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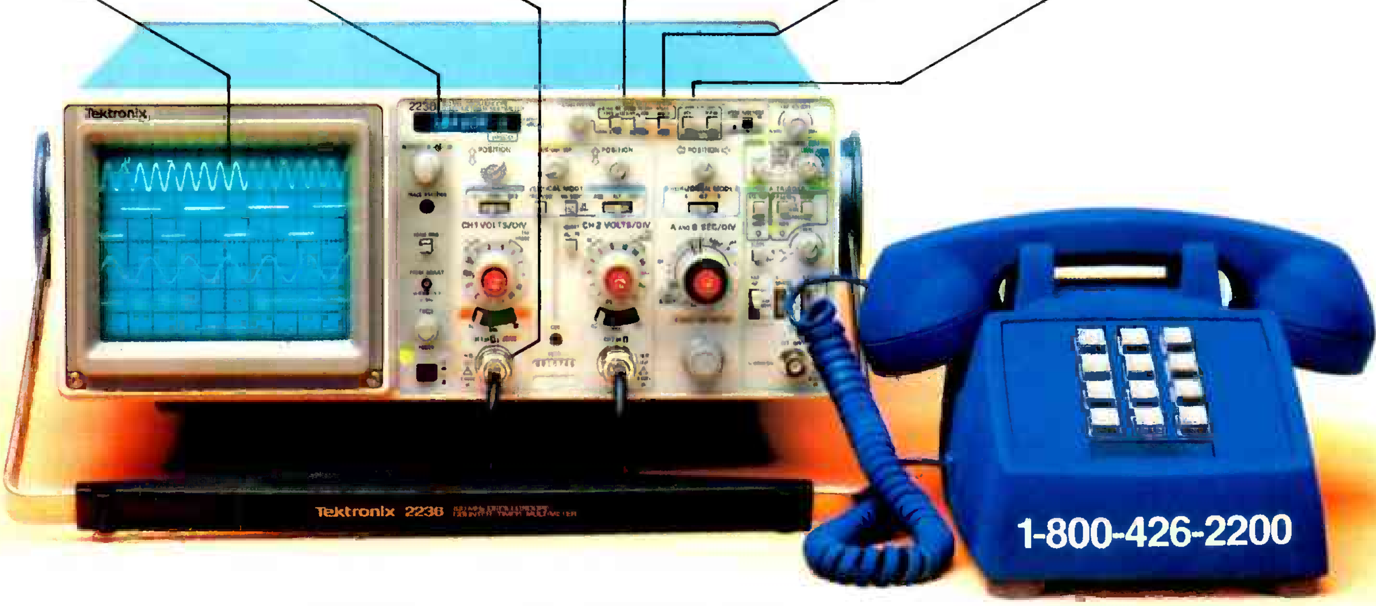

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COVER 1

You want to know more about robots but can't find any information? Well it's all here in two special articles that cover the state of personal robots in depth. First, we'll show you what's available in the marketplace: kits, assembled units, arms, rovers, turtles, and more. Second, we'll show you what's involved in building a robot from scratch. The special section starts on page 41.

The robot you see featured on the cover is the *Gemini* from Arctec systems of Columbia, Maryland. It's a sophisticated robot rover with built-in intelligence. It talks and listens. It will recharge its batteries when it senses it's getting low on power. The entire robot is available in kit form, and its subassemblies are available separately. It's just one of the robots we cover in this issue.

NEXT MONTH

THE APRIL ISSUE IS ON SALE MARCH 4

GET INTO TELETEXT
We'll introduce you to World System Teletext and then we'll show you how to build a teletext decoder so that you can join the fun.

BUILD A TELEPHONE-LINE TESTER
Save on unnecessary repair costs by keeping tabs on your phone line.

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Advertising Sales Offices listed on page 118.

EDITORIAL

Where is the "robotics revolution?"

The robotics revolution that has been promised for decades has been a long time coming. We'll be the first to admit that you shouldn't expect to see it any time soon. Why, then, are we dedicating two feature articles to personal robots?

The answer is simple; it's the same reason we started publishing microprocessor and computer articles when most computers were seen only in science-fiction movies and books. We believe that the readers of **Radio-Electronics** deserve to be informed *first* about about new electronics technology.

Even though there are more than 15,000 industrial robots installed in the United States, personal robotics is still in its infancy. But the field has come a long way since we published our Unicorn-1 construction story back about five years ago. For example, the Robotics Industries Association, once dedicated to the industrial-robotics community, has started a National Personal Robot Association (NRPA). They see the potential for robots in education and entertainment, and even doing household chores.

There is still a lot of work to be done in such areas as machine vision, voice recognition, and tactile sensing. And without the proper standards for electrical interfaces, mechanical interfaces, human interfaces, and safety, the robotics revolution will never get off the ground.

Unfortunately, the proper standards are not enough to carry personal robotics out of its infancy. But one revolutionary product could turn things around. The field of robotics incorporates so many areas of specialties, that almost everyone can find one that interests him. And I'm writing this editorial in the hopes that it will convince someone to turn his attention to robotics. Who knows? *You* may be the one to develop that one revolutionary product that will turn things around.

Brian Fenton

Brian C. Fenton
Managing Editor

WHAT'S NEWS

Talking computers seen for American banks

"Five years ago, few banks were using voice systems. In another decade—and certainly by the end of the century—the reverse will be true." That statement was made to a regional meeting of the National Association of Bank Women by Alan E. Zohott, a regional sales manager for Votrax of Troy, MI.

Among the reasons he cited were advances in microcomputer and data-communications technology, the increasing number of services offered by banks, and the hotly competitive atmosphere in banking.

Increasing postal rates will also cause greater numbers of customers to pick up their phones to pay bills, transfer money, and to check on the status of their accounts, he stated. Voice systems will be there to answer them.

But voice systems will not replace people at banks, said Zohott. "Banking is a service industry, and person-to-person dealings will always be important. But voice technology enhances the capabilities of bank personnel by working around the clock if necessary, never calling in sick, or having a car break down."

Central control unit operates everything

People definitely have a fondness for controlled devices. But with separate control units for each of the entertainment devices in a household, managing the controllers themselves can become a nuisance. A new control—which General Electric calls Control Central—is an attempt to simplify matters. The new programmable control can handle up to four in-

GE *CONTROL CENTRAL* programmable remote system

frared-controlled products, including TV's, video players, compact discs, cable converters, or stereo amplifiers, regardless of brand or model.

Most audio/video devices are controlled by a series of infrared pulses, combined in patterns similar to those of Morse code. When placed "head to head" with a component's original remote control, the new Control Central's computer learns the infrared codes that control that component's functions.

Control Central also has a memory bank and a liquid-crystal display that shows the functions that have been programmed into the computer's memory.

The new control unit is expected to list at $149.95.

Record solar cells made with amorphous material

Energy Conversion Devices, Inc. (ECD), of Troy, MI, reports an unprecedented efficiency of 12.2 percent in solar cells made with proprietary amorphous (non-crystalline) materials. Stanford Ovshinsky, ECD's president, reports that ECD, in a joint venture with Standard Oil Co. of Ohio (Sohio) is already manufacturing 1-foot-wide, 1,000-foot-long continuous-strip solar cells with efficiencies in the 8 percent range.

The 8-percent efficiency cells now being made are two-layer or tandem cells. The new higher efficiency was achieved in a solar cell consisting of three extremely thin, vertically stacked sub-cells made of amorphous alloys of silicon, hydrogen, and fluorine. Each sub-cell is sensitive to a different portion of the color spectrum. The three-layer cells are said to be not only more efficient than the two-layer type, but to have a much longer operating life.

The new cells are being produced by Sovonics Solar Systems, a partnership of ECD and Sohio.

First 20,000-gate array marketed by Honeywell

A 20,000-gate CMOS (*C*omplementary *M*etal-*O*xide *S*emiconductor) gate array will shortly be put on the market as a result of a licensing agreement between Honeywell and ETA Systems, Inc. of St. Paul, MN. The array, the HC20,000, was developed by ETA Systems for its ETA-10 supercomputer planned for delivery in 1986.

The HC20,000 integrates 18,000 gates. The remaining 2,000 gates are part of a unique feature, the *B*uilt-in *E*valuation and *S*elf-*T*est (B.E.S.T). B.E.S.T. allows the IC to generate its own test patterns and test itself at full-system clock rates, to sample the state of all I/O pins, force output pins to a known state, and shift test data on or off the HC20,000.

"With 400-picosecond internal NAND delays, the HC20,000 is the fastest high-density gate array in the world," says a Honeywell spokesman. "The internal gate delays are specified to be under 1.2 ns at 25°C, with a fanout of 3, and 5 mm of wiring attached." **R-E**

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MAGNETIC PHONO PREAMP

I installed a new turntable in my stereo system. My old turntable had a ceramic cartridge, but the new one has a magnetic cartridge. Can you supply me with a schematic of a suitable preamp for the magnetic cartridge?—B. F., St. Louis, MO

You can use a National LM387, as shown in Fig. 1. That IC is inexpensive (about $2.00) and readily available. The pin numbers in parentheses are for one channel, and the pin numbers not in parentheses are for the other channel.

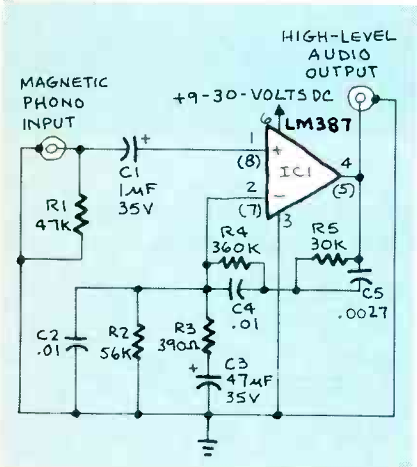

FIG. 1

The supply voltage can be anything from +9- to +30-volts DC at about 10 mA. You may be able to tap a suitable voltage from a well-filtered source in your amplifier or receiver. The output voltage swing is about $V_{CC} - 2$ volts p-p. The preamp should be able to deliver at least five volts to the AUXILLIARY input of your amplifier.

R-J SPEAKER ENCLOSURE

My dad and some of his cronies claim that a speaker built into an

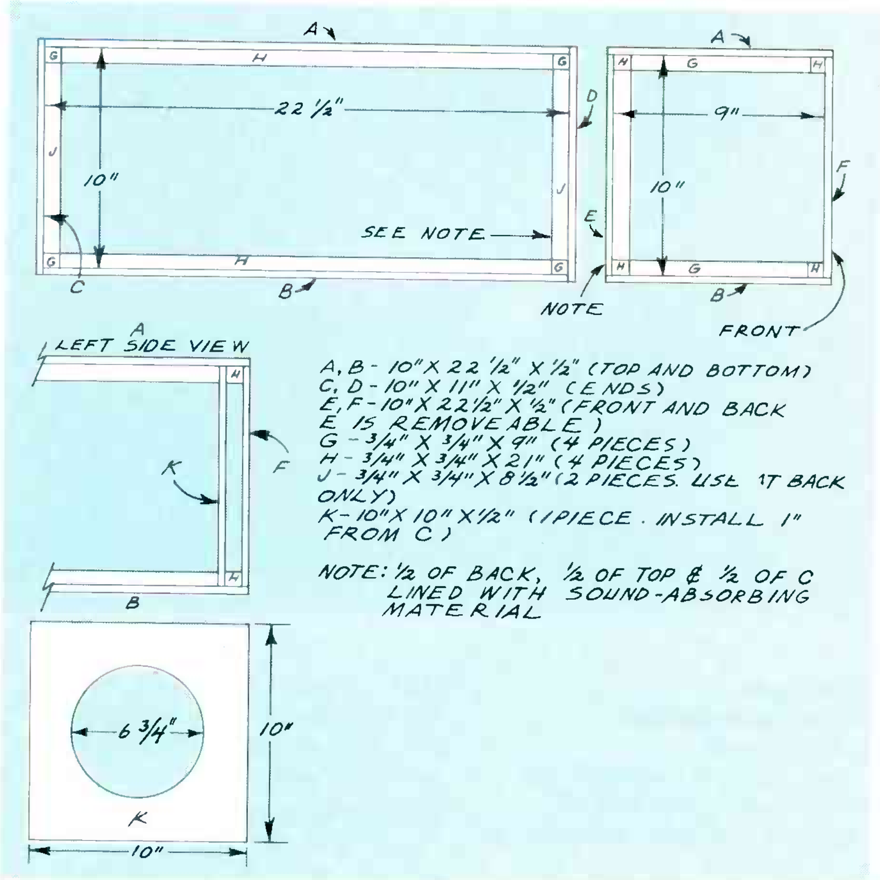

FIG. 2

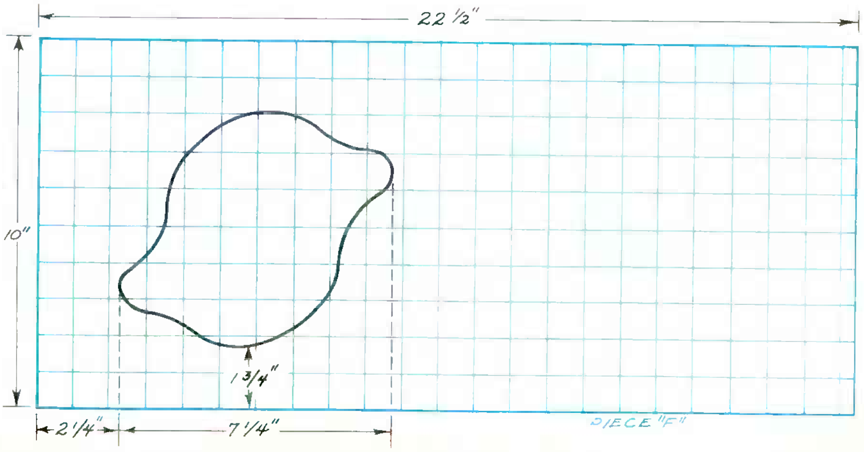

FIG. 3

enclosure called the *R-J* is one of the best bookshelf speakers they ever heard. Was the R-J really as good as they claim, or have their ears been dulled by Father Time? If it is as good as they say, I'd like to build a couple for the stereo in the Senior Citizen's Club.—H. O. M., Philadelphia, PA

The mere mention of the R-J speaker system brings back fond memories of hi-fi in the early 1950's. It was a popular system designed by Frank Robbins and William Josephs (hence the R-J). The R-J speaker system compared favorably with much larger bass-reflex enclosures, but it lacked the "boominess" of the latter. It held its own until it was gradually replaced by the AR and similar acoustic-suspension systems. The R-J design is unique because sound that emanates from the rear of the speaker emerges through a port formed by a space between the speaker mounting board and the front panel.

Plans for an eight-inch speaker enclosure are presented in Fig. 2 and Fig. 3. The front-panel opening resembles a mis-shaped lemon. The major axis is about 60 degrees from the vertical, and the minor axis is about 65 degrees from the horizontal. You can build a replica of that panel by scaling the drawing up on paper with ½-inch squares.

