the stepwise current in the other end.) Using coaxial cable would remove the electromagnetic coupling of the early and late parts of the wire.

DR. MICHEL G. BOUGON  
The Pennsylvania State University,  
University Park, PA

### MICROPROCESSOR-BASED DEVICES

I have read the January issue of **Radio-Electronics**, and find it to be superb, as usual. I am always very interested in construction articles, and have been hoping to see some on how to design microprocessor-based devices. Your article, "How To Interface Microprocessors" was fine—but too short! I would very much like to see that article expanded into a multipart series, so that those of us who are not thoroughly familiar with micros can be enlightened as to the hardware aspects of those devices.

I am certainly *not* suggesting that **Radio-Electronics** become a computer magazine. Heaven forbid! I do, however think that a regular monthly series of construction articles based on the more common microprocessors would prove to be extremely valuable to your readers. After all, it is getting to the point where anyone working in the area of digital electronics must "know" micros. I have found the micro to be such a useful device that it would be a real loss not to continue to provide your readers with applications information.

DANIEL R. TAYLOR  
Orlando, FL



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# EQUIPMENT REPORTS

## Fluke Model 8060A DMM



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Fluke		8060A											
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		1	2	3	4	5	6	7	8	9	10		
		Poor	Fair		Good			Excellent					

with its latest DMM, the model 8060. Actually, rather than a DMM, we think this instrument should be called a DMPM, or a *Digital Multi-Purpose Meter*, as it not only features the "standard" DMM functions, but also a few more that are definitely not standard. In fact, it will do so many things that we're going to concentrate on some of the more unusual ones.

Briefly, the unit is a hand-held, microprocessor-based, 4½ digit DMM, with a nice big LCD display. AC readings are true RMS up to a frequency limit of 100 kHz. Voltages, either AC or DC, can be displayed in dBm referenced to 600 ohms, or in relative dB. A relative reference (or offset) feature works with all of the meter's functions. When that feature is used, a reading is stored as a zero refer-

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A473 56	A840 1.44	Z5C352A 2.73	C799 1.50	C1213 18	C1973 61	D471 25	HA1151 1.62	STRK050 5.87	TA7227PK 4.04	UPC1186H 1.56
A483 3.57	A908 10.47	C371 32	C829 14	C1215 28	C2028 58	D525 30	HA1156W 1.26	STRK080 10.60	TA7310P 1.02	UPC2002 1.43
A489 1.54	A909 10.51	C372 16	C830H 2.71	C1226A 40	C2029 1.53	D526 81	HA1196 1.36	STRK103 7.70	TA7310P 1.02	UPC1430S 1.74
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A748 92	B561 1.8	C756A 1.40	C1169 5.69	C1816 2.26	D426 2.89	BA521 1.23	MB3756 1.99	TA7203P 2.30	UPC1155H 1.69	
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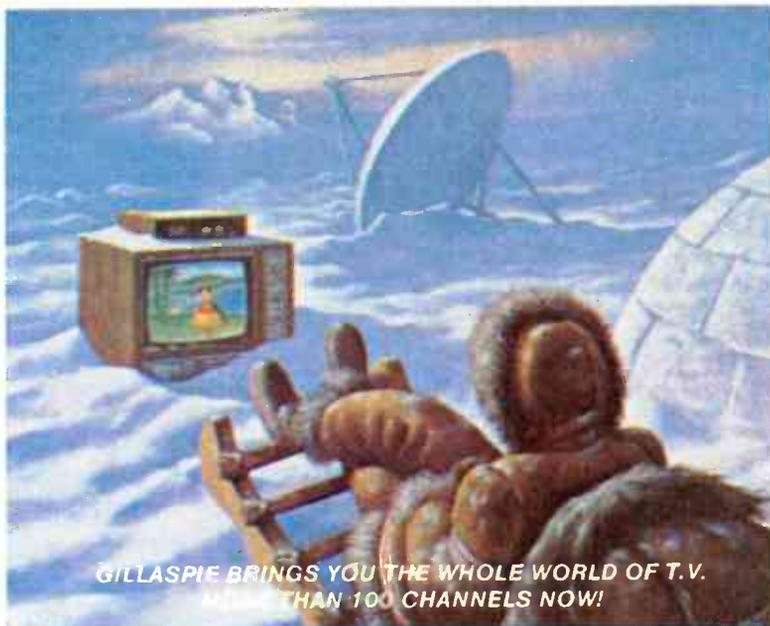
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ence and all subsequent readings are displayed as  $\pm$  deviations from that reading.

Resistance ranges are autoranging up to 300 megohms. Continuity tests can be made using either an audible or visual (on the display) indicator. A conductance range that is useful for measuring very high resistances (up to 10,000 megohms) is provided. While the reading is displayed in nanosiemens, a handy chart for converting that reading to ohms is provided. The 2000- and 20,000-ohm resistance ranges can be used for testing semiconductor junctions. Those provide a constant current that is high enough to turn on a junction. That function is clearly noted on the front panel as a reminder.

The range and standard-function switches are all located down one side of the meter for easy one-handed operation. The ON-OFF switch is also located on the side, but away from the rest and toward the top of the meter. The special-function switches are located in a row at the top of the front panel. Test leads plug into protected jacks at the bottom.

The meter performs a self-test procedure every time it is turned on. During that procedure, the entire display is activated, including all four digits (ones are displayed) as well as the function and low-battery annunciators.

The meter can be used for a wide variety of tests; let's take a look at some of

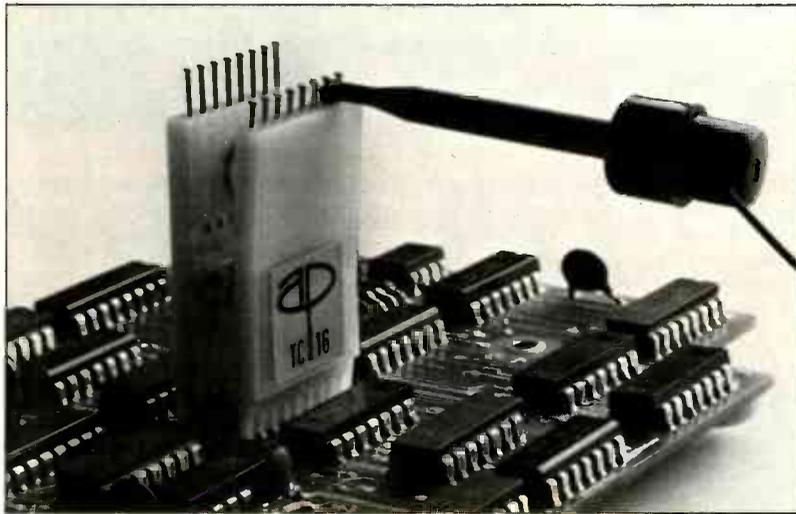
them. You can find the bandwidth of any audio amplifier (as defined by its 3-dB points) using just the DMM and an audio generator. The generator need not be calibrated that accurately, as the meter can be used to determine the generator's output fairly precisely. The first thing to do is to connect the generator to the amplifier's input (you can set the input level to whatever you want by reading it out on the meter), connect the meter to the amplifier's output, and set the meter to read AC voltage. Next, determine a zero-dB level. To do that, set the generator to 1 KHz (that is the frequency most commonly used as a standard), and push DB and the REL (relative reference) buttons on the meter. Now, all readings will be referenced to that level and read out directly in dB. To make the test, start the generator at zero dB and slowly increase the frequency until the meter reads -3dB. That is the upper limit of the bandpass. To get the precise frequency, hit the HZ button on the meter and log the reading. To find the lower bandpass limit, repeat the procedure, except this time work downward from zero dB.

The results of that test can be used to find the Q of frequency-sensitive filters (such as bandpass, high- or low-pass filters, notch filters, etc.) as well as any other type of tuned audio-frequency circuit. To find the Q of such circuits, determine the circuit's passband from the procedure above and divide the center frequency of that passband by the passband's bandwidth.

The relative reference function can be used for very rapid signal tracing. For a 3-stage amplifier, for instance, connect the DMM across the first-stage input and feed the signal from an audio generator into that input. Set whatever level you want as 0 dB and use the dB and relative reference functions on the meter to store that as a reference. Now, move the meter to the output of that stage to see what the gain is. Do the same for the remaining stages. That one test should be invaluable for checking things like the 3-4 stage direct-coupled video and audio amplifiers, as well as many other types. Any defective stage can be found easily and quickly using that technique.

The meter can also be used to quickly find the frequency response of any amplifier, record player, tape deck, or the like. Let's see how that is done for a tape deck as an example. First of all, set the DMM to read AC voltage on the 200-mV range and connect it to the output of the deck. Now, play a frequency-test tape on the deck and set the relative reference function for some convenient value, say 1000 Hz, or whatever other value you wish. Now play the whole tape through and log the response to each frequency. The frequency "cuts" on the tape should play long enough for you to get a reading. The frequency response of the main amplifier can also be checked; just connect the

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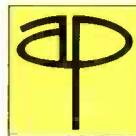
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meter across the output and be sure that the output is terminated into its rated load. Then, set the meter to a suitable range and play the frequency-test tape. Tests for stereo balance, head alignment, and many more things can be performed using that setup.

The instruction manual is very elaborate. Each function is described, and you're told how to set it up, as well as what it will do. It describes quite a few of the specialized tests that can be done using the meter, and a complete explanation of exactly how the instrument works is provided. Also provided are a parts list, schematics, a troubleshooting guide, and layout illustrations showing the location of all calibration adjustments, test points, etc. Finally, there's a list of the many accessory probes available for use with the DMM. Those include an RF probe that's used to extend the frequency range to 100 MHz, an HV probe, temperature probes, a clamp-on AC-current transformer, a current shunt, and a high-frequency probe for frequencies up to 500 MHz.

We've covered only a few of the things that the instrument can do and we're sure that you'll find quite a few more as you use it. The model 8060A is an extremely versatile piece of test equipment, and one that should be well worth its suggested list price of \$349.00. R-E

(where each head can affect the other magnetically). That head arrangement allows you to monitor your recording by listening to the signal that's actually on the tape, rather than the signal that's going to be on the tape. The record and playback heads are independently suspended and are separated by an air space of about 1.2 mm so that crosstalk is nil; there is a minimum of magnetic-flux leakage. The heads are mounted on one block, and each can be separately adjusted for precise azimuth alignment. The heads are made of both Sendust and Ferrite so that they can take advantage of metal tapes (which provide a wider dynamic range than do conventional tapes).

To reduce wow and flutter, the TC-K555 uses two sets of capstans and pinch rollers that ensure uniform tape tension and stable tape-to-head contact. For the same reason, the capstans are driven by linear-torque motors. Wow and flutter of 0.04 percent wrms indicates the success of those measures to attain stability in the tape-transport system.

The TC-K555 boasts some other impressive specifications. Total harmonic distortion is 0.8 percent when using high-performance tapes. (Although, as noted, the K555 will handle normal tapes, chances are that most audio enthusiasts will use high-performance tapes to get the best performance from the deck.)



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## Sony TC-K555 Stereo Cassette Deck



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IF YOU ARE AN AUDIO ENTHUSIAST LOOKING for a modestly priced, state-of-the-art stereo cassette deck, one unit you should consider is the TC-K555 from the Sony Corporation (Sony Drive, Park Ridge, NJ 07656).

That deck, which is priced at \$420.00, is packed with many features that a few years ago were seen only on much more expensive units.

Sony used a three-head design rather than using a two-head, sandwich design



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For normal tapes, the signal-to-noise ratios are 56 dB with Dolby off, 63 dB with Dolby-B, and 69 dB with Dolby-C. For chromium-oxide tapes, the S/N ratio is 57 dB with Dolby off, 64 dB with Dolby-B, and 70 dB with Dolby-C. Ferro-chromium tapes display markedly better performance characteristics and the system is able to make use of them, with a S/N ratio of 61 dB with Dolby off, 68 dB with Dolby-B, and 74 dB with Dolby-C. In fact, FeCr tapes outperform metal tapes (in terms of the signal-to-noise ratio), whose figures are 60 dB with Dolby off, 67 dB with Dolby-B, and 73 dB with Dolby-C.

The frequency response figures of the TC-K555 are also impressive. With Dolby off, the figures are: 20 to 18,000 Hz with normal tapes and chromium oxide tapes, and 20 to 19,000 Hz for ferro-chromium and metal tapes. However, there are other things besides the specifications that make the Sony TC-K555 an impressive stereo cassette deck. They are the many "human engineered" features that are included.

#### Features

The tape counter, usually taken for granted on cassette decks, is one feature that deserves close examination. That's because it's not simply a counter that counts arbitrary units (which seem to be different on every cassette deck) to indi-

cate elapsed "time." Instead, it's a real-time counter. It provides you with a meaningful way to index your taped selections, and it can even tell you how much time is left on a cassette that you're recording. Let's take a closer look at how that feature is used.

One thing that you can use the counter for is simply to determine how much time is available on one side of a cassette. First you insert the tape and when you are at the beginning of it you press the COUNTER RESET button. That, as you might expect, sets the counter to zero. Next, fast-forward the tape to the end and the counter will show you the approximate available recording time. Using a slightly different procedure you can also use the counter to determine the time remaining on one side of a cassette.

Perhaps the most useful way to use the counter is to monitor the remaining recording time while you are recording. As before, you insert the tape, and fast-forward it to the end. Then you reset the counter and rewind the tape. The display will show how much time is available. As you record, the digits will decrease to zero. (Actually they increase to zero—the counter display shows a minus sign to indicate that it is in that mode.)

We should point out that the counter is not a digital clock. The time that it displays is approximate, and it will vary depending on the type of tape that you

use. For best accuracy, you should use a C-60 tape. (That is what the counter is calibrated for.) Even so, the real-time tape counter is a definite improvement over the standard arbitrary counter. It's an improvement over many other real-time counters, too. It will show the tape time continuously and does not need to be adjusted when you change modes or tapes.

There is yet another feature that makes the TC-K555 easy to use: auto play and memory play/stop. If you have a tape that has to be rewound before you can listen to it, you no longer have to sit by the deck so you can press PLAY after it finally rewinds. All you need to do is press REWIND and PLAY at the same time. When the tape is completely rewound, it will play automatically. You can also use that feature along with the MEMORY mode to start the tape (after rewinding) from any point on the tape.

The dual-meter VU display also deserves some attention. The display uses two rows of LED's to indicate the recording level. The saturation level (the highest recording-level setting that will not result in distortion) is also indicated on the meter. That saturation level is different for different types of tapes, and the TC-K555 takes that into account. A row of red LED's indicates the range where saturation occurs depending on which TAPE button is pressed. (There is a choice of four, for normal, CrO<sub>2</sub>, FeCr, and metal



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tapes.) You set the recording level by making sure that the meters deflect only to the lower edge of that line.

Setting the proper level is made easy because when the MONITOR switch is set to SOURCE, the VU meters show the peak input levels, and display them for four seconds. (A higher input will be immediately indicated and held for four seconds.)

The TC-K555 includes Dolby B and Dolby C noise-reduction systems. (Dolby C, a recent development, is more effective than Dolby B. It begins to take effect at lower frequencies, and it reduces noise by 20 dB at 5 kHz as compared to 10 dB at 5 kHz for Dolby B.)

Previously, we mentioned the saturation level of a tape (the level above which a recording will be distorted). At high frequencies, a tape will saturate more easily than at low frequencies. However, to reduce that problem, the Dolby C system includes a high-frequency anti-saturation network. That network reduces the level of high-frequency signals when you record. When you play back the recording, the system boosts them back to their original level.

Among the other features on the TC-K555 is an MPX (multiplex) filter. That filter is used for recording FM stereo broadcasts from stations that are equipped with Dolby noise-reduction systems. The filter suppresses the 19-kHz

pilot signal and 38-kHz subcarrier (if they have not been adequately suppressed by the tuner). If the tuner does suppress those signals adequately, then you can record with the filter switched off.

The TC-K555 also has the usual tape-selection and bias controls found on just about all component-stereo recorders. The bias is set by pressing one of the four TAPE buttons (for normal, chromium dioxide, ferro-chromium, and metal tapes). When you are using normal tapes, you can also use the BIAS control to regulate the bias current by  $\pm 20\%$ . When bias is increased, it suppresses extremely high frequencies. High frequencies are boosted when bias is decreased.

The deck includes a timer switch, so it can be used with an external timer to record or play back at a predetermined time. A headphone jack is also included. The headphone output has its own volume control. That's a nice bit of "human engineering."

Yet another interesting function is the RECORD MUTING button. Pressing that button either inserts a blank space during a recording or eliminates unwanted material from a finished tape. It's an aid to editing. The TC-K555 has a fast-forward and rewind time of 90 seconds for a C-60 cassette.

The owner's manual for this cassette deck is good, and is aimed at the nontechnical user. It features ample pictorial

guides to help the user get started and explains some of the theory behind the various controls and features. However, it is very basic and will require the user to experiment for himself if he is to gain the fullest advantage from the recorder. R-E

### MFJ Model 959 Shortwave Receiver Antenna Tuner



CIRCLE 105 ON FREE INFORMATION CARD

MFJ	Model MFJ-959										
OVERALL PRICE	[Red bar]										
EASE OF USE	[Red bar]										
INSTRUCTION MANUAL	[Red bar]										
PRICE/VALUE	[Red bar]										
	1	2	3	4	5	6	7	8	9	10	
	Poor			Fair				Good		Excellent	

THE MOST IMPORTANT PART OF ANY radio setup—whether receiving or transmitting—is the antenna system. Of course it helps to have a good receiver or

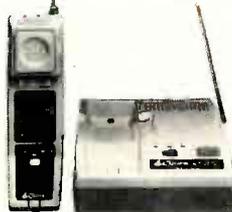
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# RCA Receiving Tubes

RCA Distributor and Special Products Division, Deptford, NJ 08096

transmitter, but without a good antenna, excellent equipment can be useless.

One trouble with tuned antennas is that their performance is good only at the narrow frequency range for which the antenna was designed. While that problem is not as critical with a shortwave receiver as it is with a transmitter, it is a problem nevertheless.

The solution to that problem, used by radio amateurs for many years, is a tuned matching circuit that presents the correct load impedance to the radio. Granted, an antenna matching circuit will not make your antenna better—it will only allow the radio to see a correct load—but it will allow the receiver to make the best use it

can of the off-resonance antenna. While transmitting tuners have been around for years, there have been few matching devices for shortwave receivers until the introduction of the MFJ model 959 receiver antenna tuner and preamp.

The MFJ-959 is made by MFJ Enterprises, Inc., (P.O. Box 494, Mississippi State, MS 39762) and is 9¼ × 6 × 2¾ inches and weighs about one pound. All the circuitry is contained in a 5 × 3 inch circuit-board. The tuner is powered by 9- to 18-volts DC that is supplied, through a subminiature jack on the back of the tuner, from a wall transformer that is included with the unit.

The unit is designed to allow the max-

imum possible signal transfer by presenting the proper match to the receiver. The tuner/preamp is broadband—designed to operate from 1.8 to 30 MHz. It has three built-in functions. Not only will it act as a straight impedance-matching network (a variation of a T-network) but it will also act as a signal attenuator and as a pre-amplifier. Those functions are controlled by a four-position, single-pole switch on the front of the tuner (the other position is OFF/BYPASS). Let's now look at the functions in greater detail.

When the switch is in the TUNER position, the signal is received at the antenna-input connector (either an SO-239 or RCA-type connector) and is then passed directly to the matching network which contains 10 inductances ranging from 0.47 μH to 47 μH. The inductors are selected by a single-pole, 10-position rotary switch. Capacitance is then added by using two 320-pF variable tuning capacitors. One is on the receiver side of the circuit, while the other is on the antenna side (those are labeled RECEIVER and ANTENNA on the front panel). Those controls are adjusted for maximum deflection on the receiver's signal meter or for maximum noise from the receiver if it has no S-meter.

When the function switch is in the TUNER-ATTENUATOR setting, an attenuation pad is placed in series with the antenna. That introduces enough resistance into the circuit to produce 20 dB of signal attenuation. That is especially useful if the receiver is being overloaded by nearby broadcast stations, amateur transmitters or CB radios. Indeed, that feature works well. It will null out almost all but the strongest signals.

In the TUNER-AMP mode, a common-collector amplifier circuit is switched in series with the antenna, and weak signals are easier to copy. That helps, especially if the sensitivity and selectivity of the receiver itself falls short. The circuit, built around a 2N3904 transistor, can provide as much as 12 to 24 dB of gain to the receiver. It is that increase in gain which also helps, seemingly, to improve the sensitivity and selectivity of the radio. It works well enough to pull in barely-readable weak signals out of the noise and make them readable. However, one drawback is that that feature will also increase the noise level of the receiver. So, it is a trade-off, but in many cases a good one.

One interesting and convenient feature of this tuner is the inclusion of the two types of antenna connectors. That makes it easy to use antennas with either RCA-type or SO-239 connectors. There is a bypass setting for those times when you are using the antenna for the frequency range for which it was cut. There is also a provision for tying a second receiver into the circuit. That is convenient for the avid

*continued on page 100*

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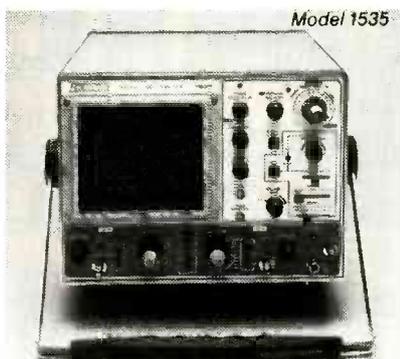
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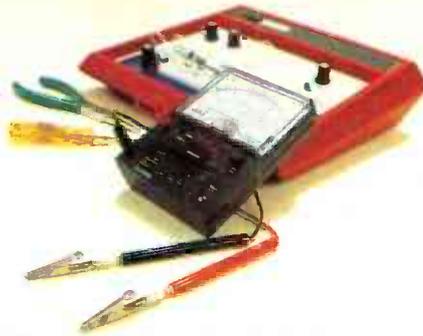
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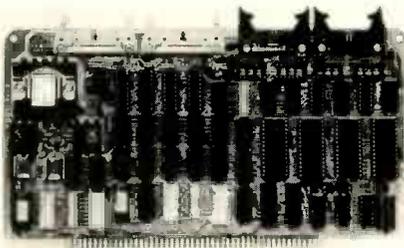
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RE-60

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*continued on page 44*

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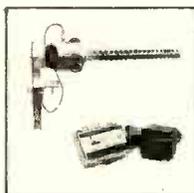
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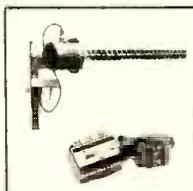
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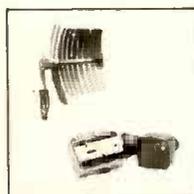
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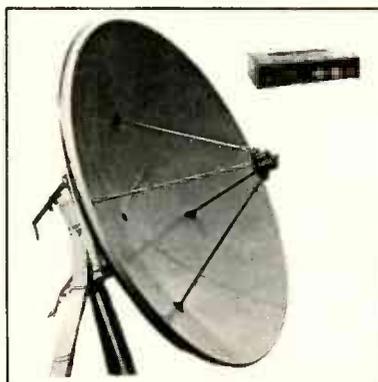
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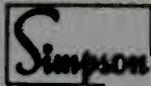
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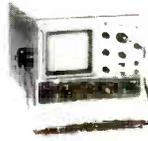
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**BK PRECISION** 10 MHz SCOPES



1466 SINGLE TRACE



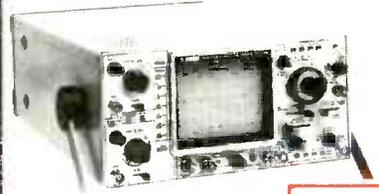
1476 DUAL TRACE

CALL FOR OUR PRICES

- Triggered and automatic sweep
- 18 calibrated sweeps
- On 1476 mode automatically shifts between CHOP and ALTERNATE
- Bright P31 blue phosphor
- Front panel X-Y operation using matched vertical amps
- Video sync separators
- Check most digital logic circuitry

PRICE DOES NOT INCLUDE PROBES

**BK PRECISION** 70 MHz. Dual Time BASE SCOPE



MODEL 1570

CALL FOR OUR PRICE

- 1 mV/division sensitivity to 70 MHz
- 500  $\mu$ V/division cascade sensitivity
- Four-input operation provides trigger view on 4 separate inputs.
- Alternate time base operation
- Switching power supply delivers best efficiency and regulation at lowest weight

**BK PRECISION** 100MHz Dual Time BASE SCOPE



MODEL 1590

**\$1,595.<sup>00</sup>**

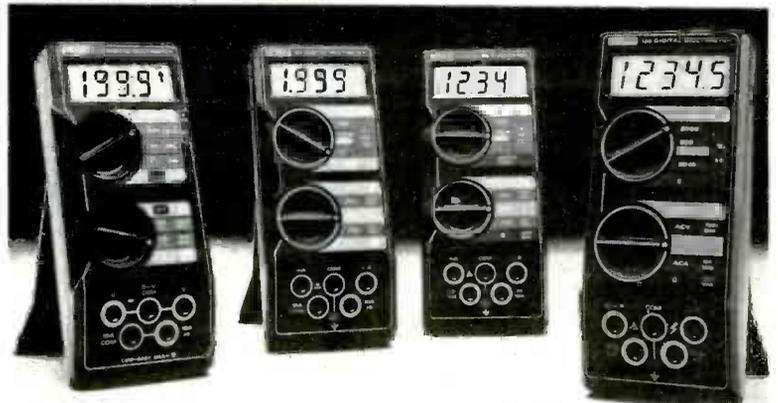
While quantities last

- 1mV/division sensitivity to 100MHz
- 500 $\mu$  V/division cascade sensitivity
- 2ns/division sweep rate with 10x magnifier
- Four-input operation provides trigger views or four separate inputs
- Selectable 1M $\Omega$  or 50 $\Omega$  inputs
- Alternate timebase operation
- 20MHz bandwidth limiter for best view of low frequency signals
- Lighted function pushbuttons employing electronic switching with non-volatile RAM memory
- Switching power supply delivers best efficiency and regulation at lowest weight
- Selectable frequencies for chop operation

PRICE DOES NOT INCLUDE PROBES

KEITHLEY

DIGITAL MULTIMETERS



**Model 128:** Beeper DMM designed to meet the tough specifications of a major computer manufacturer. See/hear display includes over/under arrow and on/off beeper.

**Model 131:** 0.25% accuracy added to the easiest to use handheld DMM. Color-coded front panels for maximum clarity, minimum confusion.

**Model 130:** Keithley user research led to unique DMM designs. Easy to read LCDs, largest DMM displays on the market.

**Model 135:** First 4 $\frac{1}{2}$ -digit handheld DMM, ideal for analytical/bio-medical service. 10A range standard on all Keithley handhelds.

Model 128: **\$139.00**

Model 130: **\$124.00**

Model 131: **\$139.00**

Model 135: **\$235.00**

ORDERING INFORMATION

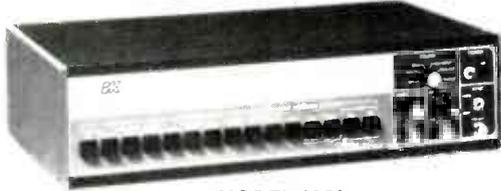
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**BK PRECISION**

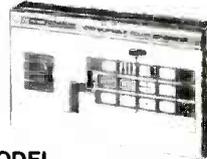
**COLOR BAR GENERATORS**



MODEL 1250

Professional studio quality generator. Ultra stable. Ideal for VTR work.

- Generates NTSC color bars with or without—IWQ signal
- Generates 5 step linear staircase; staircase with high or low chroma
- External video input—modulates fr or i-f carrier outputs



MODEL 1210

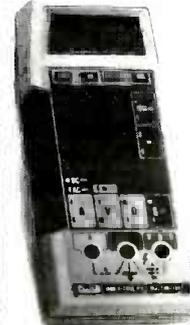
- Generates 10 stable patterns including crosshatch, 7x11 dot, gated rainbow and purity.
- Compact for convenient field service use

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**FLUKE**

**4½ DIGIT MULTIMETERS**

MODEL 8060A



- Frequency measurements to 200KHz
- dB measurements
- Basic dc accuracy 0.04%; 10 μV, 10 nA and 10 mΩ sensitivity.
- Relative measurements
- True RMS
- High-speed Beeper

**\$349<sup>00</sup>**

- Continuity and relative reference functions identical to 8060A.

MODEL 8062A

- True RMS measurements to 30 kHz.
- Basic dc accuracy 0.05%; 10 μV, 10 nA and 10 mΩ sensitivity.
- Beeper



**\$279<sup>00</sup>**

**BK PRECISION**

**INDUSTRIAL TRANSISTOR TESTER**



**\$189<sup>95</sup>**  
was \$239

MODEL 520B

- Now with HI/LO Drive
- Works in-circuit when others won't
- Identifies all three transistor leads
- Random lead connection
- Audibly and visually indicates GOOD transistor

**BK PRECISION**

**POWER SUPPLIES**



**\$279<sup>00</sup>**  
was \$354.

- Isolated 0-50VDC, continuously variable; 0-2A in four ranges
- Fully automatic shutdown, adjustable current limit
- Perfect for solid state servicing



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MODEL 1650

- Functions as three separate supplies
- Exclusive tracking circuit
- Fixed output 5VDC, 5A
- Two 0 to 25VDC outputs at 0.5A
- Fully automatic, current-limited overload protection

**BK PRECISION**

**FUNCTION GENERATORS**



MODEL 3010

- Sine, square and triangle output
- Variable and fixed TTL outputs
- 0.1 Hz to 1MHz in six ranges
- Push button range and function selection
- Typical sine wave distortion under 0.5% from 1 Hz to 100kHz

MODEL 3010 **\$179<sup>95</sup>**  
was \$220.

MODEL 3020 **\$299<sup>95</sup>**  
was \$379.

**SWEEP FUNCTION MODEL 3020**

- Four instruments in one package—sweep generator, function generator, pulse generator, tone-burst generator
- Covers 0.02Hz-2MHz
- 1000:1 tuning range
- Low-distortion high-accuracy outputs

**BK PRECISION**

**CAPACITANCE METERS**



MODEL 830

- Automatically measures capacitance from 0.1pF to 200mF
- 0.1pF resolution
- 0.2% basic accuracy
- 3½ digit LCD display

**\$179<sup>95</sup>**  
was \$229.

**\$149<sup>95</sup>**  
was \$185.



MODEL 820

- Resolves to 0.1pF
- 4 digit easy-to-read LED display
- Fuse protected against charged capacitors
- Overrange indication

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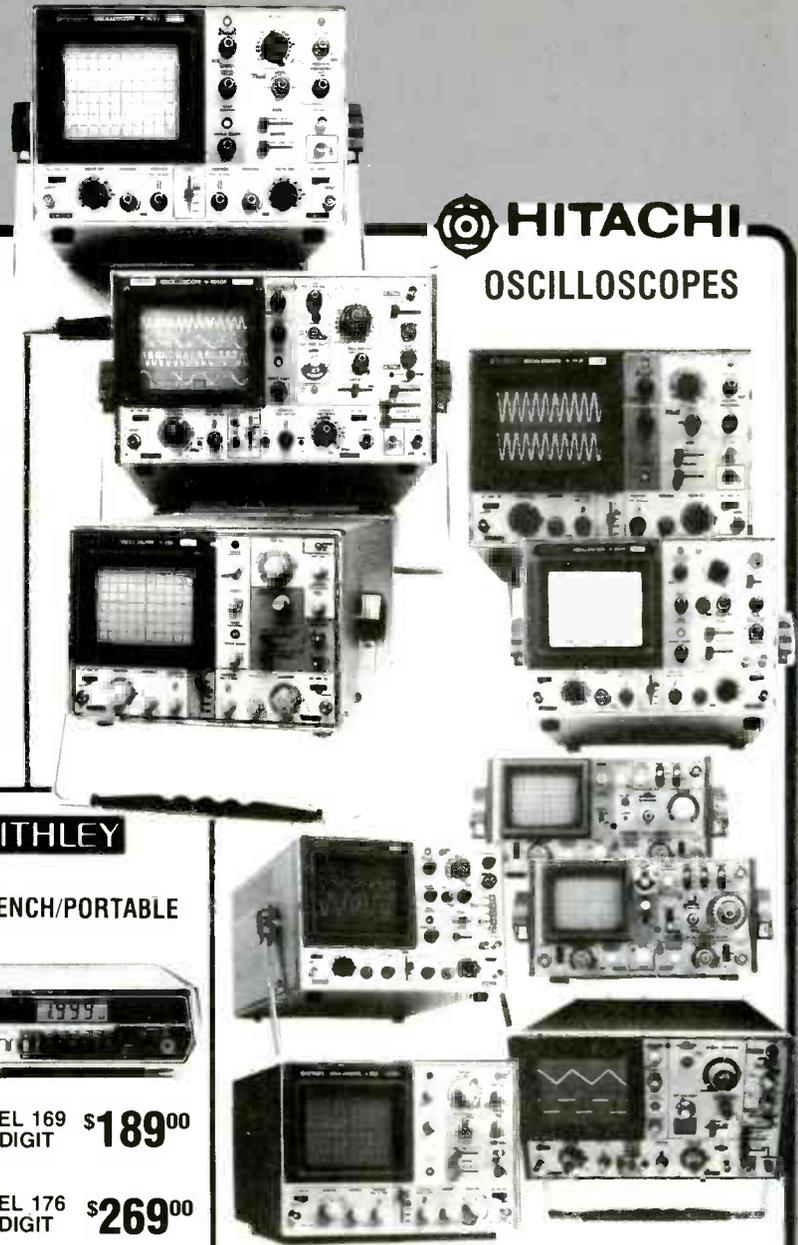
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## FLUKE

### DIGITAL MULTIMETER



**\$389<sup>00</sup>**

MODEL  
8050A

8050A-01  
RECHARGEABLE  
\$439<sup>00</sup>

- 4½ Digits
- 50 KHz frequency response
- 10 µV resolution
- .03% accuracy
- True RMS ■ dB
- measurements and memory relative

### Simpson DIGITAL MULTIMETER



MODEL 467

**\$239<sup>95</sup>**

Reg. \$279<sup>00</sup>

- True RMS
- Analog display
- Peak hold

### BK PRECISION PORTABLE TRANSISTOR TESTER



CALL FOR OUR  
PRICES

- Fast GO/NO-GO in-circuit transistor testing
- Fast and thorough GOOD/BAD out-of-circuit testing

### KEITHLEY BENCH/PORTABLE



MODEL 169 **\$189<sup>00</sup>**  
3½ DIGIT

MODEL 176 **\$269<sup>00</sup>**  
4½ DIGIT

## FLUKE HANDHELD DIGITAL MULTIMETER



MODEL  
8022B

MODEL  
8020B

MODEL  
8024B

**8022B THE TROUBLESHOOTER** ■ 6 functions ■ 0.25% basic dc accuracy ■ Overload protection

**8020B THE ANALYST** ■ 7 functions ■ 0.1% basic dc accuracy ■ LCD display ■ Safety design test leads.

**8024B THE INVESTIGATOR** ■ 9 functions ■ 0.1% basic dc accuracy ■ Peak hold on voltage and current functions ■ Selectable audible indicator for continuity or level detection.

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V134	10 MHz	Dual Trace	Storage
V202	20 MHz	Dual Trace	
V203	20 MHz	Dual Trace	w/delay sweep
V209	20 MHz	Dual Trace	Portable
V352	35 MHz	Dual Trace	w/delay line
V353	35 MHz	Dual Trace	w/delay sweep
V509	50 MHz	Dual Trace	Portable
			w/delay sweep
V650	60 MHz	Dual Trace	w/delay sweep
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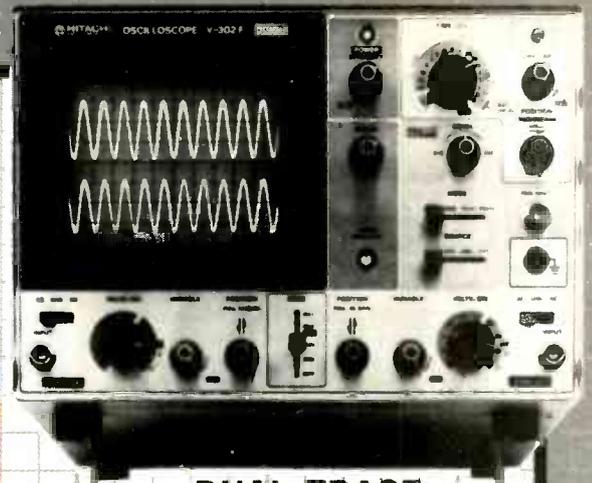


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# HITACHI

# 30 MHz SCOPE AT 15 MHz PRICE

# \$549.95



**DUAL TRACE  
W/DELAY**

**QUANTITIES ARE LIMITED**

## V-302F 30MHz

### SPECIFICATIONS

Vertical Deflection Sensitivity	5mV/div to 5V/div $\pm 5\%$ , 10 calibrated steps 1mV/div to 1V/div $\pm 6\%$ (When using x5 amplifier) (Uncalibrated continuous control between steps 1 - 2.5 (provide with click-positioning function))									
Bandwidth	DC to 30MHz, $-3dB$ (at 4 div) DC to 7MHz, $-3dB$ (at 4 div) (When using x5 amplifier)									
Rise Time	12ns (for x5) 70ns typ									
Signal Delay Line	Permits viewing leading edge of displayed waveform									
Max. Input Voltage	600Vp-p or 300V (DC + AC peak, at 1kHz)									
Input Coupling	AC, GND/DC									
Input Impedance	Direct 1M ohm, approx. 30pF									
Operating Modes	CH1, CH2, DUAL, ADD, DIFF									
X-Y Operation	CH1: X axis, CH2: Y axis									
Sensitivity	5mV/div to 5V/div (when using x5 amplifier): 1mV/div									
Horizontal Deflection	AUTO, NORM, TV (+), TV (-) CH1, CH2, LINE, EXT									
Trigger Modes	AC									
Trigger Source	TV sync-separation circuit									
Trigger Coupling	1 div or more (V sync-signal)									
TV Sync	1Vp-p or more (V sync-signal)									
Internal										
External										
Trigger Sensitivity	<table border="1"> <thead> <tr> <th>Frequency</th> <th>Internal</th> <th>External</th> </tr> </thead> <tbody> <tr> <td>20Hz to 5MHz</td> <td>0.5div</td> <td>200mV</td> </tr> <tr> <td>5 to 30MHz</td> <td>1.5div</td> <td>600mV</td> </tr> </tbody> </table>	Frequency	Internal	External	20Hz to 5MHz	0.5div	200mV	5 to 30MHz	1.5div	600mV
Frequency	Internal	External								
20Hz to 5MHz	0.5div	200mV								
5 to 30MHz	1.5div	600mV								
AUTO Low Bandwidth	30Hz									
Trigger Slope										
External Trigger Input	Input impedance: approx. 1M ohm, 30pF or less Max. input voltage: 100V (DC + AC peak at 1kHz)									
Sweep Time	0.2 $\mu$ s/div to 6.2s/div $\pm 5\%$ 19 calibrated steps Uncalibrated continuous control between steps 1 - 2.5 (provided with click-positioning function)									
Sweep Time Magnifier	10 times ( $\pm 7\%$ )									
Max. Sweep Time	100ns/div, 120ns/div and 50ns/div, not calibrated									
Power Requirements	100/120/220/240V $\pm 10\%$ 50 to 60Hz, approx. 40W									
Dimensions	Approx. 275(W) x 190(H) x 400(D) mm									
Weight	Approx. 8.5kg									

### FEATURES

- 1mV/div high sensitivity design. Effective for measurement of weak signals.
- Employs TV sync separator circuitry with one touch synchronization of both TV horizontal and vertical signals.
- Built-in signal delay line enables front observation of fast rising waves.
- X-Y operation convenient for measurement of phase difference between two signals.
- Delayed sweep function with one touch control 10X magnification.
- Trace rotation system for easily adjusting trace inclination caused by terrestrial magnetism.
- Fine adjusting click positioning function enhances measuring efficiency.
- Signal output: CH1 output terminal to Frequency Counter, etc.
- Z axis input provided - possible to use as CRT display.
- One touch shifting of waveform slopes for easy observation of rise and fall of waves.

Price does not include probes.  
Probes \$50. a pair when purchased with scope. \$10. shipping within continental U.S.

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**NEW PRODUCTS**

*continued from page 38*

countered, a non-rhythmic interrupted beeping is sounded. When radar signals of sufficient strength are encountered, a steady-alarm signal of two beeps per second is sounded, thus providing a "reminder" to drivers to stay within the speed limits.

The *Radar Intercept*, model *IN* has a suggested retail price of \$299.95.—**Leisure Time Development Corporation**, 1931 Mott Avenue, Far Rockaway, NY 11691.

**CONTROL CENTER**, *Mr. Video Master Control Center* provides six video inputs and three outputs, which will accommodate two



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sets and a VCR input and output. A 13-pushbutton control panel provides complete and convenient video-system selection.

The *Mr. Video Master Control Center* is priced at \$49.95.—**Jascon Products Co., Inc.**, 217 NE 46th, Oklahoma City, OK 73101.

**PANEL METER**, model 555, is a micro-processor-based instrument offering many display, measuring, and monitoring features. This software-programmable bargraph meter provides up to  $\pm 0.2\%$  digital accuracy with an analog display for process control, medical electronics, relay meter, quality control, and machine-tool and test-equipment applications.

Standard ranges are 0-50 mV, 0-1 mA and 4-20 mA with a dual channel (two separate inputs and outputs) standard-display mode. Other internal ranges are available from 50 millivolts to 200 volts, and 500 microamps to 100 millamps. The model 555 can be converted to single channel simply by removing a jumper wire, thus permitting the second channel to operate as an expanded scale for improved resolution, or for visual storage and display of set points.



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Multiple (DIP switch selectable) readout provides 32 possible outputs on the 50-bar LED display. Displays include: negative full scale, positive full scale, suppressed zero for transducer interface, and zero center. Different displays may be shown on each channel of a dual channel if desired. Readout modes are also selectable and include 45 or 160-millisecond update, standard meter, or single/dual setpoint control.

The model 555 is priced at \$199.00.—**Triplet Corp.**, One Triplet Drive, Bluffton, OH 45817.

**TRANSCEIVER**, model *TS-430S*, is an all solid-state SSB, CW, and AM transceiver, with FM optional. It is designed to cover the 160-10 meter amateur bands, including the new WARC bands, and also incorporates a 150kHz-30 MHz general-coverage receiver that has an exceptionally wide dynamic range.

Other features include dual digital VFO's, eight memories, memory scan, program-

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*View of wire at end of bit being wrapped on post.*

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Introducing the new GR-3000...the first information center, telephone, terminal, video bulletin board, modem and micro-computer interface... all part of the most future-thinking color television available for tomorrow, today.



Battery back-up preserves important data. And an Exclusion Password will protect preset picture fidelity parameters.

### More to come.

New modules are arriving soon, to bring you further into the teleconsumer age:

#### Directory Dialer and Modem Interface.

GR-3000 will become a two-way speaker phone with memory, auto-dial and modem capabilities.

Serial Interface will instantly access outside computer services and information, plus provide RS-232/C

The GR-3000 Television Computer System is the only receiver designed to bring you all the unlimited information plus entertainment in this spectacular new era of multi-source televiewing.

### An exclusive new microprocessor-based "telex" receiver.

The GR-3000 is an expandable kit with plug-in capacity for eight microprocessor controlled modules. The basic modules are here now. In coming months, you can add new



internal components to be ready for more advanced data retrieval, telephonic networking, and other growing life-service technologies.

But even now, with standard chassis, GR-3000 is television as you've never seen it before. Why?

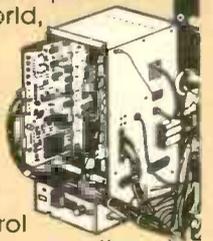
A multi-level screen display delivers your choice of 4 test patterns, super-steady Monitor

Mode, and the Message Center with 16 combinational text and backdrop colors. The broadcast screen offers direct audio and video i/o, an ultra-clear picture with channel, time and date overlay. Six screens of 'help' hints make the system user-friendly.

Infrared telemetry Remote Control. This 56-key pad can access almost every programmable feature under microcommand, including all adjustments for picture correction. And the imagination-stretching Learn Mode function, for infinitely versatile sequenced operation. Type in personal messages on your GR-3000 and the real-time calendar clock displays them whenever you want.

interface with any compatible computer in the world, and work as a superb color graphics terminal.

The Programmer will add greater memory for programming TV functions and control protocol for remote computing.



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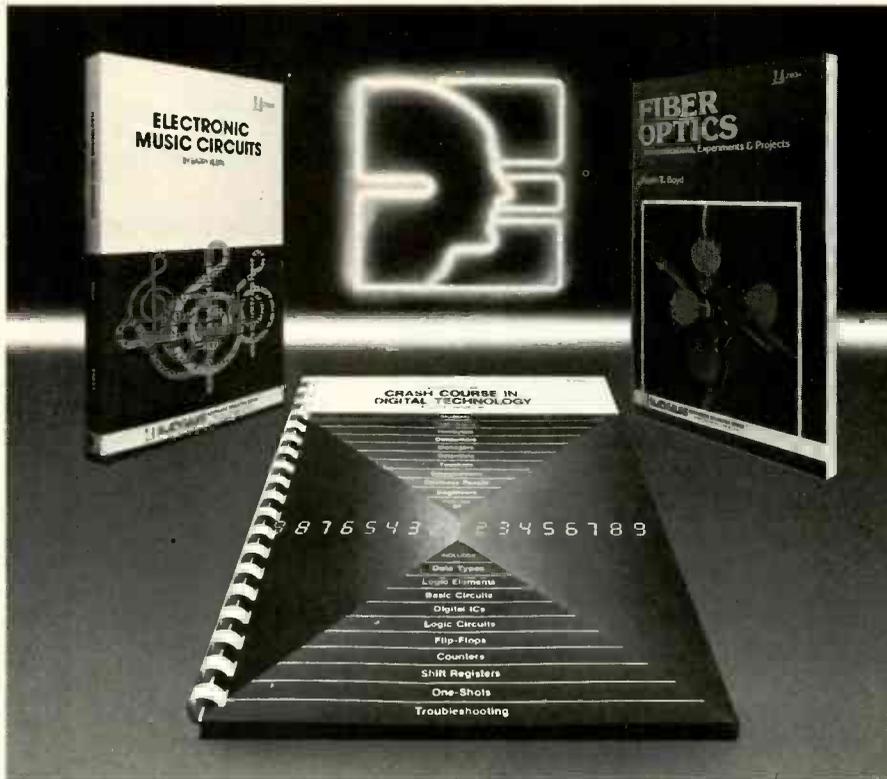
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mable band scan, fluorescent-tube digital display, and all-mode squelch. There is also VOX, a speech processor, IF shift, notch fil-



CIRCLE 145 ON FREE INFORMATION CARD

ter, and a NARROW-WIDE filter-selector switch for use with various optional filters.

The suggested retail price of the model TS-430S is \$899.95. — **Trio-Kenwood Communications, Inc.**, 1111 West Walnut Street, Compton, CA 90220.

**SURGE PROTECTORS**, the *Transi-Traps*, are the first devices available in the electronics market that are designed with an "isolated ground" that keeps damaging arc-energy off the chassis of communications equipment and routes it directly to ground.

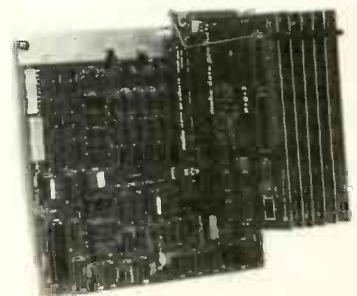


CIRCLE 146 ON FREE INFORMATION CARD

The *Transi-Trap* protector features a replaceable Arc-Plug cartridge that uses a special gas-filled ceramic tube that safely bypasses surges to ground and will fire thousands of times before requiring replacement. The *Transi-Trap* is connected in line between the receiver or transceiver and amplifier, or between the amplifier and the antenna. Configurations are available to accommodate UHF-type and N-type conductors, 200-watt and 2-kilowatt outputs, and in super low-loss models (0.1 dB at 500 MHz) for use through VHF and UHF.