Use a dense-grade of plywood or particle board for all pieces, and use glue and screws on all mating surfaces except the back (E) and the speaker board (K). Those parts are removable so that you can experiment with different speakers. Pieces of acoustically-absorbent material measuring 5 × 10 inches are centered on the back and the top, and a 5-inch square is centered on *one* end—either C or D.

GOT A QUESTION?
ASK R-E!
We welcome your questions in any area of electronics. Send them to *Ask R-E,* **Radio-Electronics,** 500-B Bi-County Boulevard, Farmingdale, NY 11735. We regret that we cannot answer your questions individually, but those of widest interest to our readers will be published.

You can use Ozite, Kimsul, Celotex, or any similar polystyrene or fiberglass insulating material.

For best results, use an 8-inch speaker with a free-air resonance of 63 Hz or lower. For high compliance, its suspension should be "soft."

ELECTRIC LOCKS

I enjoyed the item on electronic locks in "State of Solid State" in the January, 1985 issue of *Radio-Electronics.* I want to install electronic locks on some of the doors in my home. Where can I purchase the necessary hardware?—D. J. M., Salt Lake City, UT

Electric locks are used when entry is to be controlled from a remote point. You'll find them used to control entry to apartment buildings and public rest-rooms. The strike plate, mortised into the door jamb, is made so that the lock's latch-bolt is released when a low-voltage solenoid is energized. Most locksmiths can supply electric locks or tell you where to order them. **R-E**

VIDEO NEWS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

• **Electronic Snapshots.** Eastman Kodak this year will test several electronic still-imaging products on the home market. A "video floppy" disc recorder-player will be placed in selected homes. That system uses a standardized 2-inch magnetic disk to record 50 TV fields from any television set or other video source. A wireless remote control is used to trigger the recording. A

companion product is a video-image printer that can make prints from any video field, using instant color film. It will be priced at $700. Three Kodak processing labs will test film-to-disc transfer service, to put images from 35mm color negative film onto video floppies for playback on the TV screen through the recorder-player. The video floppy is a standardized electronic still-photo format, adopted by an industry-wide committee in Japan. A similar film-to-disc transfer service is already being offered by Fuji Photo in Japan. No consumer-priced electronic still camera is in sight, and Kodak officials forecast that it's about 10 years off.

• **Look Mom, No Tube!** Toshiba has demonstrated the largest color LCD screen yet—a 10-inch model that Toshiba says it will use for an eight-color graphics terminal in about two years, and in a TV set in three. The screen, which is backlighted by three fluorescent tubes, is about five inches thick. Toshiba said it consumes one-fifth the power of a picture tube, has one-tenth the thickness, but costs four times as much. Resolution of the current display is 640 by 480, for a total of 307,200 pixels. The LCD is of the active matrix type with an amorphous thin-film transistor at each pixel, each functioning as a switch to control and enhance the picture. The LCD is formed on a large glass substrate by photolithography and etching techniques. The display, as demonstrated in Japan, had brightness of more than 300 candelas—nearly that of a home color set—with a contrast ratio of 10 to one. Toshiba said that the practical size limitation for a display of this type is about 12 inches diagonally.

• **Changing of the Guard.** Two long-time consumer electronics lines are undergoing major changes. General Electric, one of the first manufacturers of television receivers in the United States—and the world—and a long-time leader in television technology, is departing from TV-set manufacture. Beset by tough competition and diminishing profits, GE has decided to have its color TV sets made by Matushita Electric Industrial Company, manufacturer of Panasonic and Quasar sets, starting next August. The GE brand name will continue to appear on those sets.

Meanwhile, H. H. Scott Company, one of the American pioneers of high fidelity, has been acquired by Emerson Radio Corporation, and the brand name will be used for a high-end line of stereo components.

Scott filed under bankruptcy proceedings in 1972 and was acquired by its Belgian licensee. Incidentally, Emerson Radio has no corporate relationship to the old Emerson Radio, which was a pioneer in both radio and television; the name was acquired several years ago from National Union Electric, which took over the original Emerson Radio.

• **Video Vignettes.** Some 58 percent of all color-TV sets sold in the United States in 1984 had built-in cable-channel tuning, according to the Electronic Industries Association.

• The 27-inch picture tubes are here—three different types, in fact. RCA's deluxe tube is called the SP (for "square planar"), and it has a flat face. Zenith's tube has square corners, but normal spherical curvature of the faceplate. Sony's is a *Trinitron* with square corners and a somewhat flattened cylindrical faceplate. **R-E**

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Other features of the 2900 series probes include a replaceable probe tip, replaceable ground lead and a **Readout Actuator option** (RA).

The **Readout Actuator option** (permanently attached) is available on the 10x fixed attenuation probes only. This option provides the necessary resistor circuit to change the range factor on the model 465, 475, 485 and 7000 series Tektronix scopes.

The **Standard Accessories** included with each probe are the sprung hook, trimmer tool, BNC adapter, tip insulator, IC tip cover, spare probe tip, 6″ ground lead, and a handy storage pouch. The **Engineers Accessory Kit** ($12.00 option) includes a wire wrap adapter tip, wire wrap adapter ground lead, alligator tip, micro sprung hook, and a 12″ ground lead.

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2904 RA	10X	RA	100	3.5	17	10	600V	$45.00
2905	10X	STD	250	1.5	17	10	600V	$45.00
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2901	10X, 1X, GND	STD	100/5	3.5/70	17/100	10/1	600V	$39.00
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1064	Engineers Accessory Kit							$12.00

- RA = Readout Actuator, STD = Standard BNC • Cable length 5½ ft.
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LETTERS

WIRELESS VIDEO-CAMERA LINKS AND FCC REGULATIONS

This letter is in regard to the use and marketing of illegal wireless video transmitters. The article in your February issue, "Build This Wireless Video-Camera Link" falls into that category.

While those transmitters have several advertised uses, the two most common are transmission of video programming throughout the home without the need for coaxial cable, and wireless transmission of video from a camera to a VCR. The sale, marketing, or use of those low-power video transmitters is illegal under Federal Laws and Regulations, despite claims to the contrary by some distributors and manufacturers. None of the devices are "FCC Approved" or "Comply with FCC Regulations" as is sometimes stated.

Use of those illegal devices constitutes unlicensed operation and subjects the user to severe penalties. Accepting advertising for those devices, or publishing articles on how to construct them, fosters use and perhaps entices your readers to unknowingly violate the law. We are currently initiating legal action against all known manufacturers and distributors of wireless video transmitters; however, we hope that in the future you will refrain from accepting advertising or publishing articles that aid and abet violation of Federal laws.

DENNIS P. CARLTON
Engineer-in-Charge
Federal Communications
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continued on page 20

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Today, thanks to the rapid development of satellite technology, a call to Paris is as clear and as easy to make as a call to your next door neighbor . . . executives from multi-national corporations and even small businesses use video conferencing to "meet" without leaving their offices . . . simultaneously a billion people witness a single event (a soccer game, an inauguration, a benefit rock concert) . . . global weather maps transmitted from satellites allow meteorologists to forecast weather trends weeks in advance . . . and scientists now explore and investigate the mysteries of outer space without leaving their labs.

And, not surprisingly, these amazing applications of satellite technology have opened up exciting new opportunities for the technician trained to install, maintain, troubleshoot and repair satellite communications equipment.

Home Satellite TV Is Just at the Start of Its Explosive Future

You've seen them in suburban backyards and alongside country farmhouses. Home satellite TV systems are springing up all across the country.

Already there are over a million TVRO (Television Receive-Only) systems in place in the U.S. alone, and experts predict that by 1990, a remarkable 60% of U.S. homes will have a satellite dish. Contributing to the field's phenomenal growth are the support of the FCC and Congress, steady improvement in product quality, the development of smaller dishes, and a growing consumer enthusiasm for satellite TV.

LETTERS

continued from page 14

Our readers should be aware that the manufacturers of such devices are not the only ones that are subject to penalty. Consumers using such equipment are also subject to a $10,000 fine, a jail term, and seizure of their equipment. Although the Commission has received petitions and requests to legalize low-powered video transmitters, it has denied them because of concern about possible interference to licensed TV broadcast stations. If, despite that warning, you continue to use the transmitter, you should reduce its output power to lessen the chance of unintentional interference.—Editor

PULSE GENERATOR ERRORS

I am building the pulse generator described in "Versatile Pulse Generator," **Radio-Electronics**, November 1985. I have found the following errors in Fig. 2, on page 59:

- J4 is not shown.
- R16 is across J7 in the figure, but the text says J6.
- IC4 (4050) is shown as 14 pin; it is 16 pin.
- D3 should be labeled D1.

Except for the second item, correction is obvious. What worries me: are there more errors? I shall be waiting impatiently for comment in an upcoming issue.

SIGMUND S. KAHN
Brooklyn, NY

The schematic is correct, so R16 should go across J7. By the way, we too are impatient sometimes—that's what causes some errors. Thanks for your eagle-eyed corrections.—Editor

THE BRAZILIAN CONNECTION

I read your article about the remote controller (**Radio-Electronics**, October, 1985) and I would like to know how can I get data sheets on those IC's, as well as other kinds of information, including typical applications, etc. And how can I get sample IC's to experiment with?

The problem is that I'm from Brazil, and it's very difficult to find those parts and that kind of information in our electronics marketplace.

Thanks for the help—and congratulations for the high quality of your magazine.

PAULO ROBERTO M.M. OLIVEIRA
Avenida Angelica, 1399 apto 112
Cep 01227, Sao Paulo, Brazil

You should be able to obtain those IC's from the supplier mentioned in the article by remitting U.S. funds. For data sheets, you should contact Motorola Semiconductor Products Inc. 3501 Ed Bluestein Blvd., Austin, TX 78721.—Editor

OWNER'S MANUAL NEEDED

I purchased a tuner-video analyzer, model 10WX from Mercury Tuner (103 East 165 Street, Bronx, NY). I lost the manual, and the company has since gone out of business. I will pay $5.00 for a copy.

WILFREDO RAMIREZ
305 W 72 Street
New York, NY 10023

R-E

EQUIPMENT REPORTS

G-E's Control Central Programmable Remote Control

Replace all of your infrared handheld remotes with a single transmitter!

CIRCLE 5 ON FREE INFORMATION CARD

REMOTE-CONTROL CAPABILITY WAS once thought to be the ultimate in convenience. But having too much of it can be a problem: It's almost impossible to pick the correct handheld remote unit on the first try! But now there's a solution to remote-control clutter: *Control Central* from G-E (General Electric Company Consumer Electronics Business Operations, Electronics Park, Syracuse, NY 13221).

Control Central is a programmable remote system that can take the place of four infrared handheld remotes. The actual programming is very easy: You simply place the *Control Central* head-to-head with an infrared transmitter and press the matching keys on each unit. Although we left out a few steps, it's really that easy. But before we fill in the programming details, let's take a look at some other features of this innovative product.

Control Central uses a Mitsubishi 50747 microprocessor (which is upward compatible with the 6502), 4K of battery-backed-up CMOS RAM, and 8K of ROM. It is designed to operate with most infrared remote-control systems. *Control Central* looks the part of a remote transmitter, except that it's slightly larger than most (about 1 × 3 × 8 inches) and it has an LCD readout. It weighs in at just over one-half pound.

The remote control has four source inputs, called TV, VCR, CABLE, and AUX, and its keypad is labelled to correspond to most common functions from those devices. For example, the keypad's primary keys include POWER, CHANNEL UP/DOWN, VOLUME UP/DOWN, and MUTE keys. The VCR section of the keypad includes such keys as RECORD, VCR/TV, PLAY, STOP, PAUSE, FAST-FORWARD, REWIND, and forward and backward SCAN. The secondary-key section is used for additional commands, and for direct channel entry or other numerical entries.

Along with the functions we mentioned, there are a host of other less-common key functions

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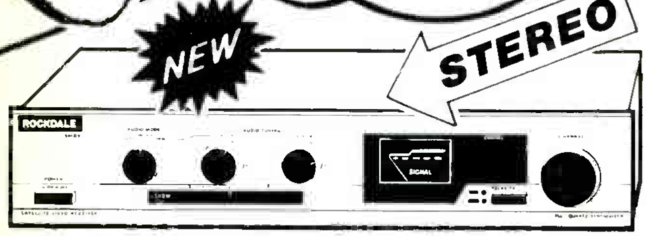
Blimey, mates! You'll be amazed at the great new products & values we have for you!



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State of the art circuitry and advanced technical standards give you stereo satellite reception with maximum performance. This 70 MHz single conversion receiver features SAW IF Filter, Auto TV Thru-Mode on Standby/Power Off, and Base-Band Output for Descramblers. Cat D-6332

ROCKDALE STEREO SATELLITE RECEIVER

See Your Favorite Show Wherever You Go!

only $79.95

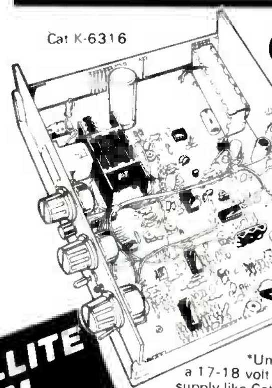
INCLUDES 12V PLUG & AC ADAPTOR

Imagine - a miniature TV that operates from a 12V supply but draws very little current! Use the cigarette lighter plug in vehicles or the AC adaptor in the house (both are included!) The 5" B & W screen offers great definition so now you can see your favorite shows everywhere - in your car, truck, boat or van!

5" B&W TELEVISION

Cat Y-6000

Cat K-6316



Or Build Your Own Receiver & SAVE A FORTUNE!

"The performance rivals commercial receivers costing hundreds of dollars more. The ease of assembly & . . . field proven circuitry is fantastic, the quality. . . better than expensive commercial units."

Richard Maddox, author of *Troubleshooting & Repairing Satellite TV Systems*

ONLY* $99.95 PLUS $4 SHIPPING

You can put this kit together in just hours! Why wait any longer to enjoy the world of satellite television?

*Unit requires a 17-18 volt AC power supply like Cat M-6672.

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AS FEATURED IN DEC & JAN RADIO ELECTRONICS

Move Your Dish Without Leaving the House!

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SATELLITE POSITIONER & ACTUATOR

Raining? don't get soaked just because you need to move your satellite dish. With this Actuator (a motor-controlled arm that attaches to dish & mount) and Positioner (the remote control unit that sits under your receiver or TV), you can position your dish in total comfort. This unit is designed to suit most dishes. Install it yourself and save!

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This is a comprehensive guide for both home TVRO owners & professional service technicians. It covers installation, testing, servicing, alignment, & information not available in other handbooks.

Cat B-1845

NEW VHF/UHF MASTHEAD AMP

$24.95

This high gain amp (VHF 25 dB, UHF 20dB) boosts TV & signals even in fringe areas. Its high input capability resists overload on strong sigals, while a built-in FM trap cuts interference. Includes UL-listed AC adaptor. Cat L-4200

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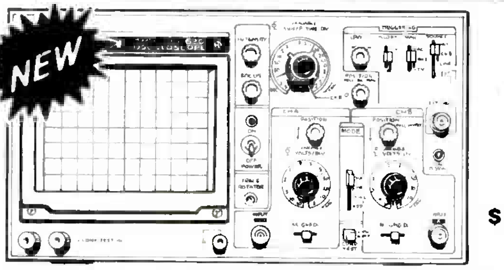


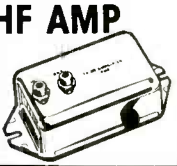
$399 Cat O-1240

As always, Dick Smith brings you more for less! Our new model dual-trace 20 MHz oscilloscope is packed with features. The high brightness CRT assures easy readability, and a specially designed circuit for component testing allows you to determine component status in or out the circuit board! Other features include: wide bandwidth & high sensitivity, very low power consumption, high sensitivity X-Y mode, 2 axis (intensity modulation) panel electrical trace rotator, & regulated power supply circuit for accuracy. And the best feature of all: our new low price!

20 MHz DUAL-TRACE OSCILLOSCOPE

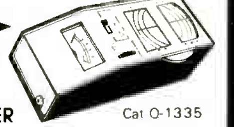
NEW IN-LINE VHF AMP

This 10dB video amp has a bandwidth of 50-450 MHz & output capability of 30 dBmV. Noise figure is 4 dB & impedance is 75 ohms.



$8.95 Cat L-4201

NEW DIP METER



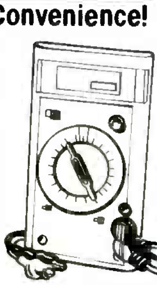
Cat O-1335

Frequency Range:	1.5-250 MHz in 6 plug-in coils
Modulation:	Approximately 2 KHz sinewave
Crystal Oscillator:	1-15 MHz
Power Supply:	9V DC
Semiconductors:	2 transistors & 1 diode

$59.95

NEW Hand-Held Convenience!

$69 Cat O-1220



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NEW Your Board Missing a Track? No Worries! Get CIRCUIT-FIX KIT

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Make circuit repairs & changes fast & simple! Kit includes spring-loaded clamp & guide, collet knife & blade, 154 asst. copper donuts, 32 sq.in of foil, & instructions.

Copper Foil Donut Refill	Cat H-5902	$4.00
1 oz. Adhesive Copper Foil	Cat H-5903	$4.00

NEW Make Your Own PCB'S Directly from Magazine Art!

$34.95 Cat H-5700

All necessary materials are in this kit! 5"x6" steel print frame, film & processing pack, yellow filter, 4 oz. etch resist, 16 oz. developer, blank copper boards, dry concentrated etch and 1:1 resist patterns & tapes, instructions.

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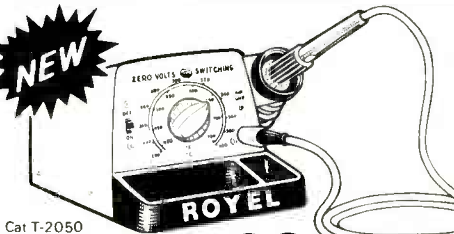

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FROM ROYEL

CIRCLE 95 ON FREE INFORMATION CARD

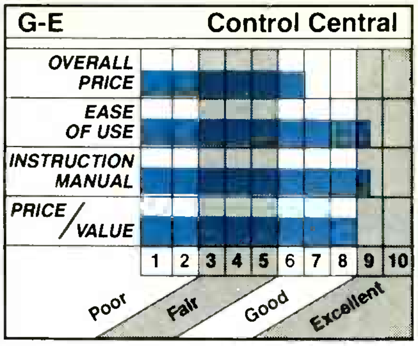
included. But it's important to remember that a key function (or a source function) is not limited to its label. For example, if you want the CHANNEL UP key to actually turn up the volume, then you're free to program the *Control Central* to do it. By the same token, if a function that your device requires is not available on the keypad, you're free to designate any key to it. It all depends on how you program the unit.

Programming *Control Central*

Teaching *Control Central* the infrared commands that your equipment needs could hardly be easier. But we should note that it might not even be necessary because the unit comes pre-programmed with codes to operate G-E equipment, and those codes work with several other brands as well. So before you start teaching *Control Central*, you should try its pre-programmed commands.

If you do have to program *Control Central*, the first step is to use a ball-point pen (or similar object) to slide the USE/LEARN switch to the LEARN position. The words "LEARN MODE" flash in the display window three times, followed by "1 SELECT SOURCE 2 PRESS ENTER." Following the displayed instructions, you press the SOURCE key to display the component name (TV VCR CABLE or AUX) that you want *Control Central* to learn, and then press the ENTER key. The display then flashes "READY PRESS MATCHING KEYS," which tells you that you should place *Control Central* head-to-head with the existing remote transmitter, and press the appropriate keys on each. When *Control Central* thinks it has learned the function, its displays prompts you to "RELEASE" the keys. But to make sure it has things right, it will ask you to "DO AGAIN", at which time you again press the matching keys. If everything works as planned, you will be greeted by the words "FUNCTION LEARNED."

There are a host of "display window functions" that are accessed by pressing the FUNCTION key after a source has been selected. Although they're too numerous to list in full here, they include functions such as TINT, BRIGHT CONTRAST, SHARP, BALANCE, TREBLE, BASE



and stereo-TV controls for the TV source; SLOW, SCAN, SELECT, CUE, TIMER, AND EJECT for the VCR source; and PROGRAM, RNDM ACC, SEEK INDEX, DISC, AND MEMORY for the AUX source.

It is possible to teach the *Control Central* the commands from more than one transmitter in a single source. For example, the AUX source could be programmed to learn some commands from your CD player, and some commands from your stereo receiver. You could also, perhaps, program both your VCR commands and your TV commands in a single source, so that you wouldn't have to switch sources to control both. Unfortunately, there are a few problems with doing that. First, mixing codes in one source memory uses memory inefficiently, so you run the risk of a memory overload if you mix codes. It's also important to realize that not all infrared links use the same frequency, so not all transmitters can be mixed on a single source.

If you have more than four devices to control, then the ability to mix codes on a single source is very important, because it can expand the number of devices that *Control Central* can operate. If that feature is important to you, we suggest that you try to mix the appropriate codes before you buy *Control Central*.

Control Central has a suggested price of $149. Whether it's worth it depends on how often you've had to search through several remotes for the correct one. We expect that many readers of this magazine would benefit from the convenience that *Control Central* offers. **R-E**

continued on page 28

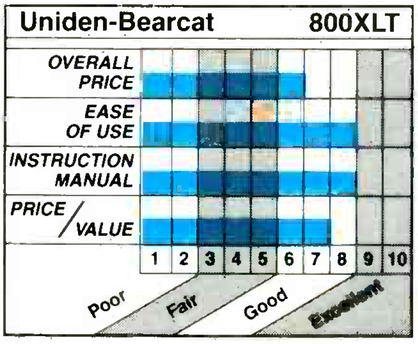
Uniden-Bearcat 800XLT Scanner Receiver

A top-of-the-line scanner with expanded frequency coverage.

CIRCLE 6 ON FREE INFORMATION CARD

WITH THE GROWING USE OF THE 800-MHz band, it was only a matter of time before scanners capable of covering that band made their appearance. One such scanner is the Uniden-Bearcat *800XLT* (6345 Castleway Court, Indianapolis, IN 46250). That microprocessor-controlled, 40-channel unit covers four ham bands; aircraft, military, public safety, and federal government frequencies, as well as the aforementioned 800-MHz band.

Specifically, the unit covers the following frequency bands: 30 to 50 MHz, 118 to 135.975 MHz, 136 to 144 MHz, 144 to 148 MHz, 148 to 174 MHz, 406 to 420 MHz, 420 to 450 MHz, 450 to 470 MHz, 470 to 512 MHz, and 806 to 912 MHz. The unit offers Uniden's track-tuning feature. That feature causes the scanner to tune a channel for peak signal-strength, and then to track a signal (in the event of drift, etc.) so that the peak strength is maintained.



The *800XLT*

When we unpacked our unit, one of the first things we noticed was its strong resemblance to earlier Bearcat units, such as the *220* or *350*. But a closer examination revealed some very important differences.

One difference that is especially significant is the addition of three LED's to the front panel. Those are used to indicate the status of a particular channel; that is whether the unit's lockout, priority, or delay functions have been selected. On other Bearcat models, that information was presented as part of the frequency/channel readout. Because that caused the readout to be cluttered, the information was sometimes difficult to discern at a glance. This system offers a much clearer indication of the channel's status. As to the channel/frequency readout, it uses a bright, easily read, fluorescent tube display.

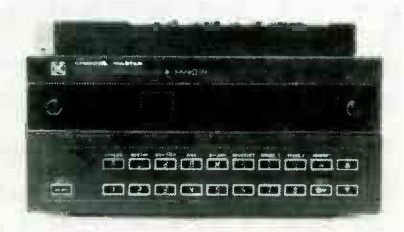
The keypad, like those on other Uniden-Bearcat scanners, and unlike those on units from many other manufacturers, uses real pushbuttons, rather than a plastic membrane overlay. The keypad is used for frequency entry, programming the priority channel, and selecting search, lockout, or delay modes. It has a positive tactile response. An interesting feature of the pad is the presence of a wx key; pressing that key activates an automatic weather-service search mode. In that mode, the unit scans all National Weather Service frequencies in the area.

On the rear of the unit there is the access hatch for the memory-backup batteries, as well as connectors for AC power, DC power (13.8 volts), ground, and antennas. Yes, we said antennas. On most other scanners, including those that offer 800-MHz coverage, a single antenna input is all that is provided. On the *800XLT*, there is a separate input for an 800-MHz antenna. Incidently, the unit is supplied with both a stub antenna for 800-MHz, and a telescoping antenna for the other frequencies. Partially due to an excellent receiving location, a hilltop that is some 230

continued on page 102

NEW PRODUCTS

ANTENNA DRIVE, the programmable Satscan, model *6254,* features solid-state operation, without mechanical relays. It allows users to access satellites directly via preprogrammed location. For example: to move the antenna to Satcom III-R, simply press the Satcom key and the number-3 key. The antenna then moves to that position automatically.



CIRCLE 21 ON FREE INFORMATION CARD

The unit's microprocessor memory also allows coded parental control. Using the lock function, access to specific satellites may be restricted, or the antenna may be locked onto a particuler satellite. Outdoor components of the Satscan drive system include a heavy-duty actuator drive with low 35-volt DC operation; the unit is protected by a weatherproof, expandable jack sleeve and motor boot. Automatic shutoff prevents motor wear by restricting movement to the range of the satellite arc.

The model *6254* is priced at $649.95.—**Channel Master,** PO Box 1416, Industrial Park Drive, Smithfield, NC 27577.

DEMODULATOR, the Quest *Video Interface,* is a stand-alone Channel 3 (NTSC standard) demodulator, designed specifically for the video enthusiast.

A high level of selectivity at the

CIRCLE 22 ON FREE INFORMATION CARD

input is accomplished by means of a SAW (*S*urface *A*coustic *W*ave) filter. The filter is specifically designed for direct signal input at the Channel 3 frequency. It circumvents the signal deterioration that results from mixing down the input signal to an intermediate frequency for processing.

The output of the SAW filter is configured for quasi-parallel signal processing. With that system, the audio and video are separated from one another and sent to individual processing circuits. That enables the device to demodulate the audio and video signals separately, rather than deriving the audio from the negative output of the video demodulation circuit, ensuring good resolution and stability.

The principal application of the *Video Interface* for video enthusiasts is the conversion of pay-cable programming. The device will convert the Channel 3 output of a cable converter, or similar device, to composite video and discrete audio. Those signals can then be routed to any other device having provisions for video and audio inputs, such as VCR, video monitor, audio amplifier, or a video processor.

The Quest *Video Interface* sells for $139.95.—**Quest Custom Video,** 22931 Edmonds Way, Edmonds, WA 98020. **R-E**

NEW IDEAS

Robot eyes

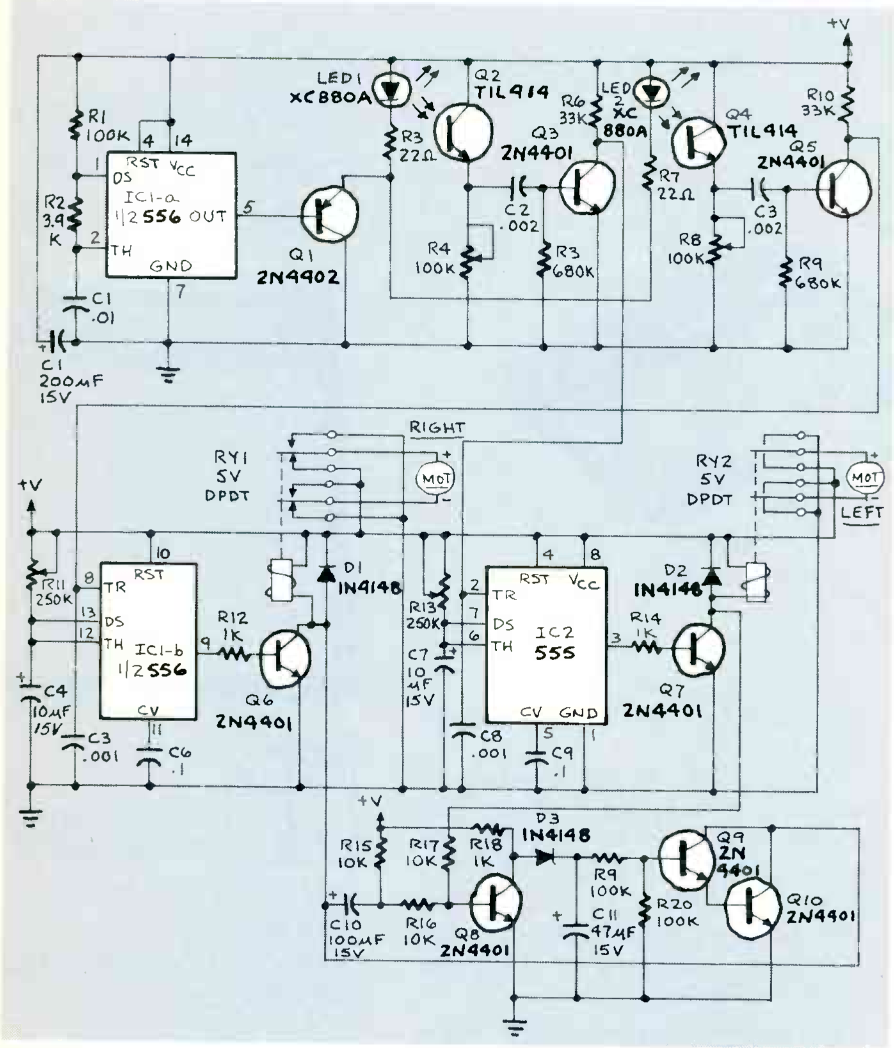


FIG. 1

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, for U.S. residents only, 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.

I agree to the above terms, and grant **Radio-Electronics** Magazine the right to publish my idea and to subsequently republish my idea in collections or compilations of reprints of similar articles. I declare that the attached idea is my own original material and that its publication does not violate any other copyright. I also declare that this material has not been previously published.