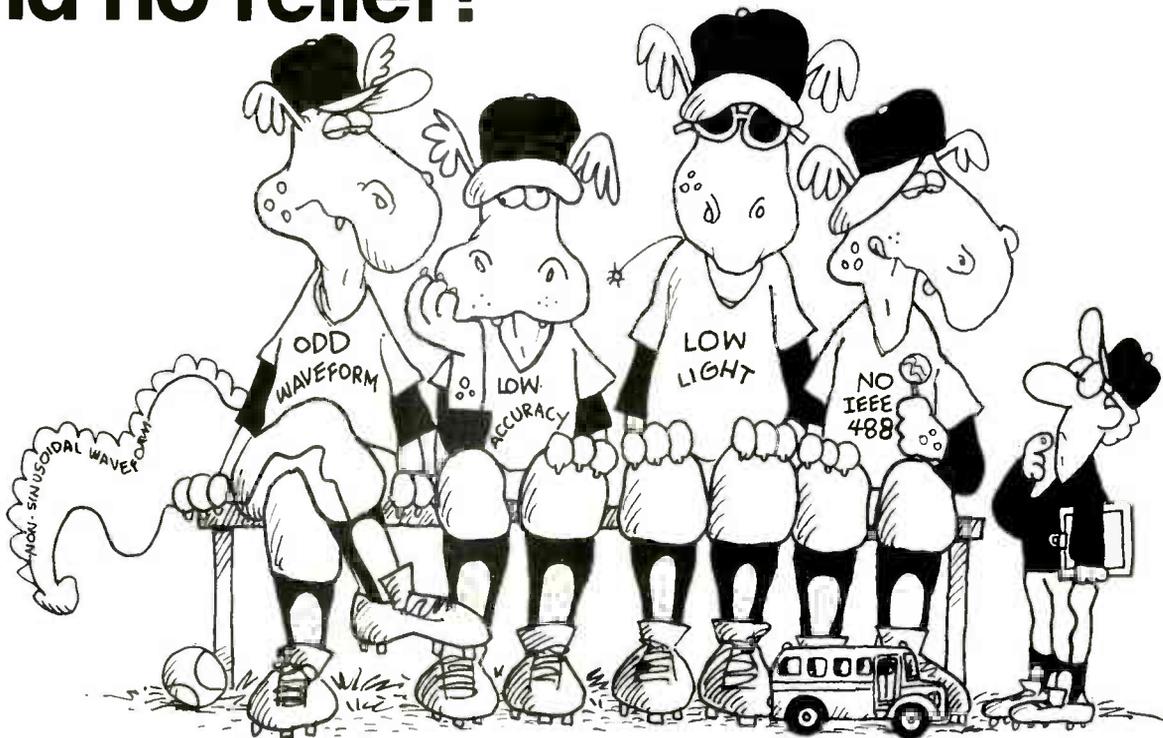
The *Transi-Trap* units range in price from \$19.95 to \$44.95. — **Alpha Delta Communications**, PO Box 571, Centerville, OH 45459.

**EXPANDER**, model *MH89 Plus 3*, is a bus expander for Heath/Zenith model *H89/Z90* computers. This accessory exactly doubles



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Send in old reliable Keithley 179A. It could help you save the game. Get the high-performance accuracy you need today, and field-installable IEEE-488 compatibility you'll need soon. Our oversized LED is easier to read. And non-sinusoidal waveforms won't throw you a curve with our TRMS. Here's your workhorse Portable/Bench DMM at a price that won't strike out your budget. Keithley DMMs and Thermometers. **The Dragon Slayers.**

# KEITHLEY

#### 179A Features

- Five full functions
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  - 20A capability
  - 0.04% DCV accuracy
  - HI-LO  $\Omega$
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  - Field-installable IEEE-488 Interface
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Write Tom Hayden for your free, frameable 9 x 12" dragon poster. Keithley Instruments, Inc., 28775 Aurora Road, Cleveland, Ohio 44139. Phone 216-248-0400. Telex: 98-5469.

CIRCLE 22 ON FREE INFORMATION CARD

[www.americanradiohistory.com](http://www.americanradiohistory.com)

the I/O expansion capabilities of those machines, while keeping them all-in-one. The model *MH89 Plus 3* replaces the right-hand accessory area with a 6-slot mother board, creating 3 additional slots. That provides ample room for the many accessory and peripheral cards offered for those machines, without the need of external boxes or cables.

The design of the model *MH89 Plus 3* allows it to be installed in minutes, without soldering or cutting traces. In use, it is invisible to the user and requires no programming or system modification. The added slots occupy previously unused port addresses. Devices to be run off those slots should have their software configured for the new port number.

The model *MH89 Plus 3* keeps all accessory boards on the right side of the machine. It does not interfere with the left side memory-expansion area. All accessory cards remain vertical for best cooling.

The model *MH89 Plus 3* is priced at \$150.00 plus a \$5 shipping charge, comes with full documentation, and has a one-year warranty (CA residents add 6% tax). — **Mako Data Products**, 1441-#B N. Red Gum, Anaheim, CA 92806.

**RECEIVER**, model *R-2000*, is an all-mode communications receiver that covers 150kHz-30MHz in 30 bands. Designed to fill the needs of the short-wave listener as well as the radio amateur, this new radio is capable of receiving signals on AM, USB, LSB, CW, and FM.

The model *R-2000* has digital VFO's, 10 memories that store frequency, band, and mode data, memory scan, programmable

band scan, and dual 24-hour quartz clocks with a timer that can be programmed to turn the radio on and off on a pre-selected schedule. Additional features include a built-in lithium-battery memory back-up (estimated

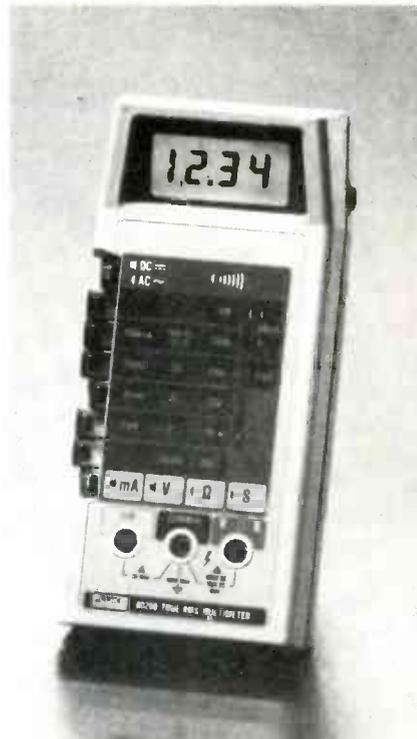


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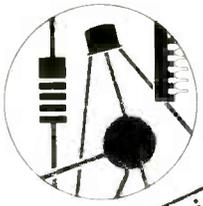
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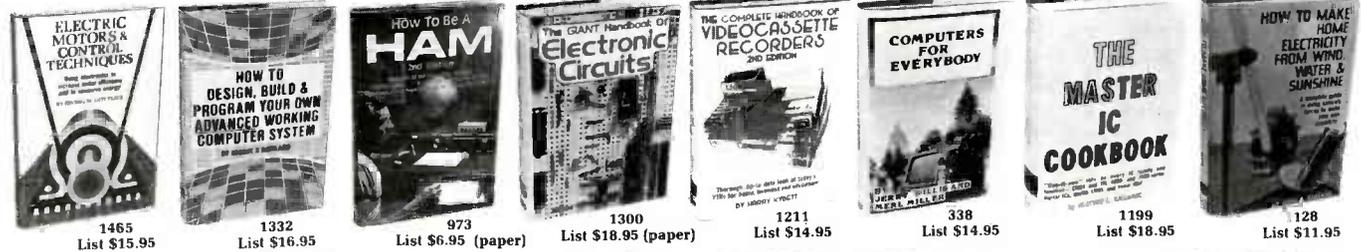
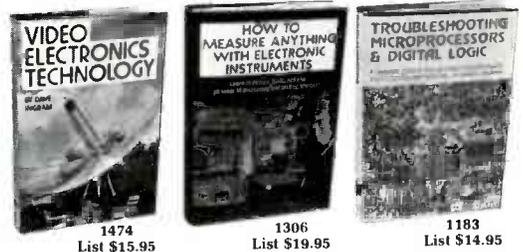


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# COMPUTER CORNER

## Selecting a terminal

LES SPINDLE\*

MANY PEOPLE PURCHASE THEIR FIRST microcomputer system as a complete package that includes the computer, video display, printer, and software. There are those, however, who will want to buy the components separately. In doing so, they can put together a system tailored to their specific requirements.

Last month, we discussed the options available when purchasing a printer for your computer system. This month, we will explore data terminals.

A terminal consists of two main parts: the keyboard and the display screen. The terminal accepts data from the user (via the keyboard) and sends it to the computer where it is processed. The terminal then gives the processed data back to the user (via the display screen). Besides the CRT screen and keyboard, the terminal includes a built-in controller and communications port(s).

### What to look for

Let's first look at a few design factors that should be considered when you shop for a terminal. Many studies have been conducted to explore possible health hazards connected to using inferior or improperly-situated CRT screens. Eye-strain, neck-muscle stress, and headaches have all been traced to improperly used or poorly designed computer workstations. Terminals that have been designed to eliminate those strain factors are termed "ergonomic," and the right terminal can help you avoid such problems.

One feature you may want to consider is a detachable keyboard—it gives you much more flexibility. If your terminal is made up of two sections (keyboard and display screen), then is it easier to place them where they will be more comfortable to use. For instance, if you need a lot of tabletop space when you are using your computer, you can put the display on a shelf above the table. (That's something you can't do if the keyboard is attached to it—unless you have very long arms.) If you need still more space to lay out plans, papers, or what have you, then you can even put the keyboard in your lap. If you do decide on a detachable keyboard, I'd advise getting one with a coiled cord—it keeps things neater.

A further note on keyboards: If you will



FIG. 1

be entering large amounts of numeric data, then a keyboard with a separate number-entry keypad will be almost a necessity. Entering numerical data on a standard keyboard can be very time consuming, frustrating, and inefficient.

### Displays

There are some things that you'll want to look for—or should I say that there are some things that you'll want to avoid. First, you want the display to be stable. A display that flickers or jitters excessively can be an annoyance, a distraction, and fatiguing as well. You will also want to make sure that the size of the characters is adequate for legibility. If the screen is too small, the letters will be cramped together and eyestrain will occur. A 12-inch screen displaying a standard format of 1,920 characters (24 lines of 80 characters) is often considered a good size both for legibility and for its ability to display a reasonable amount of information on the screen at one time. Also, since a line on  $8\frac{1}{2} \times 11$  paper is generally about 66 characters long, the 80-column display can give you a good idea of what your final output will look like.

The size of the screen is not the only factor that determines the size of the characters. For example some terminals display fewer-but-larger characters than others—say, 40 per line instead of the more-or-less standard 80. Although you want the size of the characters to be reasonably large, you don't want them to be

too large—it limits the usefulness of the terminal for many serious applications (such as word processing).

Another feature to consider in examining the terminal is variable brightness. A terminal should have a brightness control knob—much like the picture adjustments on a typical television—or some other means (such as software control) to allow you to set it for maximum readability.

Some terminals do not include the ability to highlight certain characters. Highlighting is accomplished by putting characters in *reverse video*. Reverse video is simply what its name implies. If your terminal normally displays light characters on a dark background, then reverse video would show dark characters on a light background. The highlighting can be used to make certain characters stand out. For example, in a word-processing application, a block of text that you want to delete, move, or change can be shown in reverse video so that it stands out.

Some terminals use blinking characters instead of highlighting for the same purpose. Others use half-intensity characters. Still other terminals are capable of producing both reverse video and half-intensity characters (and may even include blinking ones).

While reverse video, etc. is normally controlled by the software that you're using with your computer, some terminals are not capable of producing certain types of displays, even if the software calls for them.

Scrolling is another feature that you should look for on a terminal. Some terminals allow you to scroll only line-by-line or only page-by-page. Others permit both line-by-line scrolling and page-by-page scrolling—a definite advantage. In many applications (but not all) scrolling, like reverse video, is controlled by the software. However, keep in mind that even if the software permits (or demands) scrolling, the terminal may not.

There is one point we should mention before moving on. When you are buying software, you should check it carefully and compare it with other similar packages to make sure that it takes advantage of the full range of features that you have on your own terminal.

Other factors to keep in mind are graphics capabilities and upper/lower

\*Managing Editor, *Interface Age* magazine



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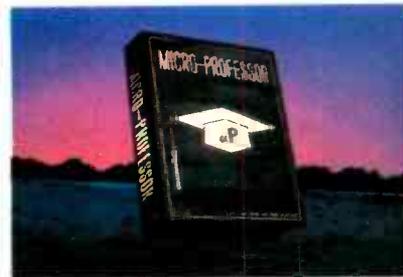
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case character capacities. If you plan to display charts, graphs, or other visual formats on your screen (like what is shown in Fig. 1 on the MVI-100 terminal from Colgraphic Communications Corp., Atlanta, GA), check the range of graphics capabilities available with the terminal. Some units may only be able to do block or straight-line graphics, but not curves. A few—usually inexpensive—terminals can display only upper-case letters. That won't be very useful for you if it is your plan to use the computer for word-processing applications.

We should not end this discussion of displays without mentioning color capability. Although many feel that color displays are not necessary (and in most business applications they really aren't), color can add emphasis when you need it. For example, they can be useful in any situation that requires the display of graphs, bar or pie charts, and the like.

### Dumb and intelligent terminals

There are two types of terminals—*dumb* and *intelligent* (or *smart*). An intelligent terminal can be custom-programmed by the user, while a dumb terminal cannot. For example, many intelligent terminals, when coupled with the appropriate software, use special-function keys that add rapid and instantaneous commands to the standard data-manipulation functions. For in-

stance, if you often use a particular function—moving blocks of text around, for example—the terminal can be programmed to accomplish that with one touch of a special-function key. A dumb terminal, on the other hand, may require many more steps or keystrokes—and much more time—to accomplish the same task. A dumb terminal, because it can do nothing more than act as a keyboard and display screen is often referred to as a "glass teletype."

There are two other factors should be considered in selecting a terminal—the baud rate and the operational modes (half-duplex or full-duplex).

The baud rate is the data-transmission rate. Most terminals have adjustable baud rates and you should be sure that the one you purchase also does—we'll explain why. Say, for example, that you are using your terminal to communicate over the phone lines (via a modem) with an information network or remote data base. Then you will have to send data at 300 baud. However, if the terminal is hard-wired to an in-house computer or another terminal, then you can use a much faster rate—typically up to 9600 baud. (Dividing the baud rate by 10 closely approximates the number of characters transmitted per second. For example, a baud rate of 75 would transmit about 7.5 characters per second.)

You may also want to be able to switch-

select either half-duplex or full-duplex operation. Let's see what that means. In the half-duplex mode, any character that you type will be displayed on your screen at the same time that it is transmitted to the network or computer. In the full-duplex mode, however, the character you type is not displayed until the terminal receives an *echo* from the computer, data base, etc. Full-duplex manipulation will cause a bit of a time lag, although it's usually not serious. However, in a multi-user system, the process will sometimes slow things down considerably.

The biggest advantage to the full-duplex mode is verification of correct data transmission to the CPU. If there is a malfunction in this passage of information, you will not know about it in the half-duplex mode, as the character you entered will still be displayed on the screen. Meanwhile, the CPU will be receiving "garbage" (the commonly-used term for erroneous data), which you will not be aware of until you try to print out a document or otherwise extract some of the information.

For applications requiring frequent simultaneous use of many terminals, you may want to use the half-duplex mode for the sake of speed. The terminal should include a switch that will allow you to use either half- or full-duplex modes, so you'll be able to use it for the greatest variety of applications. **R-E**

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74S11	35	74S85	125	74S175	95	74S257	85	74S454	450	1458	55	1458	55		
74S15	35	74S86	35	74S182	175	74S258	85	74S471	475	1488	85	1488	85		
74S20	35	74S112	45	74S188	155	74S260	55	74S472	475	1489	85	1489	85		
74S22	35	74S124	250	74S189	495	74S265	1295	74S474	475	1496	85	1496	85		
74S30	30	74S132	110	74S193	110	74S298	85			1889	1.55	1889	1.55		
										4551	1.50	4551	1.50		
										4558	75	4558	75		

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SOCKETS		SOCKETS		SOCKETS		SOCKETS		SOCKETS		SOCKETS		SOCKETS		SOCKETS	
ww	p	8	101.20	8008	2.55	8155	7.95	8212	2.95	8251A	5.75	8279	8.50	8080A	3.75
10/5.30	14	101.30	10/5.70	16	101.40	10/6.70	18	101.80	10/6.70	20	102.20	10/7.70	22	102.70	10/8.70
10/13.70	24	102.70	10/14.70	28	103.00	10/17.70	40	103.90							

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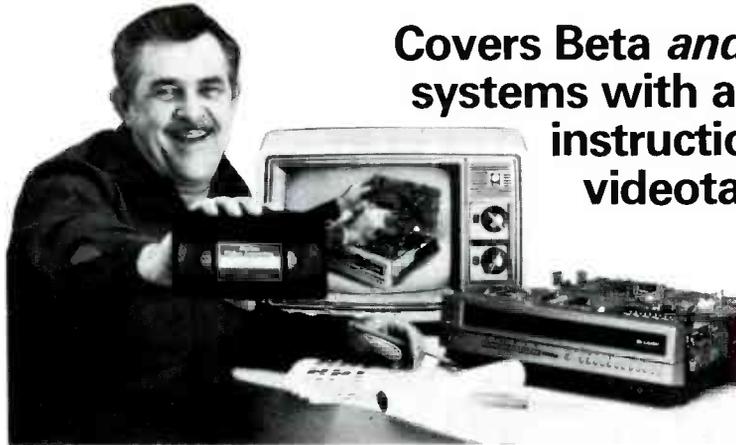
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# NEW IDEAS

## Liquid rosin flux

AFTER I RETIRED, MY INTEREST IN ELECTRONICS grew tremendously. Partly because of that, I joined the RSVP (Retired Senior Volunteer Program) and volunteered to help high-school electronics students in their electronics laboratory courses. Recently, the students began to make their own printed-circuit boards for their projects, and the instructor decided that the boards should be tinned (solder plated). What the students would do was to load the board with solder and then sop it up with *Solder Wick*. There had to be a better way to tin a board than that!

One improvement would have been to use some liquid rosin solder flux. However, that was not readily available, and an order would have taken months to fill. A solution was found, though—we made our own liquid flux. It's not very hard to do, and everything you need is shown in Fig. 1.

I saw the price she paid for it I decided against it. However, I did manage to get my hands on an empty fingernail-polish-remover bottle. That bottle was perfect for what I wanted to use it because it came with a handy applicator brush. A little acetone was used to clean both the bottle and the brush.

The next problem was to find the rosin. A violin-repair shop was the source for that. I mashed up a bit of the rosin—a piece about as big as the end of my finger—and coaxed it into the bottle that was half-filled with acetone. It was easy to tell how much rosin to put in—it dissolves very quickly, but little chunks of rosin form at the bottom of the bottle, when you've reached the saturation point. Then, no more will dissolve.

Now I had a little bottle of liquid rosin with its own applicator brush. It's a great way to put rosin flux on printed-circuit

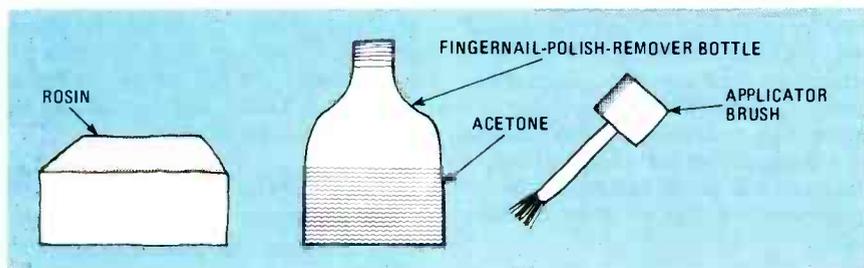


FIG. 1

I knew that the active ingredient in printed-circuit-board cleaners—acetone—dissolves rosin like crazy. So I went to raid my wife's acetone-based fingernail-polish remover—but when I

boards, to prime connections, to tin stranded wires, and so on. You can probably get by without it; but, believe me, liquid rosin can make many jobs a lot easier.—Roger F. Sheldon

### NEW IDEAS

This column is devoted to new ideas, circuits, device applications, construction techniques, helpful hints, etc.

All published entries, upon publication, will earn \$25. In addition, Panavise will donate their *model 333—The Rapid Assembly Circuit Board Holder*, having a retail price of \$39.95. It features an eight-position rotating adjustment, indexing at 45-degree increments, and six positive lock positions in the vertical plane, giving you a full ten-inch height adjustment for comfortable working. (See photo below.)



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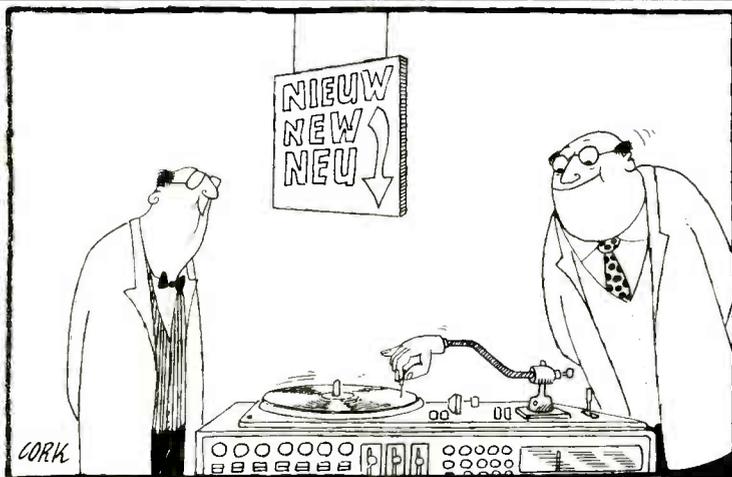
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The EXPLORER 88-PC STARTER'S KIT includes a mother board, memory I/O board, all components needed, sockets for IC's used, one 62-pin bus connector and complete assembly/test instructions. All you need is a soldering iron, solder, a +5 volt @ 3 amps & -5 & +/- 12 volt @ 5 amp power supply, and a standard RS 232 terminal (Netronics has 2 low-cost ones to choose from).

- Explorer 88-PC Starter's Kit ...\$399.95 + 10.00 p&i (wired & tested, add 100.00).
- Extra 62-pin connectors @ 4.25 ea. + 1.00 p&i.
- If you do not own a terminal you may want to consider using our IBM compatible keyboard (see photo) in conjunction with an IBM compatible color graphics board. This combination, although not necessary at the introductory level, may be desirable if you plan to expand the EXPLORER 88-PC to be fully IBM compatible. These items require additional power and are only available wired and tested as follows:
  - IBM compatible keyboard...\$299.95 + 10.00 p&i
  - IBM compatible color board...\$299.95 + 10.00 p&i
  - Additional ROM required...\$35.00



The EXPLORER 88-PC can be expanded at any pace you decide. Invest and learn at a pace that is comfortable for you. Netronics is dedicated to supplying the finest hardware and software to make this a meaningful learning experience. Hard disks, built-in modem board, eeprom burner, print buffer system plus more will be available shortly. The following items are available now:

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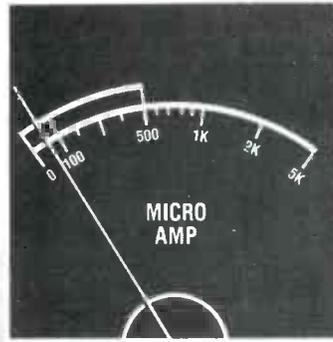
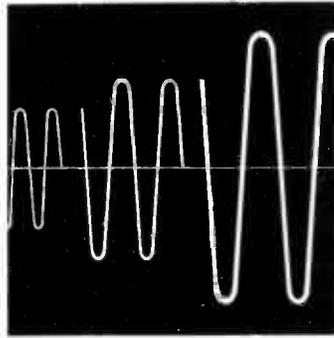
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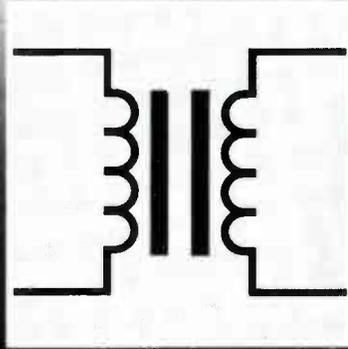
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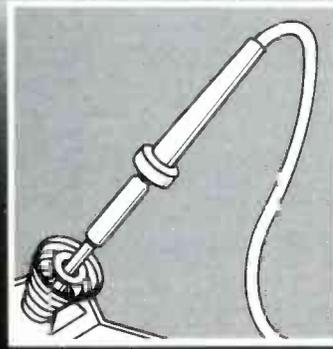
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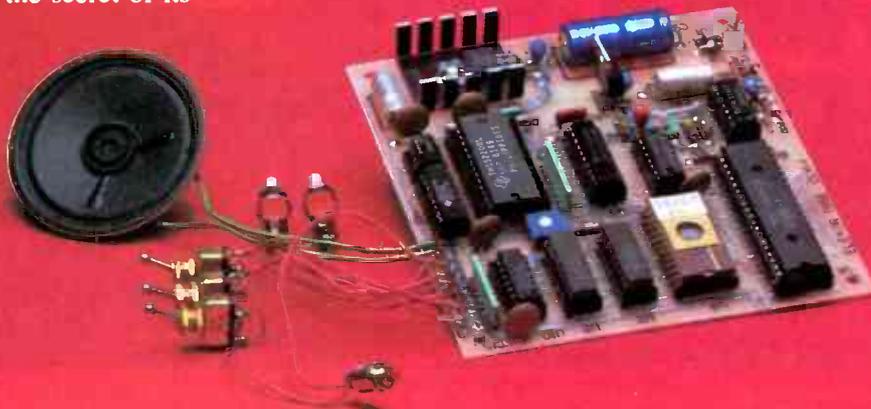
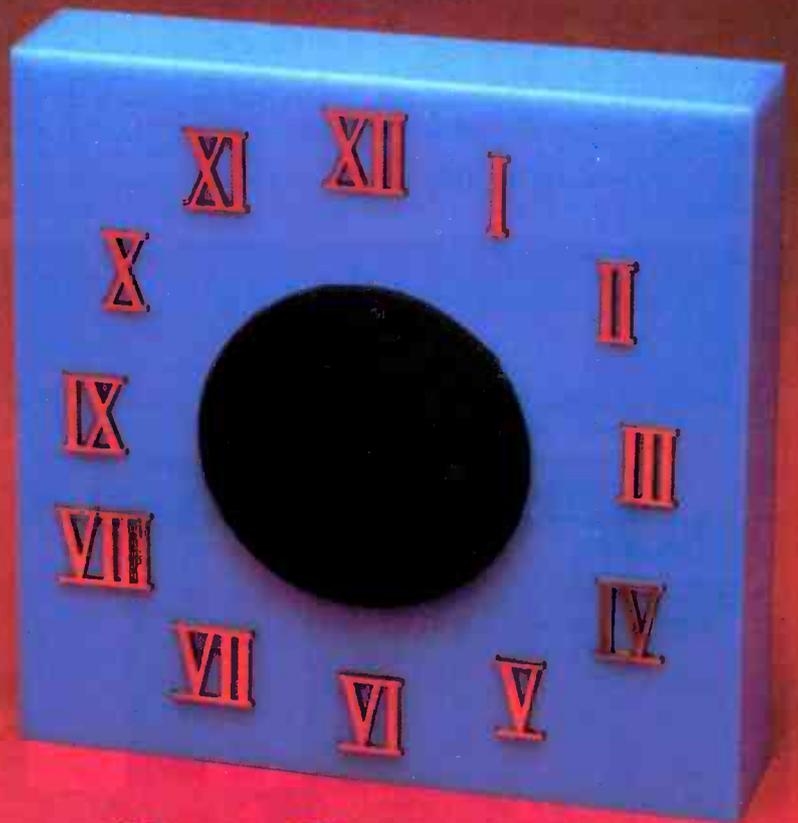
# TALKING ALARM CLOCK

Build a talking alarm clock and you'll never have to tell time again—the clock will do it for you.

LEE GLINSKI

HERE'S A LOW-COST ELECTRONIC alarm clock that really tells time—it talks. The time announcement, made in a pleasant-sounding female voice, sounds like this: "Good morning. The time is six fifteen AM." The voice is extremely life-like (and very feminine). The time can be announced either automatically or on demand by pressing a switch. In addition, the clock contains a 24-hour alarm. The alarm is not just an ordinary buzzer—it's an actual voice that tells you that it's "time to get up." Another of the clock's features is a power-failure alarm. You'll know you have to reset the clock when it says: "Power failed. Set the time."

The entire microprocessor-controlled device uses fewer than a dozen IC's, all of them standard parts. The clock's voice is produced by a speech-processor IC that uses speech data derived from human speech that has been digitized and compressed; that's the secret of its excellent sound.



## Human speech

Before describing electronic speech-synthesis, it is first necessary to have an understanding of how human speech is generated. The voice-producing mechanism in human beings consists essentially of two parts—the sound source and the vocal tract. The speech process starts with air being pushed out from the lungs. The resulting air stream stimulates the vocal cords, and causes sounds to be produced. Those are called *voiced* sounds, examples of which are vowels like "U" and "A." If the vocal cords are held open so they don't vibrate, the sound produced will be *unvoiced*, like the consonants "S" and "F."

The basic sounds enter the vocal tract—made up of the mouth, nasal passages, and other resonant cavities inside the head, throat, and chest—where they are shaped into speech. Changing the shape characteristics of the vocal tract produces different sounds.

## Speech-synthesis theory

The voice of the talking clock is generated electronically by a speech-synthesis IC, the Texas Instruments TMS5220, that simulates the human voice-producing organs described above. The speech-generation technique used is called *linear predictive coding*.

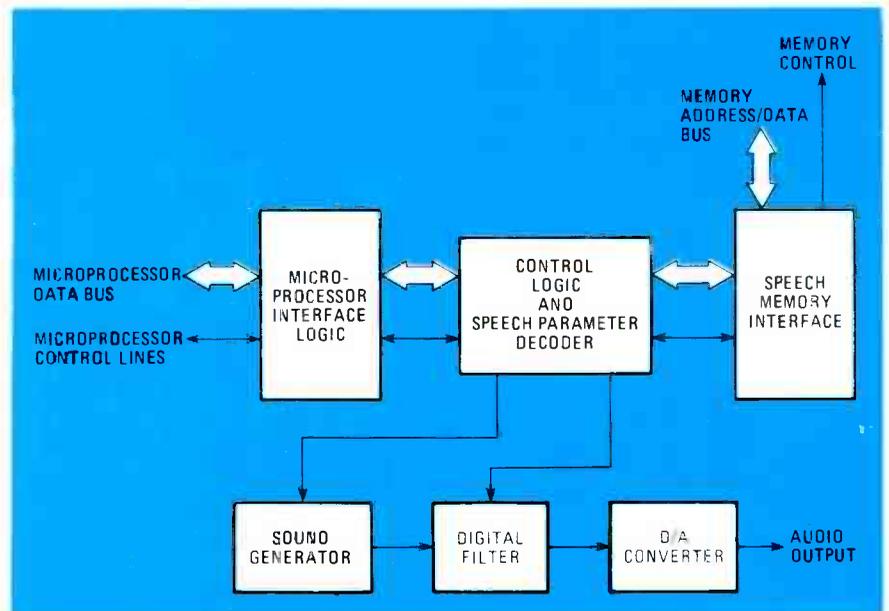


FIG. 1—VOICE-SYNTHESIS PROCESSOR IC contains all the elements necessary to reconstitute speech from compressed data stored in ROM.

Linear predictive coding, or LPC, uses a mathematical technique to model (simulate) the functions of the human vocal tract. Coherent speech is produced by stringing together many short speech-elements. Linear predictive coding determines how each of those elements is

generated. Each speech element is generated by mathematical calculations, and a formula generates each new element, based on the previous ones plus some new data. Thus the term *predictive coding*—each new speech element is partially predicted from the previous ones.

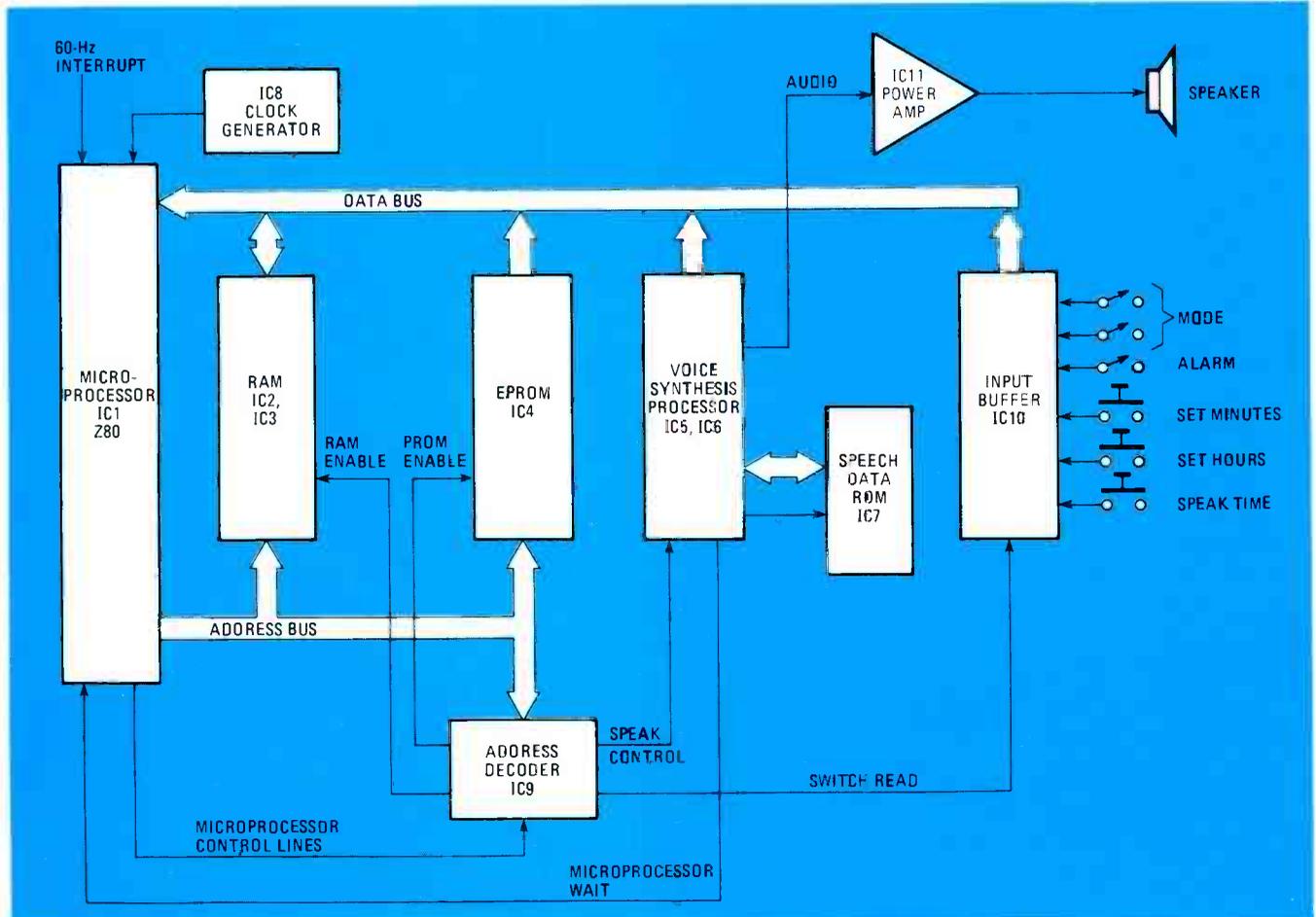


FIG. 2—SPEECH DATA IS STORED in two IC's: IC7 contains "time-telling" messages; IC4 holds messages for alarm and other functions.

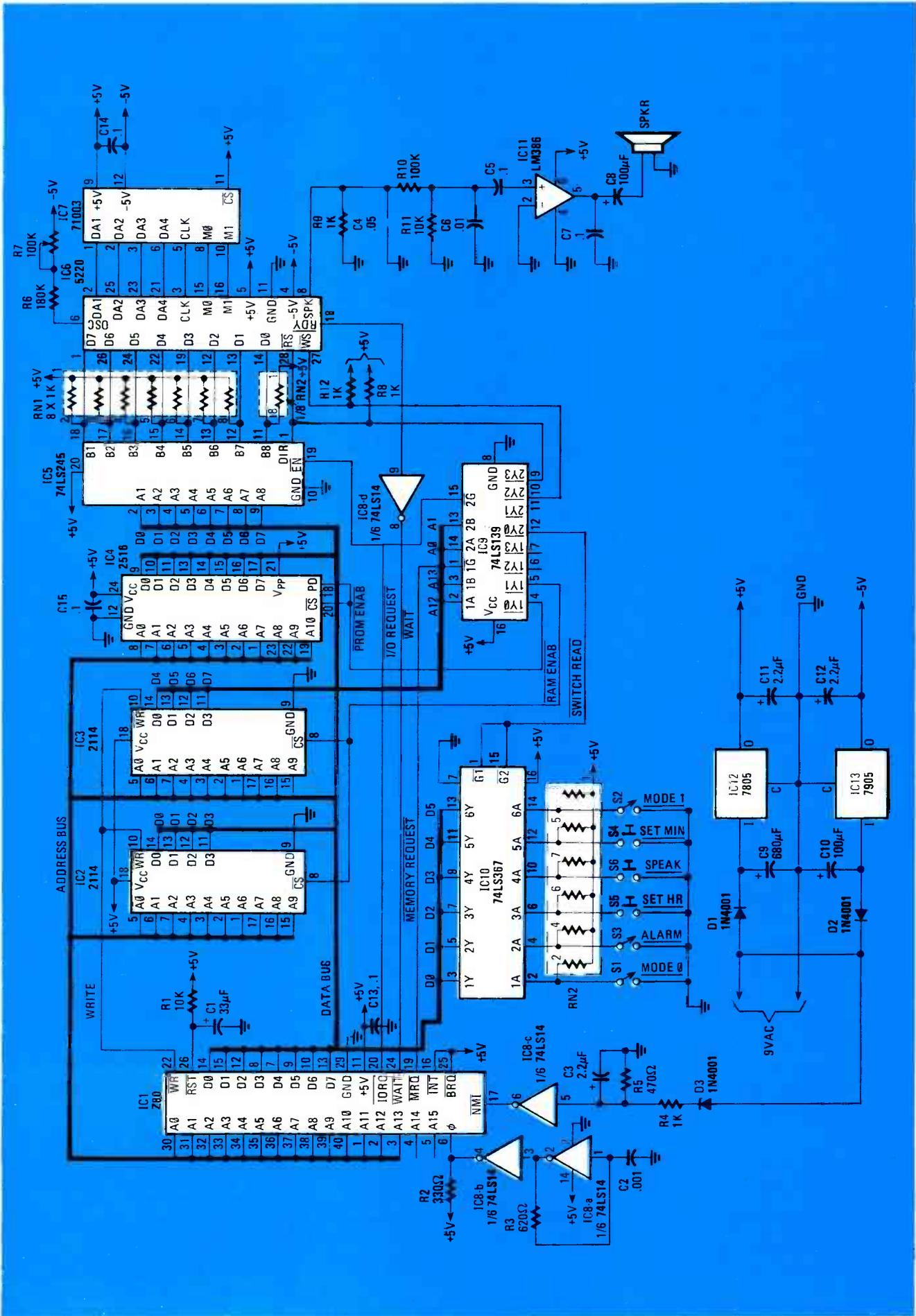


FIG. 3—BOLD LINES in schematic of talking clock represent multiple data and address lines.

The synthesizer simulates the human voice source and the vocal tract. As shown in Fig. 1, the voice is simulated by a sound generator, and the vocal tract is simulated by a digital filter. That digital filter is the mathematical model that performs the calculations to generate speech. Both the sound generator and the digital filter change their characteristics continuously as speech is produced.

There are two sound generators: a variable-frequency generator to simulate voiced sounds from the vocal cords, and a noise generator to simulate unvoiced noise-like speech sounds.

The digital filter shapes the signals from the sound generator to produce small time-samples of speech. Its characteristics can be altered to produce different sounds.

Each word produced by the synthesizer consists of many time-samples in sequence. During voice generation, one of the sound sources is selected, and the values of its pitch and loudness set. The sound source is then fed to the digital filter. The parameters of the filter are then programmed to shape the sound source into the desired speech pattern. The filter generates each speech sample from a calculated sum of the previous 10 samples. That is done to minimize the amount of data required to generate each new sample, and is the main characteristic of linear predictive coding.

The information that determines the characteristics of each sample is the *digital speech data*. That data is a description of certain parameters of the original spoken words. It contains parameters to describe the voice frequency, strength, and the filter characteristics required to create the synthetic speech. During speech generation the required data is fed to the speech synthesizer to control its operation.

A collection of speech data for a number of words makes up a speech synthesizer's vocabulary. To generate a vocabulary for the speech synthesizer, the words are first spoken and recorded on a high-quality master tape. Each word from the tape is sampled and digitized at an 8-kHz rate, and the resulting data is then fed to a computer for analysis. That's done to compress the data so that a minimum of memory is needed to store it. Typically, the data will be compressed by a factor of 100 or more.

Computer programs analyze the data using a mathematical model of the human speech-producing "mechanism." The computer extracts parameters from the data that describe the speech in terms of vocal-tract qualities, pitch, and energy level as a function of time. Once those values have been extracted, other computer programs further analyze and compress the data. That will produce speech data that can be used by the synthesizer for voice generation.

The compressed speech data is coded

in a way that the voice synthesizer can read and use effectively, and is stored in a ROM (*Read Only Memory*). The voice synthesizer reads the data contained by the ROM, performs the mathematical calculations to simulate the vocal tract, and produces synthetic speech.

### Voice synthesizers

The voice synthesizer IC used by the talking clock is manufactured by Texas Instruments. It's their TMS5220 voice-synthesis processor (VSP), and contains all the circuitry necessary to interface with a microprocessor and to generate speech. The VSP (refer to Fig. 1) consists of three major sections: the speech synthesizer itself, the microprocessor interface, and the speech-memory interface.

The speech-synthesizer section of the VSP uses the LPC method described earlier.

The TMS5220 uses a digital filter to simulate the action of the human vocal tract. The filter takes highly compressed LPC speech data from the speech memory ROM and processes it. Its output consists of another form of digital data, which is no longer compressed. The data—now in an expanded format—is a direct digital representation of the original speech waveform and is fed to an 8-bit digital-to-analog (D/A) converter, which outputs an analog voltage reproducing the original audio waveform. The voltage is then filtered to eliminate digitizing noise, and fed to an amplifier and speaker.

As explained previously, the speech synthesizer needs compressed digital speech data to generate speech. The TMS5220 was designed to accept speech data from one of two sources: from a dedicated speech memory, or directly from a microprocessor. The dedicated memory consists of specially designed ROM's. Texas Instruments has several voice ROM's, with different vocabularies, on the market. Industrial, avionics, military, and clock vocabularies are currently available. The voice ROM's are memories either 32K bits or 128K bits in size, depending on the vocabulary size.

The ROM used (a VM71003) has a capacity of 32K-bits (in a 16-pin package) and contains data for 34 words (a 128K ROM stores over 200 words). It contains words for all the numbers needed to announce the time, as well as words for other clock-related phrases like "the time is," "AM," "good morning," etc.

In addition, the clock also uses other phrases, such as "power fail" and "set the time." Those phrases are not stored in the clock-vocabulary ROM; they are stored in an EPROM (*Erasable Programmable ROM*) that also stores the program that runs the clock. That speech data is read from the PROM by the microprocessor and fed to the VSP through its microprocessor interface.

The voice ROM is connected to the

## PARTS LIST

All resistors 1/4 watt, 5% unless otherwise noted

R1, R11—10,000 ohms  
R2—330 ohms  
R3—620 ohms  
R4, R8, R9, R12—1000 ohms  
R5—470 ohms  
R5—180,000 ohms  
R7—100,000 ohms, PC-mount trimmer potentiometer  
R10—100,000 ohms  
R13, R14—8 × 1K SIP (Single In-line Package) resistor pack

### Capacitors

C1—330 μF, 10 volts, electrolytic or tantalum  
C2—0.001 μF, ceramic disc  
C3, C11, C12—2.2 μF, 10 volts, electrolytic or tantalum  
C4—0.05 μF, ceramic disc  
C5, C7, C13—C15—0.1 μF, ceramic disc  
C6—0.01 μF, ceramic disc  
C8, C10—100 μF, 16 volts, electrolytic  
C9—680 μF, 16 volts, electrolytic

### Semiconductors

IC1—Z80 microprocessor  
IC2, IC3—2114 1K × 4 RAM  
IC4—2516 or 2716 2K × 8 EPROM, pre-programmed  
IC5—74LS245 octal bus transceiver  
IC6—TMS5220 voice-synthesis processor  
IC7—VM71003 clock-vocabulary ROM  
IC8—74LS14 hex inverting Schmitt trigger  
IC9—74LS139 dual 2/4 decoder  
IC10—74LS367 hex Tri-State bus driver  
IC11—LM386 audio amplifier  
IC12—7805 5-volt positive regulator  
IC13—7905 5-volt negative regulator  
D1—D3—1N4001  
T1—9 VAC, 600 mA, wall-plug transformer  
S1—S3—SPST slide or toggle switch  
S4—S6—SPST N.O. pushbutton switch

**Miscellaneous:** PC board, speaker, IC sockets, heat sink for +5-volt regulator, enclosure, wire, solder, etc.

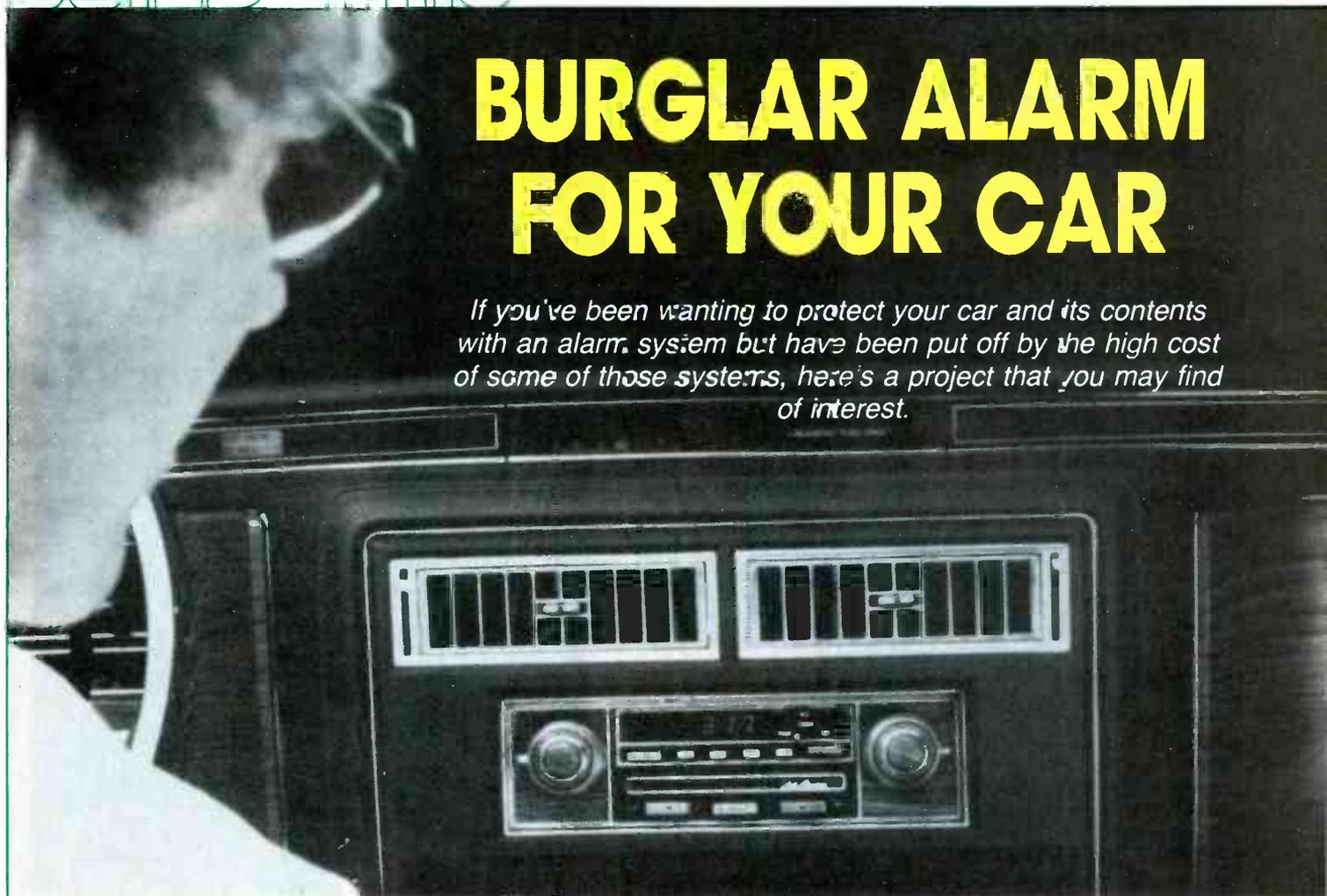
The following are available from ELEXOR, PO Box 246, Morris Plains, NJ 07950: double-sided plated-through PC board, \$12.50; IC4, \$7.50; IC6 and IC7, \$25.00; kit of all parts (less enclosure and handling as well as applicable state and local sales tax(es)).

voice synthesis processor through a memory-interface bus. That bus consists of four address lines and two control lines. The voice ROM is specially designed to work with the TMS5220 through it. When the VSP reads data from the ROM, it first sends an address to the memory IC, and then begins reading the data one-bit-at-a-time in a serial fashion. It generates speech as the data is read. During speech generation the data rate is approximately 1200 bits per second.