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I HAVE A TOY ROBOT THAT USES TWO small DC motors to move around. The robot was designed to move according to how its joystick was manipulated, but I wanted to make my robot intelligent enough to be able to move about on its own and avoid whatever obstacles happened to appear. I knew that *I* would find it difficult to move around if I had no eyes, so I figured that a pair of "eyes" would help my robot, too. The circuit shown in Fig. 1 represents the fruit of my labor.

shown in Fig. 1 represents the fruit of my labor.

Circuit operation

My robot has one motor mounted under both its left and right sides. The direction the robot moves depends on the direction each motor rotates. For example, the robot can go forward and backward by running both motors in the same direction. And the robot can turn by running one motor forward and the other backward. For example, when the left motor rotates forward, and the right motor moves backward, the robot turns to the right.

It's easy enough to use DPDT relays to control the direction of the motors, but we still need some "smarts." I used an infrared LED and a phototransistor for each eye. The rest of the circuit processes the information provided by those eyes to control the relays.

Half of a 556 timer IC (IC1-a) functions as an astable multi-

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2. 16-bit 8088 Microprocessor accepts advanced software, speeds word processing; also allows selection from the huge library of IBM software.
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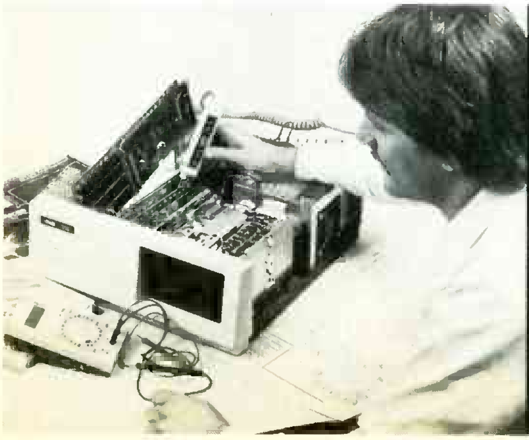
Your NTS training course will teach you to program on this outstanding PC, using lessons, texts, and diagrams to make full use of its capabilities. Catalog contains complete details.

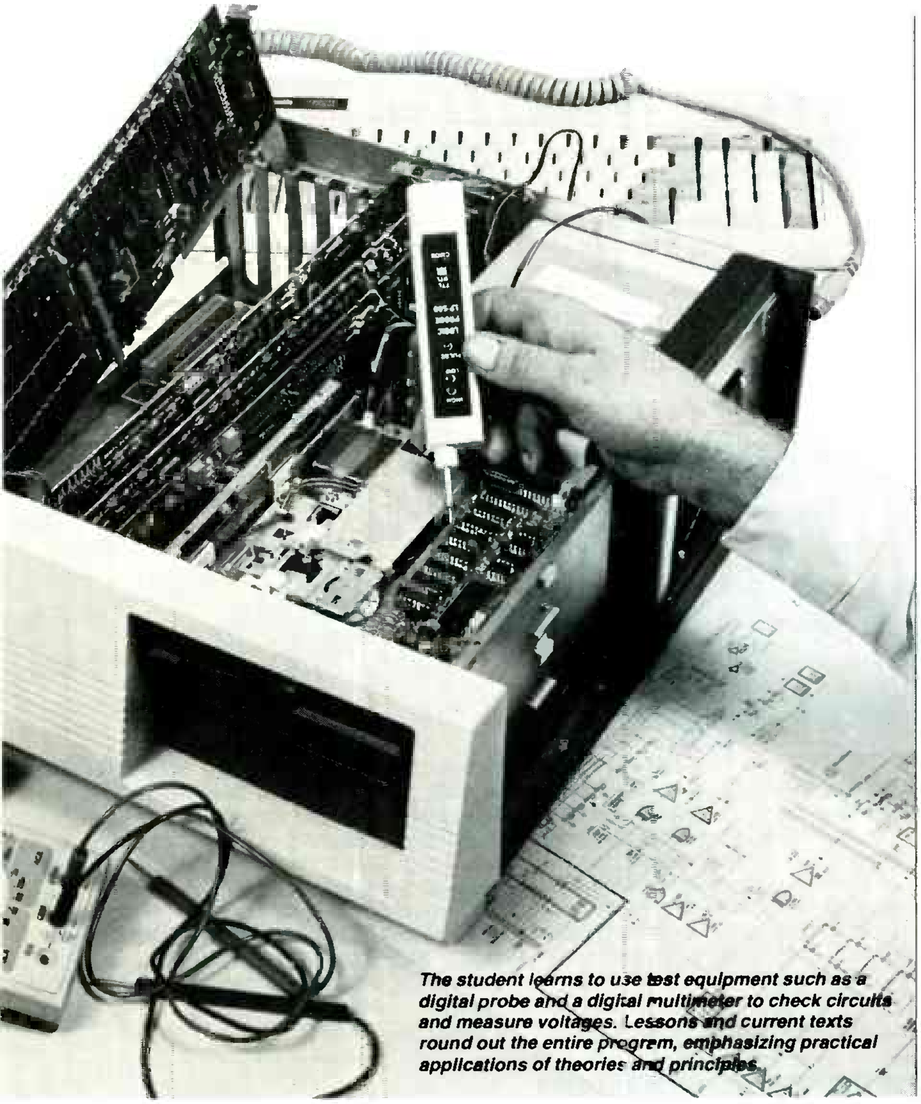
Learning circuitry through the construction of this equipment offers practical training for which there is no substitute. Test equipment is included.



Field servicing is interesting and rewarding. Technicians may work for a service company, manufacturer, or major users.

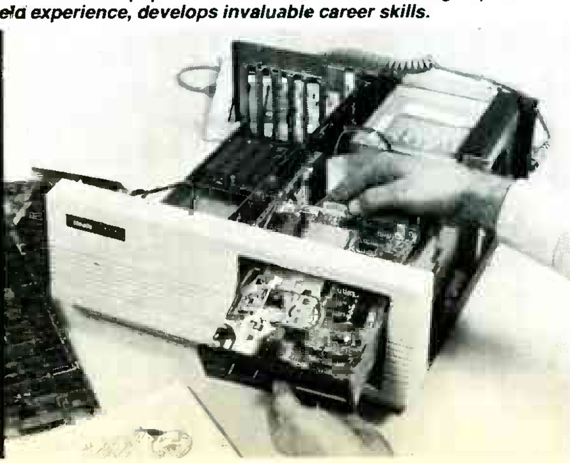
The NTS/HEATH HS-151 PC completed, include monitor and full-function keyboard with calcula style keypad, and typewriter format.

INTO PC SERVICING A MICROCOMPUTER



The student learns to use test equipment such as a digital probe and a digital multimeter to check circuits and measure voltages. Lessons and current texts round out the entire program, emphasizing practical applications of theories and principles.

Installing the disk-drive in the PC is one of the final stages in the assembly of the microcomputer. Learning the use of test equipment to check circuits is an integral part of the training which, with field experience, develops invaluable career skills.



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Robotics: Build the NTS/HEATH Hero 1 Robot as you learn robotic programming. Robot is complete with arm and gripper, voice synthesizer. Robotics is becoming increasingly important in industry as almost daily news features attest.

Video Technology: Build one of the most advanced Color TV sets in America as you learn circuit diagnostics, and the use of digital test instruments. Course covers color TV, video tape recorders, computer fundamentals, solid-state devices.

Industrial and Microprocessor Technology covers circuit analysis, microprocessors and automation applications, lasers, and basic industrial robotics.

TV & Radio Servicing is a specialized course offering an excellent foundation in the use and application of both analog and digital test equipment as applied to the TV servicing field. Learn circuits, adjustments, trouble- shooting, and servicing of Color and monochrome monitors.

Digital Electronics offers the student the opportunity to get involved with computer concepts, computer technology fundamentals, and digital equipment by training on the NTS Compu-Trainer.

Basic Electronics is a course designed for those wishing to have an over-view of electronics in many of its aspects including radio receivers, solid state devices, and electronic components.

NTS Intronic training programs include a variety of superb equipment, most of which is classified as field-type, making the training practical and career oriented. Texts and lessons have been tested in our Resident School in Los Angeles to assure home study students their courses of training are easy to understand NTS, now in its 80th. year, continues to be at the leading edge in Electronics home training.

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4000 So. Figueroa St., Los Angeles, CA 90037

vibrator oscillating at a frequency of about 1 KHz. That IC drives transistor Q1, which in turn drives the two infrared LED's, LED1 and LED2. The right eye is composed of LED1 and Q2; those components are mounted side by side—*not* facing each other—about ¼" apart. The left eye is composed of LED2 and Q4, which are mounted like the corresponding parts of the right eye, about four inches away.

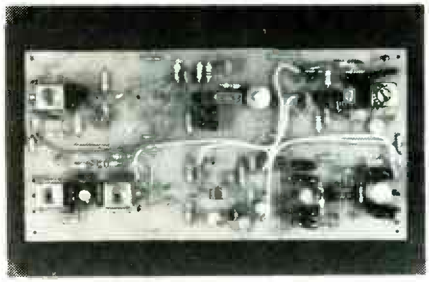
If an obstacle appears in front of the right eye, pulses from LED1 are reflected by the obstacle and detected by Q2. The signal from Q2 is amplified by Q3, which triggers IC2, a 555. That IC operates in the monostable mode, and it provides a pulse output with a width of as much as 2.75 seconds, depending on the setting of R11. That pulse output energizes relay RY1, and that reverses the polarity of the voltage applied to the motor. Corresponding portions of the circuit of the left eye operate in the same fashion, using the unused half of the 556 (IC1-b). That action causes the robot to turn away from an obstacle.

When an obstacle appears in front of both eyes, both relays will be activated, so the robot will back up. The circuit composed of Q8–Q10 (and associated components) provides additional "on" time for the right motor. That helps the robot avoid getting trapped in a narrow passage.

Construction

Construction of the circuit is not critical, so feel free to use the technique you prefer. Just be careful with the orientation of polarized components and semiconductors. The circuit can operate from any voltage between 4.75 and 7.5 volts. Potentiometers R4 and R8 adjust the sensitivity of the phototransistors; you might adjust them to respond to an obstacle that is twelve inches away. Potentiometers R11 and R13 control the amount of time the motors will be reversed. That will depend partly on the surface your robot is traversing. Too little time on a rough surface might not affect direction at all, and too much time could cause constant overshooting. You'll have to experiment a little.—*John Ellis*

Radio-Electronics mini-ADS



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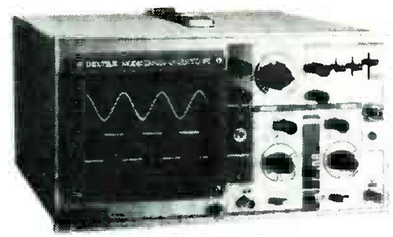

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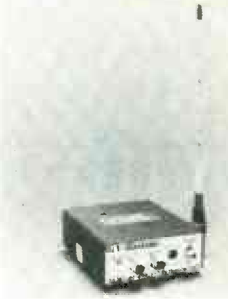

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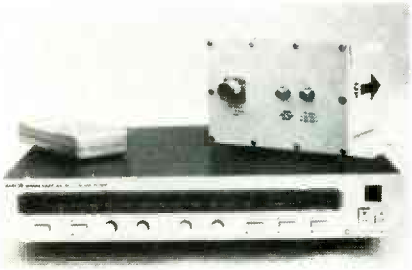

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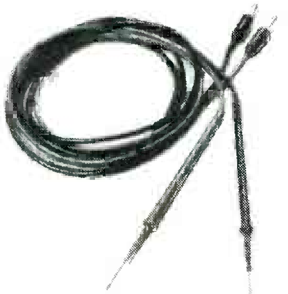

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BUYER'S GUIDE TO Personal Robots

The robots are coming! The robots are coming! Find out when, and what form they'll take, in this informative survey of the personal-robot field.

MARK J. ROBILLARD

ONCE FOUND ONLY IN INDUSTRY AND THE laboratory, over the past decade the computer has become a fixture in the vast majority of households. Now, the robot stands on the verge of making a similar transition; just as the "personal" computer is now commonplace, soon the "personal" robot will be found in many homes.

Personal robots hold the promise of creating even greater excitement than the computer. With their capabilities of movement and manipulation, personal robots have the potential to interact extensively with every member of the family. Blasphemous as it might seem, robots might even replace the family dog in some households.

So where are all of these robots? How close are we to that robot "explosion?" What are the capabilities of the robots that are currently available? Where can you obtain such a robot? Those are just some of the questions that we'll answer in this article.

What is a personal robot?

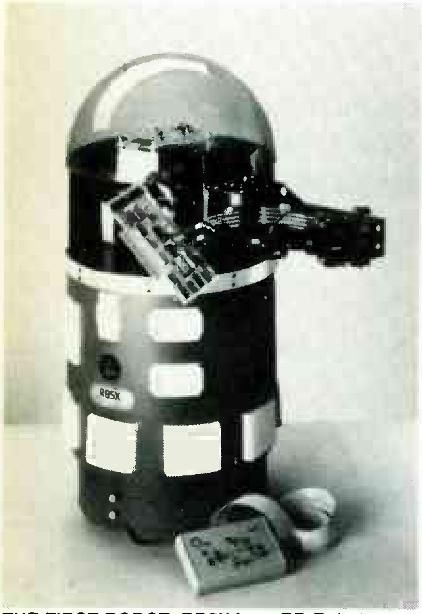
Most of you are probably familiar with the uses of robots in industry. Numerous television and film documentaries, most notably on PBS, have shown industrial robot-arms painting cars in Detroit or removing blistering-hot liquid from a furnace in Pennsylvania. Those examples depict the industrial use of robotics to improve production under somewhat hazardous factory conditions. But robot arms are not the entire realm of robotics. For that matter, robot arms, though most common, do not represent the only possible industrial application of robotics. Indeed, the possibilities are almost endless.

The same can be said for a "personal" robot. A personal robot can take almost any form, as long as it does not require an "industrial" environment in which to operate (not too many of us have pneumatic tubing, etc. running throughout our homes).

All of us can think of possible applications for mechanical slaves around the house. Some of the more obvious uses would be mowing the lawn, washing clothes and taking out the garbage. Others include vacuuming the carpets and walking the dog. Unfortunately, the scope of those applications is too ambitious—beyond the capability of most currently available robots; and that is severely limiting the market.

By the mid 1980's, hundreds of thousands of people owned personal computers. But many of those computers, particularly the less expensive ones, eventually wound up in the back of the closet. Once the novelty of the new machine wore off, the reality was that only a relatively small number of people had a real need for a computer in the home: for everyone else, it was a device without an application. The situation with personal robots is very different. There, we have many applications, but no machine yet that is capable of performing more than a few of them.

In mid-1982, a company called RB Robot, operating in Golden, Colorado, introduced the first commercially available personal robot. The *RB-5X* looked to be little more than a trash can with wheels and a clear plastic top. A closer look revealed that that machine was equipped with collision sensors and a full-fledged microcomputer system that could be programmed in BASIC.



THE FIRST ROBOT, *RB5X* from RB Robot.

The *RB-5X* was basically a toy for the dedicated hardware experimenter. Its mechanical abilities were not much more refined than a radio-controlled car. The microcomputer could only be programmed by using an external dumb terminal—something that is not found in most households. But it did provide a starting point for would-be robot experimenters.