*continued on page 106*

# BURGLAR ALARM FOR YOUR CAR

*If you've been wanting to protect your car and its contents with an alarm system but have been put off by the high cost of some of those systems, here's a project that you may find of interest.*



ABOVE ALL ELSE, A GOOD ALARM SYSTEM should offer adequate protection at an affordable cost. The project we'll be presenting here meets both those criteria. First of all, it monitors all possible entry points (doors, hood, etc.); a motion detector can even be added if desired. A relatively simple, compact timing system provides for an approximate 13-second delay upon opening the door, allowing you plenty of time to enter the car and disarm the system before the alarm sounds; the alarm sounds instantly when the hood is opened.

As far as cost goes, even if you use brand-new parts, you should be able to build the unit for about \$25.00, excluding the siren. A good siren—one that's sure to be heard and noticed—should run you about another \$20.00. If you compare that to some similar systems on the market the cost is quite reasonable, and you can reduce it a bit more if you have a reasonably well-stocked junkbox.

### About the circuit

The schematic diagram for the circuit is shown in Fig. 1. Except for the siren, it requires 5 volts DC for operation. Since

### EDWARD W. LOXTERKAMP

12 volts is available from the car battery, getting that voltage is no problem if a voltage regulator is used. That's taken care of by IC6, a 7805 5-volt regulator. If that IC is properly heat sunk—and because of the power that the device must dissipate, it has to be—it can handle one amp.

You can use a standard TO-220 heat sink, but a better solution is to take a piece of aluminum measuring  $\frac{3}{4} \times 1 \times \frac{1}{4}$  inches and bend it 90°. The result is a less expensive heat sink, but more important, one that takes up less space. And since we're trying to make the circuit as compact as possible, every little bit helps.

Returning to IC6, its output will be 5-volts DC as long as the input is maintained above 7 volts. Capacitors C1 and C2 are used to filter the IC's output, and for stability. Those capacitors are tantalum types and must not be substituted for. The regulator's output is used to power all the circuit except the siren.

As for the siren, one side is connected directly to +12 volts (the car battery).

The other side is connected through Q2, a TIP120 Darlington transistor, to ground. When 0.6 volt is applied to the base of Q2, it conducts, turning on the siren. Now let's turn to the interesting part of the circuit—how we get the siren to turn on only when we want it to...and when the thief does not.

### Hood alarm

You'll want the alarm to turn on as soon as the hood is lifted in case someone tries to tinker with your engine or battery. That's why the hood sensor should trigger the alarm without any delay.

The sensor in the hood, S1, is a normally-closed switch that is open when the hood is closed. When that switch is open, the base of Q1 is pulled up causing pin 8 of IC1-a to be pulled high. That IC is half of a 556, a dual negative-edge-triggered monostable timer. Opening the hood will release the switch, thus closing it. That, in turn, will cause Q1 to conduct, and pull pin 8 low. That high-to-low transition triggers the timer and pin 9, its output pin, goes high. When that happens, Q2 conducts and the siren sounds. Once triggered, just closing the hood

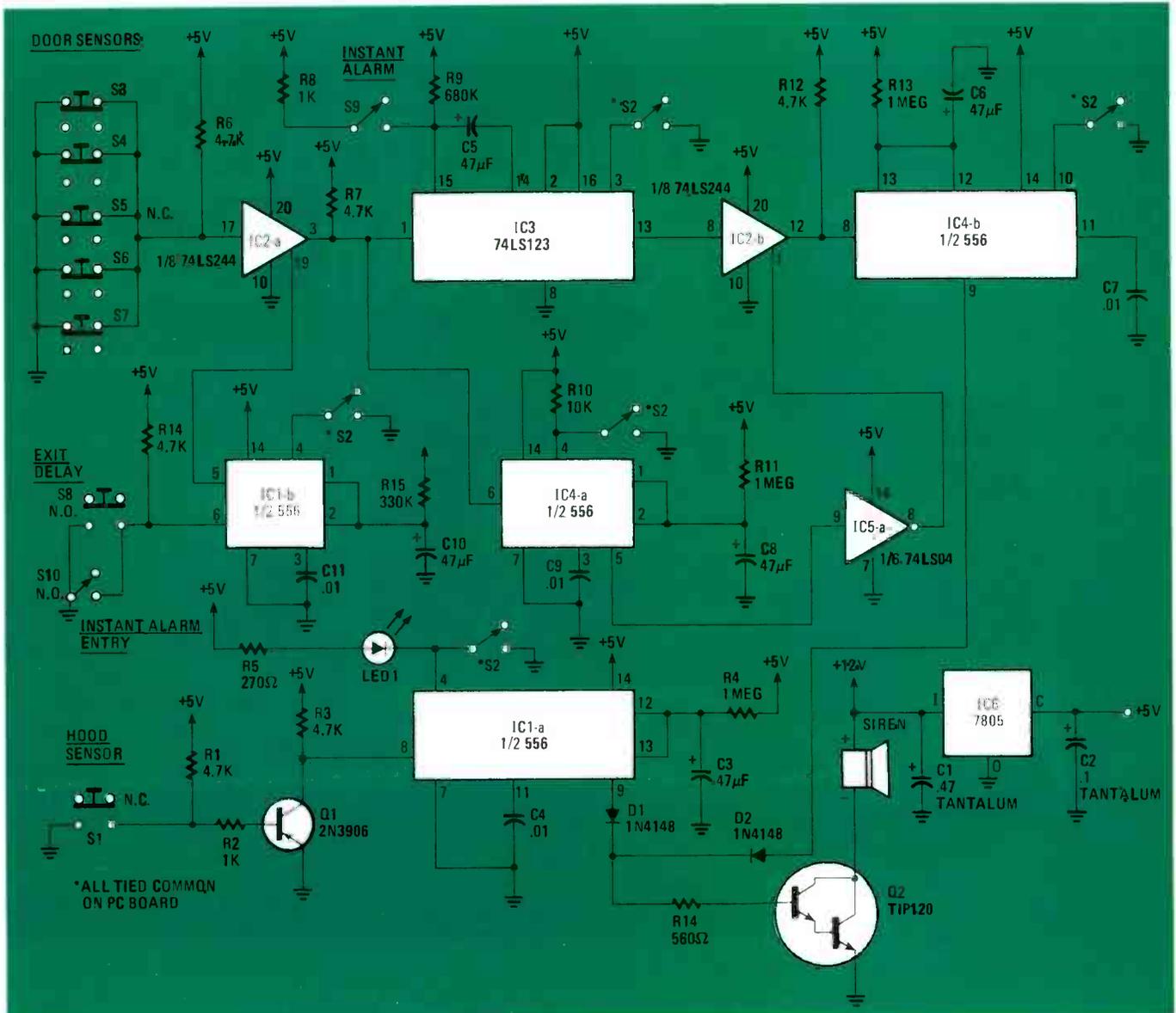


FIG. 1—SCHEMATIC DIAGRAM of the car alarm. This circuit offers reasonable protection at an affordable cost.

again will not turn the siren off. Switch S2, the master arm/disarm switch must also be thrown. If it is not, the siren will sound for a period set by the values of R4 and C3—about 52 seconds with the values shown in the schematic—before it turns off and the system is rearmed. (Note, however, that component-to-component variances can cause the alarm on-time to vary greatly from your calculated value. That on-time for this IC can be found from the formula:  $t = 1.1RC$ .) Diodes D1 and D2 are there simply to isolate the two timer-circuits from each other—D1 keeps IC4-b from outputting into IC1-a while D2 keeps IC1-a from outputting into IC4-b. We'll discuss the other timer circuit in a moment.

An LED, LED1, is connected to the reset pin (pin 4) of the timer and is off when the circuit is armed. When S2 is closed, the LED is forward biased and lights. Since closing the switch disarms the system, if the LED is lit the system is *disarmed*.

The circuitry for the other sensors differs in that it does not turn the alarm on instantly. Let's look at it next.

### Door and hatchback sensors

The basic difference between the hood-sensor circuitry and the door- and hatchback-sensor circuitry is that the latter features a time delay. That delay allows you time to enter the car and disarm the system before the alarm sounds. It also allows you time to leave the car after you've armed the system.

When a door (or the rear hatch) is opened, one of S3–S7 closes, pulling pin 17 of IC2-a low, which in turn causes pin 1 of IC3 to go low. Integrated circuit IC2-a is a quad Tri-State buffer/driver (74LS244). Normally, it passes an input signal to its output unchanged, but when the input to pin 19 is high the output becomes high impedance. Looking into pin 3, it appears as if the device were not there at all. We'll see how that IC is used in this circuit a little later.

Let's now look at IC3, a 74LS123 dual one-shot that it is negative-edge triggered. When its pin 1 goes low, the device is triggered. Once that happens, there are only two ways to turn the alarm off—wait for the system to shut off automatically, or reset the entire system.

The length of the pulse output by IC3 is determined by the values of R9 and C5. When IC3 goes low, the signal passes through IC2-b (assuming that pin 1 is low) and triggers IC4-b. When that happens, pin 9 goes high and the alarm sounds. Pin 9 will remain high, and the siren will continue to sound, for a period of time determined by the values of R13 and C6.

Pin 1 of IC2-b goes high, putting that device into its high-impedance state, shortly after IC3 triggers the alarm. What happens is that, in addition to being fed to pin 1 of IC3, the signal from IC2-a is picked off and fed to another 555, IC4-a. The values of C8 and R11 are chosen so that the duration of that IC's output pulse

## PARTS LIST

All resistors 1/4-watt, 5%, unless otherwise specified

R1, R3, R6, R7, R12, R14—4700 ohms  
 R2, R8—1000 ohms  
 R4, R11, R13—1 megohm  
 R5—270 ohms  
 R9—680 ohms  
 R10—10,000 ohms  
 R15—330,000 ohms  
 R16—560 ohms

### Capacitors

C1—0.47  $\mu$ F, 25 volts, tantalum (do not substitute)  
 C2—0.1  $\mu$ F, 25 volts, tantalum (do not substitute)  
 C3, C5, C6, C8, C10—47  $\mu$ F, 25 volts, electrolytic, radial leads  
 C4, C7, C9, C11—.01  $\mu$ F, 25 volts, ceramic disc

### Semiconductors

IC1 IC4—556 dual timer  
 IC2—74LS244 octal Tri-State noninverting driver  
 IC3—74LS123 retriggerable monostable multivibrator  
 IC5—74LS04 hex inverter  
 IC6—7804 5-volt regulator  
 Q1—2N3906 PNP transistor  
 Q2—TIP 120 NPN Darlington pair  
 D1, D2—1N4148 switching diode  
 LED1—red LED  
 S1, S3-S7—SPST momentary pushbutton, normally closed  
 S2, S9—SPST switch  
 S8—SPST momentary pushbutton, normally open  
 S10—SPST keyswitch, normally open

**Miscellaneous:** PC board, heat sink (see text), IC sockets, Molex connectors, wire, solder, etc.

is slightly longer than the pulse output by IC3. The pin-5 output of IC4-a is then fed to IC5, one section of a 74LS04 hex inverter, and then to pin 1 of IC2-b. Thus, when the output from IC4-a cuts off, the signal at pin 1 of IC2-b goes from low to high. The purpose of all of that is to prevent any spurious or accidental triggering of the alarm.

That takes care of the operation of the entry-delay circuit, but not the exit delay. Lets go back to IC2-a again. When that device is in the high-impedance mode, it effectively disarms the sensors so they have no effect on the alarm. The trick is to disarm those sensors only long enough to allow you to get out of the car. Once that is done, the sensors should be rearmed so the circuit can fulfill its intended purpose.

That function is handled by IC1-b. Using S8 to bring pin 6 of that monostable timer (half of a 556) low triggers the device. Its timing cycle is determined by R15 and C10. The timer's pin-5 output is applied to pin 1 of IC2-a, causing it to go into the high-impedance state and cutting the sensors off from the rest of the circuit. When that is done the sensors will not be able to turn on the alarm until the pulse

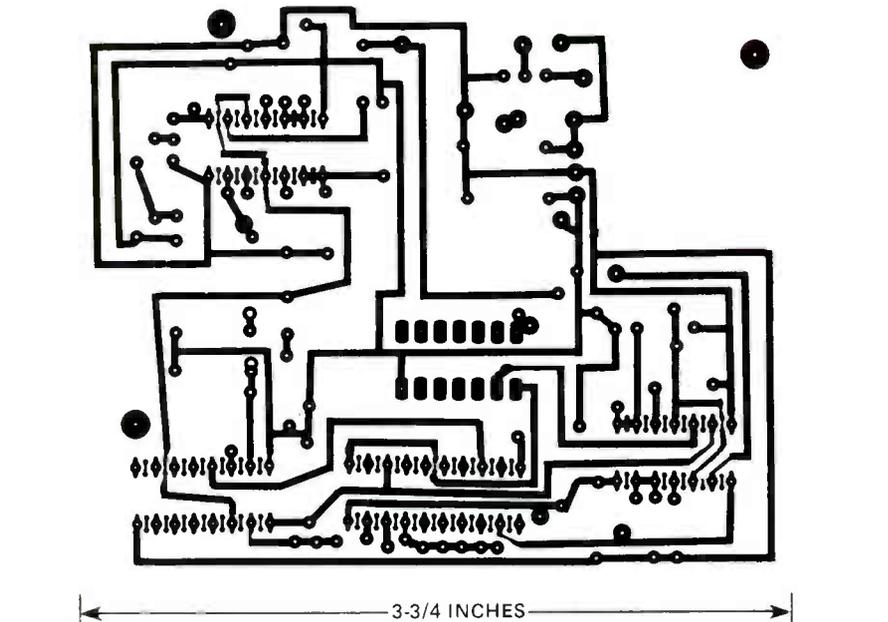


FIG. 2—HERE'S A FOIL PATTERN you can use if you wish to build the project on a PC board. Note, however, that almost any construction technique can be used.

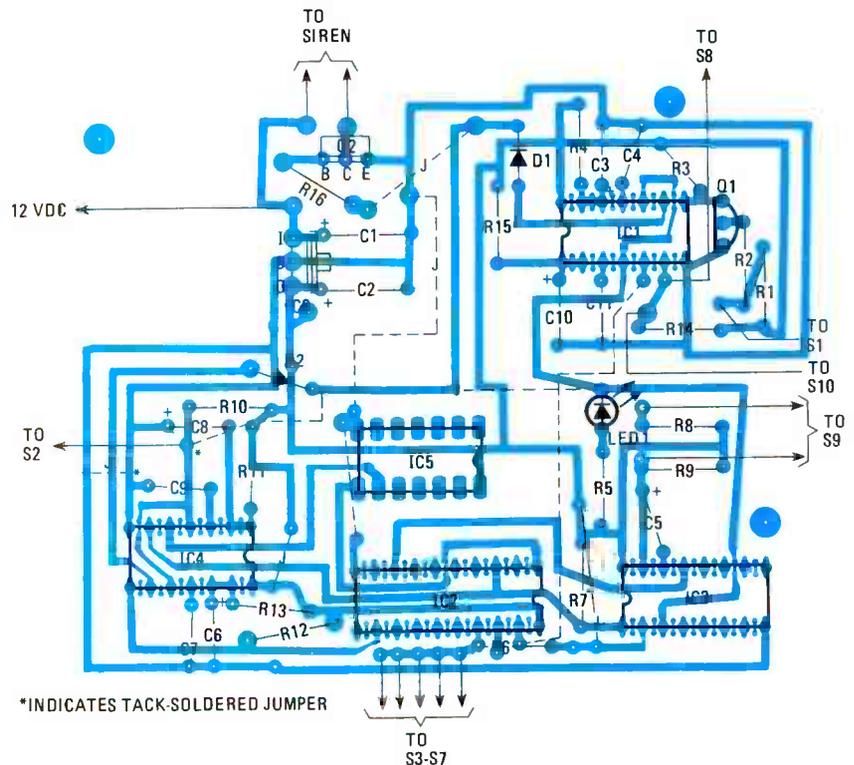
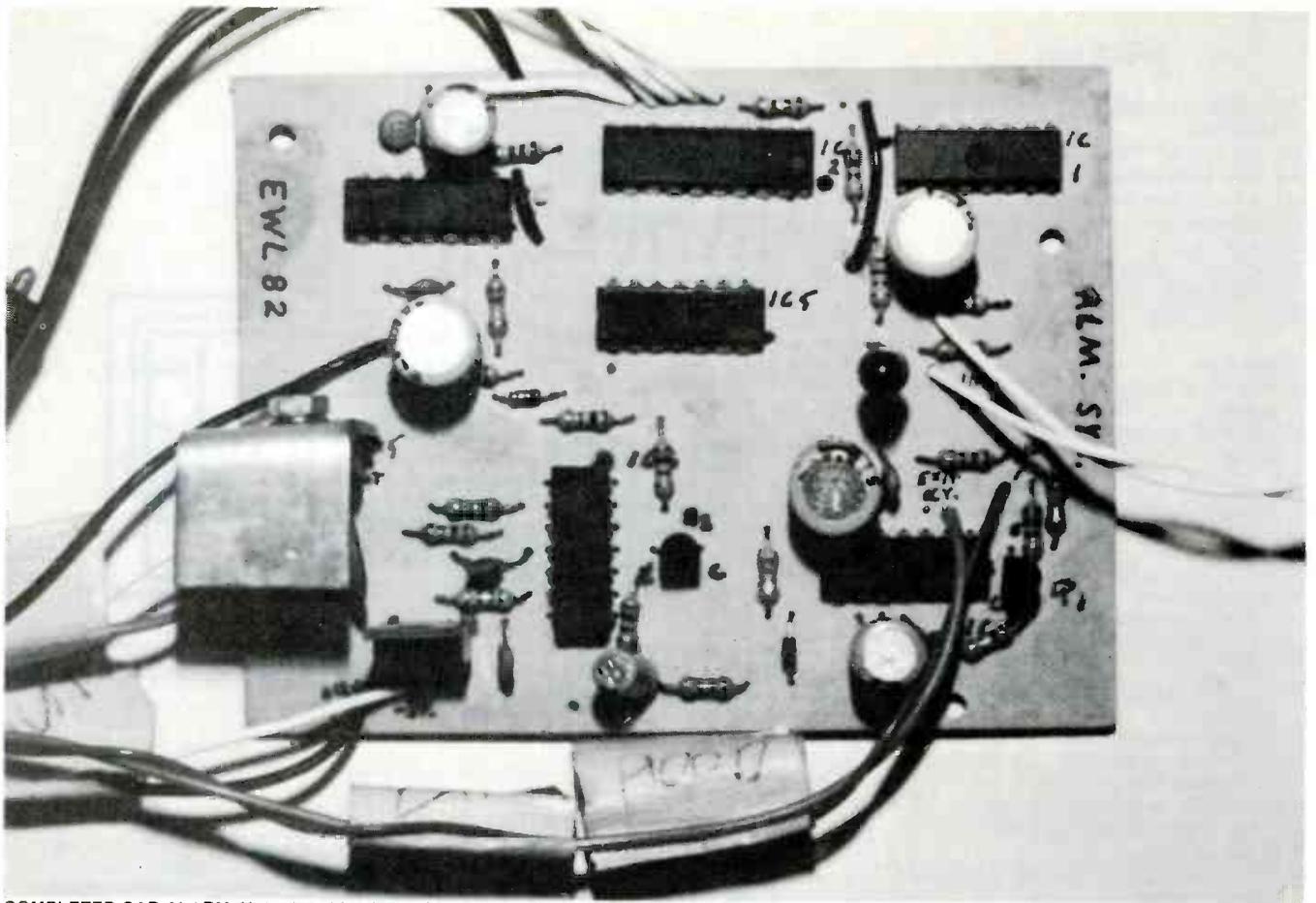


FIG. 3—PARTS-PLACEMENT DIAGRAM. Note that the foil-side jumpers are shown by dashed lines.

from the 556 goes low again. When that happens IC2-a returns to normal and the system is rearmed.

You can, if you wish, also set the alarm to sound instantly when any door or the rear hatch is opened. All that needs to be done is to throw S9. That switches R8, a 1000-ohm resistor, in parallel with R9, decreasing the entry delay-time to a few milliseconds. The net effect is an instantly triggered alarm.

Switch S10 is mounted outside the car so that you can disarm the system before entering when the system is in its instant alarm mode. That switch should be a key-type and/or mounted in a concealed location. If you don't want to include the instant-alarm-mode feature, the circuitry associated with it—S9, S10, and R8—can be eliminated without otherwise affecting performance. Another alternative would be to eliminate only S10 and to



COMPLETED CAR ALARM. Note that this photo shows the author's prototype and includes several components not used in the version described in the article.

adjust the value of R8 to give an entry delay just long enough for you to enter the car and disarm the alarm.

### Building and installing the system

Building the alarm shouldn't take more

than an hour or two. There is very little that is critical about the circuit, and just about any construction technique can be used. If you wish to use a printed-circuit board, a foil pattern is shown in Fig. 2; the parts placement diagram is shown in Fig.

3. Note that several jumpers are required if you use the foil pattern shown. Some of the jumpers mount on the component side of the board, but most of them mount on the foil side; the foil-side jumpers are indicated by a dashed line in Fig. 3.

Installing the system, particularly the sensors, in the car is a little more difficult. The type of car determines how easy it is. One of the biggest problems we had was grounding the trigger inputs. When we ran the sensor lines through the doors and fire wall, insulation was pierced, causing continuous triggering. Care not to ground the sensor lines must be taken when running them. A simple check with an ohmmeter before connecting the lines to the system will save a lot of headaches.

It is very helpful to run all the lines (sensor, power, alarm, etc.) from the circuit to a female Molex connector (any type of multiple-connection connector will do). All the connections made in the car can be run to a male Molex connector. That simplifies hooking the system up, and helps prevent getting wires crossed.

There you have it—a simple, low-cost and effective, car alarm you can build and install yourself. (You can also modify it yourself—see box copy to the left.) Now there's no reason for you not to put your mind at ease by protecting your car and belongings.

R-E

## SOME USEFUL MODIFICATIONS

While this car alarm system will do an excellent job of protecting your car, there is no reason for you to limit its design or applications to those discussed in this article.

There are many modifications you can make to the system to make it perform better in your car. Or, somewhere other than in your car (your house, for example). We'll look at just a few of the many possible changes that you might care to make.

First off, for those of you who enjoy experimenting with microprocessors, why not replace S2 (the master ARM/DISARM switch) with a "combination-lock" circuit that would require the entry of a number of digits in the correct sequence before the alarm could be disarmed? For added protection—whether or not you install a combination-lock circuit—you might want to consider tying the ARM/DISARM switch to the car's ignition switch. That would eliminate the possibility of a thief finding your

switch and disarming the system easily.

The sensors form another area of the alarm system that can be modified. Motion detectors—which would detect jacking or towing movements—can easily be added, as can sound sensors, which would "listen" for break-ins. Perhaps more reliable and effective, though, would be ultrasonic proximity-sensors.

A third area of modifications can affect what the alarm does once a break-in occurs.

Besides just sending out an audible alarm, why not also ground the vehicle's ignition coil so that it cannot be started? If that's not exotic enough for you, how about a radio-transmitted silent alarm?

To sum things up, you can see that the alarm system described here can serve as the basis of a larger, more complex system. There's really no limit to what features you can add. We encourage you to experiment, and we'd like to hear what you come up with.

## Music

# Synthesizer IC's

*The design of music synthesizers has been greatly simplified by new LSI IC's. We will discuss some of those IC's as well as the basics of synthesizer design.*

THOMAS HENRY

WHILE HOME VIDEO, PERSONAL COMPUTERS and digital recording have recently been dominating the electronic-news scene, there has been a quiet revolution going on in the area of electronic music synthesizers. What started out as an insignificant field—with research being conducted mainly in university music studios—has become a multi-million dollar business. In fact, business has been so good for the designers of electronic music equipment that some enterprising companies have even designed and produced large scale integration (LSI) devices dedicated solely to making music.

This article will review some of the common modules found in an electronic music synthesizer. In addition, we'll show sample circuits that illustrate the use of the new integrated circuits mentioned above.

### Early music synthesizers

The early days of electronic music were characterized by expensive equipment that had very inaccurate and unstable performance. The inaccuracy was caused by two things. First, until quite recently the musicians who used the equipment and the engineers who designed it were literally in two separate camps. The engineers knew very little about music and the musicians knew even less about engineering. Communication between the two groups was difficult. Engineers had to guess about what parameters were important to the musicians, and equipment design was based on those guesses. Often their assumptions were unrealistic. As a result, musicians had to make the most of the available equipment, but often found their styles or techniques cramped by it.

Most of the early composers of synthesized music came from academic backgrounds. Much of their early music was atonal—it didn't depend upon accurate reproduction of the ordinary scale. Instead, the composers were interested in the "texture" or "mood" of the music. To the untrained listener such music seems to lack continuity and to be composed of unconnected sonic events. Since that style of music didn't depend upon accurately-tuned oscillators or twelve-tone oriented keyboards, few advances were made in the design of reliable equipment.

However, that all changed because sometime in the early 1970's, pop music found the synthesizer and claimed it as its own. Pop music—being intrinsically tonal and melodic—demanded better equipment. The pop musicians needed fairly inexpensive instruments that would stay in tune, and that would work the same way from one night to the next. It also became important for the instruments to be inexpensive. That's because, instead of institutions, it was individuals who wanted to purchase the synthesizers.

Because of that new interest in synthesizers for popular music, the 1970's saw lots of activity in the area of design. Tubes and transistors were discarded in favor of the new linear integrated circuits that were starting to reach the consumer at reasonable prices. And, as research progressed, musicians started to learn more about synthesizer technology and demanded new and better instruments. Likewise, the engineers, because of that new interaction, learned more about music and were able to make design decisions based upon real needs.

The situation remained like that until

quite recently. Professional-quality instruments were available, but their prices still placed them out of the reach of experimenters, home recordists, and hobbyists. However, the new LSI integrated circuits not only bring the price down to an experimenter's level, but also make construction of high-quality synthesizers relatively easy.

### Music synthesizer fundamentals

Every sound can be described by three parameters. Those are *frequency*, *amplitude*, and *harmonic content*. Musicians have roughly synonymous terms: *pitch*, *volume*, and *timbre*. However, it is important to realize that pitch, volume, and timbre are really the psychological perception of frequency, amplitude, and harmonic content. For example a 3-Hz signal obviously has frequency, but does it have pitch? It hasn't, because it lies below the audio range. Also, amplitude affects the ear's perception of pitch. A 1-kHz tone played quietly has a different pitch than the same tone played at a high volume.

Any basic synthesizer can control the three parameters. For instance, frequency is controlled by using a voltage-controlled oscillator (VCO). Amplitude is varied via a voltage-controlled amplifier (VCA), and harmonic content is altered by the voltage-controlled filter (VCF).

### Voltage-controlled oscillators

There is no doubt that the VCO is the most critical module in a synthesizer. It is very important that the VCO—which controls the frequency of the synthesizer's output—be extremely stable and accurate, for the human ear is very sensi-

tive to frequency changes. Even non-musicians can detect detunings of, say, 10 cents (1 cent = 1/100 of a semitone, or about a 0.06% change). Compare that to the ear's sensitivity (or insensitivity) to amplitude changes—1 dB is generally taken as the smallest change that the ear can detect, and that corresponds to a change of about 12%.

Stability implies a number of things. First of all, the control-voltage input should follow some pre-assigned scale very accurately. Generally, a scale of one-volt-per-octave is used. Stability also implies low temperature-drift. That is an especially tricky problem, because to get a 1-volt-per-octave scale, an exponential converter is used. Most of those converters use the exponential relationship of a transistor's base-emitter voltage to its collector current. However, as is well known, transistors are temperature sensitive. But, clever designers over the years have come up with a number of temperature-compensating schemes that work quite well in practice. The only drawback to such schemes is that they increase the parts count of a VCO and add to its complexity.

Reliable operation requires careful thought not only at the design level but also at the construction level. Printed-circuit boards must be carefully designed to minimize stray capacitances, tuning capacitors must have good temperature-coefficients, and so on.

There are other properties, besides stability, that a VCO should have. It should have a very wide output-range—say 10 Hz to 10 kHz, minimum. Also, a variety of waveforms (such as sine, triangle, square, and so on) should be available. A linear control-voltage input should be available for frequency-modulation effects (such as vibrato).

Just several years ago a VCO incorporating all of those features would have been quite expensive and may have used a dozen IC's. However, there are now several manufacturers offering LSI integrated circuits dedicated to the VCO function. The SSM 2030 made by Solid State Micro Technology is one. Another is the Curtis CEM3340.

Figure 1 shows just how easy it is to build a VCO using one of the new IC's (in that circuit we use the CEM3340). Let's first look at the inputs available. The exponential input, which is the one most commonly used, automatically does the exponential conversion for a one-volt-per-octave response (which can be trimmed very accurately by SCALE TRIM resistor, R5).

A linear input is also provided for auxiliary control. It is used primarily for frequency-modulation effects such as vibrato. Also there are both hard-sync and soft-sync inputs available; they allow multiple oscillators to be phase locked. A non-linear feedback voltage is provided at pin 7 to correct high-frequency errors

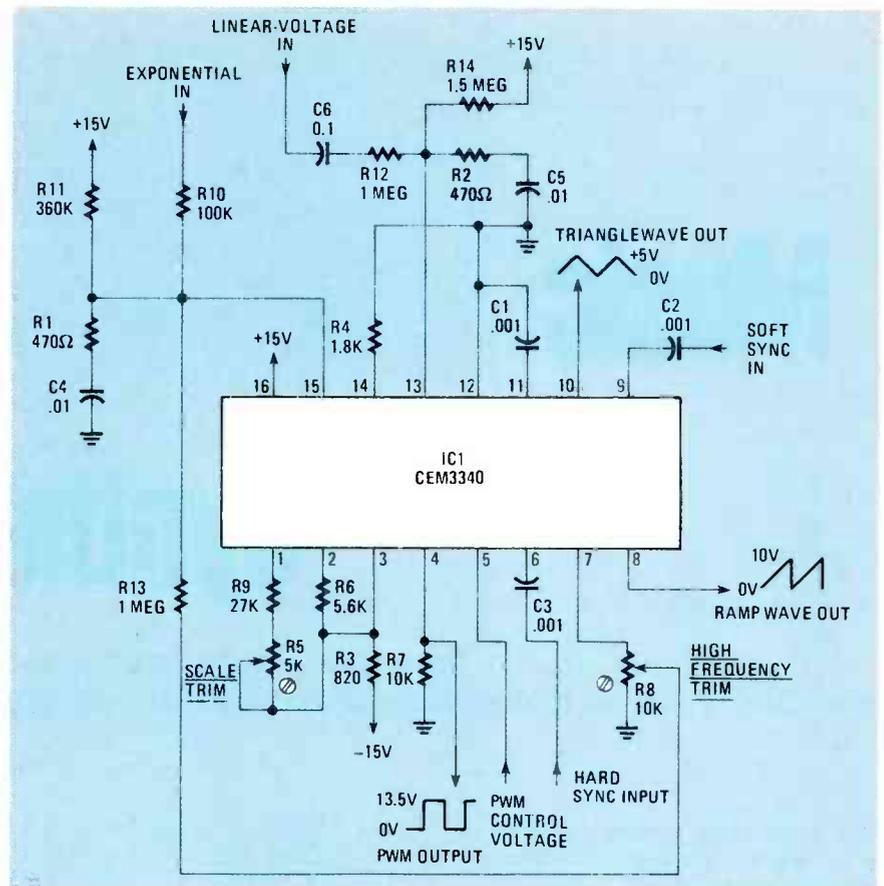


FIG. 1—THIS VCO has three output waveforms available—triangle, ramp, and a pulse train.

(which grow as the VCO is pushed toward its upper frequency-limit).

There are three output waveforms available: a trianglewave, a ramp waveform, and a pulse train. That pulse train can be modulated from 0% to 100% by applying a 0–5-volt control voltage to pin 5, the PULSE-WIDTH MODULATION input. All outputs are buffered, eliminating the need for several op-amps.

The converter is fully temperature compensated for both first and second order effects. That not only makes the designer's task easier but also reduces cost by eliminating the need for the usual thermistor required in VCO designs.

As you can see from this example, the design of a VCO is considerably simplified by use of the CEM3340 or other such LSI device. The VCO is now essentially a single-IC circuit. That simplicity makes synthesizers using multiple VCO's practical both in terms of construction and expense.

### Voltage-controlled filters

The voltage-controlled filter or VCF is used to alter the harmonic content of the signal from the VCO and is the next logical block in a synthesizer. A control voltage—using the same exponential scale as the VCO—varies the cutoff frequency of the filter. Because both the VCO and VCF use the same control-voltage scale, they can be made to track one another. That allows for an undistorted waveshape or harmonic structure over the entire frequency range.

Generally an organ-type keyboard provides the control voltage to both the VCF and the VCO.

Voltage-controlled filters come in many varieties and are classified according to the basic type. The low-pass type has been very popular in the past. That is because most non-electronic instruments use some sort of low-pass filter mechanism. (For example, a trumpet or trombone player may use a "mute," which is nothing more than a low-pass filter.)

Other types of filters have been used as well. Bandpass filters have been quite popular. They are characterized by the familiar "wah-wah" sound created when their center frequency is varied. Voltage-controlled high-pass filters are less common, probably since their effect in a synthesizer system is less dramatic than either the low-pass or bandpass types. Finally the all-pass filter is becoming common for creating artificial Doppler-shift effects and phasing- or flanging-type effects.

Early VCF designs used a large number of components. For example, a four-pole, low-pass design (almost the industry standard in filters for music) required anywhere from one- to two-dozen transistors. Two transistors were needed for each pole (for a total of eight); several more were required for input and output conditioning and still a few more were needed for the exponential converter. Even though transistors are relatively inexpensive, that type of discrete design can hardly be justified since the circuit

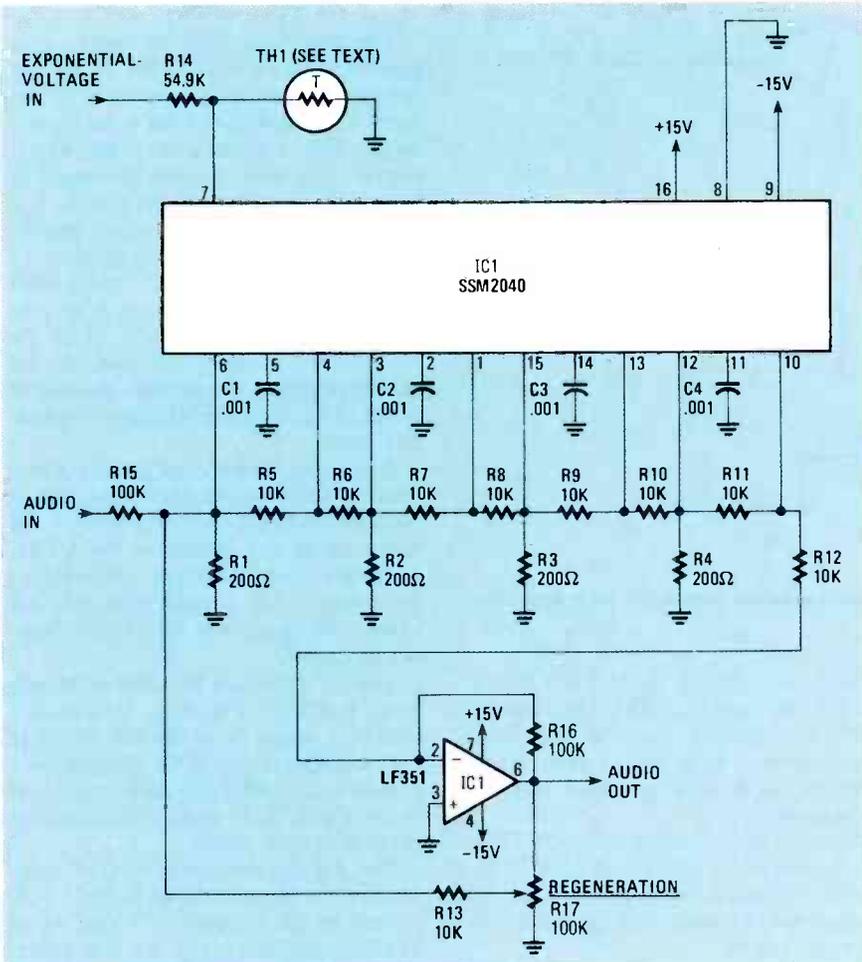


FIG. 2—NONE OF THE INTERNAL amplifiers of the SSM2040 are short-circuit proof, so none of the non-power-supply pins should contact the positive supply, the negative supply, or ground.

board layout becomes quite extensive.

The modern approach to VCF design is illustrated in Fig. 2. One IC, the SSM 2040, does all of the filtering and voltage control, while a single op-amp provides output buffering. As shown, the IC has been configured as a four pole low-pass filter. However by rearranging the components it is just as easy to create band-pass, high-pass, and all-pass types.

The VCF is internally compensated for second-order temperature effects. However, because it is not compensated for first-order effects, it is necessary to use a thermistor in the circuit. The thermistor (TH1) cancels the first-order effects and makes the VCF very stable.

Most synthesizer VCO's have a 10-volt peak-to-peak output. However, because the SSM 2040 requires an input of 1-volt peak-to-peak, input to it must be attenuated by a factor of ten. That is the purpose of R15. The output of the VCF is amplified by a factor of ten by the LF351.

Part of the output from that amplifier is fed back to the input (via R17 and R13) for regeneration. That peaks the response slightly at the filter's critical frequency, causing a more pronounced "wah" effect. Some of the newer VCF IC's (such as the Curtis CEM3320) include an on-chip gain cell that allows for voltage-controlled regeneration.

### Voltage-controlled amplifiers

The voltage-controlled amplifier, or VCA, is the next synthesizer block that we will discuss. It is used to impose an amplitude envelope upon the audio signal created by the VCO.

Early VCA's were composed of many discrete components, usually transistors configured as differential pairs. The differential-pair amplifier provides a fixed gain for a fixed control-current. If you change the control current, the gain changes as well.

One major trouble with the differential-pair amplifier is that input signals have to be restricted to 10 mV or less to avoid the non-linear region of the amplifier. Intolerable distortion will occur if the signal rises above that level. Obviously the 10-volt peak-to-peak audio signal from a typical VCO has to be attenuated before reaching that type of VCA, and then boosted after it. That is why the signal-to-noise ratio of the early synthesizers was rather poor.

Although the noise figure of that sort of VCA was adequate for live performance, the noise level became apparent when it came to recorded music. Pop musicians, who were starting to do a lot of recording, demanded something better. That "something better" was the Gilbert pre-distortion input. The differential-pair amplifier actually has an exponential response. The Gilbert input stage pre-distorts the audio signal in a logarithmic fashion. The logarithm of the input is then sent to the VCA where the exponential

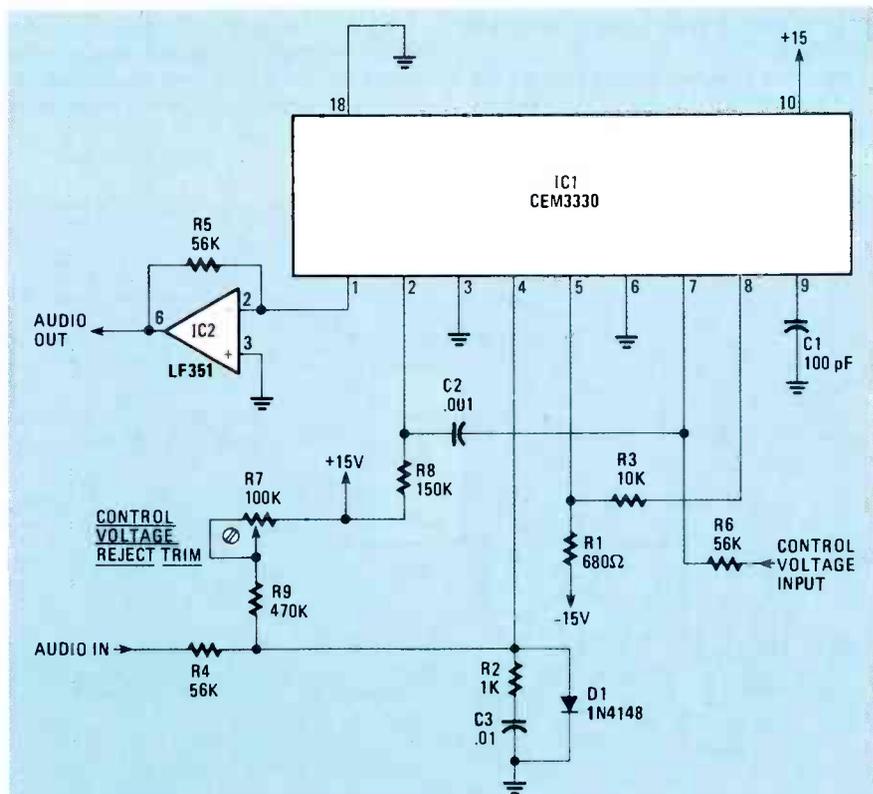


FIG. 3—MANY OF THE INPUTS of the CEM3330 are at virtual ground. That allows for easy summing of multiple inputs.

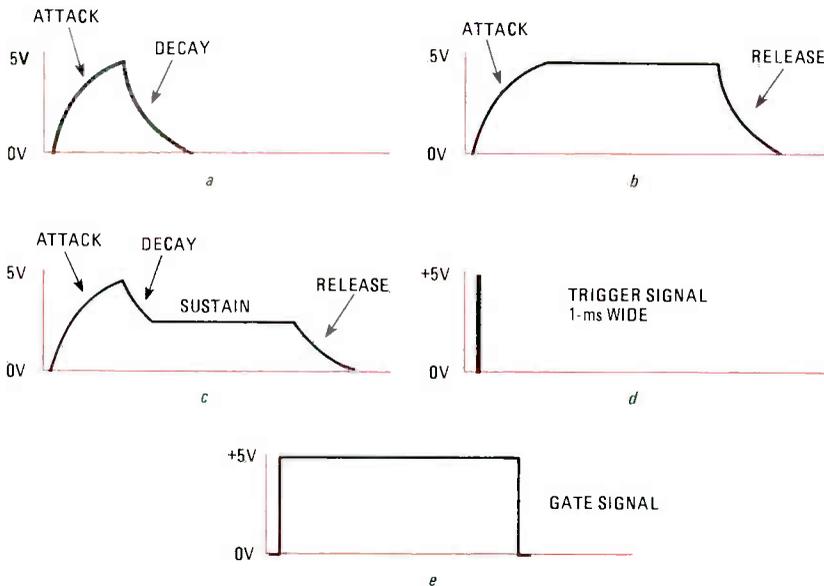


FIG. 4—TIMING DIAGRAM for some of the more common envelope generators. Each waveform requires a trigger signal, gate signal, or both.

response “unwarps” the effects of the Gilbert stage. That results in what appears to be a linear amplifier and makes possible a marked increase in the signal-to-noise ratio.

New IC’s dedicated to the VCA function now incorporate the Gilbert input-stage. A number of companies make VCA chips now, and that is probably the result of an interest in VCA’s for not only music but for other areas as well. Computer-controlled mixers in recording studios, telephone technology, radio-broadcasting equipment, and audio-frequency devices for use in other areas are all in need of good voltage-controlled amplifiers.

The most common VCA chips are the CA3280 by RCA, the LM13600 by National Semiconductor, the SSM 2000,

2010, and 2020 by Solid State Micro Technology, and the CEM3330 made by Curtis Electromusic. Some of those integrated circuits incorporate converters to give the VCA an exponential control-voltage input.

Figure 3 shows an example of a VCA configured around the Curtis CEM3330. In its simplest form, the VCA has an audio input, a control-voltage input, and an audio output.

The control-voltage input used in Fig. 3 is pin 7, the linear input. Pin 6, which is shown grounded, is an exponential control-voltage input. However, most ADSR’s (Attack, Decay, Sustain, Release—modules that are usually used to control the VCA) have an exponential output. Therefore, pin 6 is almost never used.

## Envelope generators

The last major building block of an electronic music synthesizer is the envelope generator. Its purpose is to let you control the *envelope* of the synthesizer’s output. The envelope is one of the characteristics that distinguishes the sound of the organ from that of the violin. The violin has a slow attack-time and its volume builds up to a steady state over a long time-period. The organ, on the other hand, has a very fast attack time—the sound is at full volume (almost at) the instant a key is struck and held. An envelope generator should allow the user to create either effect in addition to countless others.

In general, the envelope generator provides a non-periodic waveform that is used to modulate the amplitude of the audio signal (by means of the VCA). There are three basic types of envelope generators: AD (Attack-Decay), AR (Attack-Release), and the ADSR mentioned earlier.

The AD generator provides an attack-decay envelope (Fig. 4-a). It is usually fired by a trigger pulse like that shown in Fig. 4-d. The output of the generator is a control voltage with adjustable attack and decay times. It is most often used for percussive-type sounds.

The AR envelope-generator provides an envelope like that shown in Fig. 4-b. It is fired by the presence of a gate signal like the one shown in Fig. 4-c. The generator’s control-voltage output rises to a steady state and holds that state until the gate signal vanishes. The output control-signal then goes into the release portion of the curve. Because the AR generator is easy to design and build it has been popular in inexpensive commercial synthesizers.

*continued on page 104*

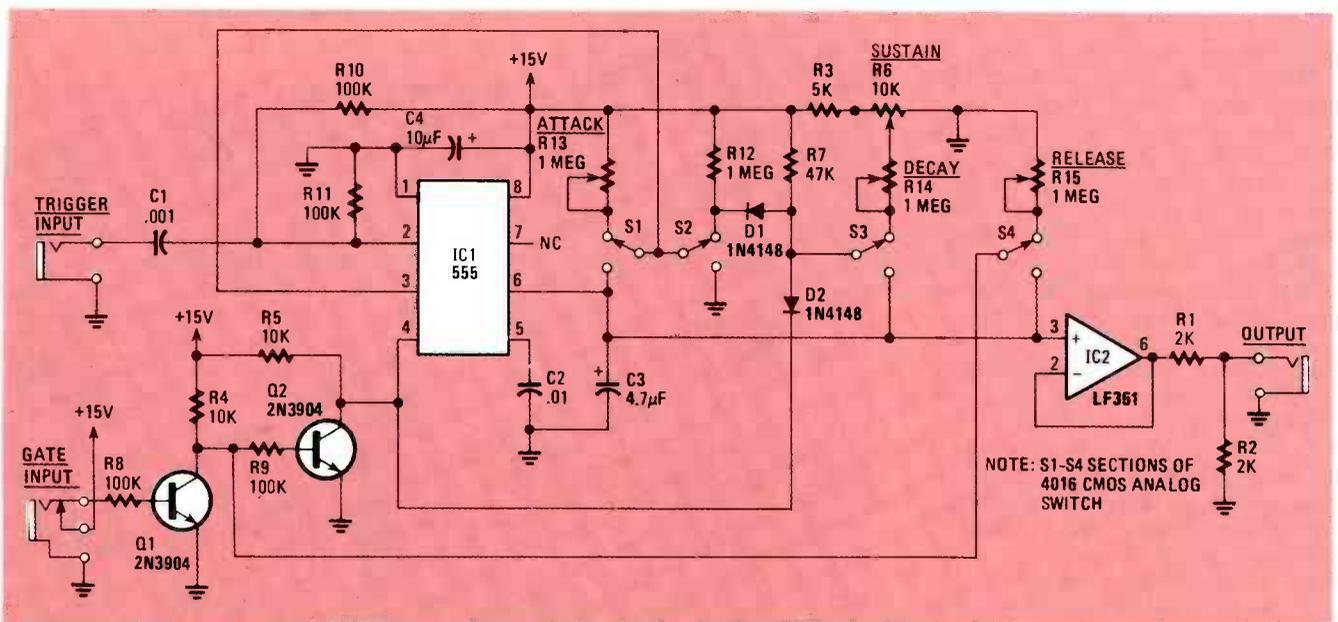


FIG. 5—THIS ADSR ENVELOPE GENERATOR circuit provides you with complete control over the attack time, decay time, sustain level, and release time.

# ALL ABOUT

JOSEPH J. CARR

FOR DIGITAL CIRCUITS AND COMPUTERS TO communicate with the real (analog) world, digital-to-analog converters are necessary. Those converters, commonly available as single IC's, allow data and information to be transferred from one world to the other.

Digital-to-analog converters (DAC's) produce an analog output that is proportional to the product of two inputs. One of those inputs is an n-bit digital word. The other input is either a reference current or a reference voltage. If that input is a reference current, then the output of the DAC can be expressed mathematically by:

$$I_O = I_{REF} \times \left( \frac{A}{2^n} \right) \quad (1)$$

where A is the n-bit digital word. If the input is, instead, a reference voltage, then the DAC's output can be expressed by:

$$E_O = E_{REF} \times \left( \frac{A}{2^n} \right) \quad (2)$$

With only a little imagination we can make the DAC perform any number of functions in which equations 1 and 2 play a part. The most obvious function, and that for which the DAC was invented, is to create a DC voltage or current level proportional to the binary number applied to the digital inputs. We could, for example, connect those digital inputs to a computer's output port. The DAC's analog output then will be proportional to

the digital value output from the computer. It will be in the form that we (in this analog world) will recognize, and it can be displayed on an oscilloscope or strip-chart recorder.

Figure 1 shows a typical 8-bit current-output multiplying DAC, the DAC-08 (Precision Monolithics, Inc., 1500 Space Park Dr., Santa Clara, CA 95050). Being a current-output device, the operation of the DAC-08 is described by equation 1. The device will produce an output current of  $(2 \text{ mA}) \times (A/256)$ , where A is the digital word applied to the digital inputs. Amplifier IC2 converts the current output of the DAC-08 to a voltage output. The amplifier output E is given by the expression  $I_O \times R3$ , so with the component values shown E will range from 0 to 5 volts.

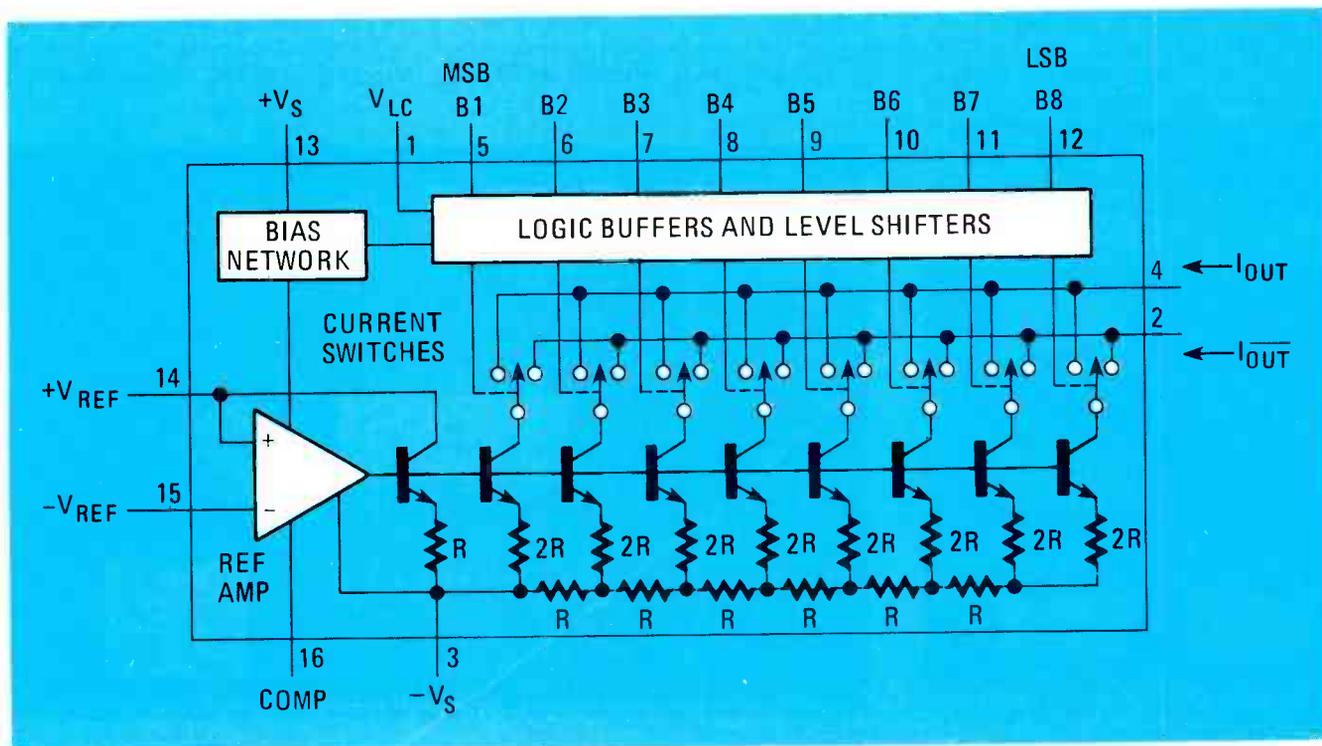
Operational amplifier IC3 is configured as a lowpass filter, and is optional. The output of a DAC is a step waveform, with each step being equal to the DAC's LSB (Least Significant Bit) voltage. The values shown in Fig. 1 will produce a gain of 2, so the output will be 10 volts for a 5-volt input. The cut-off frequency will be 1000 Hz, but circuit values can be changed to accommodate other frequencies.

## Waveform generator

A DAC can be used to generate a sawtooth output waveform by connecting its digital inputs to the output terminals of an ordinary binary counter circuit (see Fig. 2). A 7-bit CMOS 4024 counter can be used with an 8-bit DAC if the clock terminal is used as the LSB input.

# D/A Converter Applications

*A fascinating device, there's more to the digital-to-analog converter than meets the eye. Here's a closer look at the device and its applications.*



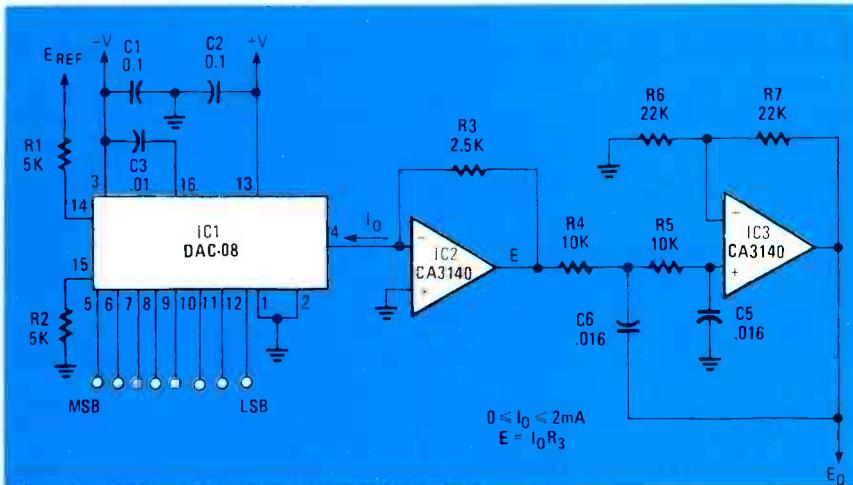


FIG. 1—A TYPICAL DIGITAL-TO-ANALOG CONVERTER, the DAC-08 used in this circuit is an 8-bit current-output multiplying device.

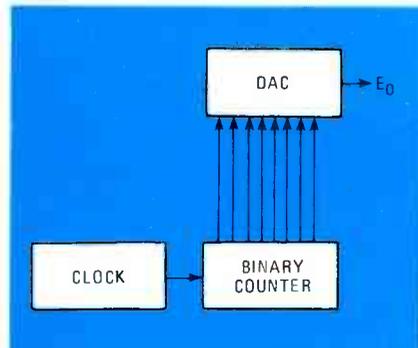


FIG. 2—A DAC CAN BE USED to generate a sawtooth waveform by connecting its input terminals to the outputs of a binary counter.

Let's see what happens. When the counter output is 00000000, the DAC output is zero. As the counter output increments, the DAC output is rising, until the counter reaches its maximum count (i.e. 11111111). At that point the DAC output is at its maximum. On the next clock pulse the counter will overflow, and reset to 00000000, so the DAC output drops back to zero. The output waveform that results is a sawtooth.

By using an up-down counter, we can

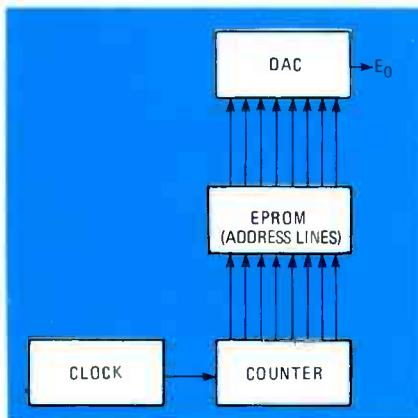


FIG. 3—ALMOST ANY WAVEFORM can be generated using a DAC. The block diagram of an appropriate circuit is shown here.

generate a positive-going (as was done above) or negative-going sawtooth. The latter requires that we count down from the counter's maximum, rather than up from zero.

A triangular waveform can also be generated using an up-down counter. If we count up from 00000000 to 11111111, and then reverse the order and count back down to 00000000 (instead of merely resetting the counter), the output waveform will be a triangle function.

We actually can generate almost any function or waveform that we desire if a circuit such as the one shown in Fig. 3 is used. The bit pattern corresponding to the points on the desired curve are stored in sequential addresses in a ROM. Those bit patterns will be applied sequentially to the digital inputs of the DAC, and cause the instantaneous value of the output voltage to change accordingly.

The clock causes the counter to sweep through the waveform by incrementing the counter outputs from 00000000 to

11111111. The frequency of the generated waveform is controlled by varying the clock speed. That type of circuit, incidentally, is used in electronic music-generation.

### Digitally controlled attenuator

Equations 1 and 2 show that a multiplying DAC produces an output proportional to two different factors; i.e. an analog reference and a digital word. Figure 4 shows how to connect the DAC-08 to accommodate a bipolar reference such as an AC signal. Current  $I_{REF}$  is equal to  $E_{REF}/R_{REF}$ , and should be 2 mA under normal operating conditions. Furthermore,  $E_{REF}$  must be greater than the peak AC value of the input signal  $E_{IN}$ .

The compensation capacitor,  $C_C$ , between the  $-V$  supply and pin 16 affects the frequency response of the DAC. The RC time constant,  $R_{REF} \times C_C$ , determines the maximum slew rate of the DAC-08. With component values of 1000 ohms and 15 pF, the slew rate will be 4 mA/ $\mu$ S.

That same circuit can be used for on-off keying of a reference signal. That is done by tying all of the digital inputs together to form a single keying terminal. When the keying terminal is low, the AC output is cut off, but when it is brought high the AC reference is passed to the output at its full amplitude.

### Op-amp offset control

A DAC can be used to control the output offset of an operational amplifier by using a circuit such as the one shown in Fig. 5. The output voltage can be expressed by:

$$E_O = \frac{-E_{IN}R_F}{R_{IN}} + \left( \frac{-AE_{REF}}{256} \times \frac{R_F}{R_1} \right)$$

We can, therefore, digitally control the output offset by varying the digital word A applied to the DAC. For current-output

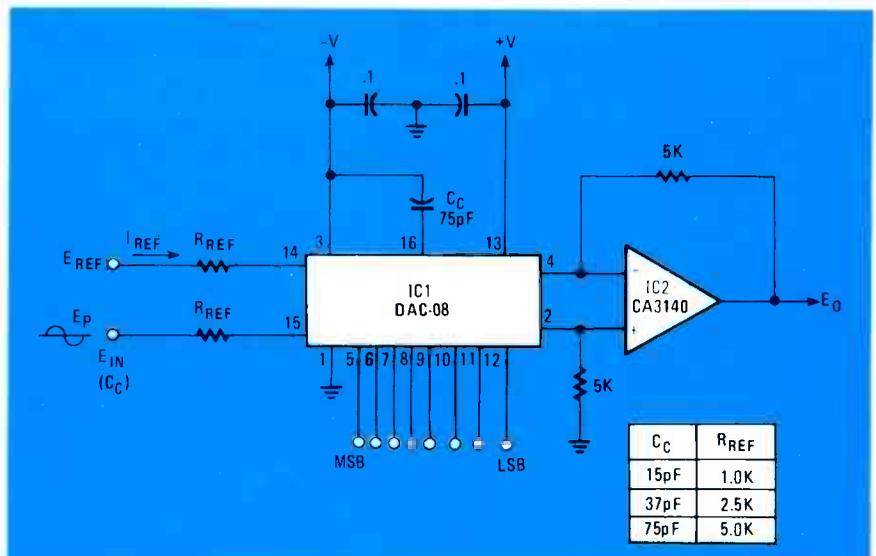


FIG. 4—THE DAC-08 CAN ACCOMMODATE a bipolar reference signal, such as an AC signal, if it is configured as shown.

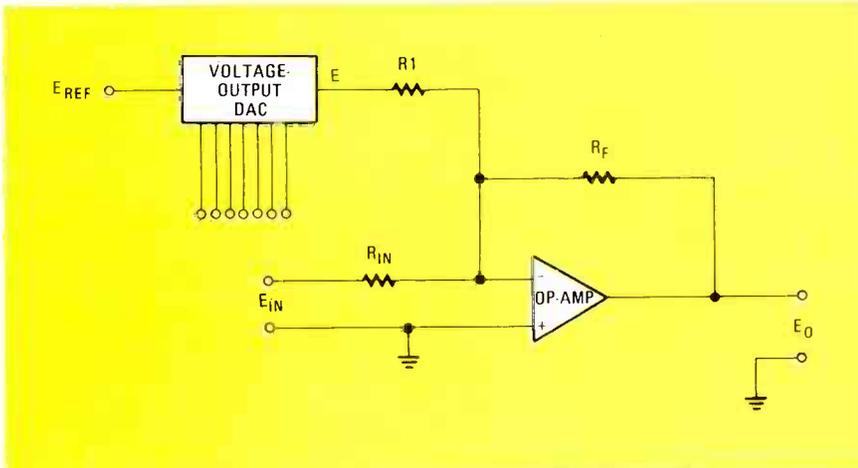


FIG. 5—THIS CIRCUIT SHOWS how a DAC can be used to control the output offset of an operational amplifier.

DAC's eliminate R1.

**Automatic zeroing circuits**

Many circuits have an offset that must be nulled before proper operation is possible. Medical, scientific, and industrial instruments, for example, use transducers to acquire data and convert it to an electrical signal. Unfortunately, almost all transducers have a certain offset voltage. That is, they will produce an output voltage even when whatever it is they're supposed to measure (blood pressure, vibration, etc.) is not present. Consider arterial blood-pressure transducers used in medical electronics. Those instruments use Wheatstone-bridge transducers to

sense the blood pressure. Theoretically, the output should be zero when the transducer is open to atmosphere. But transducer imperfections and hydrostatic pressure in the lines to the patient creates an offset in the amplifier output that must be nulled. Figure 6 shows a representative auto-zero circuit that will automatically null a circuit at the push of a button.

When power is first applied, the power-on reset circuit will reset the DAC to 00000000. When the transducer is opened to the atmosphere, a voltage will appear at the output ( $E_O$ ). That voltage represents the sum of all of the offsets in the circuit preceding that stage. When the zero button is pressed, one-shot 1 fires a

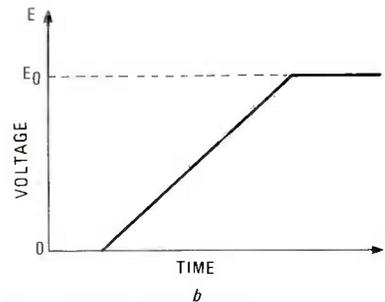
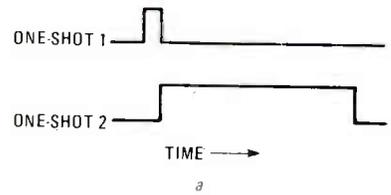


FIG. 7—TIMING DIAGRAMS for the one-shots used in Fig. 6 are shown in a; the resulting output,  $E_O$ , is shown in b.

brief pulse that ensures that the counter and DAC are reset to zero, while also triggering one-shot 2. (The timing diagrams are shown in Fig. 7). The time period of one-shot 2 is very long relative to the time period of one-shot 1 (and might actually approach one second or more). When the output of one-shot 2 is high, clock pulses are gated into the counter causing the counter and DAC to increment. The comparator will have a high output as long as  $E_O$  is not zero. Voltage  $E$ , the DAC output, will rise in ramp-like fashion as the DAC digital inputs increment (see Fig. 7). It is summed with input voltage  $-E_{IN}$  at the inverting input of the op-amp (that op-amp should be a low- or unity-gain device), so the output voltage,  $E_O$ , will drop. When  $E_O$  has dropped to zero, the output of the comparator drops low, shutting off the flow of clock pulses to the counter. The digital inputs of the DAC, therefore, remain at the last count that occurred before the comparator output dropped low. Unless the transducer offset changes, the output voltage  $E_O$  will represent only the true value of the signal, less any offset.

**Making use of a multiplying DAC**

What is a multiplying DAC? All DAC's are multiplying circuits (see equations 1 and 2); they produce an output that is the product of an analog reference and a digital word applied to the digital inputs. But in manufacturers' catalogues we note that only some DAC's are referred to as "multiplying" devices. The reason for that is that a multiplying DAC is commonly defined as a DAC that operates from an external analog reference, while one that operates only from its own internal reference is a non-multiplying DAC.

A little cleverness counts for a lot in using a multiplying DAC. You can, for example, design circuits that perform arithmetic operations and produce an an-

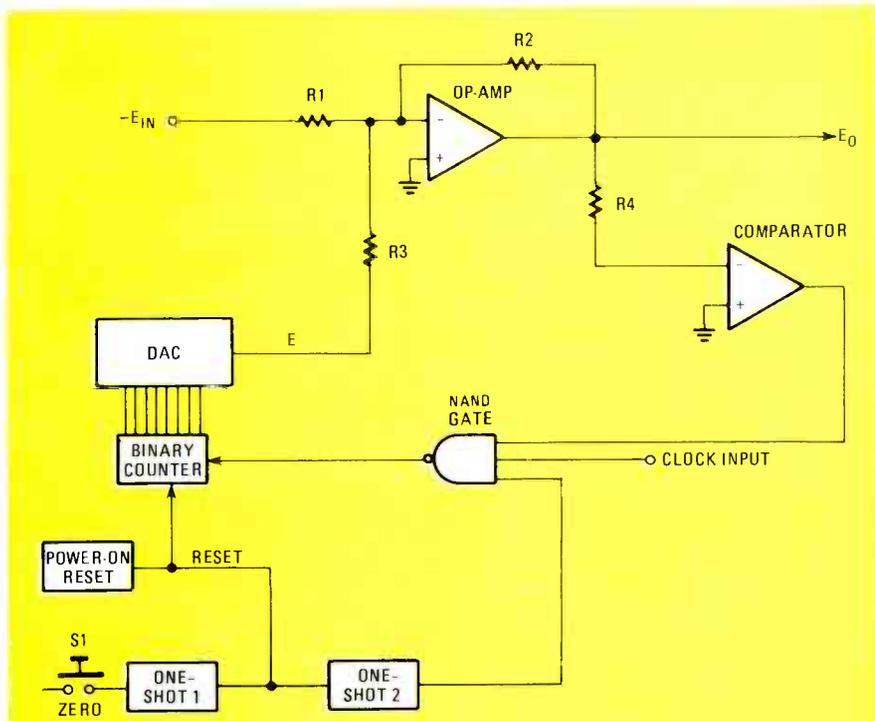


FIG. 6—A DAC CAN BE USEFUL in a circuit designed to null out any offsets in sensitive measuring equipment. Such a circuit is shown here.

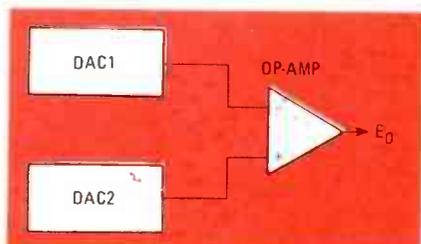


FIG. 8—TWO DAC'S AND AN OP-AMP are used in a circuit that finds the analog sum of, or difference between, two digital words.

alog output. You can also calibrate several DAC's to a single reference, thereby increasing the overall accuracy of your measurements.

Let's look at an example of an arithmetic application of the multiplying DAC, one in which it is used in a circuit that produces the analog sum or difference between two digital words. That requires two DAC's and an operational amplifier as shown in Fig. 8. Apply one digital word to each DAC. Their respective outputs are fed to the input(s) of the operational amplifier. (If the sum of the two is required, then connect both DAC outputs to the same op-amp input. But if the difference is required, connect the subtrahend—the number you wish to subtract—DAC output to the inverting input, and the minuend—the number from which it is subtracted—DAC output to the noninverting input.) The gain of the op-amp allows us to set the scaling factor (if needed), so that the op-amp output correctly represents the sum or difference between the two words.

Figures 9 and 10 show two more ways that DAC's can be used. Figure 9 shows a four-quadrant 8-bit by 8-bit digital multiplier based on the DAC-08. Two of the devices, IC1 and IC2, are connected together to make an extended range circuit, while IC3 is used to supply the analog reference for IC1 and IC2. Since the digital word applied to IC3 sets the analog reference-current applied to the other two DAC's, which are multiplying DAC's, the output will be proportional to the product of word A and word B.

Figure 10 shows a pair of DAC-08 devices connected into a ratiometric A/D converter circuit. That is the same basic circuit that is used in many A/D converters (i.e. successive approximation or binary ramp types), but with two DAC's instead of one. The resulting output word is proportional to the ratio of the two input voltages,  $V_x$  and  $V_y$ .

Ratiometric measurements are often performed by scientific, medical, and industrial instruments because they are often more reliable than actual value measurements. It seems that factors that create drift problems often affect two or more parameters, so they will cancel out if ratios are used. Take, for example transducer measurements (as previously discussed). If the transducer's excitation

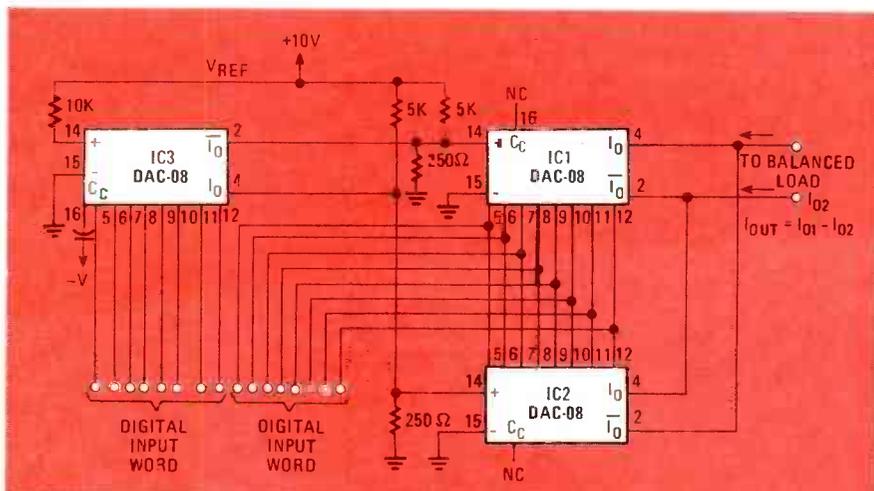


FIG. 9—THIS FOUR-QUADRANT 8-bit x 8-bit digital multiplier uses three DAC-08's. The circuit's output will be proportional to the product of word A and word B.

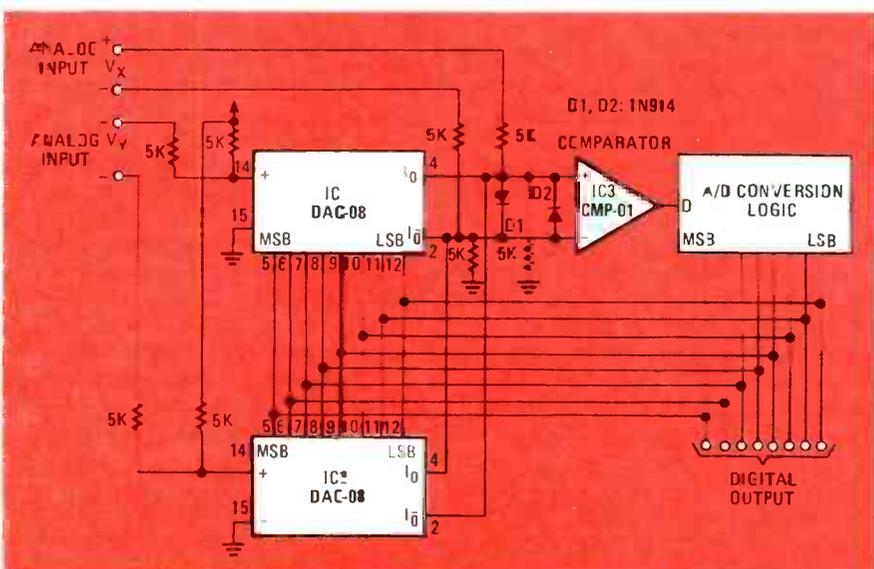


FIG. 10—A RATIO-METRIC A/D CONVERTER. Ratiometric rather than direct measurements are often made by scientific, medical, and industrial instruments for greater accuracy.

potential drifts, the resultant output-voltage change will be seen by the following amplifiers as a valid change in the signal.

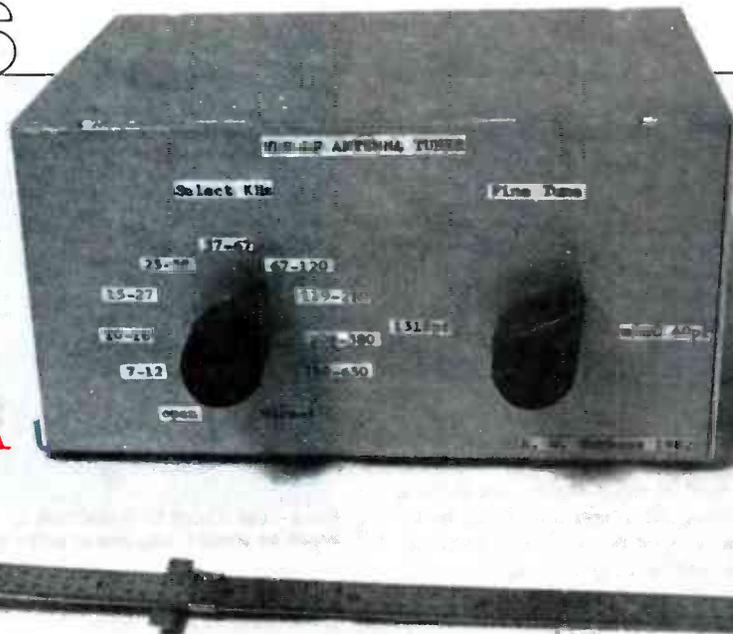
The circuitry has no way of knowing which changes are data and which are not. But we can often cancel that form of drift by using ratiometric measurements. If we apply the excitation potential to one input, and the signal potential to the other, then the output potential will be the ratio of the two inputs. If the excitation drifts, then both the excitation potential and the signal potential will change by an equal amount. The result is that no output changes occur in the ratiometric signal. But if the signal changes are valid, then the excitation potential will remain constant as the signal potential changes. The result will be a change in the output of the ratiometric circuit. The output from a ratiometric circuit is called a "normalized" output.



"The meaning of life? Just a second..."

R-E

# BUILD THIS



## PASSIVE ANTENNA TUNER

# FOR VLF-LF

One way to improve the performance of VLF-LF antennas is through the use of a passive antenna tuner. Here's the theory, and some ideas on how to use it.

R.W. BURHANS

**Part 4** PREVIOUS ARTICLES IN this series have presented some details of short active antennas for frequencies covering the range from 10 kHz to 30 MHz. Passive antenna-tuners for random-length wires are another approach to the problem of good signal reception. Commercial models are available, but they are usually designed for the medium- and shortwave bands above 150 kHz; only one system claims to be effective all the way down to 10 kHz.

Since the greatest reception problems are encountered at low frequencies, let us discuss the design of selective antenna tuners covering the range of 10 kHz to 500 kHz.

### Antenna lead-in

It is interesting to consider the idea of locating the antenna tuner at the receiver, with the antenna wire connected by a length of coaxial cable to the receiver and tuner as illustrated in Fig. 1. One problem

at low frequencies is that the shunt cable-capacitance,  $C_c$ , in parallel with the antenna capacitance,  $C_a$ , reduces the sensitivity by the factor:  $C_a / (C_a + C_c + C_i)$ . By choosing a length of relatively high impedance, low-capacitance cable, it is possible to design a tuner that takes into account the cable capacitance as part of the tuner network, and that can operate

with up to 50 feet (about 15 meters) of cable separating the antenna wire from the receiver and tuner. That antenna will be less effective than an active-antenna preamplifier system for the same length of antenna wire, but there will be fewer problems of intermodulation distortion because of the high selectivity, and no active preamplifier is involved. The

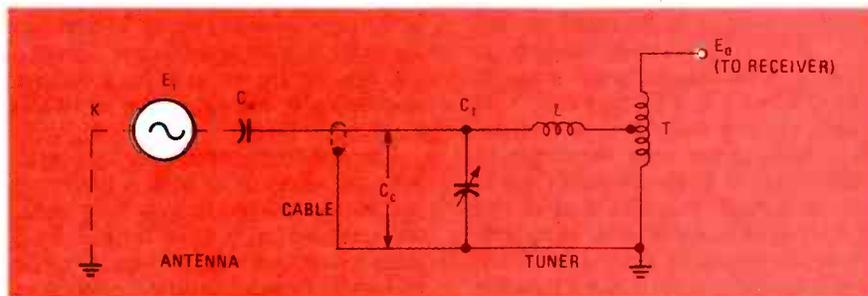


FIG. 1—IT IS IMPORTANT to take into account the capacitance,  $C_c$ , added by the coaxial cable between the antenna and tuner.

TABLE 1

Frequency range (kHz)	Inductance (mH)
10-16	150
15-27	68
23-38	33
37-67	10
67-120	3
119-210	1
208-380	0.3
380-630	0.1

advantage of having the antenna tuner located at the receiver is obvious. The coaxial lead-in helps reduce local-noise pickup since the antenna wire can be located away from power lines, home appliances, and other noise sources.

**Design considerations**

To design such a tuner system we must first measure or estimate the total minimum capacitance, including the antenna, cable, and minimum tuning capacitance. A relatively-high-value tuning capacitor is required, having a value several times greater than the total minimum capacitance. We chose a 3-gang variable capacitor, each section having a range of about 12 to 440 pF, like those found in older-style AM radios (commonly referred to as 360-pF units). They are still available new at rather high prices, but similar devices can often be found at surplus-electronics-parts stores.

Taking all the components together, the total minimum capacitance is:

Antenna capacitance	120 pF
Cable capacitance	360 pF
Minimum tuning capacitance	36 pF
Total minimum capacitance	516 pF

The total maximum capacitance (with the tuning capacitor fully meshed) is:

Antenna capacitance	120 pF
Cable capacitance	360 pF
Maximum tuning capacitance	1320 pF
Total maximum capacitance	1800 pF

**Tuner circuit**

Now that we have estimated a capacitance range for the tuning circuit of 516–1800 pF, a set of inductors is needed that will resonate with that capacitance at the frequencies we're interested in. The ratio  $\sqrt{1800:516}$  gives us the tuning range for a given fixed inductor in the circuit—a range of about 1.86:1 for each coil. A set of inductors that will provide the results we're looking for over the range of 10–500 kHz can be chosen from Table 1. The inductors are connected in series with the antenna and cable lead-in, along with a very-low-resistance toroidal coupling-transformer designed to match a 500-ohm load at the receiver as shown in Fig. 2. The inductors are selected so that each

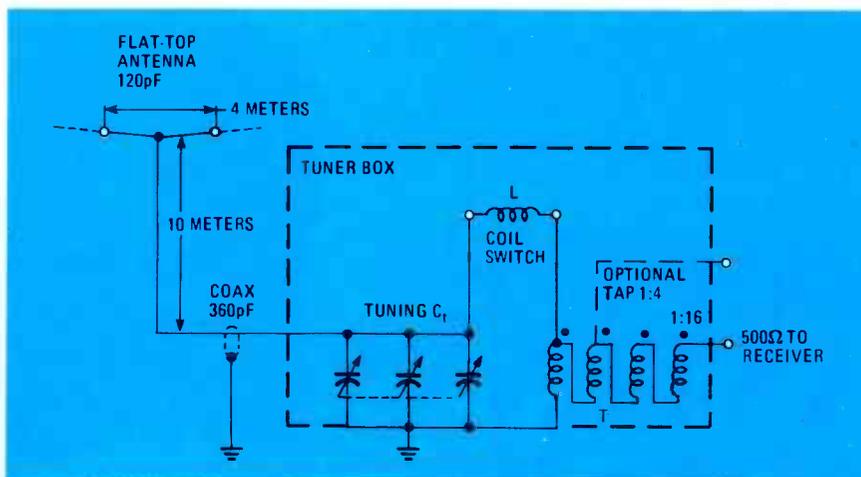


FIG. 2—THE VALUE OF INDUCTOR "L" can be determined from Table 2. In practice, several inductors would be present, only one of which would be switched into the circuit at a given time.

TABLE 2

Midband frequency (kHz)	Loss (db)	Q	Bandwidth (kHz)	Inductance (mH)	Inductor part number
13.9	-24	47	0.3	150	Mouser 43LJ415
20.1	-17	92	0.22	68	Mouser 43LJ368
30.1	-15	56	0.54	33	Mouser 43LJ333
52.7	-10	53	1.0	10	Mouser 43LH310
93.6	-9	36	2.6	3	Mouser 43LH233
168	-8	22	7.7	1	Mouser 43LH210
298	-9	12	24	0.3	Mouser 43LR334
518	-9	12	42	0.1	Mouser 43LR104

frequency range will overlap the next slightly; that means an inductance change of less than  $(1.86/1)^2$  between each set of coils selected for this example.

The wideband-output coupling-transformer takes the place of an additional set of parallel inductors to match the receiver's input impedance. In addition to the capacitive-divider loss at the antenna input, the transformer in series with a high reactance coil adds an insertion loss at the low-frequency end. That is, in part, compensated for by a higher Q. That selectivity decreases at higher frequencies, but gain increases. When connected to the 500-ohm receiver input-terminals, the low-impedance-input tap point of the output transformer looks like a 30-ohm load to all the coils. That is about the best that can be achieved because of the very wide variation in reactance and L/C ratio of the input network, but the overall performance is quite satisfactory, considering that we are using a single output-transformer to cover the range of 10 kHz to over 500 kHz.

The coil arrangement uses a multiple-position selector to switch frequency ranges and has a constant bandwidth-characteristic for each coil. That is, the Q for a given coil will be highest at the minimum capacitance-setting, decreasing by an amount equal to about the tuning ratio at maximum capacitance. The

results obtained using low cost RF-choke-type inductors with the 120-pF antenna are shown in Table 2. The antenna used was a 10-meter-high, four-meter flat-top.

**Input-capacitance variations**

If you use an antenna wire or cable with more or less capacitance than the one we did, the inductance ratios will have to be computed for a different set of coils. The cable we used was surplus marked "FT&R Corp. Type K 109," and measured only 8 pF/ft. Thus, 45 feet of cable had a capacitance of  $45 \times 8 = 360$  pF. For other high-impedance cable such as RG62, with a capacitance of 13.5 pF/ft., 360/13.5, or 27 feet, would be used with the same variable capacitor and coil-set. You may be able to find some high-impedance, low capacitance cable of the type used in automobile-radio installations. Each different system will involve a session of L-C calculations to match inductances and capacitances to the frequency range desired.

The following two formulas will help in those calculations:

$$f = \frac{10^6}{2\pi\sqrt{LC}}$$

$$L = \frac{10^{12}}{(2\pi f)^2 C}$$

TABLE 3

Frequency	10 kHz	400 kHz
Capacitive loss factor $C_a/(C_a + C_c + C_t) = C$	-23dB	-12dB
Ground loss factor estimate = K	-26dB	-14dB
Measured network loss with antenna & cable capacitance = N	-24dB	-9dB
Antenna-to-receiver Z loss-factor, direct, no cable $500/X_{Ca} = A$	-49dB	-17dB
Antenna sensitivity without tuner or cable = K + A	-75dB	-31dB
Antenna sensitivity with tuner and cable = K + N	-50dB	-23dB
Net improvement in sensitivity $(K + N) - (K + A)$	+25dB	+8dB

were determined on the bench using a signal generator. Actual antenna performance will be somewhat worse than indicated by the loss factor because it will also be affected by the ground coupling K factor. (See Part 1, in the February 1983 issue of **Radio-Electronics**.) In our tests, K varied from .05 (an additional -26 dB) at 10 kHz to about 0.2 (-14 dB) at 400 kHz.

An estimate of overall efficiency made by comparing the wire antenna connected directly to the 500-ohm input of the receiver with the same antenna connected through the coaxial cable and tuner to the receiver, is illustrated in Table 3. From that table you can see that there is an overall improvement of 25 dB at the bottom of the VLF band (10 kHz), which decreases to only 8 dB at the high end of the LF band (400 kHz).

The high antenna-loss factors shown

**PARTS LIST—PASSIVE TUNER**

- C<sub>t</sub>—three-gang tuning capacitor, 12-440 pF per gang (Allied 695-4200 or similar)
- T—quadrifilar toroidal transformer, 28 turns of four No. 30 insulated wire, twisted four-turns-per-inch on Amidon FT82-75 (or similar) core
- L—RF-chock-type inductor(s) (see Tables 1 and 2)
- Miscellaneous: high-impedance low-capacitance coaxial cable, rotary switch, metal enclosure, connectors, etc.

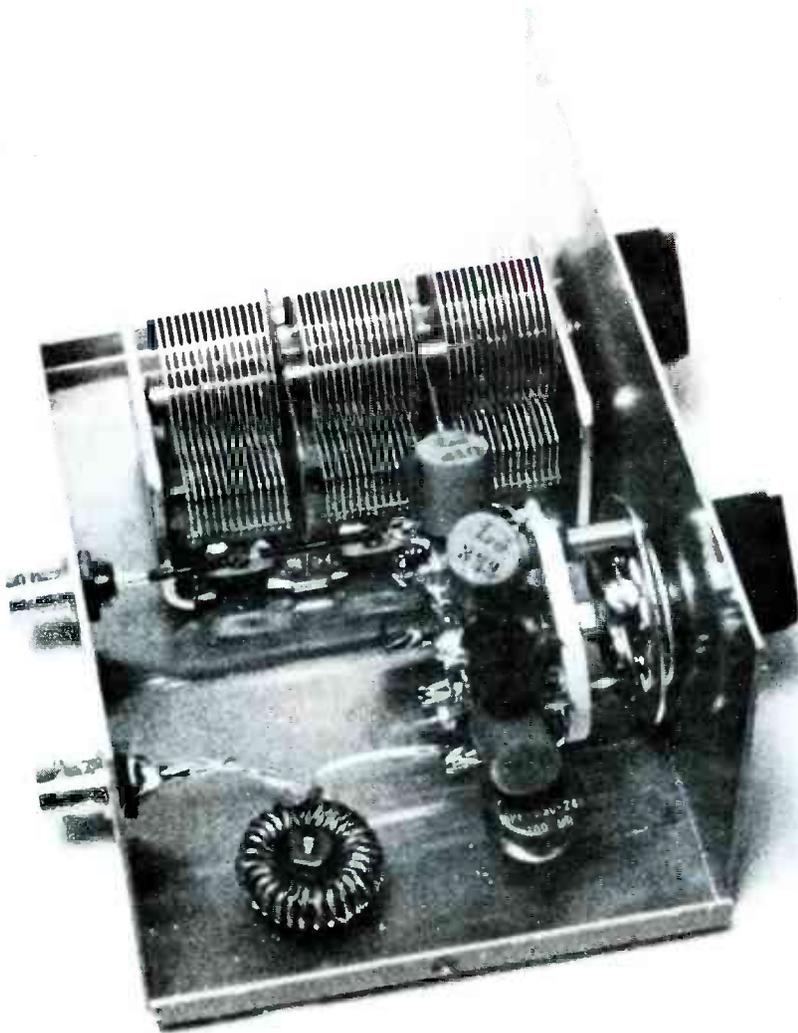


FIG. 3—INTERIOR OF THE AUTHOR'S prototype tuner. Note inductors mounted on rotary switch.

where f is the frequency measured in kHz, L is the inductance measured in  $\mu\text{H}$  (1000  $\mu\text{H} = 1\text{mH}$ ), and C is the capacitance in pF.

**Performance data**

Table 2 illustrates well the Q and mid-band loss of the tuning network with the antenna and cable connected; the figures

are typical of what happens when a random wire is connected directly to a 500-ohm receiver-input. The tuner provides an obvious improvement that is roughly proportional to the Q of the tuned circuit. In addition to increased sensitivity, the antenna tuner also provides high selectivity with practically none of the preamplifier or receiver IM problems noted with active antennas. On the other hand, active-antenna systems have better sensitivity.

The antenna tuner's narrow bandwidth requires that it be peaked whenever you shift frequency. That's easy to do if you have an S-meter, or you can listen for an increase in the signal- or background-noise level from the receiver as you adjust the tuner. For experimenters who wish to vary that method of antenna tuning, there are many factors to consider. The antenna's Q is limited by both the coils used and the series resistance of the network. That means that, even with the very best of inductors, the series resistance of the high-impedance cable and the output transformer, as well as the ground resistance, will ultimately affect performance. At the higher frequency-ranges, a lower Q is inherent in the system because of the lower coil reactance compared to the resistance in the system. Another variable is

the turns ratio of the output transformer.

One possible improvement that could be made after inspecting the data in Table 2 would be to switch the tap on the output transformer for a 4:1 ratio for the frequencies below 50 kHz, where the coils' resistance and loss are much higher. The 16:1 tap could be used for the coils for 50 kHz to 500 kHz, where the loss is relatively constant at 9–10 dB. That change would result in a lower Q for the larger inductors, but a net improvement in power transformation to the receiver as suggested in the circuit shown in Figure 2.

Figure 3 shows the parts placement in the experimental version of the antenna tuner. The inductors are mounted radially around the switch, with the output-transformer toroid toward the rear of the housing near the receiver-output terminal. The prototype shown had an extra non-standard inductor at the lowest-frequency switch position for reception below 10 kHz.

### Antenna-capacitance measurement

Most experimenters own a signal generator, oscilloscope, and frequency counter. They can be used to get a good estimate of the antenna's capacitance by following the method shown in Fig. 4. That is a simplified return-loss method where a small series-resistor takes the place of a 3-dB hybrid transformer. The resistor should have a value much lower than the reactance of the inductor at the frequency at which the measurement is made. Resistors in the range of 50 to 100 ohms, together with inductors having known values between 5 and 10 mH, can be used for antenna-capacitance measurements over the range of 10–500 pF for frequencies between 50–500 kHz. It is a good idea to make a preliminary estimate of the antenna capacitance by using the approximation of 10pF/meter of antenna length for wire antennas, and to use that figure as a rough guide to values for use in the initial test. After estimating the antenna's capacitance, the resonant frequency can be checked by substituting a capacitor of about the same value as that calculated for the antenna.

In our case, the flat-top antenna was terminated on a back porch, where it was easy to connect various pieces of test apparatus—and even a receiver—directly to its base. Variations on the substitution method can be used to measure cable capacitance with known inductors, or for unknown inductors with known capacitors, or even for coil distributed-capacity, using difference methods with known capacitors in parallel.

### Mutually-coupled antennas

An interesting effect occurs when a tuned wire antenna is placed very near a short wideband active-antenna whip. The vertical active-antenna system is mounted at ground level, directly underneath the flat-top antenna at a distance

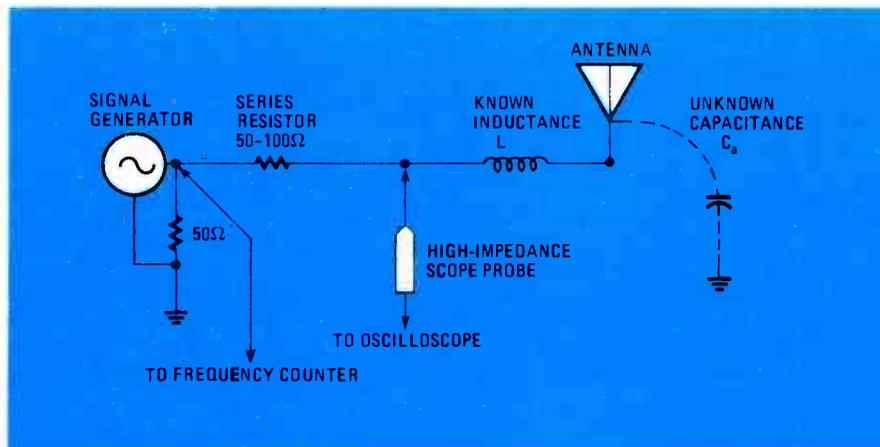


FIG. 4—TEST SETUP FOR DETERMINING antenna capacitance. Oscilloscope is used to observe slight dip in response at resonant frequency of system as frequency of signal generator is slowly varied.

of 5 to 10 meters (about 15–30 feet). The flat-top is connected to the tuner, but the output of the tuner is terminated with a resistor instead of the receiver. The active-antenna system is connected to the receiver as illustrated in Fig. 5. You may find that the amplitude of received signals is increased by 20 dB or more when the passive flat-top antenna tuner is tuned to resonance at the same frequency. That is an example of very-near-field mutual coupling. The active whip at ground level can be tuned for considerably increased sensitivity by placing it very near another tuned-antenna system.

That phenomenon could possibly be used to make directive VLF-LF arrays

antenna-effects due to things like drain pipes, gutters, power lines, telephone cables, trees, etc. Most of those can probably be accounted for by mutual-coupling phenomena, but are difficult to estimate or compute because of the unknown field-boundary conditions at a given location.

As we have seen, a single series-tuned inductor can improve the efficiency of a short-wire antenna at the VLF-LF range by 20 dB or more compared to the wire alone when connected to a typical 500-ohm receiver-input terminal. Local-noise pickup can be reduced by using a length of low-capacitance cable to connect the antenna to the receiver/tuner.

A dominating feature of passive VLF-

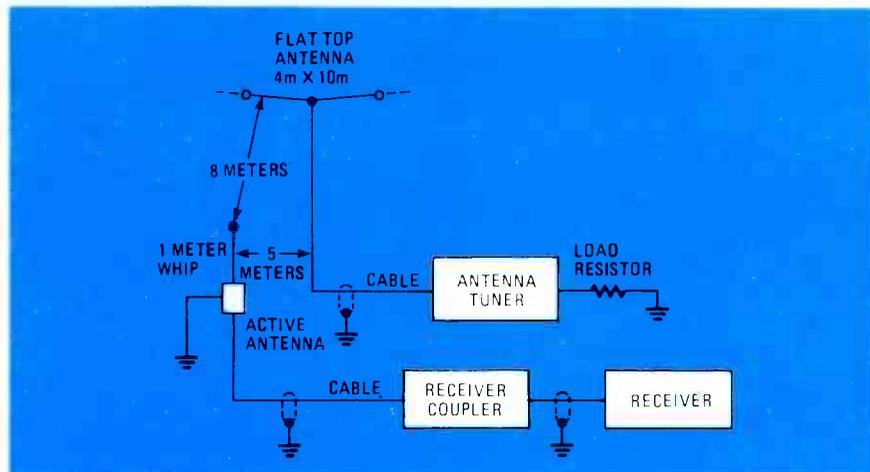


FIG. 5—MUTUAL COUPLING of antennas—one passive, one active—can improve performance by as much as 20 dB.

with very close spacings of 1/1000 wavelength or less between several tuned antennas and the excited active probe. Such a system, though, would probably require good series-inductors, and would be difficult to tune—the relative phase-change between antennas would be very steep because of the high Q of the tuned circuits.

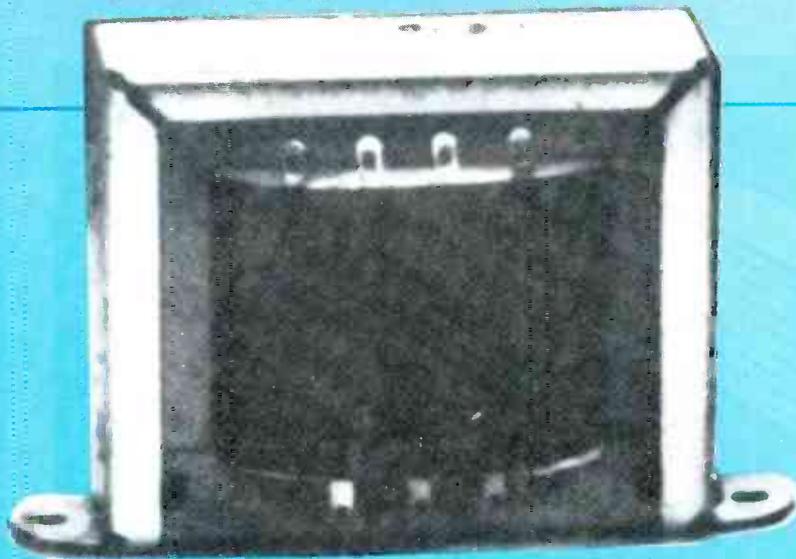
VLF observers report many unusual

LF short-wire antennas is their relatively high loss compared to the theoretical field available in space above the antenna. To offset that, though, an antenna tuner provides a considerable reduction in interference, along with high selectivity and no intermodulation distortion at the receiver input. It also offers improved sensitivity, compared to the antenna without a tuner.