Shortly after the birth of the *RB-5X*, the Heath company announced the birth of what was to become the best-selling personal robot to date, the *Hero 1*. That robot, like the *RB-5X*, was equipped with a motorized base and microcomputer. However, included with the package were several sensors for measuring light, sound, motion, and distance. Those, and the addition of an arm and voice-synthesis module, placed the *Hero* more firmly into the category of what everyone thinks of when the word "robot" is mentioned. Much like early personal computers, the *Hero* could be programmed via a keypad.

If one were to plot a time-line of the history of personal robots versus that of the PC it would show that the *Hero* is the robotic equivalent of the *Altair* microcomputer.

Since those beginnings several things have happened. Many other firms have entered the market with robot kits and completely assembled units. A Texas-based marketing-research firm, Future Computing, has forecast that the personal robotics market would be larger than that for the personal computer, and that that market was about to "take off." Many small firms entered the market with kits and assembled units.

In 1984, a magazine survey showed that there were 18 viable robotics products and manufacturers to choose from. Those products ranged from simple two-wheeled remotely operated devices called "turtles" to large-android-like, sophisticated robots. Many of the fledgling robotics firms were exceedingly small, some operating out of their owner's homes, or sharing space with other companies. Some sold only a few units; others, like Androbot, sold several hundred. In the latter case, Androbot's main product, called *Topo*, appeared to be an ideal robot system. It was large (the size of a six-year-old child) and, it had a unique drive-wheel system. The initial units ran via a special interface to an Apple *II* computer. They came with a disk of software routines that allowed the user to control the robot's motion via the computer's joystick.

One obvious limitation of the *Topo* was that it was incapable of undirected motion. Androbot promised to correct that problem in a proposed robot named *BOB*; that name was an anagram for *B*rains *O*n *B*oard. While full details were not released, indications were that the robot would be equipped with on-board microprocessors. Those microprocessors would analyze the data from "vision" sensors and use that data to control the robot's motion. Using that system, the robot reportedly would be able to seek out or follow its owner, even in a crowded room.

But, then what? The robot was not to be equipped with any manipulative capabilities (it had no "arm"), so what did it do when it approached the owner? Its only ability was to tell a joke, via a voice-synthesis circuit, from a stored library.

Obviously, such hardware is not sufficient to launch a new marketplace. The chief problem remains one of supplying the hardware that will perform an application that many people want. It is the opposite of the problems in the computer industry where the hardware exists, but finding an appropriate application is difficult.

Of the companies currently producing robots, Heath has done well because they designed their robots to be used as teaching tools, and they support them with a wealth of excellent study courses. Others have tried to produce either a general-purpose motorized toy that can only move and slightly entertain, or, on the other extreme, a high-priced replacement for a 95-cent joke book.

Today, despite optimism and high hopes, the personal robotics industry is unstable, to say the least. Of those companies that have already introduced robot products, about half have faded from the scene altogether, or are not currently in a position to adequately service the consumer. There are, of course, new manufactures appearing (and unfortunately disappearing) on the scene all the time.

Even large companies are not immune to the vagarities of the current market. Several toy companies have introduced robot products. Those products are *not* toys; many compare favorably with the RB and Heath robots already mentioned. The forerunner among that group were Ideal and Tomy. The mechanics in their products were elegant; and because toy companies are so cost-conscious, all the mechanical parts were designed to have multiple functions.

IDEAL TOY'S *Maxx Steele*.

Tomy's *Omnibot* series of programmable robots is now the leader in the field with three entries. Ideal marketed a programmable version of the popular cartoon character Maxx Steele. That robot was designed specifically for upgradability. It had an Atari-like cartridge port for add-ons and a serial interface to its RF remote-controller. The documentation suggested that an expansion port and a sonar interface would be available in the future.

Now, that future seems to be a long way off. In November of 1985 the division of Ideal responsible for *Maxx Steele* was sold off, thereby burying the product.

Our survey

To find out the state of the market, we contacted over 20 personal-robotics manufacturers. Their products were investigated—we followed the same steps that you would in purchasing a personal robot. All products mentioned in this article were available for general sale at press time. The prices quoted were accurate at the end of 1985. In all but one case, the author has actually viewed and/or tested the product listed.

Obviously, all the features of each

product could not be listed in tabular form; however the most prominent features are listed in Table 1. Also, each product is described in more detail below. All of the robots have been listed in one of four general categories; arms, turtles, rovers, and miscellaneous. All the arm products are just that. They contain no provision for mounting a base or other rover-like features. Turtles are small rover-like machines that are slaved to a personal computer. They require a cable, power supply, and some software running in the host computers. Rovers are complete robot systems that contain an on-board microcomputer and the ability to maneuver about a room. Some, but not all, include arms as well as other advanced features such as voice I/O and vision-sensor systems. In "miscellaneous" we will look at some robot products that do not fit into our other categories.

Arms

The Rhino Robots (3204 N. Mattis Ave., Champaign, IL 61320) *XR* series arms are 5-axis machines and include grippers. Built using aircraft-grade aluminum, those robots are of fine quality. The motors that run the arm are servo type; they are DC motors that have integral optical encoders. Pulses from the encoders tell the microcomputer controller of the position of the arm. The motors drive the linkages through a series of chain drive belts. The robot has the heaviest lifting capabilities of any similarly priced product—almost three pounds.

The arms themselves are only a small part of the entire automation system that is supplied. Simple ASCII commands are used to operate all motors; a microprocessor-based control is located in the base of the arm. Interaction with the "outside world" is provided via an RS-232 interface.

Several other robot devices and services are offered by Rhino. For instance, they provide indexing tables and controllable conveyer belts. With those, it is possible to create a complete, working assembly-line operation.

One note on all of that: Rhino quality does not come cheap. Figure on spending about two thousand dollars for a very basic set of materials.

Microbot's (453 Ravendale Drive Mountain View, CA 94043) *Alpha* arm was the fist to arrive in the personal robot field. It is similar to the *XR* Series from Rhino. However, all the motors are stepper types and the arm is moved via a cable system; that cable system is much like the ones used by the toy steam-shovels that you may have played with when you were young. The arm mechanics are enclosed in a rather attractive package. The arm can be computer-controlled via an RS-232 interface.

The *Alpha* arms, like those from Rhino, are high-quality units. The most significant difference between the two is the use of stepper motors in the *Alpha*; that allows for a greater degree of repeatability. (That is important if repetitious tasks, such as those found on an assembly line, are to be performed). Despite their relatively high cost, there is no other product currently on the market that will do if you have a serious interest in arms or manipulators. Those arms are miniature versions of the ones found in industry.

Turtles

Frank Hogg Labs (Regency Tower, Suite 215, 770 James St., Syracuse, NY 13203) has been supplying software and accessories to users of 6800 family of microprocessors for many years. Recently they've introduced an excellent turtle for the TRS-80 *Color Computer*. Called *Nomad*, that turtle comes complete with a well-written manual and a wealth of demonstration programs. The *Nomad* itself is equipped with a two-stepper-motor drive and an on-board ultrasonic ranger. The software extends the BASIC already in the computer to allow for motion commands. Considering its $250 price, the *Nomad* stacks up as quite a value.

The *Nomad* is by far the easiest turtle to control to date. It is much more sophisticated than the earlier devices that you might be familiar with. Typically, those were little more than DC motors and four micro switches connected to a computer. Although those devices sold well to schools investigating the benefits of the LOGO programming language, they were useful for little else.

Even more sophisticated is Rhino Robot's *Scorpion*. That unit is the most full-featured turtle on the market today. In fact we hesitate to classify it as a turtle because it has on-board "intelligence". But it still needs to be linked to a host computer for control, and it requires an external 12-volt, 5-amp power source.

The most prominent features of the *Scorpion* are its software command set, and its vision scanner. The latter has the ability of scanning an area in front of the robot and reporting the varying light levels encountered.

The on-board "intelligence" that we mentioned consists of a 6502-based controller and 2K of RAM. The RAM stores both the commands sent to it and the samples of ambient light taken by the controller. The on-board computer can be expanded, but the interface uses the old KIM standard.

Perhaps the most serious drawback of the unit is that it is only available in kit form. Normally that would not present a problem, especially to regular readers of **Radio-Electronics**; however, the assembly documentation is absolutely terrible. As such, its assembly can only be recommended for someone with a great deal of project building experience.

Rovers

Artec Systems' (9104 Red Branch Rd., Columbia, MD 21045) *Gemini*, which is shown on the cover of the magazine, is one of the more advanced personal rovers available.

THE *GEMINI* robot from Artec systems.

The unit features an advanced on-board 65C02-based control system. Altogether there are three microprocessors. One is used as the main control computer; it is supplied with 64K of ROM and 56K of RAM. A second 65C02 is used to control the sound functions (voice I/O, sound generation, etc.); it has 25K of ROM and 16K of RAM. The third microprocessor is the motion-control computer; it is supplied with 2K of ROM and 24K of RAM. Its navigation system includes 9 ultrasonic collision-avoidance sensors. In addition, there is an LCD readout and detachable keyboard for programming in BASIC, and provisions for the addition of an on-board mass-storage device (either wafer tape or 3.5-inch floppy disk). *Gemini* will seek out its charging base when its batteries run low.

The machine performs well and its documentation is excellent. For those who want to build their own variation of the *Gemini*, the manufacturer will sell all the parts that go into it separately, including the shell! Unfortunately there is no arm yet available for the unit.

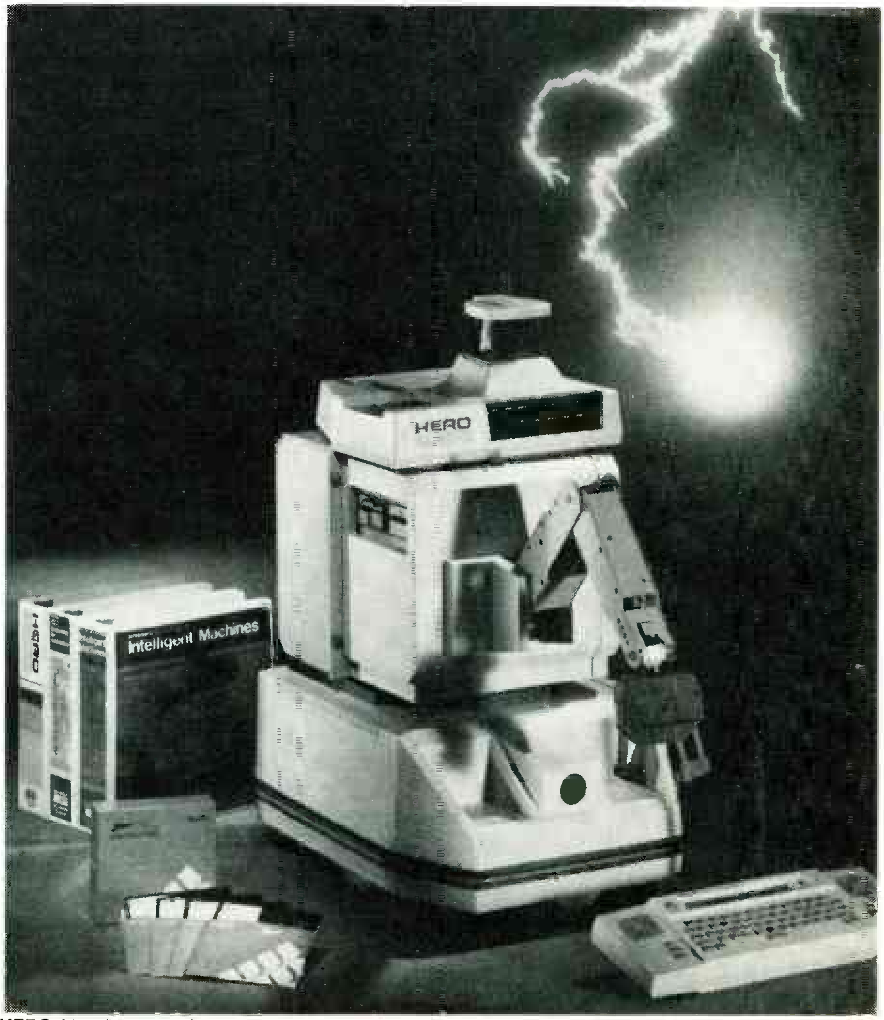
Heath (Benton Harbor, MI 49022) is the IBM of the personal-robot world. It's *Hero* family ranges from a preprogrammed pet-like robot, named *Hero Jr.*, to the most sophisticated robot commercially available today—*Hero 2000*. All Heath robots come in pre-assembled and kit form.

TABLE 1—

Manufacturer	Model	CPU Type	Memory	Drive System	Interface	Arm	Voice	Lift Capacity
ARCTEC SYSTEMS	GEMINI	65C02	56K	4 wheels DC servo	multiple	no	yes	none
FISHER AMERICA	ROBOT COMPUTING KIT	none	none	2 mini motors	multiple	see text	no	N/A
FRANK HOGG LABS	NOMAD	TRS80 Color	none	2 wheels DC stepper	TRS80 Color	no	no	none
HEATH COMPANY	HERO 2000	8088	24K up to 576K	DC servo	remote RF, RS232C	option	yes	1 lb
HEATH COMPANY	HERO 1	6808	4K up to 56K	DC and stepper	remote RF, RS232C	option	option	1 lb
HEATH COMPANY	HERO Jr.	6808	2K	DC and stepper	remote RF, RS232C	no	yes	none
IDEAL div CBS TOYS	MAXX STEELE	65C02	4K	2 wheels DC servo	remote RF	yes	yes	1 lb
MICROBOT INC.	ALPHA	none	none	DC stepper motors	RS232C	yes	no	1 lb
NINTENDO	ROB	N/A	N/A	N/A	none	yes	no	N/A
RB ROBOT INC.	RB-5X	INS8073	8K, 16K	DC motors	RS232C	option	option	1 lb
RHINO ROBOTS INC.	XR	8748	none	DC Servo	RS232C	yes	no	2.2 lbs
RHINO ROBOTS INC.	SCORPION	6502	2K	2 wheels DC stepper	RS232C	no	no	none
ROBOT SHACK	X-1	none	none	DC motors	none	no	no	none
ROBOT SHACK	Z-2	none	none	large DC motors	none	no	no	none
ROBOT SHACK	Z-1	none	none	DC motors	none	no	no	none
ROBOT SHACK	DROID BUG	none	none	DC motor	none	no	buzzer	none
TOMY	OMNIBOT 2000	N/A	audio tape	DC motors	remote RF	yes	recorded	1 lb
TOMY	OMNIBOT	N/A	audio tape	DC motors	remote RF	manual	recorded	none
TOMY	VERBOT	N/A	N/A	2 wheels DC motor	voice input	yes	input	4 oz
TTC CORPORATION	HEAROID	N/A	N/A	DC motors	remote RF	manual	input	4 oz

The *Hero Jr.* sports a 6808 microprocessor and a ROM that has been programmed with a selection of songs and activities. With the addition of an optional ROM cartridge adapter, the robot can accept a BASIC language cartridge that allows the user to program its action much like its older brother, *Hero 1*. Other options include an RF remote console for putting the robot through its paces without need of a connecting cable, and a number of pre-programmed demonstration and utility cartridges.