R-E

# HOW TO

## REWIND TRANSFORMERS



DON A. MEADOR

*If you can't find the right transformer for your project at the right price, there's an easy solution—rewind one! As this article shows, the job is not as difficult as you might think.*

ONE OF THE MOST IMPORTANT PARTS OF A power supply, whether it be for a project or your bench, is the transformer. If you've had much building experience, however, you know that getting the right transformer—one with appropriate voltage and current ratings—can be difficult and/or expensive. That's doubly true if you need something other than a "standard" voltage.

The easiest and most economical way to solve those problems is to rewind a readily available or inexpensive transformer. This article focuses on two aspects of the task: specifications, and the general guidelines for rewinding transformers. Also, we'll look at a practical example—how to rewind a transformer with a rating of 18 volts at 2.5 amps into one with a rating of 7 volts at 4.5 amps.

### Manufacturer's specifications

Transformer ratings are usually given in RMS values. A secondary rated at 12.6 volts center-tapped at 1 amp means 12.6 volts RMS is across the entire secondary and that no more than 1-amp RMS can be drawn safely from it. The voltage from either end of the secondary to the center tap is one half the voltage across the entire secondary, or, in this case, 6.3 volts RMS. The current that can be supplied by each part of the secondary simultaneously is equal to the current rating of the entire secondary, or, in this case, the halves of the secondary can supply 1-amp RMS each.

The secondary's output ratings are based on the assumption that a particular RMS voltage will be applied to the pri-

Photo courtesy of Ameccon Inc.

mary of the transformer. Favorite values used by manufacturers are 110-, 117-, and 120-volts RMS. Note that while any transformer you buy new will have the ratings stamped either on it or its packaging, surplus or salvaged transformers usually will not. For the remainder of our discussion we will assume that the input to the primary is 117-volts RMS.

Since the maximum power capability of a transformer depends on the cross-sectional area of the iron core, the maximum power that a transformer can deliver is a constant. But any combination of voltage and current is possible provided that the voltage times the current is less than or equal to the transformer's wattage rating. Thus, if the manufacturer rates the secondary for 25.2 volts at 0.5 amps, it means that the transformer can supply 12.6 watts ( $P = V \times I = 25.2 \text{ volts} \times 0.5 \text{ amps} = 12.6 \text{ watts}$ ). It also means that the transformer can handle any combination of voltage and current, so long as the product of the two is less than or equal to 12.6 watts—6 volts at 2.1 amps, for example.

Besides the wattage rating, the cross-sectional area of the wire used in the transformer puts a limitation on the amount of current that it can supply. If a transformer's secondary is rated for 22.5 volts at 2 amps, the manufacturer has told us that the wire used in the secondary will safely supply 2 amps RMS at any voltage, provided the transformer is capable of handling the resulting power.

### Finding specifications on your own

If you have a salvaged transformer, information about its voltage, power, and

current ratings is usually not available. That information is not that hard to find, however, if you follow these simple steps:

To find the voltage rating of the secondary, first find which wire belong to the primary winding. Most electronics handbooks provide a complete color code for the transformer's wires, but let's sketch out the essentials here.

The two black wires on the transformer lead to the primary and are where the 117-volts RMS line-voltage is applied. The wires to each secondary have a different color set. The wires to one secondary, for instance, may use a red color set—two solid red wires and another red wire with a different color stripe. The striped wire is the center tap of the secondary. If a secondary does not have a center tap, only two wires will be found in that color set. With the primary and secondaries identified, you simply use an AC voltmeter to find the voltages required.

To do that, hook the transformer up to your household power line and measure the voltages on each winding. **Be very careful** in performing this step. The best way to go about it is to wire a plug to the primary, attach the AC voltmeter to the winding you want to measure, and make sure that there are no exposed or touching bare wires before plugging in the transformer. To find the voltage simply plug in the transformer and read the voltage on the meter. Take enough measurements so that you know the voltage across each secondary, the voltage to each center tap, and the voltage applied to the primary. For safety, be sure to disconnect the power before you switch the meter leads.

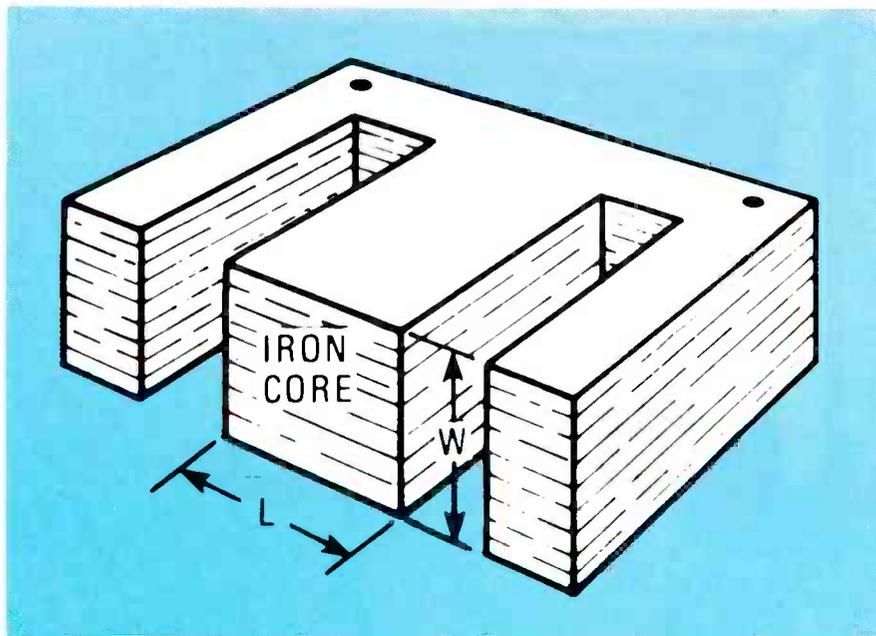


FIG. 1—TO FIND THE cross-sectional area of the transformer core, multiply  $L \times W$ . Be sure to measure  $L$  and  $W$  in inches

To find the power rating of the transformer, first find the cross-sectional area of the core by multiplying  $L \times W$  as shown in Fig. 1. Be sure to measure  $L$  and  $W$  in inches so the cross-sectional area is calculated in square inches. Then, using Table 1, find the approximate wattage rating that corresponds to the cross-sectional area.

It is possible to reuse the wire from the original secondary for the new secondary. If the rating of that wire is not known, and there is only one secondary, the maximum current that the wire can safely handle is equal to the power capability of the iron core divided by the voltage of the winding. When there is more than one secondary, you would be better off to use the cross-sectional area of the wire used in each secondary to determine its current-handling capability (more on that later).

### Rewinding a transformer

Since rewinding a primary is a job that should be avoided if at all possible (suggestions for handling that messy task will be given later on), the best transformers to rewind are those in which the primary is wound closest to the iron core. Transformers with a high-voltage secondary often have that winding wrapped next to the core, the primary wrapped on the outside of the high-voltage secondary, and finally the low-voltage secondaries as the outermost layer. Transformers with only one low-voltage secondary (less than 110 volts) usually have the primary wound closest to the core and the secondary on the outside. There is no way of knowing where the secondaries are until you disassemble the transformer.

The first step in rewinding a transformer is to determine what size transformer

TABLE 1

Cross-Sectional Area (Square Inches)	Power (Watts)
1	45
1.25	50
1.75	75
2	120
2.25	150
2.75	230
3	275
3.25	330
3.75	440
4	520

baked. That is done to keep the transformer from buzzing and to seal it from the environment; it also makes the laminations hard to remove. As each lamination is removed, the enamel holding it must be broken off; when doing so it is very easy to damage the transformer's wires, so great care must be taken.

The first few laminations are hardest to remove. To break the enamel seal, take a very small screwdriver and slip it between the outside edges of the lamination you're removing. If you ruin a few laminations at first, don't worry—you won't be able to get all of them back in anyway when the transformer is reassembled. Set the transformer on a piece of plywood so that the lamination that you are removing projects over the edge as shown in Fig. 2. Working alternately at either end of the exposed lamination, lightly tap the screwdriver until the enamel on the inside of the core breaks loose. Then remove the lamination.

After a few laminations are removed, one of the "P"-shaped laminations can be

you need. To calculate the power that is required, multiply the voltage you need by the current you need.

Using Table 1 you can approximate the core size you need. If the core size is not given in a catalogue, the total power capability of a transformer can be found simply by adding the power rating of each secondary.

After you get the transformer, check the voltages using the technique we discussed earlier. The next step is to disassemble the unit. Take out the screws and anything else holding the transformer together. Usually the laminations are soaked in a special enamel and then

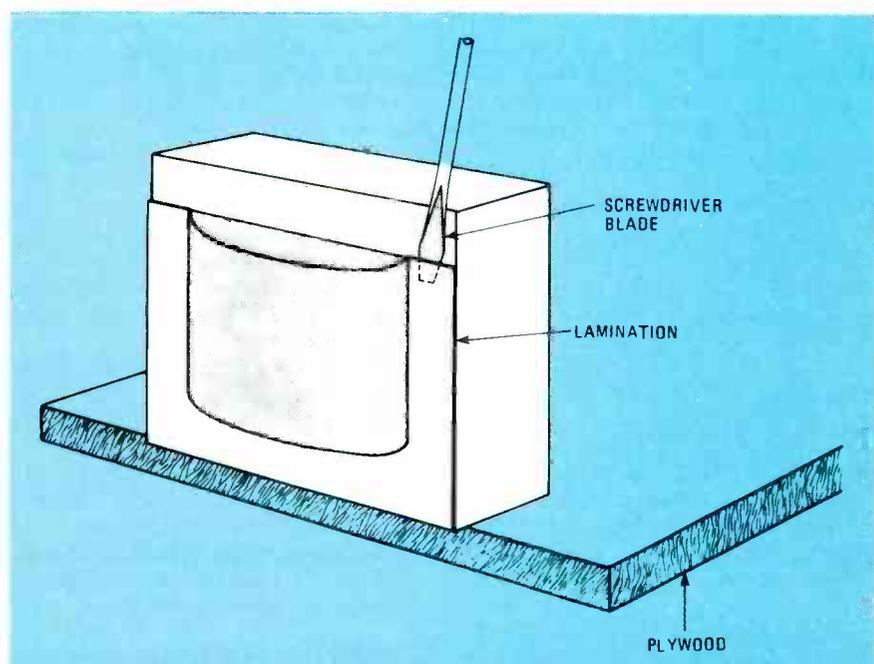


FIG. 2—TO REMOVE THE laminations, position the transformer as shown, slip a small screwdriver under the first lamination, and tap lightly with a hammer.

used to break the enamel seal on the remainder—the ones inside the coil—as shown in Fig. 3. You will still have to tap lightly with a hammer, but the “I” piece will be easier to use and cause less damage than a screwdriver.

After removing the laminations, the next step is to unwind the secondary. As you unwind the wire, count the number of turns. When the secondary is completely unwound, calculate the turns-per-volt by dividing the turns counted by the voltage previously measured on the secondary. For example, if the output from the secondary is 12.6 volts RMS and it has 40 turns, the turns-per-volt ratio is 3.175. When there is more than one secondary, the turns-per-volt ratio for each should be the same. If not, you have miscounted. In that case, use the average of the different values.

If the voltage measurements were made with something other than 117-volts RMS applied to the primary, you need to adjust the turns-per-volt value. Or, if the line voltage in your house was 112-volts RMS when you measured the secondary voltage, but most times your line voltage is 120-volts RMS, you may want to calculate the turns-per-volt value with 120 volts RMS applied to the primary. The following formula allows you to do that:

$$T_T = \frac{E_{MEAS}}{E_{NEW}} \times T_C$$

where  $T_C$  is the calculated turns-per-volt,  $E_{MEAS}$  is the voltage applied to the primary when the values were measured for the  $T_C$  calculation,  $E_{NEW}$  is the voltage you are recalculating for, and  $T_T$  is the turns-per-volt ratio with  $E_{NEW}$  applied to the primary.

The next step is to determine the number of turns you need by multiplying the turns-per-volt calculated above by the voltage you want. In the above example, if you want 6-volts RMS, then you need 19 turns (6 volts  $\times$  3.175 turns-per-volt). Keep in mind that the wire you use must be capable of handling the maximum current you desire.

The amount of current that a wire can handle, whether used for the primary or secondary, depends on the wire's cross-sectional area. The easiest way to determine its current-handling capability is to use one of the wire tables found in most complete electronics handbooks. Measure the wire's diameter in mils, using either a micrometer or a wire gauge, and using the table find the maximum current that the wire is rated to handle. The cross-sectional area of a wire is measured in a unit called the *circular mil* (a circular mil is equal to the cross-sectional area of a wire with a diameter of one mil) and wire tables often include that data for a given wire diameter or gauge. Generally speaking, a cross-sectional area of 600 mils per ampere is satisfactory for small

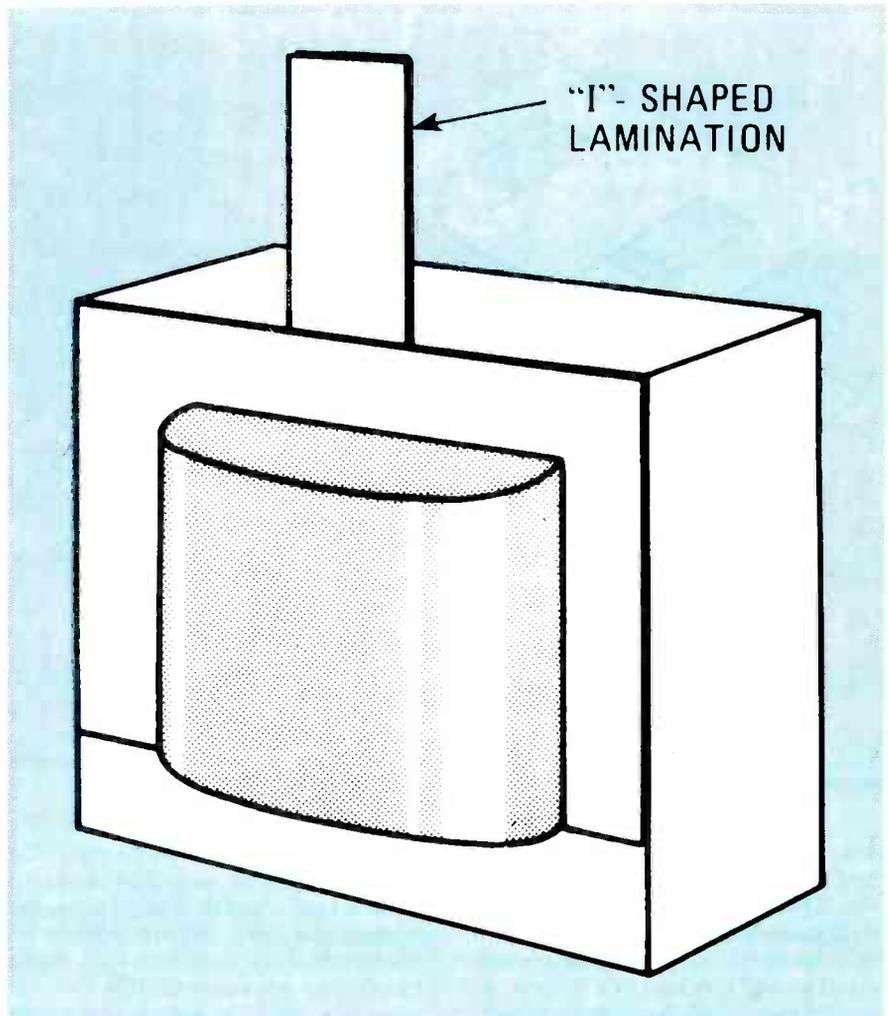


FIG. 3—AFTER A FEW laminations are removed, one of the “I”-shaped laminations can be used in place of the screwdriver.

transformers, although areas of 500 to 1000 mils are commonly used. If you are unsure about how heavy a wire you require, it is best to remember that the larger the cross-sectional area, the cooler the transformer will operate; so choose as heavy a wire as is practical.

It's best to use new wire for the new secondary, but, as we previously mentioned, if you're careful the old secondary's wire may be serviceable. Bend old wire as little as possible, and do not use it if there are any spots where the enamel has flaked off.

Once the proper wire has been chosen, the next step is to wrap the secondary. Wrap the wire without leaving any space between turns to get the maximum number of turns in the minimum amount of space. Put wax paper, duct tape, or some other type insulation capable of withstanding the maximum voltage of any one winding between each layer. The outside of the last layer should be covered extra well and taped tightly for both your and the transformer's protection.

The last step is to reassemble the transformer. Fig. 4 shows how to fit the “I”- and “E”-shaped laminations together. Most likely, there will be two to four “I”

and “E” laminations left over—you will not be able to squeeze those laminations back into the core, but that will not substantially affect the power rating of the transformer.

### Rewinding a primary

Rewinding a primary becomes necessary if the primary on the transformer you have chosen is not wound closest to the iron core. That task is not recommended, but the information is included here for the industrious.

After the turns-per-volt ratio has been calculated, the number of turns on the primary can be determined by multiplying the turns-per-volt ratio by the primary voltage. Using the example of the previous section and assuming the turns-per-volt was calculated with a primary voltage of 117 volts, the primary requires 371 turns (117 volts  $\times$  3.175 turns-per-volt). The alternative to that procedure is to actually count the turns of the primary, which may lead to errors.

Under the secondary's and primary's wire there is usually a cardboard or plastic form. Wrap the new primary and secondary on that form so that the laminations will fit into the new windings. Use the

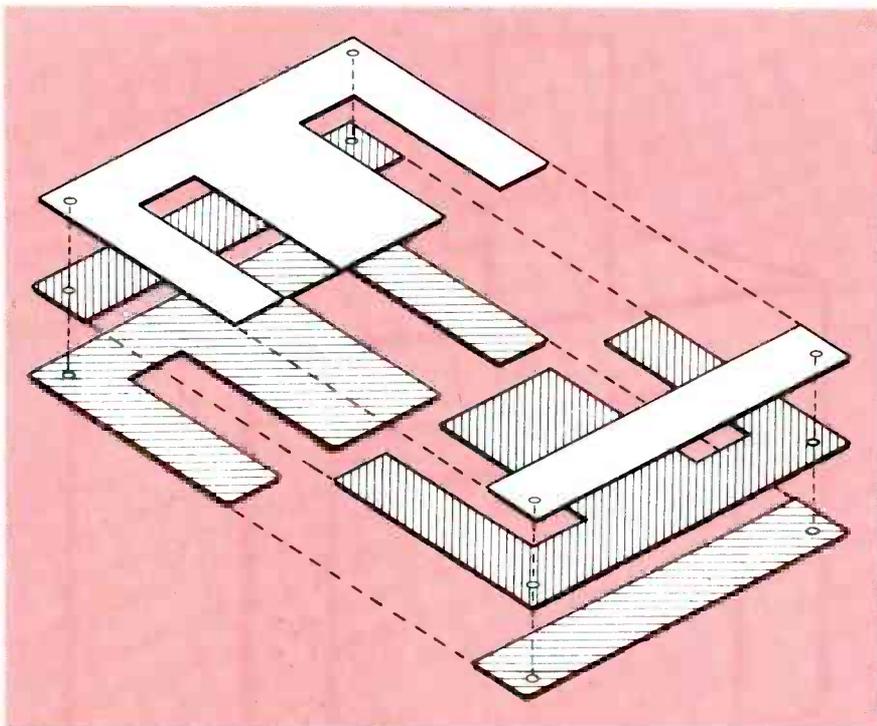


FIG. 4—THE LAMINATIONS ARE reassembled as shown. Do not worry if a couple are left over—that is sure to happen but will not have any significant effect on the rewound transformer.

same gauge wire that the manufacturer used, but do not reuse the same primary wire. That's because that wire is usually a small gauge with enamel insulation that's apt to break off easily. Since the primary wire is usually very long, it's very easy to develop shorts—when rewinding primaries, doing a lot of work for nothing is not that uncommon.

#### A practical example

Let's look at how we can rewind a transformer to deliver 8-volts DC at about 5 amps to a 5-volt regulator. That allows about 3 volts across the regulator. Also, for the purposes of this example, let's assume that we will use a bridge rectifier so that the transformer current rating would only need to be about 5 amps, since both halves of the AC cycle are used.

Using those specifications we get a pretty clear picture of exactly what kind of transformer is required. With a bridge rectifier a center tap is not needed on the secondary, but a bridge rectifier drops the transformer output voltage (voltage getting to the filter) by about 1.4 volts. The peak-value output of the transformer, therefore, has to be approximately 9.4 volts (8 volts + 1.4 volts). That means that the transformer's power rating has to be about 47 watts (9.4 volts × 5 amps).

The transformer we'll choose to rewind has a secondary rated at 18 volts at 2.5 amps. Therefore, that transformer has a power rating of 45 watts, which is close enough for our purposes.

As the transformer is disassembled, make notes of its characteristics. First thing to do is to take the voltage measurements. For the transformer chosen for the

example, the voltage from the center tap to either end of the secondary measured about 8.1 volts, and the voltage across the primary was about 105 volts. When we disassembled the transformer we found that the primary was next to the core, the secondary from the outside end to the center tap had 51 turns in two layers, and that the wire from the center tap to the other end of the secondary was shorter but had the same number of turns. Given those measured values, the turns-per-volt ratio was 6.3 (51 turns ÷ 8.1 volts). Using the correction formula, adjust that turns-per-volt ratio for 117 volts applied to the primary. The corrected turns-per-volt ratio is therefore 5.65—105 volts ÷ 117 volts) × 6.3 turns-per-volt.

Knowing that, we can calculate the number of turns required for the secondary by multiplying the turns-per-volt by the voltage desired. The 9.4 volts peak translates to 6.65-volts RMS (9.4 volts ÷  $\sqrt{2}$ ) so 37.7 turns are needed (5.667 turns-per-volt × 6.65 volts). If the line voltage that the transformer is to be used with is normally below 117 volts, such as 105 volts, for instance, round the number of turns up to 40.

Continuing with our example, since we are using a new transformer, it is reasonable to assume that the secondary wire will be in excellent condition and can be reused. But as we stated earlier, while the wire is rated for 2.5-amps RMS, we want a transformer capable of handling 5-amps RMS. The wire can still be used, however, if two secondaries—wound for the same voltage and in parallel—are used. With two parallel secondaries, the transformer can handle the 5-volts RMS and

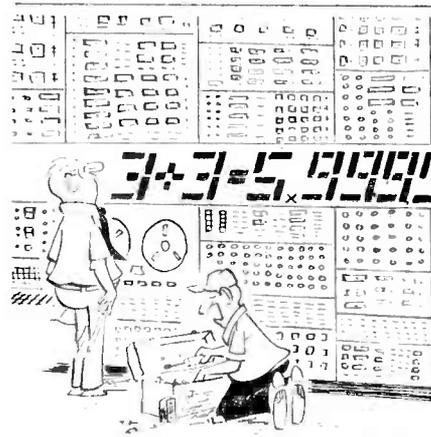
no additional wire needs to be bought.

Cut the original secondary wire at the center tap. Use the shorter length of that wire for one secondary, wrapping it on top of the primary in two layers of twenty turns each—duct tape should be placed between the layers. For the other secondary, wrap the longer length of wire on top of the first secondary in the same manner—two layers of twenty turns each. Start that outer secondary winding at the same place you started the first secondary and be sure to wind it in the same direction. The two secondaries must be wound in the same direction. Otherwise, the net effect of paralleling them is 0 volt.

The transformer is then reassembled, but before it can be used its specifications must be re-rated. Using the number of turns of the secondary divided by the turns-per-volt ratio at 117 volts, the output voltage of the transformer is 7.06-volts RMS with 117 volts applied to the primary (40 turns ÷ 5.667 turns-per-volt). The current rating is not as easy to calculate. Let's look at the problem from a power standpoint. The maximum power from the transformer is 45 watts. The maximum DC voltage is less than 9.98 volts (7.06 volts ×  $\sqrt{2}$ ), assuming full-wave rectification. The maximum DC current that can be drawn is, therefore, 4.5 amps (45 watts ÷ 9.98 volts). For half-wave rectification you would divide that value in half.

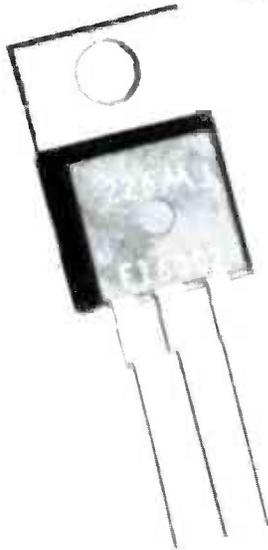
The approach outlined here can be expanded to multiple-voltage secondaries with one more bit of information. The sum of the power required by each secondary must be equal to or less than the power capability of the transformer itself.

One big advantage of winding your own transformers is the ability to compensate for house voltages that are slightly high or slightly low. You can also buy transformers that are on sale without worrying about the output voltage. You only need be concerned about the power that the transformer can handle safely. R-E



*Miller*  
"Well, now, if you insist on looking for mistakes, why, of course, you're most likely to find one or two."

## How to Design Analog Circuits Audio Power Amplifiers



MANNIE HOROWITZ

*Here's a look at some practical audio power-amplifier circuits.*

**Part 2** AS WE FINISHED UP last month, we were designing the output stage of an audio power amplifier. We were aiming for a design that did not use output capacitors, but still had a stable DC output level.

We can take the arrangement in Fig. 6 (see the March 1983 issue of **Radio-Electronics**), one step farther. We can eliminate the discrete output devices and use two power op-amps instead. That type of arrangement is known as a bridge amplifier and is shown in Fig. 7.

Signals are applied to the two op-amps. While the input is fed to the non-inverting (+) input of IC1, it is fed to the inverting input of IC2. Thus, the signals are 180° out-of-phase at the outputs of the two op-amps. Because a loudspeaker is connected to those two outputs, the out-of-phase signals add across the loudspeaker to reproduce the original input signal.

Potentiometer R1, usually about 2 megohms, is used to set the level of the signal at the output. Potentiometer R2 is used to set the DC voltage levels at the outputs of the two op-amps. By adjusting that potentiometer, those voltages can be made identical and no DC current will flow through the speaker while the circuit

is idling.

An interesting variation on the circuit shown in Fig. 6, is shown in Fig. 8. Because there is no differential amplifier at the input, a capacitor must be used between the output transistors and the loudspeaker. Only one driver or voltage-

amplifier stage is used here and the individual transistors are in each leg of the push-pull circuit. Although that is a very simple circuit, amplifiers using that

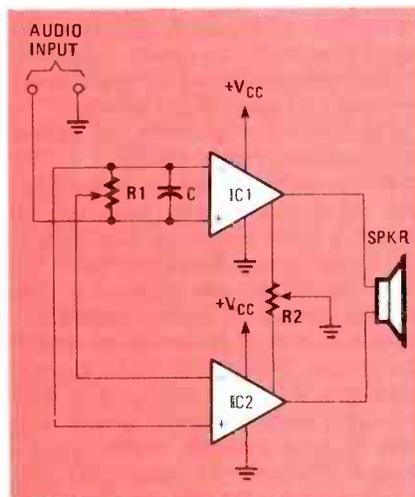
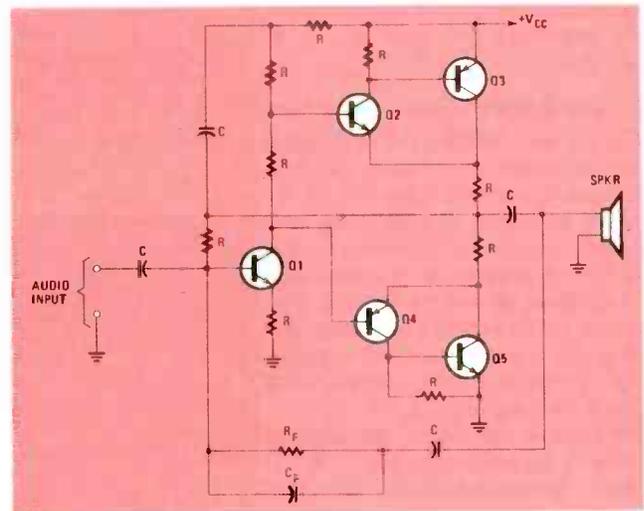


FIG. 7—ELIMINATING DISCRETE TRANSISTORS entirely, this op-amp circuit is known as a bridge amplifier.

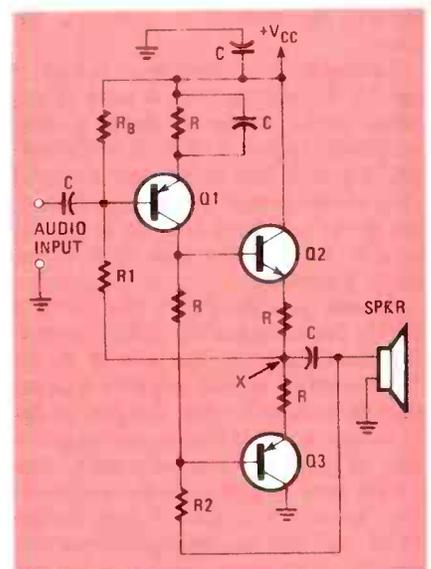


FIG. 8—ACCEPTABLE QUALITY at a reasonable price is the primary advantage of this low-cost circuit.

arrangement perform reasonably well. The big advantage here is acceptable quality at a relatively low price.

The two key components in the circuit are R1 and R2. Resistor R1 is in a DC feedback circuit. One end is connected to point the point labeled "X." Here, the voltage is ideally equal to one-half of  $+V_{CC}$ . Current is applied to the base of Q1 through R1. Resistor R<sub>B</sub>, connected between the base of Q1 and  $+V_{CC}$ , works with R1 to help stabilize the circuit against current variations due to temperature changes.

Current is supplied from the collector of Q1 to bias output transistors Q2 and Q3. Resistor R2 helps keep that current at proper levels by providing an alternate path through itself and through the loudspeaker. While there is some negative signal feedback through R1, the positive audio feedback through R2 is insignificant.

### VFET and MOSFET power amplifiers

VFET's and MOSFET's offer some major advantages over bipolar devices. Characteristics of both types of FET devices are linear, so circuits using them suffer from far less distortion than circuits using bipolar devices. As a result, even when feedback around the circuit is low, distortion can be kept to a minimum. Because of the minimal feedback required, stability problems arising from excessive feedback are insignificant.

But there is one factor that must be satisfied if depletion-type FET's are to perform without breakdown. Unless their gates are biased, they can conduct large amounts of current—enough to damage the device. As a result, bias must be applied to the gate before voltage is applied to the drain. One way to insure that this is done is to use a time-delay circuit. Another is to put a current-limiting device in series with the drain, along with a parallel circuit that will short that device a few seconds after voltage is applied to the gate.

Two basic circuits are shown in Figs. 9 and 10. Direct coupling is used in the circuit shown in Fig. 9. There, a complementary pair of VFET's is at the output. Signal is fed to the non-inverting input of the op-amp and the output from that device is applied to a pair of bipolar devices. Signal is fed from those to the output transistors.

Because junction FET's like VFET's must be biased so that the idling current is at a desirable level, the gate of the n-channel device is made negative with respect to its source while the gate of the p-channel device is biased more positive than its source. As noted earlier, bias voltage must be applied to the output devices before  $+V_{DD}$  and  $-V_{DD}$  so that the VFET will not be damaged. Note the polarity of the drain voltages in the circuit. Negative voltage with respect to ground is applied to the drain of the p-

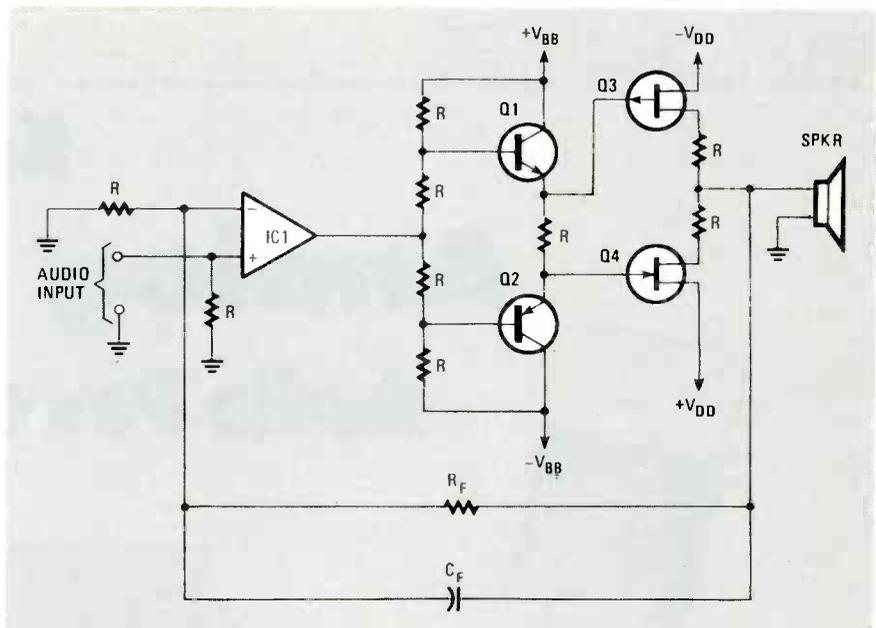


FIG. 9—VFET'S OFFER CONSIDERABLE ADVANTAGES over bipolar devices. This circuit uses a complementary pair of VFET's.

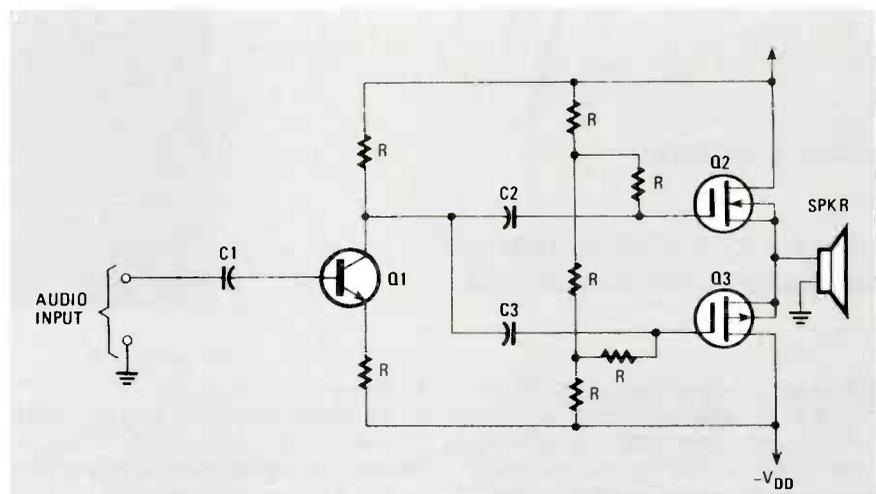


FIG. 10—A COMPLEMENTARY PAIR of MOSFET's is used in this power amplifier circuit.

channel device while positive voltage with respect to ground is applied at the drain of the n-channel device. Also note the feedback circuit from the output to the inverting (-) input of the op-amp.

The circuit shown in Fig. 10 uses a complementary pair of MOSFET's. The input is amplified by Q1. The output from that transistor is then AC-coupled through C2 and C3 to the MOSFET's. The loudspeaker is direct-coupled to the power-output devices. Note that bias must be applied for those transistors to conduct because they are enhancement-type devices. That means that for the gate to conduct, it must be more positive than the source in a n-channel device, and more negative than the source in a p-channel transistor. The time-delay circuitry required in the previous example is not needed here—enhancement-type transistors will not conduct until the bias

voltage is applied.

### Quasi-complementary amplifiers

Up to now, in the complementary amplifiers we've described each half of the push-pull output stage used identical but complementary devices or amplifier circuits. Quasi-complementary amplifiers differ in that they use dissimilar arrangements in each leg of the push-pull power section.

Let's take another look at two true complementary amplifiers. Those were shown last month in Figs. 3 and 4; the one shown in Fig. 3 used a Darlington pair in both halves of the output circuit, and the amplifier in Fig. 4 used a complementary pair. The quasi-complementary arrangement, on the other hand, uses a pair of each type in each half of the push-pull output circuit. A typical amplifier of that type, is shown in Fig. 11. There, Q2 and

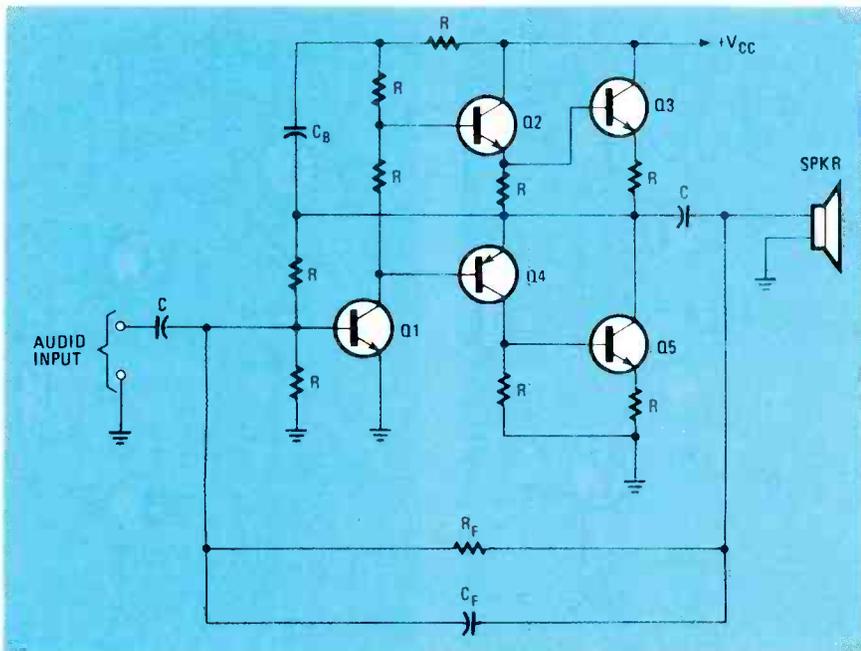


FIG. 11—THOUGH IT ACTS just like one, this circuit does not use a truly complementary arrangement. The chief advantages to this quasi-complementary amplifier are simplicity and cost.

Q3 form a Darlington pair while Q4 and Q5 form a complementary amplifier. Both circuits are driven by voltage amplifier Q1.

But why use such a circuit, especially considering that the true complementary circuit has inherently less distortion? The answer is economy and simplicity. The circuit in Fig. 11 will perform well using a minimum of critical components.

#### Modifications

A differential amplifier is used in the circuit shown last month in Fig. 5. The sum of the currents flowing through Q1 and Q2 must be constant. To do that, Q10 was used as a constant-current source. Current could also have been held relatively constant if Q10 were replaced with a large resistor and  $-V_{CC}$  made very large. That arrangement will keep the current flowing through the transistors constant, provided that the voltage drop across the devices in series with it is much lower than the voltage drop across the resistor itself.

In Fig. 5, Q10, its emitter resistor, and the diodes from the base to  $-V_{CC}$ , determine how much current will flow through the circuit. Voltage is applied to both diodes through R. If they are silicon devices, a relatively fixed 0.7 volt is developed across each diode despite any minor variations in the amount of current flowing through each of those devices. Because the diodes are in parallel with the series circuit consisting of the base-emitter junction of Q10 and resistor  $R_E$ , there must be 1.4 volts across that series circuit. Of the 1.4 volts, 0.7 volt is across the base-emitter junction of Q10 (assuming, of course, that it too is a silicon device) so the remaining 0.7 volt must be

across  $R_E$ . Thus, the current flowing through  $R_E$  is  $0.7/R_E$ . That same current also flows through the emitter and collector of Q10 and into Q1 and Q2. Thus, the sum of collector currents in Q1 and Q2 equals the the current from Q10 at all times.

Alternate constant-current sources using FET's, are shown in Fig. 12. In Fig. 12-a, the gate is connected to the source, making  $V_{GS}$  equal to 0. Now the current in the drain of the transistor is  $I_{DSS}$ . In Fig. 12-b, the fixed current can be adjusted by the potentiometer. It's setting determines the gate-source bias voltage, which, in turn, sets the drain current.

Another way to modify the various circuits we've described is to add some way to vary the bias; such a circuit would let you vary the idling current. A circuit of that type is included in the MOSFET amplifier shown in Fig. 13. Such an arrangement can also be used in circuits using bipolar devices. Because of the presence of Q1, the idling current is temperature-compensated, just as if diodes had been used instead.

Potentiometer R1 is used to adjust the amount of current flowing through Q1 and hence through R2, R3, and R4. The voltage across R1, and at the gates of Q2 and Q3, is equal to the sum of the voltages across Q1 and R2. Those voltages change with the setting of R1 and, in turn, change the bias voltage applied to the gates of the FET's.

#### Protecting output transistors

Output transistors are quite vulnerable when used in an amplifier. If a load or loudspeaker is shorted, the transistors may conduct excess current. If that current exceeds the rated maximum current

permitted to flow in the device, the transistor may be forced to dissipate more power than it safely can and the device may suffer breakdown. Transistors may also break down if there is an instantaneous excess voltage applied across the device due to the presence of an inductive load. Another possible cause of breakdown is undesirable oscillation. That can be due to a capacitive load across the output, such as an electrostatic loudspeaker.

Several precautions can be taken to protect those devices. If a fuse is placed in series with the loudspeaker load, it should blow out before the output transistors are destroyed. (On the other hand, you may be unlucky enough that the transistors will be the first to go.) Another method is to keep the voltage applied to the driver transistor at the minimum level possible. In another arrangement, very poorly regulated voltage is applied to the output circuit, so that the voltage drops radically when there is a large demand for current from the power transistors. Fortunately, more effective protection circuits have been designed.

In the simplest arrangement, a resistor is placed between the loudspeaker and ground. Its resistance should be small—less than 20% of the resistance of the loudspeaker. Parallel-connected diodes,

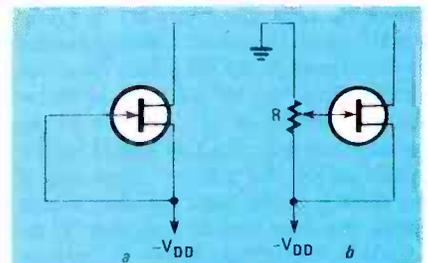


FIG. 12—CONSTANT-CURRENT SOURCES using FET's are shown here.

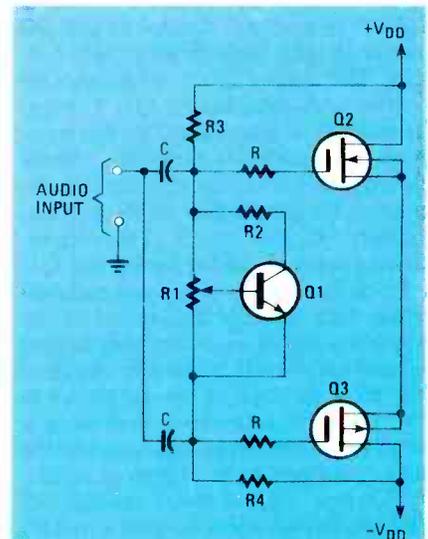


FIG. 13—TRANSISTOR Q1 in this circuit is used to vary the bias voltage applied to the output transistors.

but with the cathode of one device connected to the anode of the second, are placed in a negative feedback loop from the junction of the resistor and loudspeaker to the driver transistor circuit. A voltage is developed across the resistor due to current flowing through it, through the loudspeaker, and through the output transistor. In direct-coupled circuits, that voltage may be due to an audio signal or DC, while in capacitor-coupled circuits, it is due solely to the audio. When that voltage exceeds the forward breakdown voltage of the diodes, they conduct and the resulting negative feedback reduces the circuit gain.

An alternate and more effective arrangement is shown in Fig. 14. Current from Q1 flows in  $R_{E1}$  and current from Q2 flows in  $R_{E2}$ . Those resistors are selected so that the voltage developed across them due to current from Q1 and Q2, turn on Q3 and Q4 when the output transistor current ratings are exceeded. After being turned on, transistors Q3 and Q4 divert current from the bases of the output devices. Limiting the base current reduces the collector currents of the output transistors to safe levels.

Yet another arrangement is shown in Fig. 15. Diodes D4 and D5 are normally turned off. Diodes D1, D2, and D3 conduct to bias Q2 and Q3 to the desirable collector-current levels. If the voltage across R3 becomes excessive due to the current through Q2, diodes D5, D3, D2, and D1 are all turned on, forming a series circuit consisting of R4 and the base-emitter junction of Q3. Similar to the constant-current circuit described earlier in this article, the voltage across one of the diodes is the same as the voltage across the base-emitter junction. Consequently, the voltage across the resistor R4 must be equal to that across the remaining three diodes in the circuit. The voltage across the resistor is fixed at that value. Because the resistor's current is equal to this voltage divided by R4, the current flowing through R4 is also constant. That current also flows through the emitter and collector of Q3. Current through Q3 is thus limited to that maximum. Because D5 is turned on, it limits the base-emitter voltage of Q3 and thereby limits the current flowing through that transistor to safe levels. The current-limiting setup is similar for R3 and Q2.

Up to this point, we've concerned ourselves with limiting the current in the output transistors only when that current became excessively high. The circuit in Fig. 16, a variation of the one shown in Fig. 14, limits collector current when it either gets excessively high or when the output load gets to be extremely small.

If excess current flows through R5 from Q4, the voltage developed across R5 is applied to the base-emitter junction of Q2 through R3. Transistor Q2 is turned on to shunt current from the base of Q4. A

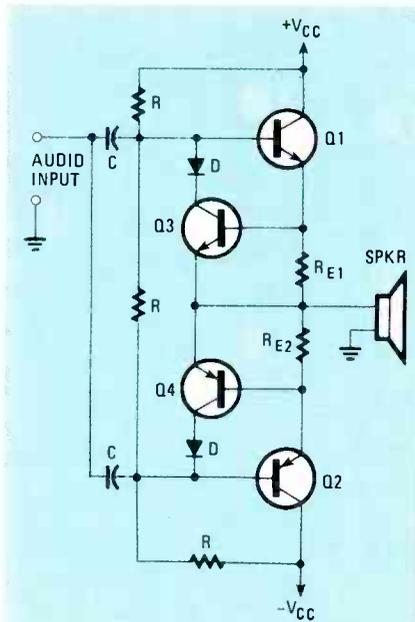


FIG. 14—WHEN THE CURRENT THROUGH Q1 and Q2 exceeds safe levels, Q3 and Q4 are turned on and current is diverted from the bases of the output devices.

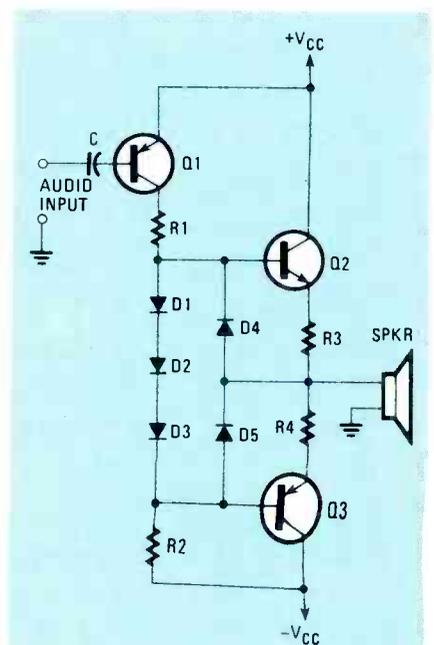


FIG. 15—THE DIODES in this circuit are included to protect the output transistors.