As mentioned, the *Hero Jr.* is a scaled-down version of the *Hero 1*. In its basic form, the latter computer is supplied with just 4K of RAM, but that can be expanded to 56K through an optional internally-mounted board. That robot comes equipped with practically every sensor you could want, including sonic ranging. Options include a somewhat limited-use arm, a Votrax SC01-based voice synthesizer, and an RF remote- control console. That console mimics the one mounted on the robot itself (that is located in the "head" area). Via the remote console, a wireless link between a host computer or terminal and the robot can be established. Among the available options are a limited version of BASIC and complete training courses in industrial electronics and robot applications. The courses are particularly worthwhile; you might want to consider obtaining them separately if you build your own robot. As an example, the applications course provides a wealth of robotics experiments, ranging from simple vision projects to tactile sensing.



HERO 2000 **from Heath.**

The newest addition to the family is the most powerful robot available. It has many times the capabilities of the *Hero 1*, and costs only slightly less than twice as much! That robot is the *Hero 2000*. Unlike Heath's other robots, that unit makes use of 80C88 microprocessors; it comes with 24K of RAM, expandable to 576K. An internal expansion bus has slots for up to 12 expansion boards. Individual microprocessors are used to control a variety of functions, ranging from operating the ser-

PERSONAL ROBOT COMPARISON CHART

Expandability	Other Features	Price
Apple Bus	Sonic ranging, keyboard, disc drive	assemb. $6995 kit $3595
Can be combined w/other Fisher kits	10 project kit	N/A
None	Sonic ranger, extension to Color Basic	assemb. $250
S100-like Bus	Complete robot system, optional disc drive, MS DOS-like operating system	assemb. $4500 w/arm kit $3000 w/arm
Memory and serial boards etc.	Complete courses on hardware, BASIC Demo ROMS, RF remote option	assemb. $1700 kit $800
Cartridge port, external sensors	Built-in games, songs expandable with BASIC cartridge. RF remote option	kit $400
Cartridge port	Serial interface to remote controller, built in games, programming language	assemb. $399
None	Full feature arm with 6 degrees of freedom	N/A
N/A	Part of videogame system	N/A
44 pin Bus, many options	Sonic ranger, tactile sensors, robot programming languages, courses	assemb. $2540 (base, voice) $1395 w/arm
None	Full feature arm with 6 degress of freedom	N/A
KIM Bus	Optical scanner, 8 tactile sensors	kit $299
Can add complete computer	Robot base motors and structure plus controls for 25 lb robot	kit $399
Can add complete computer	Robot base motors and electrical controls for 100 lb robot	kit $250
Can add complete computer	Robot base motors and electrical controls only for 25 lb robot	kit $150
None	Wired robot bounces off objects and changes direction	kit $130
External sensors for light, etc.	Built-in tape recorder. One arm powered, head moves, optional computer interface	assemb. $399
None	Built-in tape records program steps. Two arms are manually operated	assemb. $199
None	Programs by training commands using remote microphone	assemb. $60
External sensors for light etc.	Built-in tape records program steps. Voice recognition through wireless mic	assemb. $299

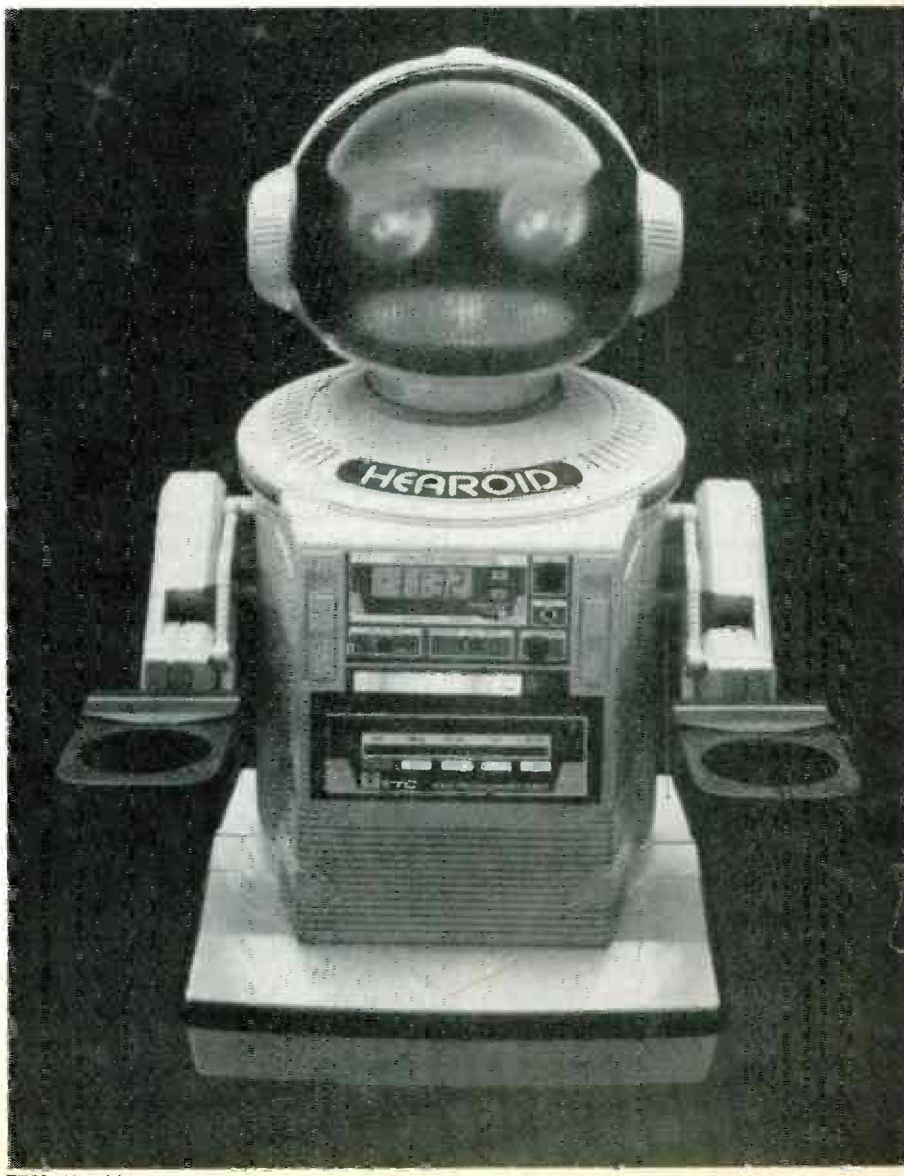
vo-motor base-motion system to determining distance from an object via ultrasonics. The arm offered with the unit compares favorably with the ones offered by Rhino and Microbot. Rounding out the features are a self-recharging power supply and a sophisticated voice-synthesis system.

Heath's major difficulty with that robot may be in the area of marketing. The *Hero I's* limited mechanical abilities disappointed many, and it may be hard to convince would-be buyers that there truly is a difference. There is! See the robot in action and you're sure to want one, even if it does cost around $3000.

Tomy Toys (901 E.233 St., Carson, CA 90749) is the largest selling toy robot manufacturer. Several years ago, they introduced a mechanical arm that is now sold exclusively through Radio Shack stores. Their family of true robots ranges from an inexpensive voice-operated unit to a sophisticated double-armed remotely-operated one.

Verbot, the voice-activated unit, is a small (under 12-inches) robot with a pair of arms and a dome head. Inside is a microprocessor-based voice-recognition system. The user pushes one of the operation-function buttons on the front of the robot, then speaks the command word. Thereafter, speaking that word will activate that function. The functions that can be activated in that manner include motion in the four basic directions (left, right, front, and back) and a grasp and release command for picking up very light objects with the arm. *Verbot* is technically sophisticated, yet its cost is fairly low (around $50).

Shortly after the introduction of *Verbot*, Tomy came out with the first member of the *Omnibot* series. That robot was taller than *Verbot* and sported an internal audio-



TTC's *Heroid*.

cassette recorder/player that could be used to store commands sent to the robot via its RF remote-command module (included). The unit has two manually-operated arms and the ability to receive your voice through a wireless microphone built into the RF remote.

That initial *Omnibot* still was limited by its small size. Recently, Tomy introduced a much larger version, called the *Omnibot 2000*. It has two arms with very functional three-fingered grippers. Unfortunately only one of the arms is powered. In addition, the robot comes with a unique tray for serving beverages. The robot can activate the tray, which has built-in cup holders; those holders move the cups under the robot arm automatically.

Although the expansion capabilities of the series do not match those of the *Hero* series, there should be plenty for the hobbyist to explore. Tomy plans on introducing both an infrared sensor and a sonic ranger.

The TTC Corporation (2009 East 233rd St., Carson, CA 90810), a spin-off from Tomy, is also offering a robot, called *Hearoid*, that has many of the features of the *Omnibot* and the *Verbot*. In addition, an optional videocamera is available; that opens up some interesting applications in the area of security.

RB Robot (14618 W Sixth Ave., Suite 115, Golden, CO 80401), is still producing the *RB-5X*, the first personal robot. That unit, of course, has gone through a number of changes and enhancements over the years. The current version is as expandable as the *Hero 1*. To go into detail, the *RB-5X* uses an INS8073 microprocessor. That National Semiconductor IC is set up to execute a version of Tiny BASIC. Programming is done via an external terminal or host computer. Communication is via an RS-232 interface. The robot comes with 8K of RAM; that can be upgraded to 28K. The on-board system can be expanded via add-on cards; a 44-pin card-edge connector has been provided for that. Sensors include a Polaroid ultrasonic rangefinder, and an infrared transceiver.

Lately, RB has been in reorganization following some rough business climates. Their main thrust now is aimed at the educational market, which has been perceived by the company as the only real avenue left in the field. To go along with that, an entire robot-learning course has been developed along the same lines as the industrial courses offered by Heath.

Robot Shack (PO Box 582, El Toro, CA 92630) provides plans and parts for a number of robot systems. Those systems would have to be considered low-end or experimental in nature, however. Further, though the company would appear to be a good source for robot parts, etc. at first glance, closer examination reveals that that might not be the case.

The company offers four robots in all. Their *Droid Bug* is an electro-mechanical motorized unit with a bumper switch. When the bumper contacts an object, the motors reverse direction. That "robot" has no provision for adding any type of computer control.

FISHER AMERICA'S *Robotic Computing Kit*.

The *Z-1* appears to consist of a motor from a Milton-Bradley *Big-Trak*, some wheels, and six switches. Those switches are all that comprise the robot's "control system." At $149.00, you might find that you can do much better scrounging the parts on your own.

The *Z-2* is not much better. For $249 you get two heavier duty motors (available on the surplus market for about $24.00 apiece), the same switch package as the *Z-2*, and about $10.00 worth of furniture castors and hook-up wire.

Finally, the *X-1* adds some lights, sound effects, and a device called a "function cycle timer." It costs $399.00.

Miscellaneous robots

Fisher America's (Parsec Research, Drawer 1766, Freemont, CA 94538) Fischertechnik *Robot Computing Kit* offers a fascinating introduction to the world of robotics for someone who is completely new to the field. Resembling somewhat the *Lego* plastic construction blocks we all played with as children, that product includes the parts and plans to build 10 computer-controlled robotic projects including a sorting system, materials lift, computer plotter, and a "teachable" robot arm. An interface for connection to an IBM *PC*, a Commodore, or Apple computer is also provided, as is a disk of BASIC programs designed to help the novice computer programmer the most from his creations.

YOU CAN PLAY VIDEOGAMES with *ROB*, from Nintendo.

Finally, computers, for the most part, first entered our home in the form of entertainment devices (i.e. video games). Perhaps robots will follow the same path. Consider, for instance, the Nintendo (4820 150th Ave NE, PO Box 957, Redmond, WA 98052) *Entertainment System*. One of the hot gifts this past holiday season, that product is essentially a video game. However, several of the system's games made use of a limited robotic device. That device, called ROB (*R*obotic *O*perating *B*uddy) has a light-sensing system and limited gripping and lifting capability, but not much else. The robot is incapable of motion; it is mounted on a stationary base. Still for many it provides a first exposure to the world of robotics.

The state of the industry

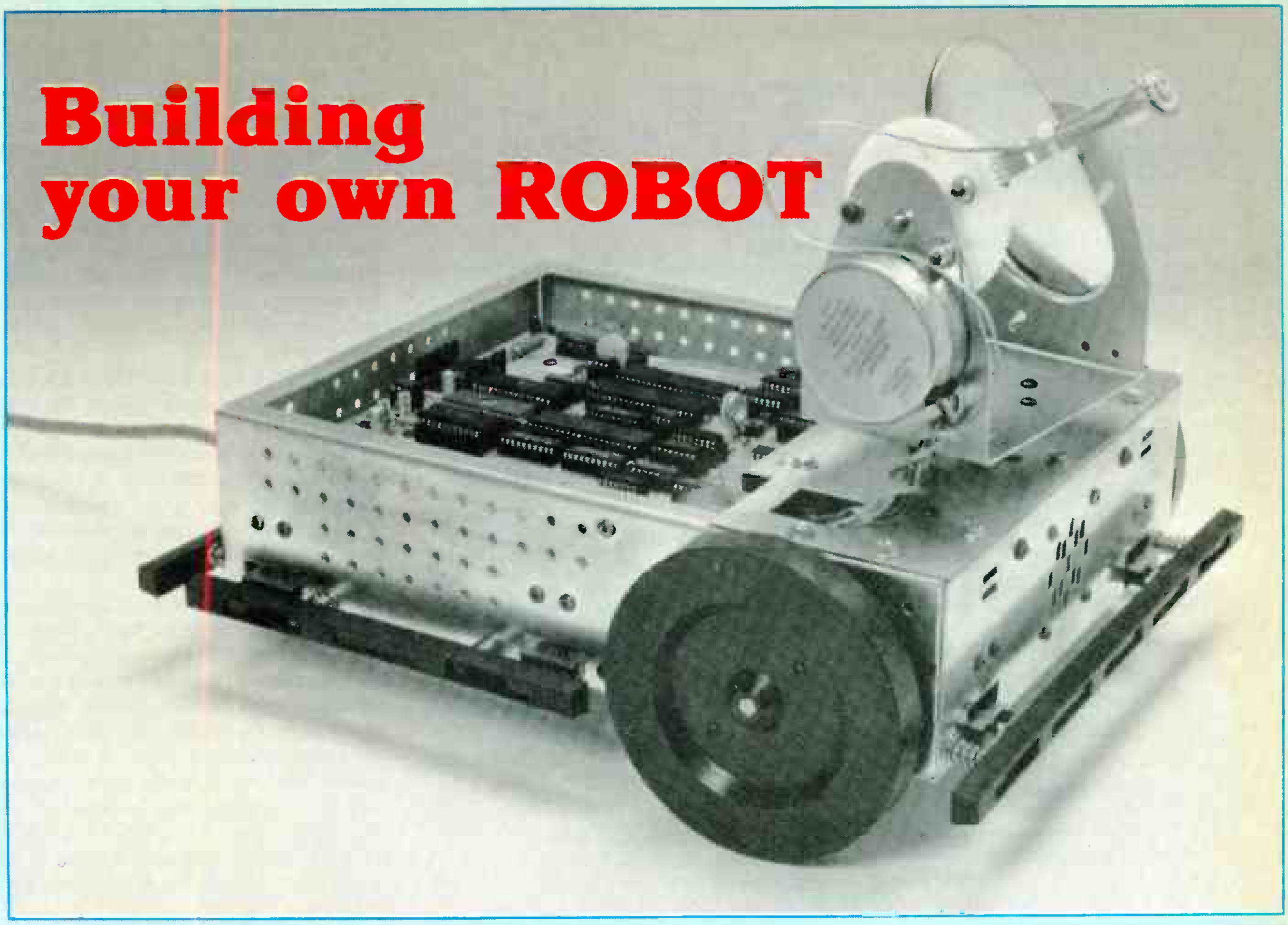
For better or worse, that's the current state of the market. Of course, we may have missed one or two new or less-prominent manufacturers, but all of the main players have been represented here.