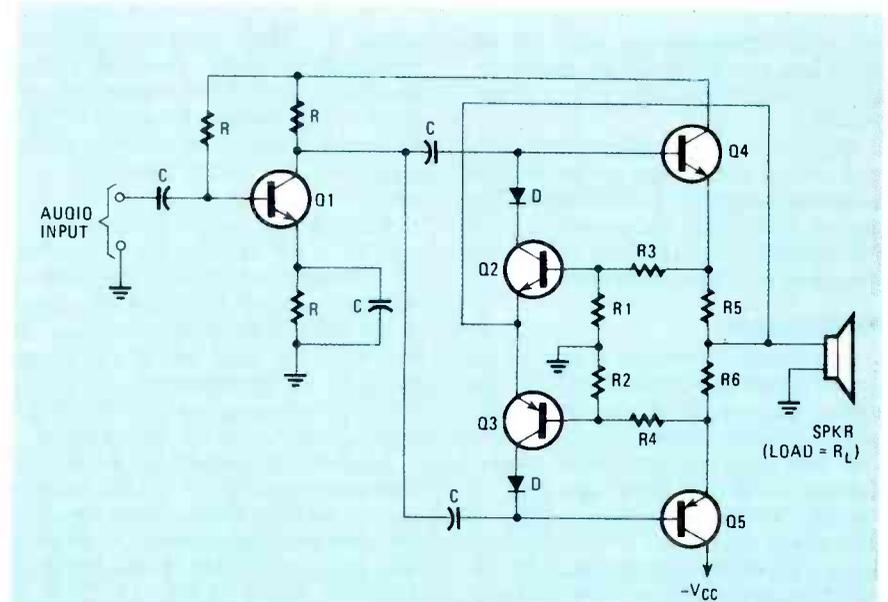


FIG. 16—RATHER THAN just protecting against excessive current, this circuit also protects the output devices against an insufficient load.

similar situation exists if excess current from Q5 flows through R6.

Should  $R_L$  be greater than a predetermined value, the voltage developed across the load, added to that across R5, is applied to Q2. The voltage across R5 is  $180^\circ$  out-of-phase with the voltage across  $R_L$ . The polarity of the sum of the voltages across  $R_L$  and R5 is such as to turn off the shunting transistor, Q2. If the resistance of  $R_L$  is below the predetermined acceptable minimum value, the voltage developed across  $R_L$  is low. Now the voltage across R5 is considerably above that developed across  $R_L$ . When the two out-of-phase voltages are added, the polarity is such as to turn on Q2. It can now shunt the base circuit of Q4. The

magnitude of the load resistance as well as the emitter (and collector) current through Q4, are the two factors that determine if signal is to be shunted from the base of Q4. When the voltage across  $R_L$  is considered in together with that developed across R6 due to current in Q5, the magnitude of  $R_L$  is now an important factor in determining when shunting transistor Q3 is to be turned on.

Throughout this article and the previous one, feedback arrangements were mentioned as integral parts of various circuits. Feedback circuits are important in many different applications. In the next article, we will discuss different feedback circuits, their characteristics, and their importance in different applications. R-E

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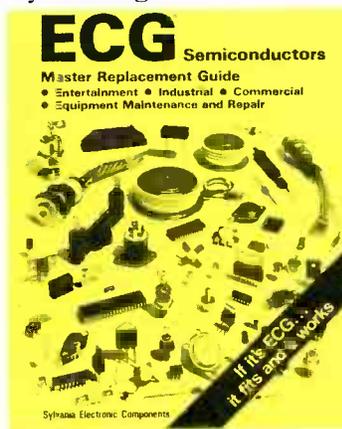
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Of course, you may be lucky enough to find a motor that runs at an acceptable new speed and that can simply be installed where the old one was.

## The second method—electronic

Do not overlook the possibility of decreasing the speed of the motor in the machine *without* making mechanical changes. If you can do that and still have enough power to pull the tape steadily, you have it made. Whether or not it can be done depends on the motor in your cassette player. The speed of some motors is determined by the precisely set voltage applied to them—change the voltage and you change the speed. If fidelity is important, that may require the installation of a voltage-regulator circuit. If all that's required is to be "in the ballpark," a simple power resistor may do the trick. You might even get fancy and install a variable-speed control. Then, you could have available a range of speeds for various purposes.

There are, of course, other methods of controlling the speed of a motor. For example, you might run into a machine that uses the frequency of the supply voltage to determine the speed. In that case, you could modify the frequency-determining circuit. In general, to successfully change motor speed in a given machine, you will have to study the circuit used. Except for the method that requires filing the capstan, you can experiment with a method and, if you are unsuccessful, put everything back exactly as it was.

If you do attempt to change the speed of a cassette machine, choose an old/inexpensive one on which to experiment. Study your cassette recorder/player to see which methods are possible, and which of them is most practical. Don't overlook the possibility of using a combination of methods to cause a greater change than you could get with just one. Watch out for the power available versus the power required from the motor as the speed is changed. Also, when the speed is changed significantly, it may be desirable or necessary to change the frequency compensation in the record/playback circuit(s).

The success of your efforts to slow the tape speed will depend upon two factors. One, of course, is the care with which you work. The other is the minimum quality of sound reproduction acceptable in your particular application. The less stringent your requirements, the more likely you are to be satisfied with the results. Good luck!

## Reminder

Your questions are welcomed, of course. We'll try to answer those of greatest general interest to all readers. Don't forget that we'll be glad, also, to get word of any unusual circuits and applications that you work out.

R-E

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on how far you go and the motor in your particular machine, you could reach the point that the motor would not be able to pull the tape at all!

It is very difficult, if not impossible, to back out after going too far. That is an additional reason for not attempting to modify an expensive machine—at least, not until you have some experience.

## Pulley-driven machines

The mechanical method of modifying a pulley-driven-capstan machine is not fraught with quite as many pitfalls as is modifying direct-drive machines. Nevertheless, considerable care must be taken. In this case, your task is to change the size of one or more of the belt-driven pulleys. The general rules for this method are:

1—Tape speed changes directly with the size of the *driving* pulley. In other words, decrease the diameter of the pulley on the motor shaft and you decrease the speed of the tape, and vice versa.

2—Tape speed changes inversely with the size of the *driven* pulley. In other words, increase the diameter of the pulley on the capstan and you decrease the speed of the tape, and vice versa.

So, all you have to do is locate and fit a pulley of the correct size on the shaft and then install a belt of the right length. It isn't easy, but it can be done on some machines without tearing them up. (You can even change both pulleys.)



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# HOBBY CORNER

## Cassette-speed modifications

EARL "DOC" SAVAGE, K4SDS, HOBBY EDITOR

A SHORT WHILE BACK, A VERY THOUGHT-PROVOKING letter came from Larry White of Texas. He has a certain brand and model of audio cassette player and would like advice on making a couple of modifications to it. Sorry, Larry, that I don't have that particular machine here for experimentation, but here are some ideas that you or any of our other readers can check out with any recorder/player.

Before discussing ways to vary tape speed, however, I feel it necessary to point out that we are very fortunate that tape-machine manufacturers have decided upon standard speeds for tape travel. The typical speeds for audio tapes for various applications are 15, 7.5 (15/2), 3.75 (15/4), 1.875 (15/8), and 0.9375 (15/16) inches-per-second (ips). All other things being equal, the faster the tape moves, the higher will be the fidelity of the recording. "Normal" audio cassettes run at 1.875 ips, more commonly referred to as 1 7/8 ips.

Since all standard cassettes and machines operate at the same speed, it is evident that cassettes made on one machine will play properly on another machine (at least as far as speed is concerned). Without such standardization, you would not want to buy a pre-recorded tape; you could not send a tape to your buddy; and if you had to replace an old

machine, your old tapes could not be played on the new one. The cassette world would be in chaos. And now, that obvious caveat: if you change the speed of a recorder/player, the only cassettes you will be able to play on it will be those recorded on it. Those tapes will not play on another machine. (Of course, that is not true if the accuracy of sound reproduction is unimportant!)

With that said, let's see how to do some speed changing. Some of the methods give better results than others on a given machine. No one way is better or easier on every make or model. Proceed with caution. Some of the changes are irreversible—if they don't work properly, your recorder/player can be ruined for normal use. I would not recommend your applying these procedures to a good (expensive) machine.

### The first method—mechanical

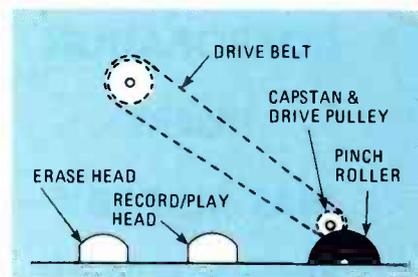
The most obvious way to change tape speed is to change the size of the capstan. That's the little spinning shaft that sticks up and squeezes the tape against a rubber roller, called the pinch roller or capstan roller (see Fig. 1). In most machines, you can see those parts easily by pushing the PLAY button with no cassette in place. If you aren't familiar with the capstan and pinch roller, stop now and check them out—we'll be discussing them at some length.

Mechanically, there are two basic types of cassette players. The first type may be called direct-drive machines, and includes those in which the capstan is actually the shaft of the drive motor. The second type includes machines in which the capstan is driven by a belt-and-pulley arrangement—usually, the capstan is the shaft of a large and relatively heavy flywheel. You can determine which type your machine is by going into the case and taking a look.

With both types, one of the factors determining the tape speed is the diameter or circumference of the capstan. At any given capstan rotational speed, the tape speed varies proportionally with the size of the shaft. The smaller the diameter, the slower the tape. The larger the diameter, the faster the tape.

### Direct-drive machines

The mechanical method of modifying the first type (direct drive) machine in-



volves actually changing the size of the capstan. If you fit a "cap" of some kind on the shaft to increase its diameter, it will pull the tape faster. Great care must be taken to make the cap of a material that will not have a tendency to cause the tape to adhere to it—you can imagine, and may have experienced, the problems resulting from tape wrapping itself around the capstan! Further, the cap must be perfectly round. Metal and very hard plastic have been used with success.

Larry's need, however, is to *slow* the tape speed. That is what most folks want to do, and it involves decreasing the capstan diameter—a task which is easier said than done. If you really want to try that, remove the motor (and thus the capstan) from the machine and *gently* hold a file against the capstan while the motor runs. (If you don't remove the motor, everything may be ruined by falling filings.) Work very carefully so the capstan remains of equal diameter throughout the length that presses against the roller. The sides must be exactly straight—neither bowed in nor out, and not slanting up or down in a cone shape. If the shape isn't right, the tape will be pulled sideways as well as forward and that will cause obvious problems.

Do not change the size of the capstan much without stopping to test the results of your labors. The best way to do that is to reassemble the machine and play a previously recorded tape, listening for a change in tones of speech or musical pitch. In addition, record and play a tape at the new speed to see how things are working. If you are satisfied with the results but want greater change, continue with the operation.

I do not advise attempting to make large speed-changes in that manner. The main reason is that there is a definite relationship between speed and the power required from the motor. Depending up-

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# THE DRAWING BOARD

## Voltage regulators and power supplies

ROBERT GROSSBLATT

ONE THING THAT EVERY ELECTRONICS hobbyist who builds or designs his own equipment will eventually have to contend with is a power supply—it doesn't matter whether you're working on a space shuttle or on an electric toothbrush. It's obvious that there are tremendous differences between the power requirements of a rocket ship and those of a toothbrush, but the point is that if you're designing your own equipment, you're going to have to spend some time thinking about what you want your power supply to do.

It's true that most of the things we'll be discussing in this column can be powered by nothing more complicated than a fresh battery and a pair of alligator clips. From the point of view of elegance however, that approach leaves something to be desired. The power supply you use in your designs can do a lot more for you than just supply power. Most notably, the power supply can provide *protection*.

Even the most carefully designed project in the world can blow up the first time power is applied. But a well-designed power supply can go a long way toward saving you from having to repeat the work you've done in the event of a mishap. It can guard against short circuits; it can limit the current and/or voltage; it can offer protection from transient spikes, and so on. In short, it can be an extremely valuable friend when your project is still in the development stage. Let's look at some of the many possibilities.

### Series regulators

There are many different approaches to power-supply design, but this time we're going to see what we can do with the simple series regulators that we're all familiar with. Those are three-terminal devices that are set up internally to provide a fixed output-voltage of a particular polarity.

The 78xx series of positive regulators (and the 79xx series of negative regulators) are usually used by themselves to provide basic voltage regulation in small electronic systems. Like most things though, those IC's can be made to provide as many exotic features as we want, including the ability to handle much more current than their basic rated capacities would seem to indicate.

Just about everyone is familiar with the circuit shown in Fig. 1, a basic five-volt regulator. Capacitor C1 is the huge filter

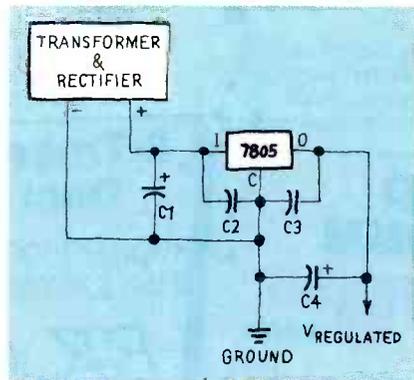


FIG. 1

capacitor that sits across the output of the rectifier. It's used to smooth out the spikes (ripple) on the line and to "brute-force" regulate the voltage going into the 7805. Even though the regulator was designed to reject noise (referred to in the specs as "ripple rejection"), it can only cope with noise that is a certain proportion of the input voltage. Put simply, the bigger the input-voltage fluctuations, the more noise at the output.

Capacitors C2 and C3 are also filter capacitors. They are generally less than one  $\mu\text{F}$  and provide the regulator with local help in dealing with transients. If the regulator is physically far away from the large filter capacitor (C1), a voltage, however small, can develop on the line connecting the rectifier and the IC. The job of C2, therefore, is to make sure that those small voltage transients are eliminated before they reach the regulator. That's why C2 is always located as close to the regulator as possible—in some systems it will be soldered right to the regulator pins. Capacitor C3 does the same job at the output of the device.

Capacitor C4 can be called the "surge capacitor" because its job is to take care of the sudden surges that show up on the system +V line during power-up or power-down. The size of those surges, and consequently the size of C4, depends on the current drawn by the system. Typically though, the value of C4 is somewhere between 10 and 100  $\mu\text{F}$ .

The 78xx family of regulators (and most other series regulators) is designed to be as foolproof as possible. The regulators monitor their internal temperature; and if they get too hot, they turn off. Short circuits will also cause the IC's to shut down. The trip point isn't a definite figure

because it depends on the input/output voltage difference and the temperature. In general, a 78xx-series regulator that is well heat-sinked will be able to handle about an amp—but that's really the upper limit.

Now that we understand the circuit in Fig. 1, let's see what's wrong with it. As a side note here, one rule of design is *always* to design with worst-case operation in mind. Remember Murphy's Law and don't forget that one of the drawbacks to original design-work is that the responsibility for backing the warranty is yours.

### Problems

Someone once said that there's no such thing as a free lunch, and that applies here. We're using capacitors to help the regulator minimize noise and transients, but capacitors cause another problem. A rapid reduction in either the input or output voltage will cause the capacitors to discharge. How much discharge current is generated depends on a lot of variables—the values of the capacitors, the rate of voltage reduction, and so on. Most regulators are built to withstand a certain amount of discharge current, but the unpredictability of the amount of that current makes for a real problem. In order to put things in perspective, consider that a 10  $\mu\text{F}$  capacitor can develop 20-amp spikes when it's shorted.

If you're designing a power supply only for low-current systems, that doesn't present much of a problem. But if you're going to need a healthy amount of current, something has to be done to protect the regulator against accidental capacitor-discharge.

It will help to think of the regulator as a bunch of control circuits with a beefy pass-transistor at the output. In Fig. 2 we show only C1 and C4; since C2 and C3 are relatively small, we don't have to pay as much attention to them.

In the case of an input short, we have a big problem with C4. When the input short occurs, C1 will discharge through it and the input voltage to the collector of internal pass-transistor Q1 will rapidly fall to zero. That means the output voltage will be greater than the input voltage. Since C4 will have stored a nice, healthy charge, it will start to discharge. Some of the discharge current will go through  $R_{\text{ce}}$ —the equivalent resistance of the regulator's protection circuitry. If the current

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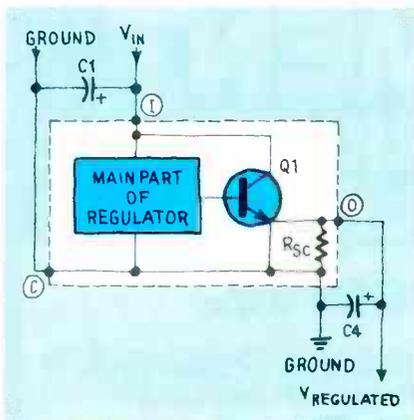


FIG. 2

is substantial enough.  $R_{sc}$  isn't going to pass it fast enough and the emitter-base junction of Q1 is going to be reverse biased. If the current is great enough, Q1 is going to break down and the regulator will be—to use a technical term—zapped.

Fortunately, an output short isn't anywhere near as serious. In that case, C4 will discharge across the output short and the input voltage will be greater than the output voltage. Luckily, the regulator was designed to deal with that. It will start to pass more and more current until its thermal-overload point is reached and it shuts down. Remember, the regulator was designed to source current, not sink

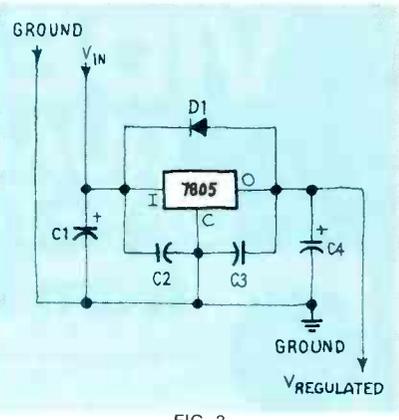


FIG. 3

it. That's why an input short is so much more potentially dangerous than an output short.

In order to protect against input shorts, we have to find a way to provide an escape path for the discharge current of C4. We'll add a diode as shown in Fig. 3.

Adding protective diode D1 gives us a really slick solution to the problem. If the input shorts out now, the discharge current from C4 will forward bias the diode and all the "bad" current will be shunted to ground through the input short. You may wonder why the diode doesn't bleed off some of the "good" current when the regulator is operating normally. But we're out of space, so you'll have to wait until next month for the answer. R-E

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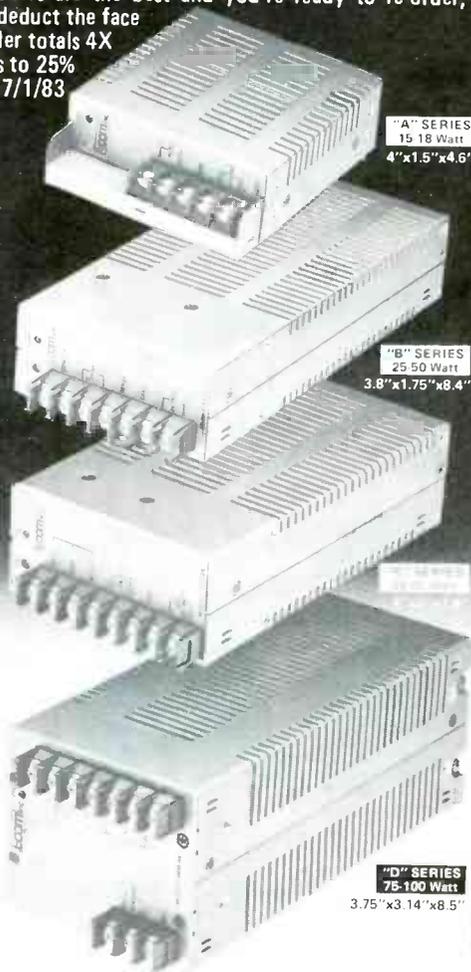
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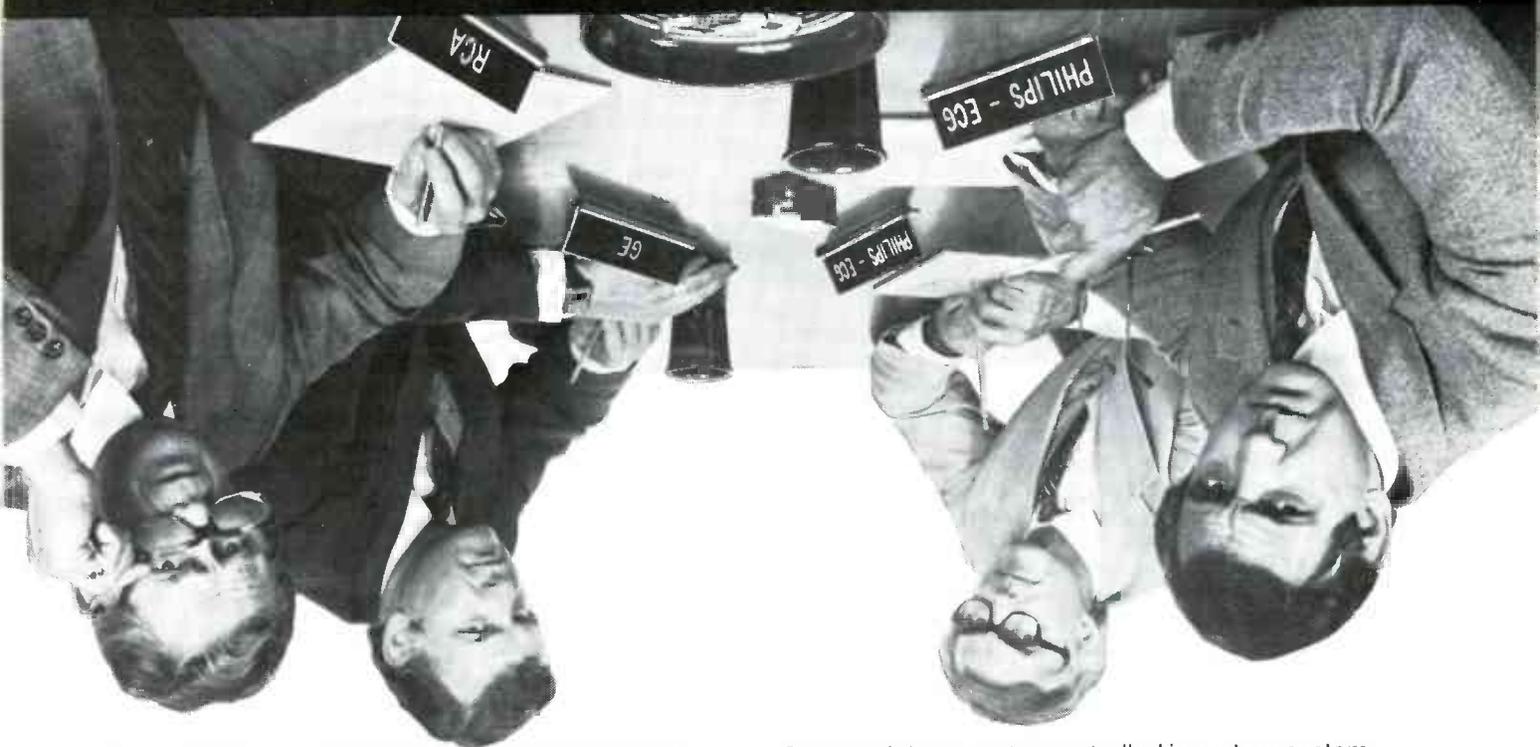
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# SERVICE CLINIC

## An oddball output-stage problem

JACK DARR, SERVICE EDITOR

WHAT WOULD YOU DO IN THE FOLLOWING situation? Assume that a set comes to you for repair with a blown fuse and a shorted horizontal-output transistor. That's nothing unusual so far, so you would probably replace the fuse and transistor. Now, would you plug the set in and turn it on to see the results? *No!* If you did, you might find that you then had *two* dead output transistors—one of which belonged to you! For safety, plug the set into a *Variac* (a variable-output transformer), run the line voltage well down, and measure the current through the fuse. *Then*, slowly increase the output voltage of the transformer, watching the ammeter carefully to see that it doesn't go out of bounds. Keep an eye on the DC voltages, too.

There is a new variation of this too-common symptom that's been popping up in my mail quite often lately. In fact, it appeared twice in one batch last week. That variation has the same symptoms to start with, and when you replace the transistor and fuse, you find that there's still too much current being drawn by the new output transistor. Here's the oddball thing: Grounding the base of the output transistor brings the current back down to normal! I'll count to ten while you're thinking of what could be responsible for that. It's a good symptom because it's one that tells us something—it clears the previous stages. It tells us that the output stage is working (because the drive is there), and that it's trying to drive the flyback and all of its loads (the low-voltage DC supplies from the flyback, the yoke, and the tripler—see Fig. 1). Before we go any farther, you *did* check the

regulated DC voltage, didn't you? If not, do so.

### What's causing the problem?

Now that the previous stages are clear, we know that we've got an overload problem somewhere in the flyback or its load. If the flyback uses a yoke-return capacitor, that could be shorted. To find the exact cause of the problem, the old process of elimination is best. Check all of the low-voltage diodes, their filter capacitors, etc. for shorts. The best way to check the rest of the loads is by load-shedding—unhook suspected things (the tripler, the yoke, etc.) one at a time and then recheck for excess current.

The yoke can be checked by unhooking it. Many sets have a B+ jumper on the yoke plug and you'll have to jumper that with a clip lead. If your test indicates a short, check the yoke-return capacitor before condemning the yoke. The "4-legged capacitor" (which is used as a collector-shunt capacitor on horizontal-output transistors) can be checked with the ohmmeter or by unhooking it and jumping it to get collector voltage to the output. Those capacitors don't seem to short too often, but sometimes, nevertheless, they do.

Check the flyback circuit. Some of them have a tuning coil in the output. Check that for shorted turns, and check the capacitor across it. One more thing: In most sets, the pincushion-correction circuits are hooked to the flyback/yoke. Those, too, can develop shorts in the transformer or capacitors. You might also have a wiring short or arc-over.

### Once again

To sum things up, what you have to do is check everything that could cause the flyback to be overloaded, and thus cause the symptoms you're seeing. It doesn't take as long as you'd think. What you have to do is eliminate everything that could overload a good flyback, and if it all checks out, then you're left with one thing that could be causing the problem—the flyback itself. Because of the high cost and difficulty of replacing flybacks, we'd recommend that all the other tests be made first. Replacing a flyback and finding that you still have the same old symptoms can be a real bummer. Something like that can ruin a technician's day (and a couple of days' profits!). So, make sure that you have eliminated everything that *could* cause an overload on a good flyback before you suspect the flyback itself.

We check things like that because what we're dealing with is an "AC short." Note that there is no short when there's nothing but DC on the flyback (when the base is grounded the DC's still there). But when we start feeding drive pulses into the flyback, we see the short. So, something like a shorted winding in the flyback, or an overload on one of its outputs, is responsible for the short symptoms. We're "pumping into a short" when the flyback is getting normal drive.

The scope can be a lot of help in checking things. You can (should!) check the base drive for correct frequency, peak-to-peak voltage, etc. Judging from the symptoms, something will be there. With the voltage reduced, check each output for pulses. On a working output, you should see the normal pulse as shown on the schematic, but at a reduced level—the pulse level will be in proportion to the line input. If you've reduced the line voltage to one half of normal, the pulse should be only one half of the normal amplitude. Quick checks of the low-voltage supplies can use the same test and ratios. You can even check for pulse input to the tripler; hold the probe near, but *not* touching it, and check for a good high pulse. If you find an output that should have a pulse but has nothing, that could be the shorted winding. Disconnect everything from that terminal and check the resistance at that point. It will be very low, and you may not get a usable reading. Turn the set on with the winding open and check for a

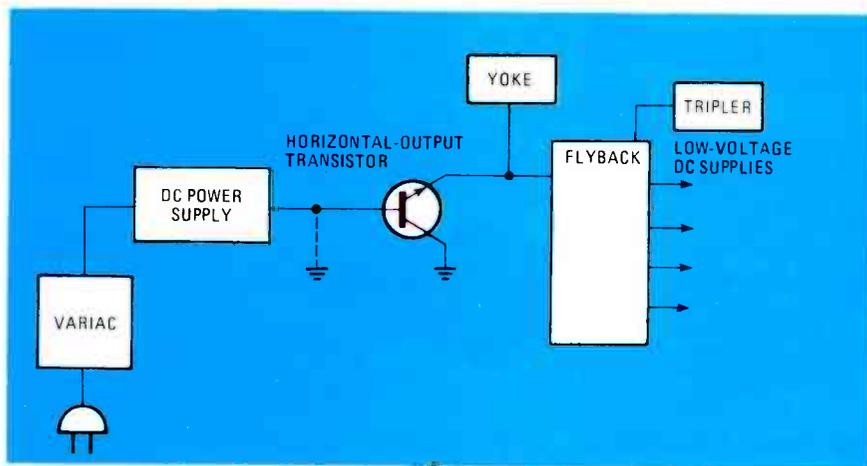


FIG. 1

This talking phone TELLS you in clear English what numbers you're dialing.

# We'll Try to Describe Everything This Space-Age Phone Does In One Page of Small Type. It Won't Be Easy.



The Everything Phone is a handsome, contemporary ivory phone with a standard modular plug, ready to go.

It's as though someone said—

"Let's think of *everything* any telephone can do, and combine them into one fantastic instrument."

Someone did say that. This is it.

We call it THE EVERYTHING PHONE because it does everything. It advances the science of phone communications by ten years, even in this age of wild changes and improvements.

For example—

#### This Phone Actually TALKS To You

The Everything Phone speaks to you in a warm, gentle voice. It never tells you wrong.

Touch the "Voice" switch and when you push a button, the phone tells you the number you've pushed. If you're working in dim light, you won't dial a wrong number, because your friendly phone voice repeats each digit immediately, as you dial it.

#### A Complete Phone Answering System

If you press the "Prefix" key, the "Clear" key, the Direct Memory Keys, or any of the other special function keys (more about these later), your Phone Voice tells you what you've pushed. If you get tired of company, you can shut off the voice; but it's like having a friend right inside your phone.

This feature takes some explaining.

In the bank of keys to the right of the dial pad are three marked M1, M2, and M3. M1 and M2 will tell a caller, when you're out, either when to call back or another number where you can be reached

What about M3?

M3 makes any cassette recorder an answering device. Using the connector (supplied), your recorder can take messages up to the total length of any tape cassette. The Everything Phone turns the recorder on and off automatically when a call comes in.

So— you have your voice of 1) a message, in the phone's own voice, to call back at whatever hour you designate; 2) a message that you're out and can be reached at whatever number you designate; 3) an invitation to leave a message after the tone, with a capacity as long as the cassette—an hour or more.

#### Memory Keys Galore for Automatic Dialing

At the left of the numeric keypad are ten Direct Memory Keys. The key at the upper left is for MCI, Sprint, or other computer-code dialings. It holds the access number and your personal code number.

The other nine let you dial stored numbers, including long distance numbers, by pressing one key. You can inset a tab showing whose number is stored.

But you ain't see nothin' yet!

You actually can store up to 50 numbers of 20 digits each, using a two-number code. Example: if you already have 30 numbers in memory and you want to store 1-305-473-2044, punch in that number, use the "Store" key and "31", and you'll be able to dial that number in the future just by pressing "31".

#### Quality Speaker-Phone

Of Course The Everything Phone has one-way speaker-phone capability. Of course it's high quality sound.

Just press the "Speaker" button and you have a hands-free phone. A volume control gives you just the right amount of amplification.

#### Music on Hold; "Mute" Switch

You can put a caller on hold just by pressing the "Hold" key. What a pleasant surprise! Instead of dead sound, the person on hold hears a pleasant melody. (You'll hear it too, so you won't forget he's on hold.)

You have a "Mute" privacy button, and it couldn't be more convenient—it's right in the center of the modern hand-phone. Press that button, and although the other party won't be able to hear you, you'll still be able to hear him or her. Release the button and communications are normal again. (No telltale "click" when you press the Mute button.)

#### Here's a List of Other Built-in Benefits

Your Everything Phone is an electronic butler. It has—

— Automatic redial. Press this key and your phone will redial the last number you called either once (if the phone is off the cradle) or four times (if the phone is in the cradle).

Each key has a separate function. Each one talks to you, if you want it to. What a conversation piece The Everything Phone is!

- Pulse/Tone selector switch. In areas with rotary dialing only, slide the switch to "P". In areas with touch-tone, slide it to "T".
- Ringer off switch. You can turn off the pleasant "chirper" (it isn't a bell) when you don't want to be disturbed. A separate ringer l.e.d. light will alert you, if you're interested.
- Access pause key. For Sprint, MCI, and other code numbers, the Pause button gives you the proper gap between the original dialing and the time the system takes to answer with a tone. The Pause has other uses, too, but we just can't list all of them here.
- Secretarial aids. Open a little door and you have a memo pad to jot notes. For the numbers stored in automatic dialing memory, slide out the Directory Card, concealed under the phone unit.
- Battery backup. Two tiny, easily replaceable batteries keep your memory intact. A power failure, even one that lasts for months, won't wipe out what's stored in the memory.

#### Anything Else?

Probably. We ourselves haven't figured out all the phone assistance The Everything Phone can give you. But we do know this:

*No other phone ever made has all the benefits and comforts this one has for you.*

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pulse. If it is there, check external components for breakdown under load. The best way to do that is by replacing them.

As I said, we've been getting too many letters about this oddball problem to ignore it; I thought this little run-through might be of some help. I certainly hope it will, and wish you good luck. R-E

## SERVICE QUESTIONS

### HORIZONTAL OSCILLATOR PROBLEM

I wrote you about a problem in a Sylvania A-12—the horizontal oscillator wouldn't start. Well, after quite a bit of trouble I finally found the solution. I replaced the FET (part No. 13-28654-5, new part No. 13-43112-1). What they don't tell you is that the pinout of the new part is different from that of the old one, so watch out! I would also suggest that capacitors C410, C414, and C416 be changed.

Thanks to Ray Green of Camden, AR. That's the kind of feedback that can be a lot of help to the rest of us.

### HEAT-SHRINK HINT

I have a hint for shrinking heat-sensitive tubing in tight or enclosed places. I wrap a few turns of 1/8-inch copper tubing around the barrel of a pencil-type soldering iron, slip about an inch of Teflon tubing over the top of the copper, and then slip rubber tubing over the Teflon. When you blow into the rubber tubing, your breath is heated as it passes through the hot copper. You can easily direct a stream of hot air into tight places using this method. I used an old iron with a broken tip that was no longer any good for soldering.

That sounds like a very good trick. Thanks to James Bohm of Florissant, MO for that hint.

### RETRACE PROBLEM

I've got a terrible retrace problem in a Zenith 14A9C50. Nothing I can find seems to be bad, but the retrace lines are there, and they are bright enough to upset the customer. Help!—S.H., Irmo, SC.

I told him to check this and that, and as a last resort, to check the setting of the CRT screen controls. If they are too high, you'll get retrace lines. That turned out to be his problem. In older sets, those controls should be checked as a matter of course—they are too easy to get at and "twiddle."

### INTERMITTENT PICTURE

The picture on this Zenith System 3 went blank intermittently, but the sound was OK, although a bit hashy. Changing channels or turning the set off and on would sometimes bring the picture back.

No wonder they call it the SUPERFONE!

# At Last—a Cordless Phone with TWICE the Range, Sound Fidelity to Rival Phones with Cords, and a Privacy Code System—All This in a Phone Less Than an Inch Thick!

*The Super Fone is less than 1" thick. The base unit has a built-in speaker phone, a fully independent intercom and is 110 volt-220 volt switchable.*



Until now, cordless phones have given you wonderful convenience. But they've had two problems:

1. The range is limited to 600 to 700 feet.
2. Some of them sound as though you're talking inside a barrel.

As cordless phones have become enormously popular, another problem has arisen: two people, living near each other, can have the same channel. Not only is there line confusion, but someone else can literally make a long distance call on your phone.

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## Range: 1500 Feet OR MORE!

The SuperFone 650 uses state-of-the-art electronics to bring you the ultimate cordless phone. Sound quality is superb — and it stays superb, 1500 feet or more from the base station. That's more than twice the distance of standard cordless phones.

Only SuperFone 650 has a secret code system to prevent interference and false operation of the phone. You choose from 512 possible "code" combinations. Both the base unit and the phone are locked onto that code, which you can change when you want to.

No other phone can interfere. No other unit can share the signal. No one else can hear or speak on your carrier-wave.

## Enormous Range

We say the SuperFone 650 has a range of 1500 feet.

Notice we didn't say "up to" or "as far as" 1500 feet. There's no hedging, because this seems to be the minimum, not the maximum range.

Users report 1800 and 2000 feet. That's nearly half a mile. SuperFone 650 is a radiophone, not a toy, and that's why its signal doesn't break up or start hissing or crackling when you get half a block away.

You can tell when you heft it. It's a Little Giant. You can feel the power inside. What a marvel of electronic engineering it is! And it's tough, too. It fits into your shirt pocket, and you can bounce it around all day without damaging it.

## Speakerphone, Intercom — Everything!

SuperFone 650 is The Everything Phone. Anything any phone can do, it can do.

First, the base station is a speaker phone. Touch a button and you can have a hands-free conference conversation in the room in which the base station sits.

Next, it's an intercom. You can page the handset from the base unit and have a private conversation. You have a true wireless intercom, not just a signal.

Third, you have a privacy button. Push that button and you'll still be able to hear anything the other party says, but he or she won't be able to hear you until you take the button off "hold."

Fourth, you have an automatic redial. Touch the key and the SuperFone will redial the last complete number.

What else? A security switch which makes it impossible for anyone to call out on the remote phone, without changing the ability to receive calls. A volume control for the speaker on the base unit. A call button to page the base from the cordless phone. THIS PHONE HAS EVERYTHING!

## 30-Second Installation

Plug your SuperFone 650 into any wall AC outlet. Push its standard modular terminal into the telephone plug. You're in business.

Every component is heavy-duty, from the built-in condenser microphone (with automatic gain control) to the LED indicator lights. This phone is designed for hard use.

The SuperFone 650 is yours for \$249.95. If you want the SuperAntenna with it, giving you a range of a mile — or even more — you can have both for \$319.95. (Or you can get the SuperAntenna alone for \$79.95.)

## We Absolutely Guarantee!

Use the SuperFone 650 (or any electronic instrument you acquire from us) for up to 30 days. If for any reason you decide not to keep it, return it for a 100% refund.

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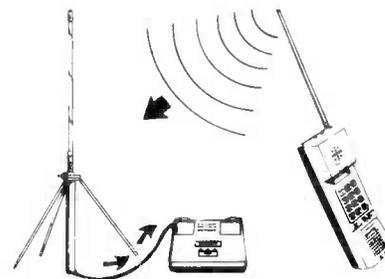
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Also, sometimes it would come back by itself. I suspected the Chroma-Luminance module, but the problem really could be anywhere. You suggested some things to try, including lightly tapping stages.

I found that the picture could always be restored by a tap on the shield over video amplifiers Q1226 and Q1227. Our Zenith distributor supplied a new circuit board without charge (after a letter from Zenith Customer Service, Chicago). The new board is 9-151-03C—the same number as the original, but with a "C" suffix instead of the original "A." The difference is that the shield on this one is soldered instead of pressed on. Also, there's no zero-carrier adjust as there was on the old one. That control might have been the faulty part. I hope this will help others who run into this problem.

*It certainly will. Thanks to J.H. Sutton of Conway, AR for the feedback.*

### COMPUTERS NOW!

*I've got a TRS-80 microcomputer with an intermittent video output. The screen goes dark, but the computer still works and the printer output is normal. The computer technician hasn't found the problem yet.—E.L.G., Merritt Island, FL*

Whee! Now I'm a computer technician—and I know nothing about them. However, I do know how to find

out why a picture tube goes dark.

Check all of the things around the CRT such as high voltage, all the DC voltages on the base, and the socket contacts. Loss of high voltage will cause your problem, as will incorrect bias and intermittent socket contacts. You may have to monitor some of those voltages to find out which one changes when cutoff occurs—but one of them does! Check and log all DC voltages while the monitor is working, and then recheck them when the fault shows up.

### MUSIC-AMP DISTORTION

I asked you about distortion in a Poly-tone musical amplifier. Your suggestion for checking pin 9 (the feedback pin for distortion correction) of the LM-391 IC was the clue. An open resistor, R20, between pin 9 and the emitter of the 92PU07 transistor was the cause of the distortion. By the way, there's a mistake in the diagram—pin 16 is B+ and pin 11 goes to the junction of R10 and R9. G.F.

### TUNER PROBLEM

This GE 25YME had no sound and no video, and the tuning voltage on the control assembly was a constant 30 volts on all channels, instead of the normal 1-25 volts. I replaced the PLL IC as the service manual said, but with no success. I replaced both the tuning-control assembly,

EP93X168, and the wideband amp with an EP93X289 tuning assembly. That fixed it.

*Thanks to David E. Law of Astoria, IL for that hint. One of these days we'll get into the problem of those tuners and their repair. More and more of them are showing up.*

### MORE ODD TUBES

*I need a 6DL4 tube, but can't find one anywhere. Do you have ideas?—T.M., Spring, TX*

Try Transeletronic, 1365 39th Street, Brooklyn, NY 11218.

*(Feedback: Thanks! They said they had 30 of them in stock, and they shipped four of them to me quickly.)*

### SYNC PROBLEM

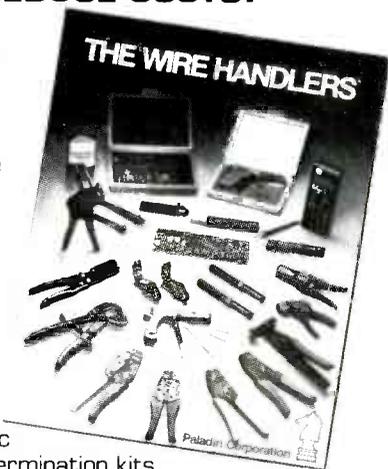
*I've got a dandy in a Magnavox T8-9 chassis. There are four or five vertical lines in the picture with ringing at the top—they look like upside-down Christmas trees! I'm lost.—D.A., Babbitt, MN*

The ringing at the top of the picture is due to horizontal instability. I'd say that that could be due to "something" getting into the horizontal sync. That can come from an open filter or bypass capacitor that is letting pulses get into the sync. Use a scope to check the DC supplies to the sync separator and horizontal oscillator. Check the composite sync to see if the

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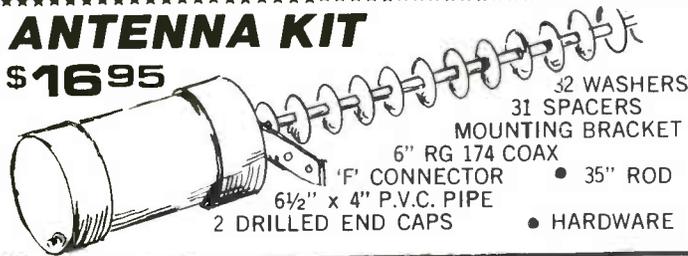
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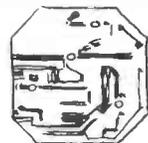
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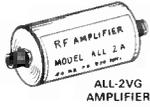
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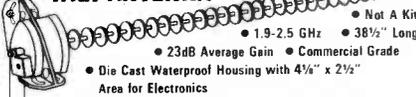


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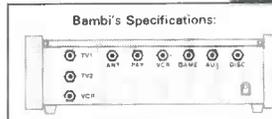
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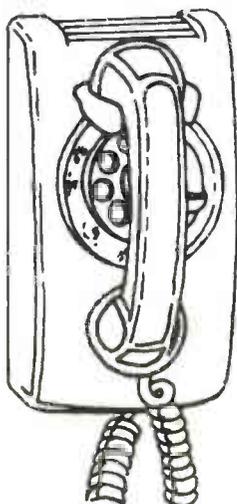
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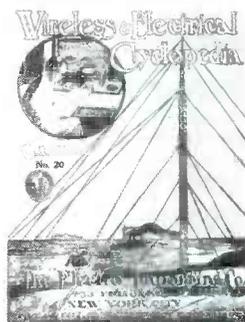
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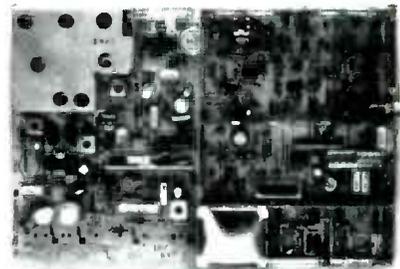
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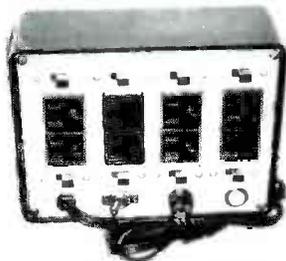
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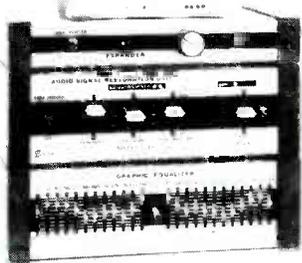
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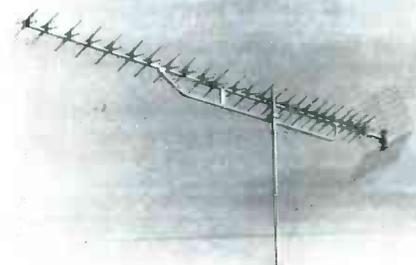


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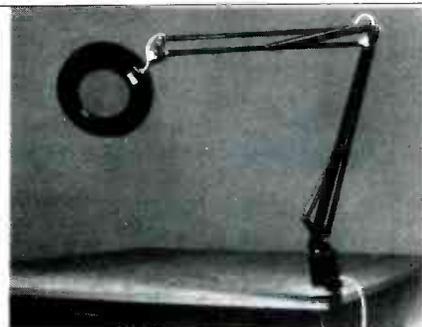


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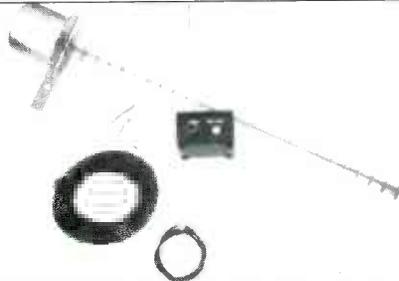
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CIRCLE 9 ON FREE INFORMATION CARD

## MUSIC SYNTHESIZERS

*continued from page 68*

ADSR generators have been most popular among professional musicians. It is felt that that generator—which provides control over the attack time, decay time, sustain level, and release time—is the minimum required to imitate traditional instruments. ADSR-type generators require both gate and trigger signals.

Unlike the other modules that we have discussed, the envelope generator is not an audio module; it is a logic module. The output, though analog in nature, must respond to a number of digital conditions. (Is the gate present? Is the trigger present? Are both present?) Envelope-generator logic hasn't changed over many years; only the means of implementing the logic has changed. For example, early units were discrete and were composed mainly of diodes, transistors, and various R-C networks. Later, many units were designed using TTL integrated circuits. Recently many designs have been appearing that incorporate CMOS-type circuits. Finally, within the last several years a number of LSI circuits have appeared that incorporate the entire ADSR envelope generator on one chip. Some examples are the SSM 2050 and 2055 by Solid State Micro Technology, and the 3310 from Curtis. Those LSI versions are especially attractive for computer-controlled synthesizers where many ADSR's (perhaps as many as 32) are required in one unit.

The use of one-IC envelope generators cannot really be justified (except for the computer controlled synthesizers mentioned above) because of the relatively high cost of the units. Single-IC envelope generators still cost seven or eight dollars apiece. In contrast, the circuit in Fig. 5 (which uses about two-dollars-worth of IC's) accomplishes the same thing—it provides complete control over the attack, decay, sustain, and release portions of the envelope. In addition, it allows for retriggering. That means that if the gate is still present and the waveform is in the sustain portion of its curve, a new trigger will initiate the attack cycle once again.

While there is no doubt that use of LSI technology can make the designer's work much simpler in regard to VCO's, VCF's, and VCA's, it appears that, for now, the use of standard components is much more cost-effective in the design of ADSR's.

We have barely touched the four main synthesizer-components, and there are many other types of modules available such as balanced "ring" modulators, echo units, sequencers, sample-and-hold units, etc. Those other types of modules have also been affected by advances in LSI technology, bringing parts counts and prices down to a minimum. R-E

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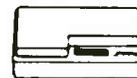
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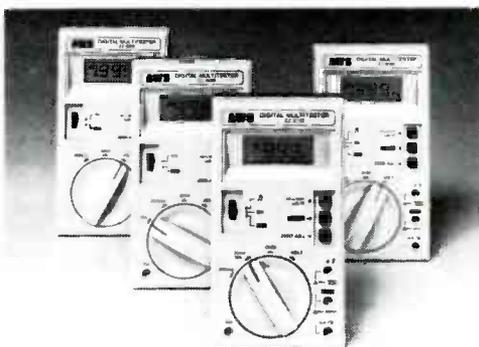
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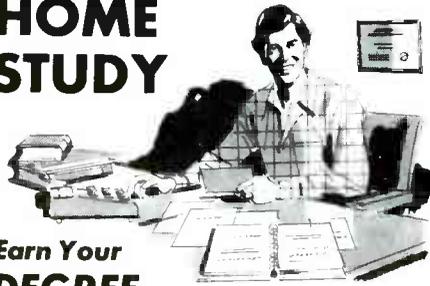
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**TALKING ALARM CLOCK**

*continued from page 60*

The second way of feeding data to the VSP is through its microprocessor interface. The interface consists of a bidirectional data bus with some control lines. In addition to being used to carry speech data, that bus is also used to send commands to the VSP. Those commands control all the VSP functions.

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When we continue next time, we'll describe the clock hardware as well as the software that is needed to drive it. And of course we'll cover completely construction, checkout, and use. R-E

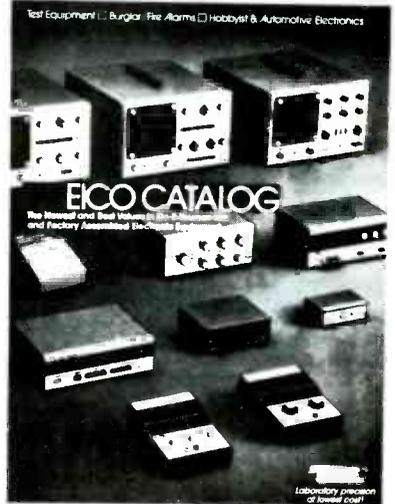
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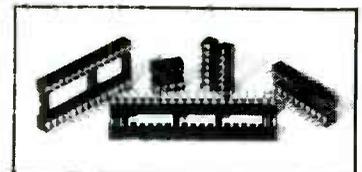
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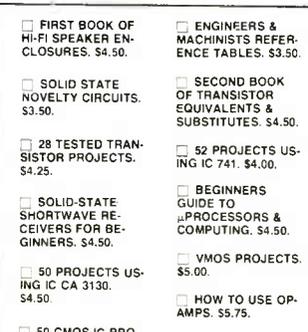
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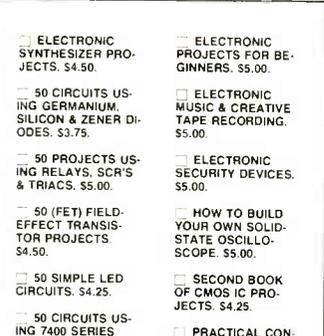
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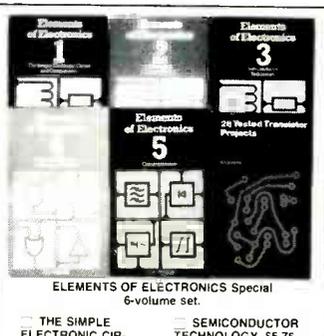
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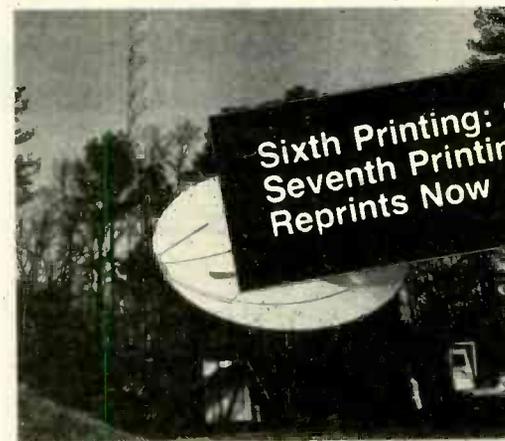
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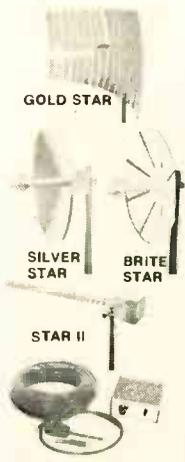
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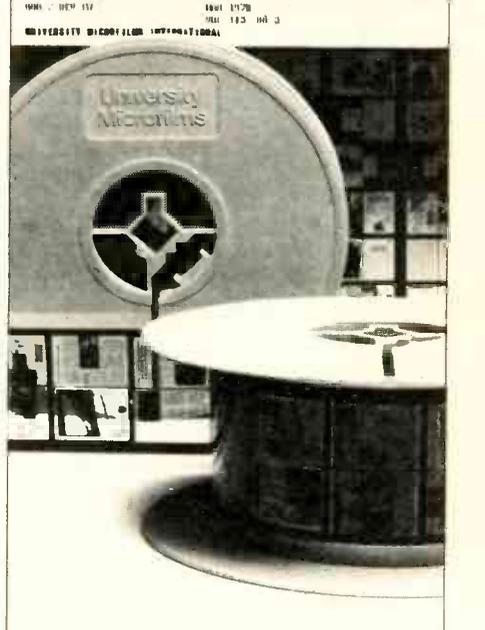


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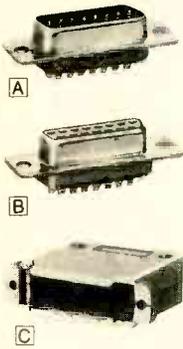
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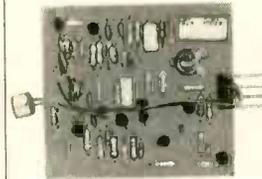
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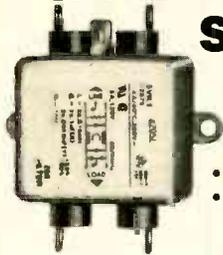
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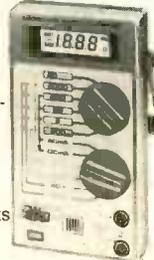
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Normally open momentary contact. Mount in 1/4" hole. 0.5A at 125VAC. 275-1547 ..... 5/2.49

## UHF Adapters and Connectors

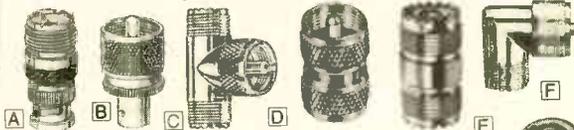


Fig.	Type	Adapts	To Fit	Cat. No.	Each
A	UG-255/U	Female BNC	PL-259	278-120	2.99
B	UG-273/U	Male BNC	SO-239	278-121	2.99
C	M-358 "T"	SO-239	(2) PL-259	278-198	2.59
D	—	SO-239	SO-239	278-192	1.89
E	PL-258	PL-259	PL-259	278-1369	1.59
F	M-359	Right-Angle	Adapter	278-199	2.09
G	Solderless Push-On PL-259. For RG58/59. 278-190 ..... 1.59				
H	1094 Female BNC. Mounts in 5/8" hole. 278-105 ..... 1.59				
J	UG-88 Male BNC. Solderless. For RG58. 278-103 ..... 2.29				
K	UG-88 Male BNC. Above, for RG59/RG62. 278-104 ..... 2.29				
L	Inline Female BNC. For RG58 cable. 278-113 ..... 2.49				
M	Inline Female BNC. For RG59, RG62 cable. 278-114 ..... 2.49				

## Mike Element **119**



For Projects, Replacement

PC Board-Mount Electret. Omni-directional. 2-10VDC, 1 mA max. 20 Hz to 15 kHz ± 4 dB. 270-090 ..... 1.19

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1/4-Watt, 5% Tolerance. 13 of the most popular values. 271-308. Sale, Set/1.99

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120 volt primaries

5.6 VOLTS at 750 MA \$3.00  
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 16.5 V. at 3 AMPS \$6.50  
 18 V at 650 MA \$3.50  
 18 VOLTS at 1 AMP \$4.50  
 18 V.C.T. at 2 AMP \$5.50  
 24 VOLTS at 250 MA \$2.50  
 24 VCT at 1 AMP \$4.50  
 42 V.C.T. at 1.2 AMP \$4.50

## DC WALL TRANSFORMER

ALL ARE 115 VAC PLUG IN

4 VDC at 70 MA \$2.50  
 9 VDC at 100 MA \$2.00  
 9 VDC at 225 MA \$3.00  
 16.5 VAC at 10 VA \$3.50  
 17 VAC at 50 MA \$4.00  
 22 VDC at 60 MA \$2.50

## VARACTOR DIODE

MV2205 3 FOR \$1.00  
 16 PF 100 FOR \$30.00

BB-103 3 for \$1.00  
 33 PF 100 FOR \$30.00

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EASILY HOOKS INTO STEREO SPEAKERS AND ALLOWS 110 VAC LIGHTS TO DANCE WITH MUSIC. TWO SEPARATE 110 VAC OUTPUTS FOR HIGH AND LOW FREQUENCY AUDIO SIGNALS. USE TWO ORGANS FOR STEREO.

\$6.50 PER UNIT  
 COLOR LIGHT STRING AVAILABLE \$1.75 EA

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1 1/2 AMP 400 P.I.V.  
 TO-5 CASE 3/8" DIA.  
 3/16" HIGH 2 for \$1.25

6 AMP 200 P.I.V.  
 5/8" SQUARE  
 \$1.00 EACH

10 AMP 200 P.I.V.  
 5/8" SQUARE  
 \$1.50 EACH

## 25 AMP BRIDGE RECTIFIERS

1 1/8" SQUARE  
 25 AMP 200 P.I.V. \$2.00 EACH  
 25 AMP 600 P.I.V. \$3.00 EACH

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1 AMP 50 VOLTS 15 for \$1.00  
 1 AMP 200 VOLTS 10 for \$1.00  
 1 AMP 800 VOLTS 6 for \$1.00  
 2 1/2 AMP 1000 VOLTS 4 for \$1.00

## CRYSTALS

CASE STYLE HC33/U  
 2 MHZ: COLORBURST 3579 545 KC \$3.50 EACH  
 \$1.00 EACH

## T.V. GAME SWITCH

RCA PLUG or 300 OHM IN  
 300 ohms OUT  
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## S.C.R.

0.8 AMPS 30 VOLTS 5 for \$1.00  
 4 AMPS 200 VOLTS 65¢ EACH  
 4 AMPS 500 VOLTS 85¢ EACH

## TRIAC

6 AMPS 400 VOLTS 75¢ EACH

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 2N2904 4 for \$1.00  
 2N2905 4 for \$1.00  
 2N2907 4 for \$1.00  
 MJ3030 \$2.50  
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 2N3585 \$1.00  
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 2N3906 5 for \$1.00  
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 2N4403 5 for \$1.00  
 2N4898 \$1.50  
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 TIP 126 .75

## MICROWAVE TRANSISTOR

MRF 901 REDUCED TO N.P.N. SILICON \$2.00 EACH

## LIGHTS

### GRAIN OF WHEAT T1 SIZE

125" DIA. (3.15mm)

3 to 6 VOLTS 3 for \$1.00  
 Rated: 55ma @ 5 VOLTS

6 to 12 VOLTS 3 for \$1.00  
 Rated: 55ma @ 8 VOLTS

12 to 24 VOLTS 3 for \$1.00  
 Rated: 45ma @ 14 VOLTS

### T1 SIZE WITH WIRE LEADS

3 to 6 VOLTS 2 for \$1.00  
 Rated: 55ma @ 5 VOLTS

6 to 12 VOLTS 2 for \$1.00  
 Rated: 55ma @ 8 VOLTS

12 to 24 VOLTS 2 for \$1.00  
 Rated: 45ma @ 14 VOLTS

### T1- 3/4 SIZE WITH WIRE LEADS

163" DIA. (4.14mm)

3 to 6 VOLTS 2 for \$1.00  
 Rated: 45ma @ 6 VOLTS

6 to 12 VOLTS 2 for \$1.00  
 Rated: 55ma @ 8 VOLTS

12 to 24 VOLTS 2 for \$1.00  
 Rated: 45ma @ 14 VOLTS

### NEON W/ RESISTOR

DIRECT OPERATION FROM 120 VOLT  
 7 for \$1.00

### 120V INDICATOR

NEON INDICATOR. RATED 120 V 1/3 W. MOUNTS IN 5/16" HOLE. RED LENS.  
 75¢ EACH  
 10 FOR \$7.00  
 100 FOR \$65.00

## 12 VOLT A.C. POWER UNIT

THIS UNIT CONSISTS OF A 12 VOLT 2 AMP TRANSFORMER, 1 AMP CIRCUIT BREAKER, 4 PRONG CINC H JONES SOCKET AND A 3 WIRE A.C. CORD ALL MOUNTED IN AN ATTRACTIVE 4 1/2" x 5 1/2" x 3" CHASSIS BOX. GOOD FOR PARTS OR A NICE START FOR D.C. POWER SUPPLY. \$8.50 PER UNIT

## CO-AX SWITCH (A/B SWITCH)

75 ohms IN TWO  
 75 ohms OUT  
 \$3.50 EACH

## METERS

### 0 - 20 V.D.C.

0-20 VDC FULL SCALE FACEPLATE BATTERY TEST SET-UP AS INDICATOR \$5.50 EACH

### 1 MA

2 5/16" SQUARE PANEL METER MOUNTS IN 2 1/8" HOLE \$5.50 EACH

### 0 - 15 V.D.C.

THIS 2-1/4" SQUARE METER MEASURES 0-15 VDC. \$4.50 EACH

## METAL OXIDE VARISTOR

2 FOR \$1.50  
 G.E. # V82ZA12 50 VOLTS NOMINAL D.C. VOLTAGE. 5/8" DIAMETER.

## LINE CORDS

### TWO WIRE

6' 18ga TWO WIRE 3 FOR \$1.00

### THREE WIRE

18 INCH 18ga THREE WIRE 2 for \$1.00  
 8 FOOT 18ga THREE WIRE \$2.00 EACH

## SWITCHES

### MINI-PUSH BUTTON

S.P.S.T. MOMENTARY NORMALLY OPEN 1/4" BUSHING 35¢ EACH 10 FOR \$3.25 100 FOR \$30.00 SPECIFY COLOR: RED, BLACK WHITE, GREEN, YELLOW.

### KEY SWITCH

S.P.S.T. 4 AMPS @ 125 VAC KEY REMOVES BOTH POSITIONS \$3.50 EA

### LIGHTED PUSH BUTTON

RED LIGHTED 120 VAC 10 AMP. S.P.S.T. "POWER" PRINTED ON FACE. MOUNTS IN 7/8" SQUARE HOLE. \$1.50 EA 10 FOR \$13.50

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THESE SPEAKERS COME IN HEAT RESISTANT ABS PLASTIC CABINETS. IDEAL FOR CAR INTERIORS WHERE HEAT CHANGE OCCURS. POWER RATING: 15 WATT NOM 45 WATT MAX. EACH SYSTEM CONTAINS A 4 INCH 10 OZ. WOOFER AND 2 INCH TWEETER

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6 VDC RELAY  
 MINIATURE D.P.D.T. 3 AMP CONTACTS FUJITSU # FBR321D006 \$1.75 EA 10 / 16.00

### MINIATURE 6 VDC RELAY

SUPER SMALL SPDT RELAY; GOLD COBALT CONTACTS  
 RATED 1 AMP AT 30 VDC; HIGHLY SENSITIVE. TTL DIRECT DRIVE POSSIBLE. OPERATES FROM 4.3 TO 6 V. COIL RES. 220 OHM.  
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### 13 VDC RELAY

CONTACT: S.P.N.C. 10 AMP @ 120 VAC. ENERGIZE COIL TO OPEN CONTACT...  
 COIL: 13 VDC 650 OHMS  
 SPECIAL PRICE \$1.00 EACH

### 4 PDT RELAY

14 pin style  
 3 amp contacts  
 24 volt d.c. or 120 volt a.c. coil  
 Used but fully tested \$1.70 EACH  
 specify coil voltage  
 LARGE QUANTITIES AVAILABLE  
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1700 mfd. 150 VDC \$2.00  
 2 1/2" DIA. x 4 3/4" HIGH  
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 6,000 mfd. 600VDC \$2.50  
 1 3/8" DIA. x 4 1/4" HIGH  
 18,000 mfd. 75 VDC \$4.00  
 2 1/2" DIA. x 4 1/2" HIGH  
 22,000 mfd. 15 VDC 2" DIA. x 2 1/2" HIGH \$2.00  
 22,000 mfd. 40 VDC 2" DIA. x 6" HIGH \$3.00  
 24,000 mfd. 30 VDC 1 3/4" DIA. x 4" HIGH \$3.50  
 31,000 mfd. 15 VDC 1 3/4" DIA. x 4" HIGH \$2.50  
 72,000 mfd. 15 VDC 2" DIA. x 4" HIGH \$3.50  
 180,000 mfd. at 6V 2 1/2" DIA. x 4 1/2" HIGH \$1.50  
 CLAMPS TO FIT CAPACITORS 50¢ ea.

## BLACK LIGHT (ULTRAVIOLET)

G.E. # F6T5BL \$2.50 each

## POWER SUPPLY WITH PRE-AMP

THIS SUPPLY WAS USED TO POWER AN 8 TRACK/CASSETTE UNIT. IT WILL SUPPLY APPROX. 18 VDC AND INCLUDES A SMALL PRE-AMP TO BOOST SIGNAL LEVEL. RCA PLUGS FOR LINE IN/OUT. \$4.50 EACH

## EDGE CONNECTORS

ALL ARE .156" SPACING

15 PIN GOLD SOLDER EYELET \$1.75 EACH

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BLACK PLASTIC ENCLOSURE ADJUSTABLE HEIGHT FROM 1.63" TO 2.93"; WIDTH 6.85"; DEPTH 8". BUILT-IN STAND OFFS FOR P.C. BOARDS. FRONT AND BACK PANELS NOT INCLUDED. \$5.25 PER CASE

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170 MFD 330 VOLT 1 1/8" x 7/8" 2 FOR \$1.50 10 FOR \$7.00

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 CONTAINS 5 SINGLE-POLE NORMALLY OPEN SWITCHES. MEASURES 3 3/4" LONG

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CONTAINS 6 SINGLE-POLE NORMALLY OPEN SWITCHES. MEASURES 4 1/4" LONG.

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ADDING MACHINE STYLE SWITCH ASSEMBLY. CONTAINS 15 SINGLE-POLE NORMALLY OPEN SWITCHES (PUSH TO MAKE).

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## POTS

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## SLIDE POTS

500K linear taper 2 7/8" LONG 1 3/4" TRAVEL 75¢ EACH

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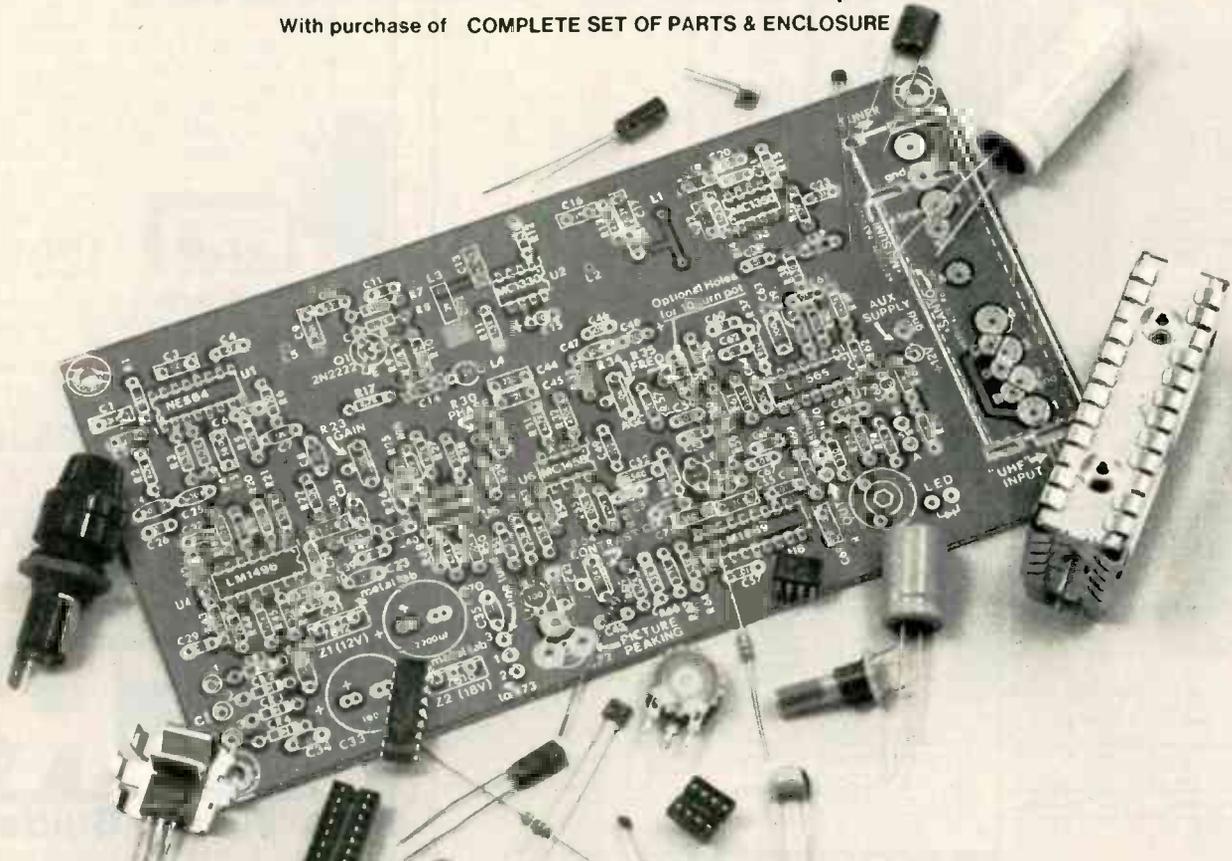
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MM5056	2.50	8839	2.25
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4008	70	4048	35	74C04	35	
4009	39	4050	36	74C08	30	
4010	45	4051	80	74C10	27	
4011	22	4052	75	74C14	55	
4012	22	4053	75	74C20	27	
4013	35	4060	80	74C24	39	
4014	70	4066	38	74C24	1.00	
4015	39	4068	35	74C74	40	
4016	30	4070	35	74C76	70	
4017	60	4071	35	74C85	1.40	
4018	40	4072	26	74C86	39	
4019	39	4073	26	74C90	90	
4020	70	4076	65	74C93	50	
4021	65	4077	25	74C161	1.15	
4022	75	4077	25	74C157	1.75	
4023	22	4082	25	74C180	1.20	
4024	22	4083	25	74C181	1.15	
4025	25	4083	49	74C183	1.15	
4026	95	4089	1.15	74C173	75	
4027	55	4501	95	74C174	1.19	
4028	55	4510	95	74C192	1.30	
4029	75	4511	95	74C190	39	
4030	35	4514	1.25	74C302	90	
4034	1.75	4515	1.50	74C91	75	
4035	75	4516	75	74C91A	1.75	
4040	65	4518	85	74C92	3.95	
4042	55	4520	70	74C93	1.25	
		4528	1.00	74C83	1.25	
		4539	1.25			

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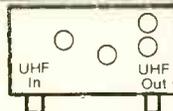
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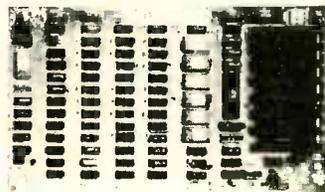


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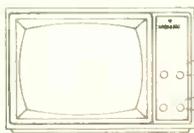
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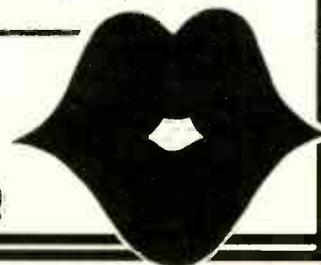
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\* Yes All Prices Are Correct! • \$10.00 Minimum Order on All Above Capacitors • Some Quantity Pricing Available •

## MORE \$1.00 SPECIALS

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2SC828	5/1.00	7 Seg. LED Readout	1.00
2SC644	5/1.00	HP 5082-7650	1.00
SPS7390/ECG213P	5/1.00	5/1.00	
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ACU-1 75-300Ω ... 85¢

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12 Application Schematics

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Continuous Tune Model 45MHz Output

While They Last

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5 or more \$2.25 ea.

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TOP QUALITY NO SECONDS

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LM-386N-3	Low Voltage Audio Amp	1.59	1.19
50W8V		3.50	2.89
NE-564N	Digital Phase Locked Loop	1.69	1.27
LM-565N	Phase Locked Loop	2.49	1.87
LM-733N	Video Amp	2.08	1.55
MC-1330	Video Detector	1.75	1.31
MC-1349	Video If Amp	2.89	2.09
MC-1350	Video If Amp	1.95	1.46
MC-1362	Video If Amp AGC	3.19	2.39
MC-1358	Audio If Amp	88	66
MC-1374P	R.F. Modulator	1.79	1.34
MC-1458	Dual Comp Op Amp	4.49	3.37
MC-1498N	Balance Mod/Demodulator	2.19	2.19
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MBD-101 ..... .98  
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25-Up ..... .30  
2N6603 (formerly MRF 902) ..... 11.96

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Woodgrain

This box is 11 1/4" W - 4 1/4" H - 5 1/2" D with a removable aluminum U-shaped chassis

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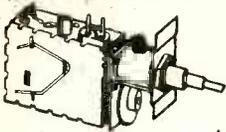
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Available on request: Ch 2 or 4.

Part No. B20

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1. The first thing we do is change the standard diode found in every tuner to a Hot Carrier Diode.
2. The tuners output is then measured and compared to our computer derived chart from which we determine the correct value coil to add across the IF output for maximum Pre-Added gain.
3. The tuner is fed a standard 10db antenna input, and while monitoring the output on our Spectrum Analyzer, the tuner is tuned to the desired channel and its oscillator is offset for the desired output frequency as follows:

Ch. 2: 58MHz Ch. 3: 63MHz Ch. 4: 68MHz

We call this step peaking because the tuners output looks like a peak on our spectrum analyzer and the highest point of that peak is actually adjusted for the desired output.

4. Finally, we measure the tuners output one more time which is again compared to our computer derived performance chart to ascertain the correct value of the second coil which is added to the tuners internal connections.

This procedure was developed by GILCO and its our computer derived performance charts that make our tuner better. That's because almost every tuner gets a different value coil before it's peaked and then a different value coil after it's peaked. The combinations are endless and the way we determine the values is our secret.

### PRINTED CIRCUIT BOARDS

Part No. B21 Printed Circuit Board. . . . . **\$17.00**

1. This Printed Circuit Board uses only one jumper, others use 9.
2. The component layout is screen printed on the Component side of the pre-drilled P/C Board.
3. The solder side of the P/C Board is covered with High Temperature Solder Resist for ease of assembly.
4. This P/C board was designed to take advantage of the Gilco High Gain Tuner which means its circuitry is simpler and more efficient than those circuits that require inferior Varactor Tuners.

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74LS26	.30	74LS156	.89	74LS352	1.49
74LS27	.24	74LS157	.75	74LS353	1.49
74LS28	.30	74LS158	.75	74LS363	1.49
74LS30	.24	74LS160	.95	74LS364	1.95
74LS32	.36	74LS161	.95	74LS365	.89
74LS33	.55	74LS162	.95	74LS366	.89
74LS37	.55	74LS163	.95	74LS367	.69
74LS38	.35	74LS164	.95	74LS368	.69
74LS40	.30	74LS165	.95	74LS373	.99
74LS42	.49	74LS166	1.95	74LS374	1.69
74LS47	.75	74LS168	1.69	74LS377	1.40
74LS48	.75	74LS169	1.69	74LS378	1.15
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74LS90	.65	74LS197	.79	74LS674	9.50
74LS91	.79	74LS221	1.10	74LS682	2.99
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74LS93	.59	74LS241	.95	74LS684	2.39
74LS95	.79	74LS242	1.79	74LS685	2.39
74LS96	.79	74LS243	1.79	74LS688	2.39
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74LS109	.39	74LS245	1.89		
74LS112	.39	74LS247	.79	81LS95	1.65
74LS113	.39	74LS248	1.20	81LS96	1.65
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4001	.30
4002	.30
4006	.90
4007	.25
4008	.90
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LM311	.64
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LM317K	1.70
LM318	1.49
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LM324	.59
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LM380	1.25
LM386	1.00
LM555	.38
LM556	.65
LM565	.95
LM566	1.45
LM567	.99
LM723	.49
LM733	.95

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4018	.90
4019	.45
4020	.90
4021	.90
4022	1.10
4023	.35
4024	.75
4025	.35
4026	1.60
4027	.60
4028	.75
4029	.90
4030	.45
4034	2.90
4035	.85
4040	.90
4041	1.20
4042	.75
4043	.75
4044	.75
4046	.90
4047	.90
4049	.50
4050	.50
4051	.90
4053	.90
4060	1.39
4066	.75
4068	.39
4069	.30
4070	.35
4071	.30
4072	.30
4073	.30
4075	.30
4076	.90
4078	.30
4081	.30

### CMOS

4082	.30
4085	.90
4086	.90
4093	.90
4098	2.49
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4503	.60
4508	1.90
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DJ1-16	924112-36	16 single end 36"	2.59
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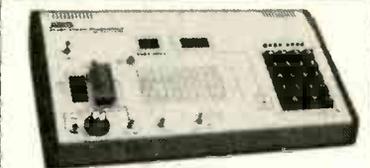
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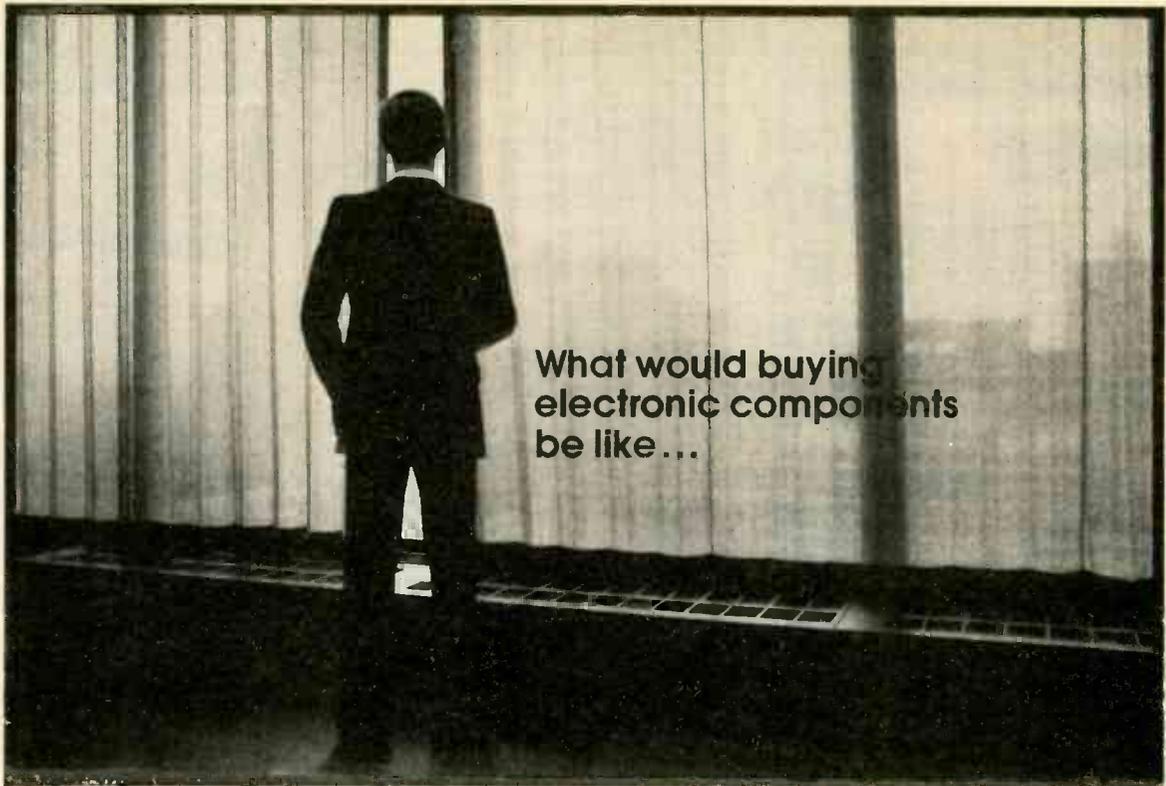
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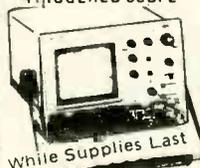
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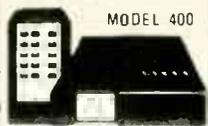
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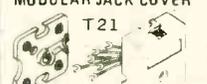
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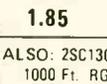
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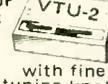
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7404	74LS04	74504	4004		
7405	74LS05	74505	4005		
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7407	74LS07	74507	4007		
7408	74LS08	74508	4008		
7409	74LS09	74509	4009		
7410	74LS10	74510	4010		
7411	74LS11	74511	4011		
7412	74LS12	74512	4012		
7413	74LS13	74513	4013		
7414	74LS14	74514	4014		
7415	74LS15	74515	4015		
7416	74LS16	74516	4016		
7417	74LS17	74517	4017		
7418	74LS18	74518	4018		
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7402	74LS02	74502	4002		
7403	74LS03	74503	4003		
7404	74LS04	74504	4004		
7405	74LS05	74505	4005		
7406	74LS06	74506	4006		
7407	74LS07	74507	4007		
7408	74LS08	74508	4008		
7409	74LS09	74509	4009		
7410	74LS10	74510	4010		
7411	74LS11	74511	4011		
7412	74LS12	74512	4012		
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7416	74LS16	74516	4016		
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7453	74LS53	74553	4053		
7454	74LS54	74554	4054		
7455	74LS55	74555	4055		
7456	74LS56	74556	4056		
7457	74LS57	74557	4057		
7458	74LS58	74558	4058		
7459	74LS59	74559	4059		
7460	74LS60	74560	4060		
7461	74LS61	74561	4061		
7462	74LS62	74562	4062		
7463	74LS63	74563	4063		
7464	74LS64	74564	4064		
7465	74LS65	74565	4065		
7466	74LS66	74566	4066		
7467	74LS67	74567	4067		
7468	74LS68	74568	4068		
7469	74LS69	74569	4069		
7470	74LS70	74570	4070		
7471	74LS71	74571	4071		
7472	74LS72	74572	4072		
7473	74LS73	74573	4073		
7474	74LS74	74574	4074		
7475	74LS75	74575	4075		
7476	74LS76	74576	4076		
7477	74LS77	74577	4077		
7478	74LS78	74578	4078		
7479	74LS79	74579	4079		
7480	74LS80	74580	4080		
7481	74LS81	74581	4081		
7482	74LS82	74582	4082		
7483	74LS83	74583	4083		
7484	74LS84	74584	4084		
7485	74LS85	74585	4085		
7486	74LS86	74586	4086		
7487	74LS87	74587	4087		
7488	74LS88	74588	4088		
7489	74LS89	74589	4089		
7490	74LS90	74590	4090		
7491	74LS91	74591	4091		
7492	74LS92	74592	4092		
7493	74LS93	74593	4093		
7494	74LS94	74594	4094		
7495	74LS95	74595	4095		
7496	74LS96	74596	4096		
7497	74LS97	74597	4097		
7498					

**★ ★ COMING IN MAY ★ ★**

**1% Metal Film Resistors at a Low DIGI-KEY Price**

The Big DIGI-KEY Discount makes a Big Price Difference

### SILICON RECTIFIERS

#### ZENER DIODES

**3 AMP SILICON RECTIFIER**

**100W SILICON ZENER DIODES**

Part No. Price

1A100	1.00	100.00
1A150	1.50	150.00
1A200	2.00	200.00
1A250	2.50	250.00
1A300	3.00	300.00
1A350	3.50	350.00
1A400	4.00	400.00
1A450	4.50	450.00
1A500	5.00	500.00
1A550	5.50	550.00
1A600	6.00	600.00
1A650	6.50	650.00
1A700	7.00	700.00
1A750	7.50	750.00
1A800	8.00	800.00
1A850	8.50	850.00
1A900	9.00	900.00
1A950	9.50	950.00
1A1000	10.00	1000.00

### National Semiconductor

#### MA1026 Temp. Clock Module

Client's 7 Inch Digital LED Display

- P and/or D and virtually any number of sensors
- 50/100 Hz line frequency operation
- 12 or 24 Hour operation

Typical Applications: Weather, Clock Radio, Alarm Clock, Clock, TV and Stereo Tuner, Instrument Panel, Clock, Digital Thermometer and much more.

Part No. Price

MA1026	1.00	100.00
MA1027	1.50	150.00
MA1028	2.00	200.00
MA1029	2.50	250.00
MA1030	3.00	300.00
MA1031	3.50	350.00
MA1032	4.00	400.00
MA1033	4.50	450.00
MA1034	5.00	500.00
MA1035	5.50	550.00
MA1036	6.00	600.00
MA1037	6.50	650.00
MA1038	7.00	700.00
MA1039	7.50	750.00
MA1040	8.00	800.00
MA1041	8.50	850.00
MA1042	9.00	900.00
MA1043	9.50	950.00
MA1044	10.00	1000.00

### SILICON TRANSISTORS

Part No. Price

2N2005	1.44	12.00	160.00	800.00
2N2006	20	1.75	18.25	140.25
2N2007	20	1.75	18.25	140.25
2N2008	22	2.01	19.25	154.25
2N2009	21	1.81	17.50	136.50
2N2010	24	2.20	20.00	170.00
2N2011	24	2.20	20.00	170.00
2N2012	27	2.42	22.50	187.50
2N2013	27	2.42	22.50	187.50
2N2014	38	3.42	30.00	270.00
2N2015	38	3.42	30.00	270.00
2N2016	41	3.69	32.50	292.50
2N2017	41	3.69	32.50	292.50
2N2018	147	13.44	122.50	1100.00
2N2019	174	6.66	60.13	541.13
2N2020	174	6.66	60.13	541.13
2N2021	58	4.00	36.00	320.00
2N2022	58	4.00	36.00	320.00
2N2023	69	6.01	54.00	486.00
2N2024	69	6.01	54.00	486.00
2N2025	110	9.90	89.38	804.38
2N2026	110	9.90	89.38	804.38
2N2027	66	7.74	69.66	627.66
2N2028	66	7.74	69.66	627.66
2N2029	78	6.88	61.93	551.93
2N2030	78	6.88	61.93	551.93
2N2031	101	10.90	97.10	870.10
2N2032	101	10.90	97.10	870.10
2N2033	145	12.87	115.83	1043.83
2N2034	145	12.87	115.83	1043.83
2N2035	23	2.00	18.00	162.00
2N2036	23	2.00	18.00	162.00
2N2037	23	2.00	18.00	162.00
2N2038	23	2.00	18.00	162.00
2N2039	23	2.00	18.00	162.00
2N2040	23	2.00	18.00	162.00
2N2041	23	2.00	18.00	162.00
2N2042	23	2.00	18.00	162.00
2N2043	23	2.00	18.00	162.00
2N2044	23	2.00	18.00	162.00
2N2045	23	2.00	18.00	162.00
2N2046	23	2.00	18.00	162.00
2N2047	23	2.00	18.00	162.00
2N2048	23	2.00	18.00	162.00
2N2049	23	2.00	18.00	162.00
2N2050	23	2.00	18.00	162.00

### TERMINATION JUMPERS

**B-SOCKET CONNECTION TERMINATION**

**P-PCB CONNECTION TERMINATION**

**X-CARD EDGE CONNECTION TERMINATION**

Number After Dash Is Cable Length In Inches

Part No. Price

10	1.00	10.00
15	1.50	15.00
20	2.00	20.00
25	2.50	25.00
30	3.00	30.00
35	3.50	35.00
40	4.00	40.00
45	4.50	45.00
50	5.00	50.00
55	5.50	55.00
60	6.00	60.00
65	6.50	65.00
70	7.00	70.00
75	7.50	75.00
80	8.00	80.00
85	8.50	85.00
90	9.00	90.00
95	9.50	95.00
100	10.00	100.00

### alpha

#### Weld Cable Tubing

Product: Wire Stranded PVC Insulated

Part No. Price

10	1.00	10.00
15	1.50	15.00
20	2.00	20.00
25	2.50	25.00
30	3.00	30.00
35	3.50	35.00
40	4.00	40.00
45	4.50	45.00
50	5.00	50.00
55	5.50	55.00
60	6.00	60.00
65	6.50	65.00
70	7.00	70.00
75	7.50	75.00
80	8.00	80.00
85	8.50	85.00
90	9.00	90.00
95	9.50	95.00
100	10.00	100.00

### SILICON ZENER DIODES

Part No. Price

1A100	1.00	100.00
1A150	1.50	150.00
1A200	2.00	200.00
1A250	2.50	250.00
1A300	3.00	300.00
1A350	3.50	350.00
1A400	4.00	400.00
1A450	4.50	450.00
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2N2045	23	2.00	18.00	162.00
2N2046	23	2.00	18.00	162.00
2N2047	23	2.00	18.00	162.00
2N2048	23	2.00	18.00	162.00
2N2049	23	2.00	18.00	162.00
2N2050	23	2.00	18.00	162.00

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35	3.50	35.00
40	4.00	40.00
45	4.50	45.00
50	5.00	50.00
55	5.50	55.00
60	6.00	60.00
65	6.50	65.00
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75	7.50	75.00
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95	9.50	95.00
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### alpha

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35	3.50	35.00
40	4.00	40.00
45	4.50	45.00
50	5.00	50.00
55	5.50	55.00
60	6.00	60.00
65	6.50	65.00
70	7.00	70.00
75	7.50	75.00
80	8.00	80.00
85	8.50	85.00
90	9.00	90.00
95	9.50	95.00
100	10.00	100.00

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Part No. Price

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1A300	3.00	300.00
1A350	3.50	350.00
1A400	4.00	400.00
1A450	4.50	450.00
1A500	5.00	500.00
1A550	5.50	550.00
1A600	6.00	600.00
1A650	6.50	650.00
1A700	7.00	700.00
1A750	7.50	750.00
1A800	8.00	800.00
1A850	8.50	850.00
1A900	9.00	900.00
1A950	9.50	950.00
1A1000	10.00	1000.00

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Part No. Price

MA1026	1.00	100.00
MA1027	1.50	15

**Touch Tone Generator Mini-Kit**  
K-1263  
**\$5.95**  
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NEW, FOR UPGRADE OR CONVERTER USE.  
IF OUTPUT, USES +12V AND +24V SUPPLY. T-1195 WT 1/2 LB

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GREAT STUFF AT A FRACTION OF ITS NORMAL COST. EASILY CUT WITH HAND SHEARS, WON'T CRACK OR CHIP. GOOD VARIETY OF SIZES, NONE LESS THAN 3" X 3". INCLUDES SOME DOUBLE SIDED  
PC-10 **\$4.95**  
(OVER 200 SQ IN.)

**6 VDC 4PDT Relay w/Socket**  
CUBE TYPE 1 1/8" SQ X 7" GOLD CONTACTS 3 A  
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10/17.50  
100/17.40  
WT 0.2 LB R-1290

**REED SWITCH**  
1-1/8" X 1/8" DIA  
8-4808  
USE WITH MAGNET OR COIL  
**20/1**

**4' LINE CORDS**  
18 GA. BROWN  
2 WIRE CORD WITH MOLDED PLUG  
**18¢**  
10/1.50  
WT 0.2 LB C-1000

**ETCHANT**  
Ammonium Persulfate  
FAST & EASY TO USE, MIX A HALF POUND TO A GALLON, 1 OZ TO 1 PINT OF WATER AND ETCH! THE WHITE CRYSTALS MAKE A CLEAR SOLUTION THAT TURNS BLUE WHEN FULL OF COPPER. 1 LB MAKES 2 GALLONS.  
H-2240 **\$1.75**  
1 LB **\$1.95** 10 LB @ **\$1.95 EA**

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5' CORD WITH POWER PLUG  
**\$2.25**  
10/19.50  
100/165  
T-1230 WT 0.5 LB

**SOLID CARBIDE PC DRILL BITS**  
Last 1000's of times longer than std bits!

STOCK #	SIZE
D-0400	#60 0400
D-0420	#58 0420
D-0465	#56 0465
D-0520	#55 0520
D-0595	#53 0595

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**CRIMPING TOOL FOR RG-58, RG-59**  
**\$4.49** A-2535  
WT 0.4 LB

**74S124 DUAL VCO**  
CRYSTAL OR RC  
1.42 TO 85 MHZ  
16 PIN DIP  
DATA SHEET 25¢  
**\$1.50**

**ALARM MATS**  
CLOSES SWITCH WHEN STEPPED ON. TAPESWITCH MODEL CVP  
SIZE 6" X 23"  
OUTPUT IS 2 PIN MOLEX  
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WEST COAST ADD \$1.80 FOR THE FIRST POUND & 50¢ FOR EACH ADDITIONAL POUND  
COD & MAIL ORDER \*7 MINIMUM, CREDIT CARDS \*15 MIN.

**TRANSFORMER BALUN**  
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WT 0.1 LB  
ALL TV CHANNELS PLUS FM  
75.5A TO 300.0  
**89¢**

**LIGHTED 5-Pushbutton Assy**  
SWITCHCRAFT SERIES 37000  
DIPOT SILVER LEAFS  
.9" X 6" BUTTONS  
14V 50,000 HOUR BULBS  
LIST OVER \$30.00  
MOMENTARY  
8-3016 WT 0.4 LB 10/\$35

**AMAZING DEVICES**

**PHASOR LASERS SECURITY**

**PHASOR PAIN FIELD** — Patented and recently developed in our labs is being tested by Gov't for riot control. Soon to come under weapons restrictions as an internal machine. Easily hand-held. Hazardous IF NOT USED WITH DISCRETION.  
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IPG-3 PLANS **\$7.00** IPG-3K KIT & PLANS **\$44.50**  
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**PHASOR STUN/BURNING WAND** — Produces sufficient electrical energy capable of burning flesh. Intended as a personal defense device.  
PSW-3 PLANS **\$8.00** PSW-3K KIT & PLANS **\$59.50**

**RUBY LASER RAY PISTOL** — Intense visible red, burns, hazardous, with parts sources **\$15.00**  
RUBY PLAN (includes all part sources) **\$15.00**  
**CARBON DIOXIDE LASER** — Generates 20-40 watts of continuous power capable of burning, cutting, hazardous. (with all part sources) **\$15.00**

**LASER RIFLE** — Produces 200-3000 pulses of 30 watt optical energy. Portable and easily hand-held  
LRG-3 PLANS **\$10.00**  
LRG-3K KIT PLANS (minus diode) **\$129.50**

**POCKET LASER** — For the beginner, visible red "optical version", non-hazardous.  
LHC-2 **\$5.00** LHC-2K KIT & PLANS **\$24.50**

**HIGH POWERED PORTABLE ENERGY SOURCE FOR LASERS AND MAGNETIC WEAPONS** — Exploding wires, shockwave, etc. Miniature size  
HPS-1 PLANS **\$8.00** HPS-1K KIT & PLANS **\$49.50**  
**PARTICLE BEAM WEAPON** — PLANS **\$15.00**

**INFINITY XMTR** — Uses telephone lines for selective home or office listening while away on business or vacation.  
INF-1 PLANS **\$15.00**

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SD-4 PLANS **\$10.00**

**LONG RANGE WIRELESS MIKE** — Crystal clear quality — miniature  
FBT-7 PLANS **\$7.00** FBT-7K PLANS & KIT **\$34.50**  
**WIRELESS TELEPHONE TRANSMITTER** — Long range, automatic.  
VWPM-5 PLANS **\$10.00** VWPM-5K PLANS & KIT **\$34.50**

Send for **FREE** catalog description of above plus hundreds more plans, kits and completed items. We accept MC or Visa or when ordering, send check or money order. We pay shipping charges on orders over \$50.00, otherwise include 10% with remittance.  
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7200 Standard Soldering Gun

**WTCPN Soldering Station**  
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**7200 Soldering Iron**  
Lightweight • Fingertip Trigger • Self Support Back **\$10.99**

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TC-150	279.99
TC-200	176.75

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DB25P	\$1.46
DB25S	\$1.25
DA51226-1	\$ .98

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SPECIAL PRICING SALE

New Quality Control Video Tape For Home And Professional Use.

L-500 2 HOUR BETA	\$6.95
T-120 5 HOUR VHS	\$9.85

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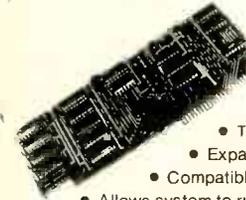
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SEND \$2.00 for 1983 CATALOG

## 16K Apple™ Ramcard



LIST 195 ACP  
\$59.95

- Full 1 year warranty
- Top quality — gold fingers
- Expand Apple II 48K to 64K
- Compatible with Z-80 Softcard™
- Allows system to run with CP/M™, PASCAL, DOS 3.3, COBAL, Visicalc, etc.
- Supplied with extra 16K RAM & has (2) LED's

## 32K STATIC RAM



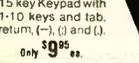
2 or 4 MHz Expandable Uses 2114L's  
16K 4 MHz Kit \$159.95  
16K 4 MHz A&T \$217.95  
32K 4 MHz Kit \$129.95  
32K 4 MHz A&T \$339.00  
BARE BOARD 39.95  
Bare Bd w/all parts less mem. 99.95

## REPEAT OF SELL-OUT 58 Key Unencoded Keyboard



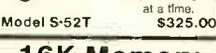
\$19.95 ea.  
This is a new 58 key terminal keyboard manufactured by a major manufacturer. It is unencoded with SPST keys unattached to any PC board. Solid molded plastic 1 1/4" x 4" base.