What can we look forward to next? Right now, things seem to be in a holding pattern. The philosophy of most of the manufacturers seems to be to pack as much hardware as they can in a box, and leave it to the public to put it to some type of use. As a result, most of the products announced or released in the past three years have not been widely accepted by the public.

For the most part, educational institutions have purchased the lion's share of the really sophisticated units, and consumers have bought the toy robots for their kids. Have any of those products advanced the state of personal robotics? The sad answer is no. None of the numerous applications we listed earlier are being addressed. University researchers will tell you that we are decades away from a robot that can clean house. With that attitude, it might take centuries to get a viable robot maid.

Then again, we are talking about a market that could be larger than the personal-computer market. That means that there are fortunes to be made here. Although things have been slow until now, it should take just one miracle to kick-start the robotics industry! **R-E**

Building your own ROBOT



If you can't find the robot you are looking for, why not build it yourself? Here are some pointers to help get you started.

MARK J. ROBILLARD

MUCH LIKE ARTISTS WHO TOIL WITH MESsy pastes to create their masterpieces, there are artisans who use the tools of technology to fashion their creations. In electronics, there is almost always a new art form to present a challenge to those creative minds. Three decades ago, two-way voice and code communications presented the challenge. Ten years ago it was the microcomputer that captured their fancy. Today, it's the robot.

Although experimenters were building robot-like machines decades ago, none could approach the sophistication of today's units. Several companies have begun offering both complete kits of parts for everything from robotic arms to complete computer-controlled robots. Because of the demand by hobbyists, many traditional electronics-parts suppliers are beginning to carry more robot-oriented supplies.

This article is for those of you who would like to try building your own robot. Here, we will attempt to tell you about the various components you might need, and, if possible, where they can be obtained.

Getting started

Whenever you are starting a new venture, it is useful to have some idea about what you are getting into. And, although you must have already had some exposure to the field for personal robots to interest you, there's always room for more knowledge. Thus, the best way to start is to get hold of as many good robotics books as you can.

There are a wealth of books available now. They range from the theoretical to the practical. Some of the better ones are listed in Table 1.

One problem with such books is that the information they present can become out-of-date quickly. For more up-to-date information, you may want to consult one of the magazines that cover the field. At the present, there is only one periodical dedicated to the robot craftsman. *The Robot Experimenter* (174 Concord St., Suite 31, PO Box 458, Peterborough, NH 03458) was created to fill the void after *Robotics Age* (174 Concord St., Peterborough, NH 03458) began covering only industrial robotics. For those of you with more than a passing knowledge of the field there are two professional journals that should be of interest. Those are the *International Journal of Robotic Research* (28 Carleton St., Cambridge, MA 02142) and the *Journal of Robotics Systems* (605 Third Ave., New York, NY 10157). Both report on the latest in robotics research throughout the world.

All about parts

If you are like most of us, about halfway through reading about robot construction, you'll develop an insatiable desire to begin tinkering. To keep yourself sane, you might want to have some basic robotic parts on hand for that moment.

When you think about robots, the first thing that should come to mind is motors. (You could also build a robot using pneumatics, but such a device would be out of place in the home.) Things are a lot easier now than they used to be. Just a few years ago, the overwhelming majority of the available hobby motors were simple three-volt types. On their own, those had negligible "pulling" power. To do any

TABLE 1—ROBOT BOOKS

How To Build A Computer-Controlled Robot
Tod Loofbourrow
Hayden Publishing
Rochelle Park, NJ 07662
$7.95

Build Your Own Self-Programming Robot
David Heiserman
Tab Books
Blue Ridge Summit, PA 17214
$10.25

Robotics Age: In The Beginning
Edited by Carl Helmers
Hayden Publishing
Rochelle Park, NJ 07662
$19.95

The Complete Handbook of Robotics
Edward Safford
Tab Books
Blue Ridge Summit, PA 17214
$11.50

Microprocessor-Based Robotics
Mark J. Robillard
Howard W. Sams Inc.
Indianapolis, IN 46268
$16.95

Advanced Robot Systems
Mark J. Robillard
Howard W. Sams Inc.
Indianapolis, IN 46268
$19.95

Basic Robotic Concepts
John Holland
Howard W. Sams Inc.
Indianapolis, IN 46268
$19.95

How To Design And Build Your Own Custom Robot
David Heiserman
Tab Books
Blue Ridge Summit, PA 17214
$13.50

Handbook Of Advanced Robotics
Edward Safford
Tab Books
Blue Ridge Summit, PA 17124
$16.50

How to Build Your Own Robot Pet
Frank Dacosta
Tab Books
Blue Ridge Summit, PA 17124
$8.95

Design And Application Of Small Standardized Components
Data Book 757, Volume 2
Stock Drive Products
Educational Products
PO Box 606
Mineola, NY 11501
$7.95 (paperback)
$12.95 (hardcover)

Apple II/IIe Robotic Arm Projects
John Blakenship
Prentice-Hall Inc.
Englewood Cliffs, NJ 07632
$16.95

useful work, a complex gear-train assembly was needed. The cost was nearly a hundred times higher than that of the motor itself.

Fortunately, that has changed; it is now possible to purchase hobbyist motors that can actually do something. For those interested in experimenting with arms, the *Robotix 2000* building set from Milton Bradley (Springfield, MA 01101) is recommended. That kit contains four motors with integral gear trains, and a host of other structural pieces. Using the kit, it is possible to build a four-jointed arm, complete with gripper (supplied), in approximately five minutes. The motors are connected to manual control boxes via plug-in cables. It is also a simple matter to control those motors using a computer. To get some idea of how it can be done, see "Computer-Controlled Robot Arm," in the May 1985 issue of **Radio-Electronics**.

Another source for motors is H&R Corporation (401 E. Erie Ave., Philadelphia PA 19134). They have an impressive selection of some of the most powerful motors available to the hobbyist. Also impressive is the value you get for your money.

For some applications, you may find that stepper motors are more useful than DC motors. Steppers provide you with a greater degree of control. There are two basic types of steppers that are appropriate for hobby experimentation—the four-phase unipolar stepper and the bipolar stepper; the former is more easily obtained.

Stepper motors carry supply-voltage and mechanical-power ratings. The power rating has to do with the amount of work the motor is capable of doing. A motor with a rating of 1-ounce-inch is capable of pulling a 1-ounce weight, located 1-inch away, about its shaft pivot. That is shown in Fig. 1.

The four-phase unipolar stepper motor

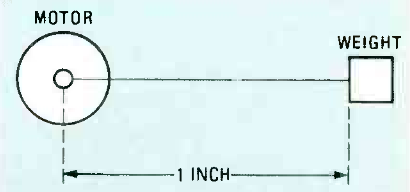


FIG. 1—THE AMOUNT OF WORK (torque) performed by a motor is equal to the weight to be lifted multiplied by the distance between that weight and the motor shaft.

is easy to control. Beside being able to interface them to microprocessor circuitry (through appropriate driver circuits), there are several sources of dedicated IC controllers for those motors. Basically, there are four separate windings and one or two common leads. The common is connected to a voltage source. To effect motion, one must supply a path for current to flow in each of the four windings by grounding their leads. The order in which the windings are energized determines the direction and the speed in which the motor turns.

Figure 2-*a* shows the basic hook-up scheme for a four-phase stepper. The transistors Q1–Q4 are the output stages of the driver circuitry. When a voltage is applied to the base of a transistor, it conducts, energizing the appropriate winding. Figure 2-*b* shows the timing sequence for those drivers for movement in either direction.

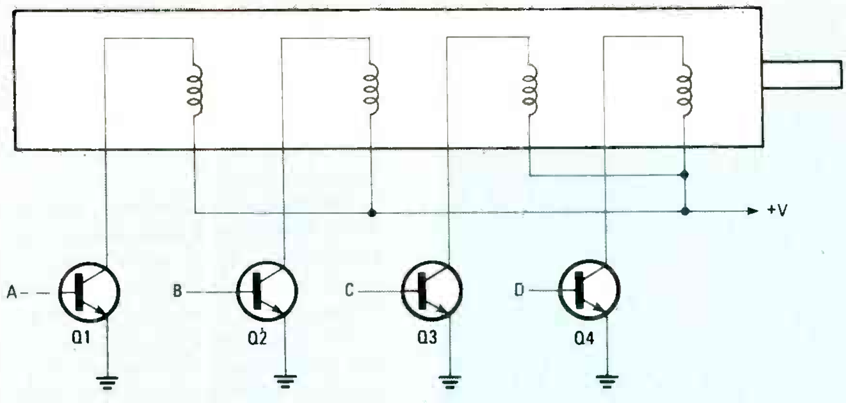
The bipolar stepper is connected in a different fashion. Its basic hook-up scheme is shown in Fig. 3-*a*. As you can see in that figure, there are only two windings. One side of each is connected to the power supply common. The other winding connections are used to direct the motor. Note that a bipolar power supply, ±5-volts in this case, is required for movement in both directions. Once again, the transistors are the output stage of the driver circuitry, and the timing sequence is shown in Fig. 3-*b*.

When would you use a bipolar motor over a unipolar type? For hobby robotics that decision really rests on the question of availability and price. If you have found a nice little stepper that has the torque required by your project, and it will run from the available supply voltages, then buy it. If you have questions about the hook-up required, most of the hobby suppliers will often send appropriate information along with the motor. Otherwise, many of the books listed in Table 1 provide information on how to hook up various motors.

Now that you've got the motors, you're going to need to mount them on something. Although it might sound archaic, one of the best building materials for robotics is wood. Wood is cheap, easily handled, and can be worked with using inexpensive tools. If you want your robot structure to look professional, simply paint it or finish it with plastic laminate.

Of course, wood comes in many grades, and some of those are not appropriate for this application. Regular lumber-yard-grade plywood is out. The voids in the middle of such woods make for a shabby appearance and drilling produces many splinters. For best results, stick with marine grade and special laminates.

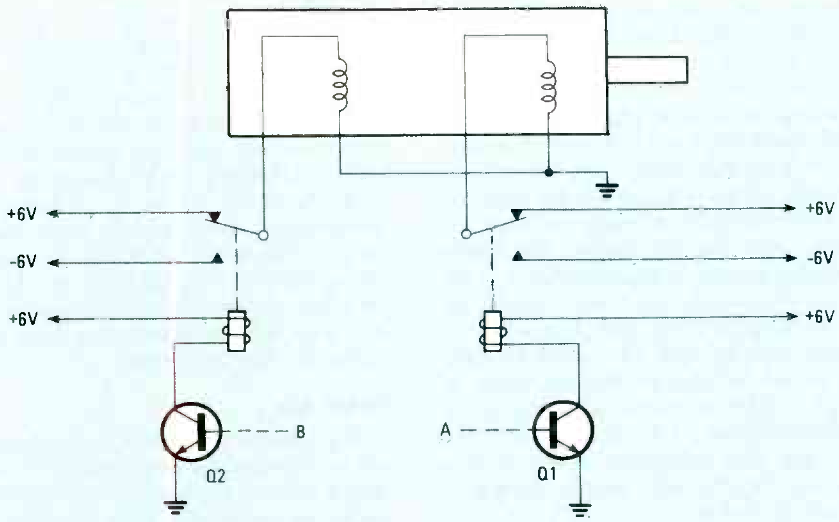
Other items you will need include fasteners, support rods, and various mechan-



STEP	TRANSISTOR Q1	Q2	Q3	Q4
1	ON	OFF	ON	OFF
2	ON	OFF	OFF	ON
3	OFF	ON	OFF	ON
4	OFF	ON	ON	OFF
5	ON	OFF	ON	OFF

b

FIG. 2—HOOKING UP a four-phase stepper motor. The table in *b* shows the order in which the transistors must be turned on to advance the motor in the clockwise direction.



STEP	TRANSISTOR Q2	Q1
1	OFF	OFF
2	ON	OFF
3	ON	ON
4	OFF	ON
5	OFF	OFF

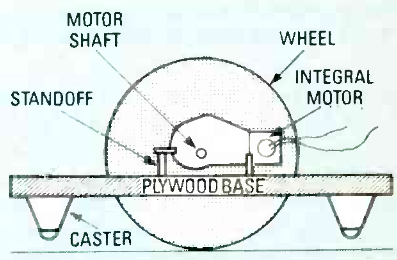
b

FIG. 3—A BIPOLAR STEPPER is wired up in this manner. To advance the motor in the counterclockwise direction, reverse the turn-on sequence shown in *b*.

ical assemblies. The first place to look for those is a well-stocked hardware store. In fact any time you need wheels for robot carts, get the lawnmower type available in most stores. You can always get a replacement and they come in many sizes. The one standard feature of those wheels is that they all mount on half-inch diameter shafts.

To give you an idea of what can be accomplished with wood, take a look at Fig. 4. That "hand" has been built from wooden dowels and two pieces of thin aluminum. The motor that activates the gripping action is mounted in the middle palm region. The dowels are made of basswood and are available in almost all hobby shops. The aluminum was purchased in the same shop. If you prefer to work in plastics, your local hobby shop is also a good source for styrene; that's the

FIG. 4—THIS ROBOT "HAND" was build almost entirely from wood.



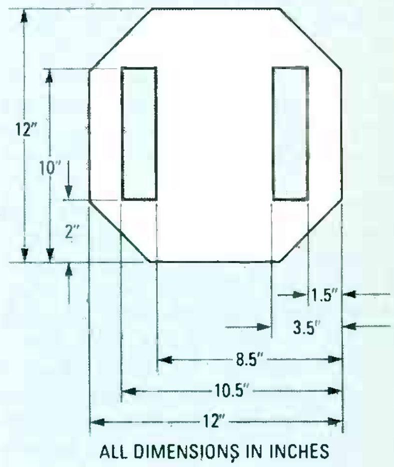


FIG. 5—A SIMPLE MOBILE BASE. A side view is shown in *a*; the top view in *b*.

material that's used to make airplane models.

Once you've got the motors and structural pieces on hand you can start tinkering. A two wheeled cart using two furniture casters for balance is a simple first project. The layout for a cart of that type is shown in Fig. 5.