## Unencoded Key Pad



15 key keypad with 1-10 keys and tab, return, (-) (3) and (1). Only \$9.95 ea.

## UV "EPROM" ERASER

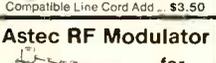


Model DE-4 \$89.95  
Holds 4 EPROM's at a time. \$325.00

## 16K Memory Expansion Kits for Apple/TRS-80

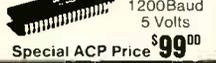
8 pcs 4x16 16K 200/250N \$12.95  
Specify computer  
CALL FOR VOLUME PRICING

## CORCOM FILTER



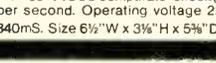
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## Astec RF Modulator



for COLOR & B/W P/N 1082 Channel 3 or 4 \$6.95

## AMD MODEM IC



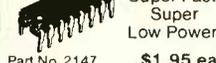
P/N AM7910 1200Baud 5 Volts \$99.00  
Special ACP Price

## 64K CMOS RAMCARD



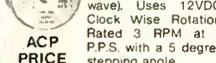
IEEE Compatible Uses Low Power 6116 IC's \$299.00  
5VOLT Single Supply Assm and Tested

## INTEL 4K STATIC RAMS



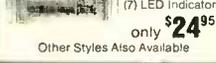
Super Fast! Super Low Power!  
Part No. 2147 ..... \$1.95 ea.

## STEPPER MOTOR



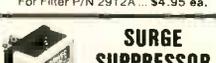
Operates by applying 12VDC in one direction and then reversing polarity (or square wave). Uses 12VDC. Clock Wise Rotation. Rated 3 RPM at 4 P.P.S. with a degree stepping angle.

## RS232 SIGNAL TESTER



COEX RS232 Line Tester (7) LED Indicators only \$24.95  
Other Styles Also Available

## INTEL CODEC IC



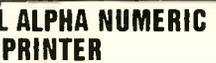
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For Filter P/N 2912A... \$4.95 ea.

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Hood 1.25  
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19 Column Printer prints 16 numerical columns plus 3 columns which have math, alpha and other notations. Each wheel has 12 positions with position 12 blank. Position 11 on numerical columns have decimal point or #. Utilizes 2.75" wide adding machine tape and a dual color ink ribbon. Input data parallel with four bit BCD comparator circuit (schematic provided). Print rate, 3 lines per second. Operating voltage 22-28VDC with typical cycle time of 340ms. Size 6 1/2" W x 3 3/4" H x 5 1/2" Dp. New. \$9.95 ea. \$3/27

## MICROPROCESSORS

Z8001	\$99.00	8008-1	\$14.95	6802P	14.95
Z8002	69.00	2801	9.90	8035	14.95
Z8003	69.00	2901A	14.95	8035	12.95
Z8004	11.95	8008A	4.95	8073N	34.95
F-8 (3850)	16.95	6502	9.95	8755	49.95
2650	18.95	8502A	16.95	8748	49.95
1802	3.75	8800	29.95	8800	30.00
8080A	4.75	6800	11.75	8086	49.95
8085	14.95	6800B	19.95	6800C	179.95

## CALL FOR QTY PRICING

6116/2016	\$7.95	2147	\$5.99	5290	\$1.99
8284-64K	5.95	411	5.99	5298	1.49
4116-2	1.99	414	4.69	6508	4.50
4116-2	8/12.95	1101	.99	6518	6.79
2101	.39	1103	.99	6561	3.79
2102-2	.79	4027	.69	6904	3.99
2102-4	1.49	4044	3.99	6905	7.99
2102-4	1.29	4050	4.69	9130	8.99
2111	3.49	4060	4.69	9140	8.99
2112	3.49	4096	3.99	9345	6.99
2114	1.99	4115	1.49	93425	6.99
2114L-2	3.25	4202	7.95		
2114L-4	3.29	4402	3.99		
2125	6.99	5280	4.80		

## SUPPORT

8155	\$9.95	8259	\$8.95	68047	\$22.95
2732 (4Kx8) TS	12.95	6275	19.95	634863	19.95
8202	23.95	8273	9.50	46505	22.95
8205	2.69	6810	4.75	6520	6.95
8212	2.75	6820	6.50	6522	9.95
8214	4.95	6821	6.50	6530-X	24.95
8216	2.75	6828	10.50	6532	17.95
8224	2.95	6834	16.95	6551	19.95
8226	2.95	6845	22.95	Z80-PIO	6.50
8228	3.95	6847	27.95	Z80A-PIO	9.50
8243	9.50	6850	5.25	Z80-C/TC	6.50
8250	14.95	6852	5.25	Z80A-C/TC	9.50
8251	6.50	6850	10.55	Z80-DMA	9.95
8253	11.95	6852	10.95	Z80A-DMA	27.95
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8257	9.50	6880	2.49	Z80A-SIO	29.95

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2732 (4Kx8) TS	12.95	2708 (650N's)	5.25
2716/2516, 5V, 12V	17.95	1702A	5.75
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MC686710 Mem Symbol 13.95		LM565	1.95
MC686750 Alpha Control 13.45		XR2205	Function Generator \$29
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1791-01 Dual Floppy	36.95	AY51014/1612 (5-14V)	6.95
1791-02 Dual Floppy	44.95	AY51015A/1633 (5V)	8.95
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1797 01/08 Floppy	54.95	IM6403	8.95
1691 Data Separator	18.95	2350 USRT	9.95
2143 Clock Generator	18.95	16718 Astros	24.95
8702 8 bit Binary	13.50	MC14411	11.95
8701 10 bit Binary	22.00	4703	9.95
8703 8 bit TS	13.50	WD1941	9.95
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8750 3 1/2 Digit BCD	13.95	INSR250	15.95
140816 6 bit	3.95	AY5-2376	13.95
140818 8 bit	5.95	AY5-3600	13.95
DAC01 D to A	8.95	MM7460AC	8.95

## SOCKETS

1-24	25-49	50-100	
8 pin LP	.16	.15	.14
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.24	.23	.22
20 pin LP	.26	.25	.24
22 pin LP	.28	.27	.26
24 pin LP	.30	.29	.28
26 pin LP	.32	.31	.30
28 pin LP	.34	.33	.32
30 pin LP	.36	.35	.34
32 pin LP	.38	.37	.36
34 pin LP	.40	.39	.38
36 pin LP	.42	.41	.40
38 pin LP	.44	.43	.42
40 pin LP	.46	.45	.44

## LOW PROFILE SOCKETS (TIN)

1-24	25-49	50-100	
8 pin WW	.55	.54	.49
10 pin WW (Tin)	.65	.63	.58
14 pin WW	.75	.73	.67
16 pin WW	.80	.77	.70
18 pin WW	.95	.93	.81
20 pin WW	1.15	1.08	.99
22 pin WW	1.45	1.35	1.23
24 pin WW	1.35	1.26	1.14
26 pin WW	1.60	1.53	1.38
28 pin WW	1.80	2.09	1.89

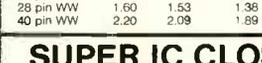
## 3K WIREWRAP SOCKETS (GOLD)

8 pin WW	.55	.54	.49
10 pin WW (Tin)	.65	.63	.58
14 pin WW	.75	.73	.67
16 pin WW	.80	.77	.70
18 pin WW	.95	.93	.81
20 pin WW	1.15	1.08	.99
22 pin WW	1.45	1.35	1.23
24 pin WW	1.35	1.26	1.14
26 pin WW	1.60	1.53	1.38
28 pin WW	1.80	2.09	1.89

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74LS377	2/1.99	8253	6.95	4060 RAM	1.40	8039	9.99
74LS241	2/1.99	2758 EPROM	2.95	2732	6.95	MM5320	5.99
8259	6.95	1802	8.95	UPD410	2.98	9131 RAM	1.99
6561 RAM	2.95	Z80A CPU	4.95	UPD411	2.98	EMM4402	1.99
LM733CN	3/1.99	6522	6.95	2708 EPROM	8/29.95	10415	4.95
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78M10	.49	MC1468N	.99	7402 22	7479 46.00	74186 87
LM1084H	2.95	MC1489N	.99	7403 22	7480 37	74194 87
LM3000	.99	LM1496N	.89	7404 22	7482 95	74195 87
LM301CN	.35	LM1556N	1.50	7405 23	7483 55	74196 1.20
LM304H	1.98	LM1820N	.95	7406 35	7485 65	74197 1.95
LM305H	1.89	LM1850N	.95	7407 35	7486 35	74197 1.69
LM306H	3.25	LM1889N	3.10	7408 26	7489 1.75	74197 4.75
LM310CN	1.25	LM2111N	1.75	7409 23	7490 39	74197 1.75
LM310CN	.98	LM2900N	.99	7410 22	7491 57	74174 89
LM303K	1.49	LM2901N	2.50	7411 29	7492 45	74175 85
LM310CN	1.25	LM2917N	2.95	7412 29	7493 45	74176 75
LM3112/CD	.99	CA3013T	2.19	7413 39	7494 69	74177 75
LM312H	1.75	CA3018T	1.99	7414 59	7495 65	74179 1.34
LM317T	1.75	CA3021T	3.49	7415 29	7496 69	74180 75
LM318CN	1.49	CA3023T	2.99	7416 29	7497 2.90	74181 1.75
LM319N/H	1.25	CA3035T	2.75	7420 22	74100 2.90	74182 75
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LM320H-XX	1.25	LM3053N	1.49	7423 29	74116 1.95	74186 9.95
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LM324N	.95	CA3060N	3.19	7426 29	74122 39	74190 1.15
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LM339N	.95	CA3080T	1.29	7430 23	74126	

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- CRY-27 3695.833 KHZ KHZ
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- CRY-29 3779.167 KHZ KHZ
- CRY-30 3.775.00 MHZ
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**DCK-18 (18) LONG LEAD CERAMIC DISC CAPACITORS. HAND PICKED FOR THE BEST VALUES IN STOCK. 90c PKG.**

**DCK-21 (21) HIGH QUALITY POLYSTYRENE CAPACITORS. THESE CAN REPLACE MICA, FILM, PAPER AND CERAMIC TYPES IN MOST CASES. \$1.00 PKG.**

**DCK-25 (25) HIGH VOLTAGE CERAMIC DISC CAPACITORS. 1kv to 7.5 kv. \$2.90 PKG.**

**DCK-100 (100) PRINTED CIRCUIT DISCAPS. PICKED FROM STOCK TO ASSURE THE CORRECT ASSORTMENT OF VALUES FOR EVERYDAY USE. \$2.50 PKG.**

**DIK-10 (10) UNIVERSAL SIGNAL DIODES, SUCH AS .n34, 1n60, 1n64, 1n295 AND ECG-177. PACKED IN A REUSEABLE PLASTIC CASE. \$0.65 PKG.**

CIRCLE 44 ON FREE INFORMATION CARD

# ramsey the first name in Counters!

## 9 DIGITS 600 MHz \$129<sup>95</sup> WIRED



**PRICES:**

CT-90 wired, 1 year warranty	\$129.95
CT-90 Kit, 90 day parts warranty	109.95
AC-1 AC adapter	3.95
BP-1 Nicad pack + AC Adapter/Charger	12.95
OV-1, Micro-power Oven time base	49.95
External time base input	14.95

The CT-90 is the most versatile, feature packed counter available for less than \$300.00! Advanced design features include; three selectable gate times, nine digits, gate indicator and a unique display hold function which holds the displayed count after the input signal is removed! Also, a 10mHz TCXO time base is used which enables easy zero beat calibration checks against WWV. Optionally, an internal nicad battery pack, external time base input and Micro-power high stability crystal oven time base are available. The CT-90, performance you can count on!

**SPECIFICATIONS:**

Range:	20 Hz to 600 MHz
Sensitivity:	Less than 10 MV to 150 MHz Less than 50 MV to 500 MHz
Resolution:	0.1 Hz (10 MHz range) 1.0 Hz (60 MHz range) 10.0 Hz (600 MHz range)
Display:	9 digits 0.4" LED
Time base:	Standard-10,000 mHz, 1.0 ppm 20-40°C. Optional Micro-power oven-0.1 ppm 20-40°C
Power:	8-15 VAC @ 250 ma

## 7 DIGITS 525 MHz \$99<sup>95</sup> WIRED



**SPECIFICATIONS:**

Range:	20 Hz to 525 MHz
Sensitivity:	Less than 50 MV to 150 MHz Less than 150 MV to 500 MHz
Resolution:	1.0 Hz (5 MHz range) 10.0 Hz (50 MHz range) 100.0 Hz (500 MHz range)
Display:	7 digits 0.4" LED
Time base:	1.0 ppm TCXO 20-40°C
Power:	12 VAC @ 250 ma

The CT-70 breaks the price barrier on lab quality frequency counters. Deluxe features such as; three frequency ranges - each with pre-amplification, dual selectable gate times, and gate activity indication make measurements a snap. The wide frequency range enables you to accurately measure signals from audio thru UHF with 1.0 ppm accuracy- that's .0001%! The CT-70 is the answer to all your measurement needs, in the field, lab or ham shack.

**PRICES:**

CT-70 wired, 1 year warranty	\$99.95
CT-70 Kit, 90 day parts warranty	84.95
AC-1 AC adapter	3.95
BP-1 Nicad pack + AC adapter/charger	12.95



## 7 DIGITS 500 MHz \$79<sup>95</sup> WIRED

**PRICES:**

MINI-100 wired, 1 year warranty	\$79.95
AC-Z Ac adapter for MINI-100	3.95
BP-Z Nicad pack and AC adapter/charger	12.95

Here's a handy, general purpose counter that provides most counter functions at an unbelievable price. The MINI-100 doesn't have the full frequency range or input impedance qualities found in higher price units, but for basic RF signal measurements, it can't be beat! Accurate measurements can be made from 1 MHz all the way up to 500 MHz with excellent sensitivity throughout the range, and the two gate times let you select the resolution desired. Add the nicad pack option and the MINI-100 makes an ideal addition to your tool box for "in-the-field" frequency checks and repairs.

**SPECIFICATIONS:**

Range:	1 MHz to 500 MHz
Sensitivity:	Less than 25 MV
Resolution:	100 Hz (slow gate) 1.0 KHz (fast gate)
Display:	7 digits, 0.4" LED
Time base:	2.0 ppm 20-40°C
Power:	5 VDC @ 200 ma

## 8 DIGITS 600 MHz \$159<sup>95</sup> WIRED



**SPECIFICATIONS:**

Range:	20 Hz to 600 MHz
Sensitivity:	Less than 25 mv to 150 MHz Less than 150 mv to 600 MHz
Resolution:	1.0 Hz (60 MHz range) 10.0 Hz (600 MHz range)
Display:	8 digits 0.4" LED
Time base:	2.0 ppm 20-40°C
Power:	110 VAC or 12 VDC

The CT-50 is a versatile lab/bench counter that will measure up to 600 MHz with 8 digit precision. And, one of its best features is the Receive Frequency Adapter, which turns the CT-50 into a digital readout for any receiver. The adapter is easily programmed for any receiver and a simple connection to the receiver's VFO is all that is required for use. Adding the receiver adapter in no way limits the operation of the CT-50, the adapter can be conveniently switched on or off. The CT-50, a counter that can work double-duty!

**PRICES:**

CT-50 wired, 1 year warranty	\$159.95
CT-50 Kit, 90 day parts warranty	119.95
RA-1, receiver adapter kit	14.95
RA-1 wired and pre-programmed (send copy of receiver schematic)	29.95

**NEW READ RECEIVER FREQUENCY**



## DIGITAL MULTIMETER \$99<sup>95</sup> WIRED

**PRICES:**

DM-700 wired, 1 year warranty	\$99.95
DM-700 Kit, 90 day parts warranty	79.95
AC-1, AC adaptor	3.95
BP-3, Nicad pack + AC adapter/charger	19.95
MP-1, Probe kit	2.95

The DM-700 offers professional quality performance at a hobbyist price. Features include; 26 different ranges and 5 functions, all arranged in a convenient, easy to use format. Measurements are displayed on a large 3 1/2 digit, 1/2 inch LED readout with automatic decimal placement, automatic polarity, overrange indication and overload protection up to 1250 volts on all ranges, making it virtually goof-proof! The DM-700 looks great, a handsome, jet black, rugged ABS case with convenient retractable tilt bail makes it an ideal addition to any shop.

**SPECIFICATIONS:**

DC/AC volts:	100uV to 1 KV, 5 ranges
DC/AC current:	0.1 uA to 2.0 Amps, 5 ranges
Resistance:	0.1 ohms to 20 Megohms, 6 ranges
Input impedance:	10 Megohms, DC/AC volts
Accuracy:	0.1% basic DC volts
Power:	4 °C cells

### AUDIO SCALER

For high resolution audio measurements, multiplies UP in frequency.

- Great for PL tones
- Multiplies by 10 or 100
- 0.01 Hz resolution!

\$29.95 Kit \$39.95 Wired

### ACCESSORIES

Telescopic whip antenna - BNC plug	\$ 7.95
High impedance probe, light loading	15.95
Low pass probe, for audio measurements	15.95
Direct probe, general purpose usage	12.95
Tilt bail, for CT 70, 90, MINI-100	3.95
Color burst calibration unit, calibrates counter against color TV signal.	14.95

### COUNTER PREAMP

For measuring extremely weak signals from 10 to 1,000 MHz. Small size, powered by plug transformer-included.

- Flat 25 db gain
- BNC Connectors
- Great for sniffing RF with pick-up loop

\$34.95 Kit \$44.95 Wired

ramsey electronics, inc.  
2575 BAIRD RD. • PENFIELD, NY 14526

PHONE ORDERS  
CALL 716-586-3950

TERMS

Satisfaction guaranteed - examine for 10 days, if not pleased, return in original form for refund. Add 5% for shipping - insurance to a maximum of \$10. Overseas add 15%. COD, add \$2. Orders under \$10., add \$1.50. NY residents, add 7% tax.

CIRCLE 79 ON FREE INFORMATION CARD

# 4164

## 64K DYNAMIC 200 NS

# \$595

# TMM2016

## 2KX8 STATIC 200 NS

# 74LS00

74LS00	.24	74LS173	.69
74LS01	.25	74LS174	.55
74LS02	.25	74LS175	.55
74LS03	.25	74LS181	2.15
74LS04	.24	74LS189	8.95
74LS05	.25	74LS190	.89
74LS08	.28	74LS191	.89
74LS09	.29	74LS192	.79
74LS10	.25	74LS193	.79
74LS11	.35	74LS194	.69
74LS12	.35	74LS195	.69
74LS13	.45	74LS196	.79
74LS14	.59	74LS197	.79
74LS15	.35	74LS221	.89
74LS20	.25	74LS240	.95
74LS21	.29	74LS241	.99
74LS22	.25	74LS242	.99
74LS26	.29	74LS243	.99
74LS27	.29	74LS244	.99
74LS28	.35	74LS245	1.49
74LS30	.25	74LS247	.75
74LS32	.29	74LS248	.99
74LS33	.55	74LS249	.99
74LS37	.35	74LS251	.59
74LS38	.35	74LS253	.59
74LS40	.25	74LS257	.59
74LS42	.49	74LS258	.59
74LS47	.75	74LS259	2.75
74LS48	.75	74LS260	.59
74LS49	.75	74LS266	.55
74LS51	.25	74LS273	1.49
74LS54	.29	74LS275	3.35
74LS55	.29	74LS279	.49
74LS63	1.25	74LS280	1.98
74LS73	.39	74LS283	.69
74LS74	.35	74LS290	.89
74LS75	.39	74LS293	.89
74LS76	.39	74LS295	.99
74LS78	.49	74LS298	.89
74LS83	.60	74LS299	1.75
74LS85	.69	74LS323	3.50
74LS86	.39	74LS324	1.75
74LS90	.55	74LS352	1.29
74LS91	.89	74LS353	1.29
74LS92	.55	74LS363	1.35
74LS93	.55	74LS364	1.95
74LS95	.75	74LS365	.49
74LS96	.89	74LS366	.49
74LS107	.39	74LS367	.45
74LS109	.39	74LS368	.45
74LS112	.39	74LS373	.99
74LS113	.39	74LS374	.99
74LS114	.39	74LS377	1.39
74LS122	.45	74LS378	1.18
74LS123	.79	74LS379	1.35
74LS124	2.90	74LS385	1.90
74LS125	.49	74LS386	.45
74LS126	.49	74LS390	1.19
74LS132	.59	74LS393	1.19
74LS133	.59	74LS395	1.19
74LS136	.39	74LS399	1.49
74LS137	.99	74LS424	2.95
74LS138	.55	74LS447	.37
74LS139	.55	74LS490	1.95
74LS145	1.20	74LS624	3.99
74LS147	2.49	74LS640	2.20
74LS148	1.35	74LS645	2.20
74LS151	.55	74LS668	1.69
74LS153	.55	74LS669	1.89
74LS154	1.90	74LS670	1.49
74LS155	.69	74LS674	9.65
74LS156	.69	74LS682	3.20
74LS157	.65	74LS683	3.20
74LS158	.59	74LS684	3.20
74LS160	.69	74LS685	3.20
74LS161	.65	74LS688	2.40
74LS162	.69	74LS689	3.20
74LS163	.65	74LS783	24.95
74LS164	.69	81LS95	1.49
74LS165	.95	81LS96	1.49
74LS166	1.95	81LS97	1.49
74LS168	1.75	81LS98	1.49
74LS169	1.75	25LS2521	2.80
74LS170	1.49	25LS2569	4.25

### STATIC RAMS

2101	256 x 4 (450ns)	1.95
5101	256 x 4 (450ns) (cmos)	3.95
2102-1	1024 x 1 (450ns)	.89
2102L-4	1024 x 1 (450ns) (LP)	.99
2102L-2	1024 x 1 (250ns) (LP)	1.49
2111	256 x 4 (450ns)	2.49
2112	256 x 4 (450ns)	2.99
2114	1024 x 4 (450ns)	8/9.95
2114L-4	1024 x 4 (450ns) (LP)	8/12.95
2114L-3	1024 x 4 (300ns) (LP)	8/13.45
2114L-2	1024 x 4 (200ns) (LP)	8/13.95
2147	4096 x 1 (55ns)	4.95
TMS4044-4	4096 x 1 (450ns)	3.49
TMS4044-3	4096 x 1 (300ns)	3.99
TMS4044-2	4096 x 1 (200ns)	4.49
MK4118	1024 x 8 (250ns)	9.95
TMM2016-200	2048 x 8 (200ns)	4.15
TMM2016-150	2048 x 8 (150ns)	4.95
TMM2016-100	2048 x 8 (100ns)	6.15
HM6116-4	2048 x 8 (200ns) (cmos)	4.75
HM6116-3	2048 x 8 (150ns) (cmos)	4.95
HM6116-2	2048 x 8 (120ns) (cmos)	8.95
HM6116LP-4	2048 x 8 (200ns) (cmos)(LP)	5.95
HM6116LP-3	2048 x 8 (150ns) (cmos)(LP)	6.95
HM6116LP-2	2048 x 8 (120ns) (cmos)(LP)	10.95
Z-6132	4096 x 8 (300ns) (Qstat)	34.95

LP = Low Power Qstat = Quasi-Static

### DYNAMIC RAMS

TMS4027	4096 x 1 (250ns)	1.99
UPD411	4096 x 1 (300ns)	3.00
MM5280	4096 x 1 (300ns)	3.00
MK4108	8192 x 1 (200ns)	1.95
MM5298	8192 x 1 (250ns)	1.85
4116-300	16384 x 1 (300ns)	8/11.75
4116-250	16384 x 1 (250ns)	8/11.95
4116-200	16384 x 1 (200ns)	8/12.95
4116-150	16384 x 1 (150ns)	8/14.95
4116-120	16384 x 1 (120ns)	8/29.95
2118	16384 x 1 (150ns) (5v)	4.95
4164-200	65536 x 1 (200ns) (5v)	5.95
4164-150	65536 x 1 (150ns) (5v)	6.95

5V = single 5 volt supply

### EPROMS

1702	256 x 8 (1us)	4.50
2708	1024 x 8 (450ns)	3.95
2758	1024 x 8 (450ns) (5v)	5.95
2716	2048 x 8 (450ns) (5v)	3.95
2716-1	2048 x 8 (350ns) (5v)	5.95
TMS2516	2048 x 8 (450ns) (5v)	5.95
TMS2716	2048 x 8 (450ns)	7.95
TMS2532	4096 x 8 (450ns) (5v)	5.95
2732	4096 x 8 (450ns) (5v)	4.95
2732-250	4096 x 8 (250ns) (5v)	8.95
2732-200	4096 x 8 (200ns) (5v)	11.95
2764	8192 x 8 (450ns) (5v)	9.95
2764-250	8192 x 8 (250ns) (5v)	14.95
2764-200	8192 x 8 (200ns) (5v)	24.95
TMS2564	8192 x 8 (450ns) (5v)	17.95
MC68764	8192 x 8 (450ns) (5v) (24 pin)	39.95

5v = Single 5 Volt Supply

### EPROM ERASERS

	Timer	Capacity Chip	Intensity (uW/Cm <sup>2</sup> )	
PE-14		6	5,200	83.00
PE-14T	X	6	5,200	119.00
PE-24T	X	9	6,700	175.00
PL-265T	X	20	6,700	255.00
PR-125T	X	16	15,000	349.00
PR-320	X	32	15,000	595.00

### Z-80 2.5 Mhz

Z80-CPU	3.95
Z80-CTC	4.49
Z80-DART	10.95
Z80-DMA	14.95
Z80-PIO	4.49
Z80-SIO/0	16.95
Z80-SIO/1	16.95
Z80-SIO/2	16.95
Z80-SIO/9	16.95

### 4.0 Mhz

Z80A-CPU	4.95
Z80A-CTC	4.95
Z80A-DART	11.95
Z80A-DMA	16.95
Z80A-PIO	4.95
Z80A-SIO/0	16.95
Z80A-SIO/1	16.95
Z80A-SIO/2	16.95
Z80A-SIO/9	16.95

### 6.0 Mhz

Z80B-CPU	11.95
Z80B-CTC	13.95
Z80B-PIO	13.95
Z80B-DART	19.95

### ZILOG

Z6132	34.95
Z8671	39.95

### CRYSTALS

32.768 khz	1.95
1.0 mhz	4.95
1.8432	4.95
2.0	3.95
2.097152	3.95
8/11.95	2.4576
8/12.95	3.2768
8/14.95	3.579535
4.0	3.95
5.0	3.95
5.0688	3.95
5.185	3.95
5.7143	3.95
6.0	3.95
6.144	3.95
6.5536	3.95
8.0	3.95
10.738635	3.95
14.31818	3.95
15.0	3.95
16.0	3.95
17.430	3.95
18.0	3.95
18.432	3.95
20.0	3.95
22.1184	3.95
32.0	3.95

### CRT CONTROLLERS

6845	14.95
68B45	35.95
HD46505SP	15.95
6847	12.25
MC1372	6.95
68047	24.95
8275	29.95
7220	99.95
CRT5027	39.95
CRT5037	49.95
TMS9918A	39.95
DP8350	49.95

### KEYBOARD CHIPS

AY5-2376	11.95
AY5-3600	11.95

### 8000

8035	5.95
8039	6.95
INS-8060	17.95
INS-8073	24.95
8080	3.95
8085	5.95
8085A-2	11.95
8086	29.95
8087	CALL
8088	39.95
8089	89.95
8155	6.95
8155-2	7.95
8156	6.95
8185	29.95
8185-2	39.95
8741	39.95
8748	24.95
8755	24.95

### 8200

8202	24.95
8203	39.95
8205	3.50
8212	1.80
8214	3.85
8216	1.75
8224	2.25
8226	1.80
8228	3.49
8231	call
8237	19.95
8237-5	21.95
8238	4.49
8243	4.45
8250	10.95
8251	4.49
8253	6.95
8253-5	7.95
8255	4.49
8255-5	5.25
8257	7.95
8257-5	8.95
8259	6.90
8259-5	7.50
8271	39.95
8272	39.95
8275	29.95
8279	8.95
8279-5	10.00
8282	6.50
8283	6.50
8284	5.50
8286	6.50
8287	6.50
8288	25.00
8289	49.95

### DISC CONTROLLERS

1771	16.95
1791	24.95
1793	26.95
1795	49.95
1797	49.95
2791	54.95
2793	54.95
2795	59.95
2797	59.95
6843	34.95
8272	39.95
UPD765	39.95
1691	17.95
2143	18.95

### CONNECTORS

RS232 MALE	2.50
RS232 FEMALE	3.25
RS232 HOOD	1.25
S-100 ST	3.95

### 6800

68000	59.95
6800	3.95
6802	7.95
6808	13.90
6809E	19.95
6809	11.95
6810	2.95
6820	4.35
6821	3.25
6828	14.95
6840	12.95
6843	34.95
6844	25.95
6845	14.95
6847	11.95
6850	3.25
6852	5.75
6860	9.95
6862	11.95
6875	6.95
6880	2.25
6883	22.95
68047	24.95
68488	19.95

### 6800 - 1MHZ

68B00	10.95
68B02	22.25
68B09E	29.95
68B09	29.95
68B10	6.95
68B21	6.95
68B45	19.95
68B50	5.95

### 6800 - 2MHZ

68B00	10.95
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# 2114 450 NS 8/\$9<sup>95</sup>

# 2114 250 NS 8/\$10<sup>95</sup>

## 7400

7400	.19	74132	.45
7401	.19	74136	.50
7402	.19	74141	.65
7403	.19	74142	2.95
7404	.19	74143	2.95
7405	.25	74145	.60
7406	.29	74147	1.75
7407	.29	74148	1.20
7408	.24	74150	1.35
7409	.19	74151	.55
7410	.19	74152	.65
7411	.25	74153	.55
7412	.30	74154	1.25
7413	.35	74155	.75
7414	.49	74156	.65
7416	.25	74157	.55
7417	.25	74159	1.65
7420	.19	74160	.85
7421	.35	74161	.69
7422	.35	74162	.85
7423	.29	74163	.69
7425	.29	74164	.85
7426	.29	74165	.85
7427	.29	74166	1.00
7428	.45	74167	2.95
7430	.19	74170	1.65
7432	.29	74172	5.95
7433	.45	74173	.75
7437	.29	74174	.89
7438	.29	74175	.89
7440	.19	74176	.89
7442	.49	74177	.75
7443	.65	74178	1.15
7444	.69	74179	1.75
7445	.69	74180	.75
7446	.69	74181	2.25
7447	.69	74182	.75
7448	.69	74184	2.00
7450	.19	74185	2.00
7451	.23	74190	1.15
7453	.23	74191	1.15
7454	.23	74192	.79
7460	.23	74193	.79
7470	.35	74194	.85
7472	.29	74195	.85
7473	.34	74196	.79
7474	.33	74197	.75
7475	.45	74198	1.35
7476	.35	74199	1.35
7480	.59	74221	1.35
7481	1.10	74246	1.35
7482	.95	74247	1.25
7483	.50	74248	1.85
7485	.59	74249	1.95
7486	.35	74251	.75
7489	2.15	74259	2.25
7490	.35	74265	1.35
7491	.40	74273	1.95
7492	.50	74276	1.25
7493	.35	74279	.75
7494	.65	74283	2.00
7495	.55	74284	3.75
7496	.70	74285	3.75
7497	2.75	74290	.95
74100	1.75	74293	.75
74107	.30	74298	.85
74109	.45	74351	2.25
74110	.45	74365	.65
74111	.55	74366	.65
74116	1.55	74367	.65
74120	1.20	74368	.65
74121	.29	74376	2.20
74122	.45	74390	1.75
74123	.49	74393	1.35
74125	.45	74425	3.15
74126	.45	74426	.85
74128	.55	74490	2.55

## LINEAR

LM301	.34	LM340 (see 7800)	1.49	LM566	1.49	LM1800	2.37
LM301H	.79	LM348	.99	LM567	.89	LM1812	8.25
LM307	.45	LM350K	4.95	NE570	3.95	LM1830	3.50
LM308	.69	LM350T	4.60	NE571	2.95	LM1871	5.49
LM308H	1.15	LM358	.69	NE592	2.75	LM1872	5.49
LM309H	1.95	LM359	1.79	LM709	.59	LM1877	3.25
LM309K	1.25	LM376	3.75	LM710	.75	LM1889	1.95
LM310	1.75	LM377	1.95	LM711	.79	LM1896	1.75
LM311	.64	LM378	2.50	LM723	.49	ULN2003	2.49
LM311H	.89	LM379	4.50	LM723H	.55	LM2877	2.05
LM312H	1.75	LM380	.89	LM733	.98	LM2878	2.25
LM317K	3.95	LM380N-8	1.10	LM741	.35	LM2900	.85
LM317T	1.19	LM381	1.60	LM741N-14	.35	LM2901	1.00
LM318	1.49	LM382	1.60	LM741H	.40	LM3900	.59
LM318H	1.59	LM383	1.95	LM747	.69	LM3905	1.25
LM319H	1.90	LM384	1.95	LM748	.59	LM3909	.98
LM319	1.25	LM386	.89	LM1014	1.19	LM3911	2.25
LM320 (see 7900)	LM387	1.40	LM1303	1.95	LM3914	3.95	
LM322	1.65	LM389	1.35	LM1310	1.49	LM3915	3.95
LM323K	4.95	LM390	1.95	MC1330	1.69	LM3916	3.95
LM324	.59	LM392	.69	MC1349	1.89	MC4024	3.95
LM329	.65	LM394H	4.60	MC1350	1.19	MC4044	4.50
LM331	3.95	LM399H	5.00	MC1358	1.69	RC4136	1.25
LM334	1.19	NE531	2.95	MC1372	6.95	RC4151	3.95
LM335	1.40	NE555	.34	LM1414	1.59	LM4250	1.75
LM336	1.75	NE556	.65	LM1458	.59	LM4500	3.25
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LM337T	1.95	NE561	24.95	LM1489	.69	LM13080	1.29
LM338K	6.95	NE564	2.95	LM1496	.85	LM13600	1.49
LM339	.99	LM565	.99	LM1558H	3.10	LM13700	1.49

H = TO-5 CAN

T = TO-220

K = TO-3

## RCA

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CA 3039	1.29	CA 3083	1.55
CA 3046	1.25	CA 3086	.80
CA 3059	2.90	CA 3089	2.99
CA 3060	2.90	CA 3096	3.49
CA 3065	1.75	CA 3130	1.30
CA 3080	1.10	CA 3140	1.15
CA 3081	1.65	CA 3146	1.85
CA 3160	1.19		

## TI

TL494	4.20	75365	1.95
TL496	1.65	75450	.59
TL497	3.25	75451	.39
75107	1.49	75452	.39
75110	1.95	75453	.39
75150	1.95	75454	.39
75154	1.95	75491	.79
75188	1.25	75492	.79
75189	1.25	75493	.89
75494	.89		

## BI FET

TL071	.79	TL084	2.19
TL072	1.19	LF347	2.19
TL074	2.19	LF351	.60
TL081	.79	LF353	1.00
TL082	1.19	LF355	1.10
TL083	1.19	LF356	1.10
LF357	1.40		

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8T28	1.89
8T95	.89
8T96	.89
8T97	.89
8T98	.89
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DP8304	2.29
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7815T	.75	7915T	.85
7824T	.75	7924T	.85
7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49
7815K	1.39	7915K	1.49
7824K	1.39	7924K	1.49
78L05	.69	79L05	.79
78L12	.69	79L12	.79
78L15	.69	79L15	.79
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72 pin WW	7.95

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CONTACTS	SINGLE COLOR		COLOR CODED	
	1'	10'	1'	10'
10	.50	4.40	.83	7.30
20	.65	5.70	1.25	11.00
26	.75	6.60	1.32	11.60
34	.98	8.60	1.65	14.50
40	1.32	11.60	1.92	16.80
50	1.38	12.10	2.50	22.00

## D-SUBMINIATURE

DESCRIPTION	SOLDER		RIGHT ANGLE SOLDER		RIBBON CABLE		HOODS	
	MALE DBxxP	FEMALE DBxxS	MALE DBxxPR	FEMALE DBxxSR	MALE IDBxxP	FEMALE IDBxxS	BLACK HOOD-B	GREY HOOD
CONTACTS 9	2.08	2.66	1.65	2.18	3.37	3.69	---	1.60
15	2.69	3.63	2.20	3.03	4.70	5.13	---	1.60
25	2.50	3.25	3.00	4.42	6.23	6.84	1.25	1.25
37	4.80	7.11	4.83	6.19	9.22	10.08	---	2.95
50	6.06	9.24	---	---	---	---	---	3.50

For order instructions see "IDC Connectors" below.

## IDC CONNECTORS

DESCRIPTION	SOLDER HEADER	RIGHT ANGLE SOLDER HEADER	WW HEADER	RIGHT ANGLE WW HEADER	RIBBON HEADER SOCKET	RIBBON HEADER	RIBBON EDGE CARD
ORDER BY	IDHxxS	IDHxxSR	IDHxxW	IDHxxWR	IDSxx	IDMxx	IDExx
CONTACTS 10	.82	.85	.86	2.05	1.15	---	2.25
20	1.29	1.35	2.98	2.28	1.86	5.50	2.36
26	1.68	1.76	3.84	2.22	2.43	6.25	2.65
34	2.20	2.31	4.50	2.45	3.15	7.00	3.25
40	2.58	2.72	5.28	2.30	3.73	7.50	3.80
50	3.24	3.39	6.63	7.30	4.65	8.50	4.74

ORDERING INSTRUCTIONS: Insert the number of contacts in the position marked "xx" of the "order by" part number listed. Example: A 10 pin right angle solder style header would be IDH10SR.

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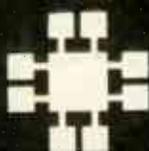
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### **THE LATEST VIDEOGAME SYSTEMS FOR 83**

A look at the latest videogame consoles announced at the WCES show, including Intellivision II, Intellivision III, and Odyssey.

### **COLECOVISION**

An in-depth look at the Colecovision console and accessories, and new game cartridges.

### **GCE'S VECTREX ARCADE GAME**

A look at the first home videogame with a built-in CRT and vector-type graphics. The discussion will include a look at some of the game cartridges.

### **THE ATARI 5200 SUPER GAME SYSTEM**

Atari's latest entry in the videogame market is described along with the game cartridges for the new system.

### **STARPATH'S SUPERCHARGER**

A plug-in adaptor for Atari's 2600 console that improves the graphic resolution.

### **NEW SOFTWARE AND ADD-ONS FOR 83**

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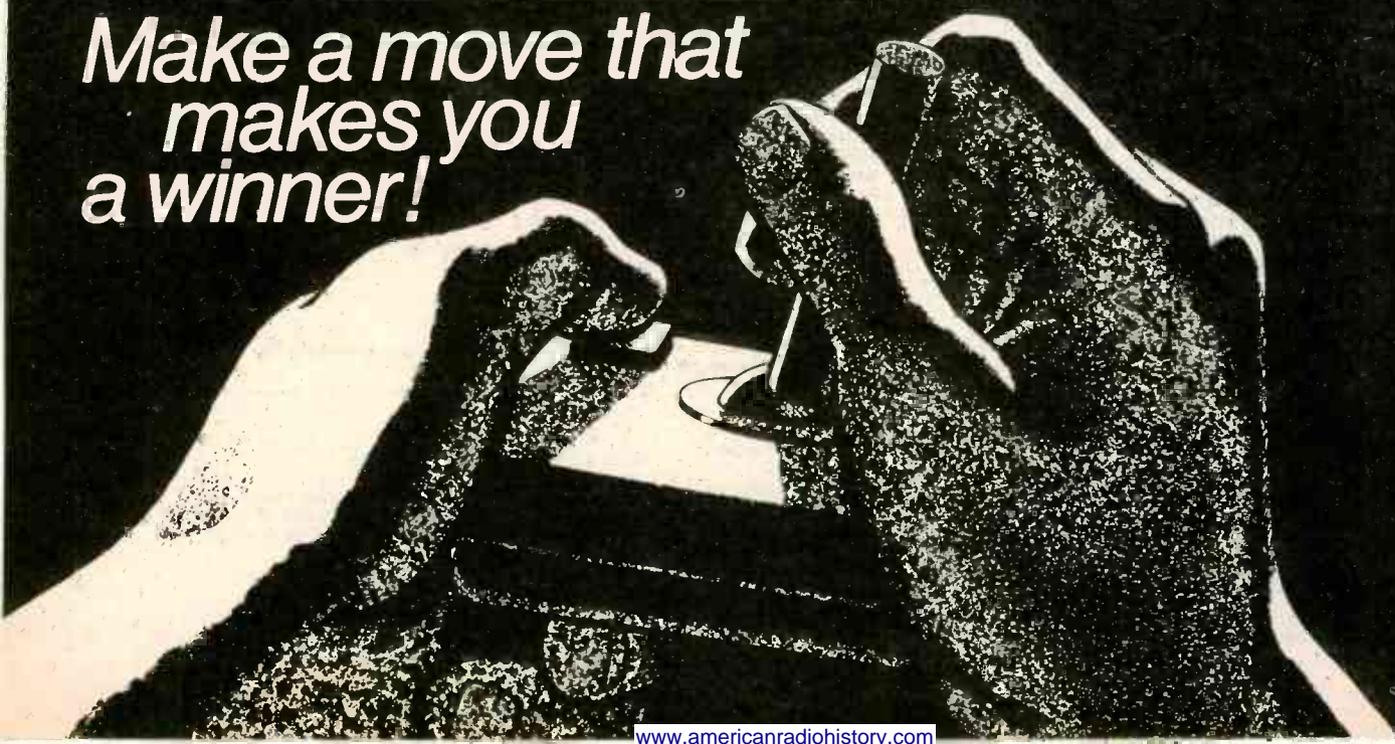
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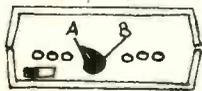
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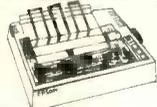
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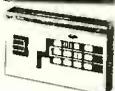


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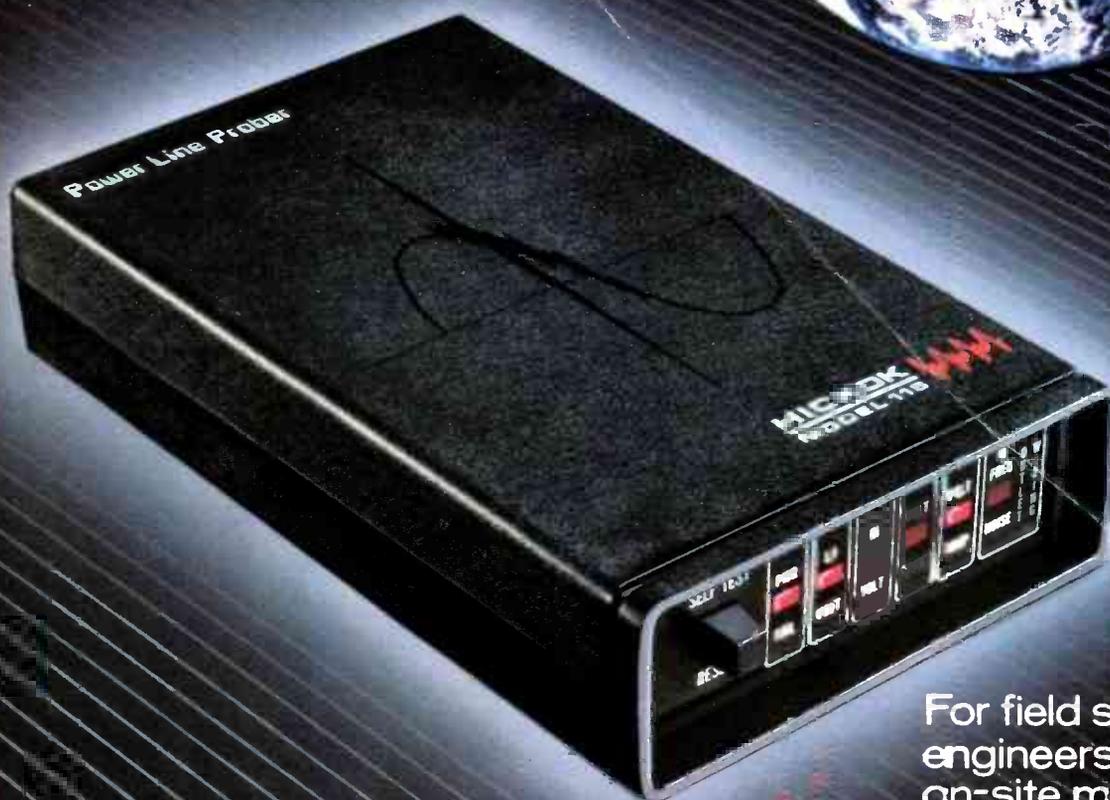
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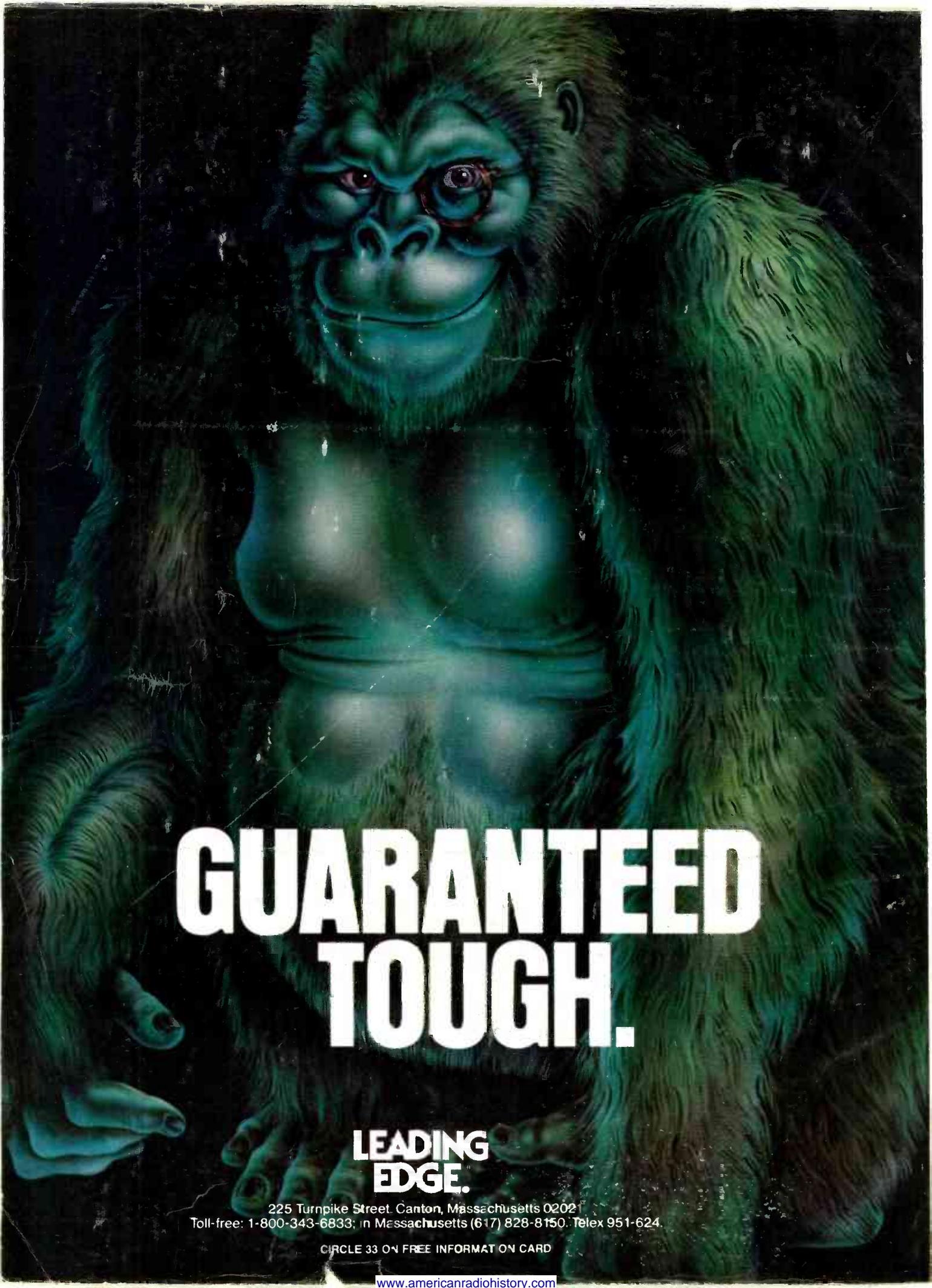
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