Once you've built the cart itself, it's time to devise a control system. Your first effort should be to build a system to control the cart manually using a joystick. Hook up the switches in the joystick so that they control the motors to move the cart in the appropriate direction.

Once you get the basic operation of the cart down, its time to add more functions. To do that, you'll need more parts. Gears

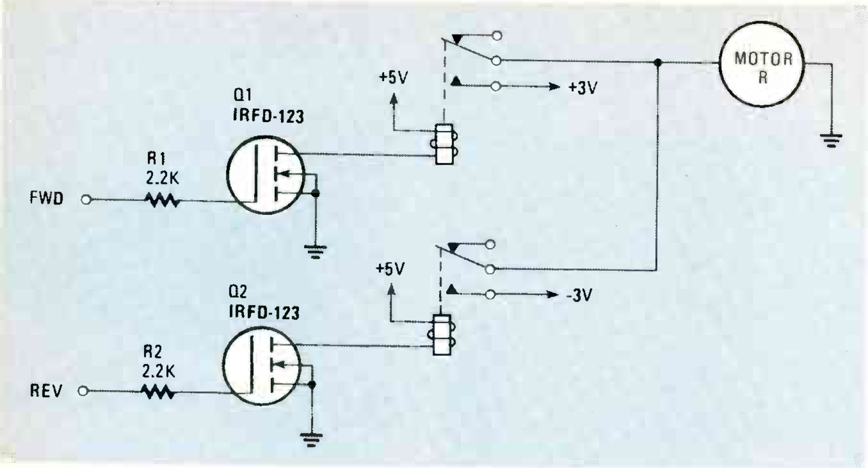


FIG. 6—WHEN USING AN ELECTRONIC circuit, such as a computer, to control motor operation, a simple transistor driver like the one shown here must be used.

are used to reduce the speed of a motor while increasing its torque. They can also be used to change the direction of a motor or to transmit the motor's rotational power into other types of movement. Finding gears that will mount onto the shaft of your particular motor may not be easy. Each motor has its own shaft size and hobby-grade motors tend to posses particularly small-diameter shafts. Most of the generally available gears and pulleys are made for much larger motors. For instance, you can get a number of gears from an automotive supply store, but the chances of them fitting your robot motor are slim.

We've thus far found two supply houses that sell gears in sizes, styles, and types appropriate for robot experimentation. Those are Stock Drive Products (55 South Denton Ave. New Hyde Park, NY 11040) and PIC Design (PO Box 1004, Benson Road, Middlebury, CT 06762). Both are very reputable vendors, and supply extensive catalogs for free. The cost of their parts, though, is not cheap. Yes, the material is high quality, but the cost of a few gears can set your project budget back a few years. I suggest using those suppliers when you absolutely need a particular gear or pulley and there is no other source.

In addition, one of the vendors, Stock Drive Products, has published a very complete manual on mechanical design for non-engineers. That book would be a valuable addition to any robot experimenters bookshelf. It is called the *Design and Application of Small Standardized Components Data Book 757*. It retails for $7.95 in softcover and $12.95 in hardcover. Among other things, the book contains a 51-page section on the mechanics of robots that contains information we have not seen published elsewhere.

Control

Because robots are supposed to move on their own, it will be necessary to develop some control circuits eventually. A computer is not an absolute necessity, but one will make your robot capable of doing a whole lot more. Be that as it may, let's start with a less ambitious control system.

What parts are required to provide at least a minimum level of control? First of all, you're going to need relays if your motors are small DC types. Transistor motor-switches do work, but sometimes they do not provide full power to the motor. Small 5-volt SPDT relays do not take up much room, and are readily available from your local electronics supplier.

To drive those relays you've got to determine what will control the robot. If simple manually-activated switches are used, then you can connect the supply voltage directly through the switch to the relay. When other electronic circuits are controlling the relay, some form of power driver must be used. That can be a simple transistor switch like the one shown in Fig. 6. Each transistor is turned on by applying about 3 volts to the base via the resistor. That will cause current to flow through the relay coil, causing the relay's contacts to close.

When designing your control circuitry, you should keep power consumption in mind. While that might not be critical in the case of robotic arms, mobile units require battery-based on-board supplies. Because of that, use low-power technologies (CMOS, etc.) in your circuitry.

Power supply

Since we've already brought it up, now is as good a time as any to look into the types of power supplies that your robot might need. Once again: with robot arms or other stationary devices, don't worry about batteries; just use an adequate AC power supply. But when your robot must move around, then the only real choice is battery power.

What about the type of battery? Standard, non-rechargable alkaline batteries can power a properly designed system for a surprisingly long time. For example, the author has used two six-volt alkaline batteries in series to provide both a positive and negative supply that has powered six *Robotix* motors for about eleven months! Also, the same supply has been simultaneously powering a CMOS microprocessor circuit.

There are cases, however, that require much more current than alkaline batteries can provide. Those applications require use of lead-acid batteries. That is the type of battery that is used to power your car.

For robotic use, the lead-acid battery has one serious drawback (other than weight). Those batteries can leak corrosive acid if tipped. In some robot applications, that could prove disastrous. In fact, if you plan to use your robot in your home, you should seriously investigate other possible sources of power.

More appropriate are the newer types of lead-acid battery; in them, the acid is in the form of a gel. Obviously, those batteries are much less prone to leakage. Several suppliers, offer many different types of those "gel-cells."

Lead-acid batteries are rated in amp-hours. For instance, if a battery is rated at 4 amp-hours, that means that a robot can draw 4 amps from the battery for one hour, or 1 amp from the battery for 4 hours.

All lead-acid batteries can be recharged. Recharging should be done in a well-ventilated area; the gasses emitted during recharging can be dangerous.

If you decide to go the rechargable power-supply route, you may want to look into the possibility of having the robot charge himself. After all, were you using the robot for security, it would be unfortunate if the batteries were to run down just before the burglar arrives.

Robot kits

There are times when it really doesn't pay to do everything from scratch. If your goal is to learn to program robots, then it might pay you to take some shortcuts so that you can begin using the machine as soon as possible. Buying a pre-engineered kit takes all the worry out of the job. There are several good robots that come as kits. Arctec systems, manufacturers of the *Gemini* robot, sells that robot in kit form. They also will sell you, in kit form, the various subassemblies that make up the robot. Heath's *Hero* series is also sold in kit form, while Rhino Robot's *Scorpion* is only available in that form. And there are many others; for more information see "A Buyer's Guide to Personal Robots" elsewhere in this issue.

There is a lot of satisfaction that goes along with building your own robot. And though things may be a little tough now, this is a brand-new field. In the near future, there will be standard robot buses, standard mechanical interfaces, and even a standard programming language. It looks as if the fun is just beginning. R-E

STEREO TV Decoder

Are you still listening to TV in mono? Double your TV-listening pleasure with this stereo-TV decoder!

STEVE SOKOLOWSKI

STEREO SOUND—IT'S THE MOST EXCITING thing to happen to television since color! Now's the time for *you* to find out how exciting it can be. We explained what it is and how it works a year ago (in the February and March 1985 issues of **Radio-Electronics**). Now it's time to get your hands dirty. Our simple, one-IC circuit will double your viewing pleasure, yet it can be built for about the cost of a single pre-recorded videotape. But before we dive in to discuss circuit operation and construction, let's quickly review the basics of MTS (*M*ulti-channel *T*elevision *S*ound) transmission.

Stereo-TV signals

As with standard FM-broadcast signals, the stereo-TV audio signal has three components. As shown in Fig. 1, they are: the pilot signal, left + right (L + R) audio, and left − right (L − R) audio. In a conventional TV receiver the L + R signal, or the *main channel* is the only one that is detected—it's the monaural signal that you normally hear through your TV's speaker. Note that it is a frequency-modulated (FM) signal with a 75-µs pre-emphasis, and a bandwidth of about 15 kHz.

Just above the main channel is the *pilot* tone, which is used to alert the receiving circuitry that the L − R signal, or the *stereo-difference* subchannel is available for processing. The MTS pilot signal is 15.734 kHz—the standard TV horizontal-scanning frequency, f_H.

As you can see in Fig. 1, the L − R signal or *stereo subchannel* occupies the TV baseband frequency ranging from $2f_H$ to $3f_H$.

MTS allows for additional subchannels that can be used for a number of purposes. One possible audio-baseband configuration is shown in Fig. 1. That configuration incudes two additional subchannels: the SAP, or *S*econd *A*udio *P*rogram, channel (which can be used for bilingual broadcasts and other program-related material) and the *professional channel* (which can be used for communicating with remote news crews, and other non-program-related purposes.) Our stereo adapter cannot decode any of those additional subchannels.

Stereo TV is generated in a manner quite similar to the manner in which broadcast FM is generated. As shown in Fig. 2, separate left and right audio inputs are applied, after low-pass filtering, to the matrix that provides the stereo sum (L + R) and difference (L − R) signals. The sum, or monophonic, signal gets the 75-µs pre-emphasis; it is then clipped, filtered, and mixed with the difference signal. Rather than pre-emphasis, the L − R signal is processed by the *dbx* compressor/noise-reduction system. (See the article mentioned above for information on how that system works.)

Those audio signals are then mixed with the 15.734-kHz pilot signal, which, as we said above, is derived from the the horizontal sync. The resulting signal is filtered and then sent to the audio-modulation circuitry where it is modulated in the usual manner.

To receive stereo TV signals, all we really need is a circuit that will process that composite-audio signal in the converse manner. The basic idea is indicated in Fig. 3. The "TV detector" block separates the sum and difference channels, each of which is filtered (and expanded, if necessary). Then the L + R and L − R signals are applied to a matrix circuit that restores the original left and right channels. At that point they're ready for ampli-

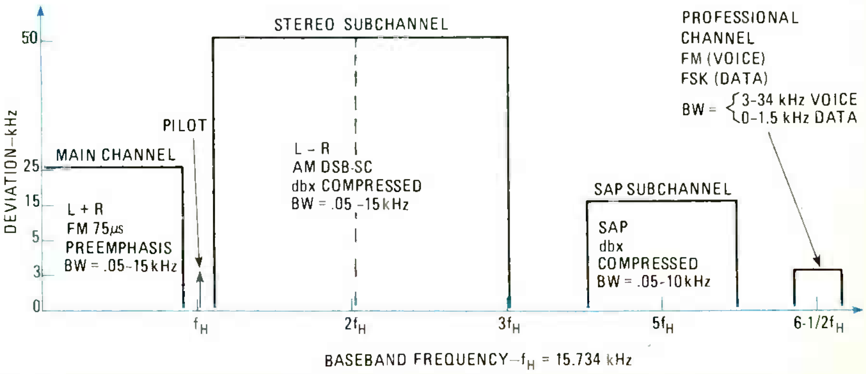
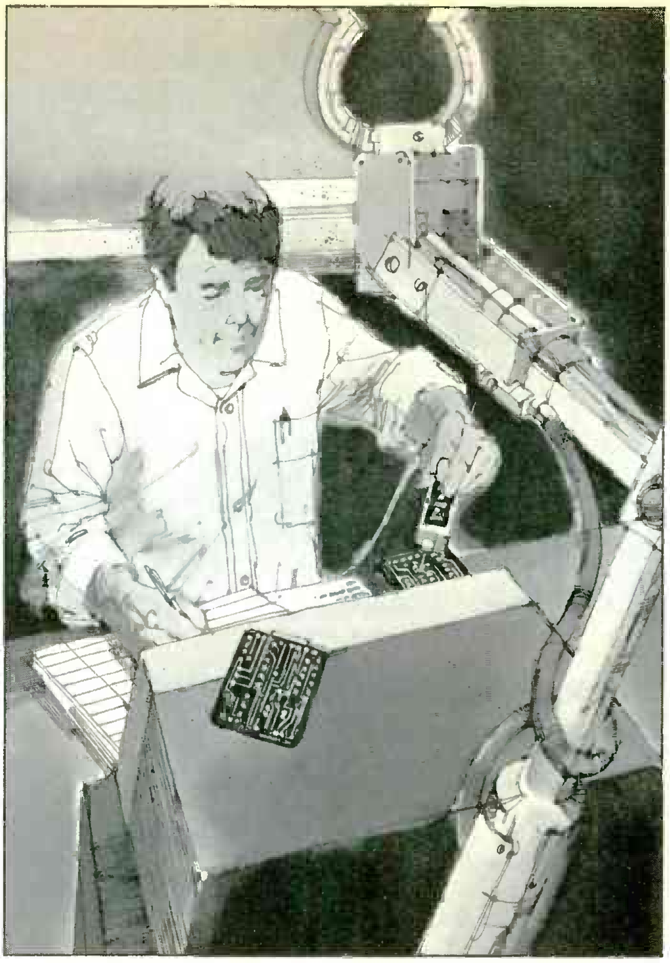
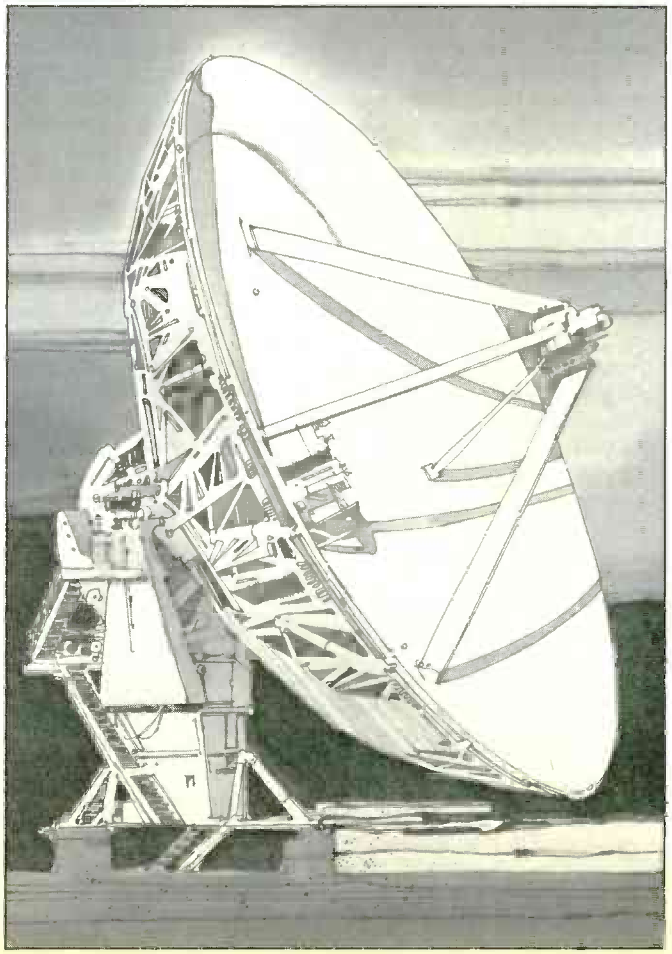


FIG. 1—THE MTS DISTRIBUTION OF SIGNALS provides for a monaural main channel, sub-channels for the stereo sub-carrier and a secondary audio program (SAP), and a professional channel for voice or computer (FSK) data.





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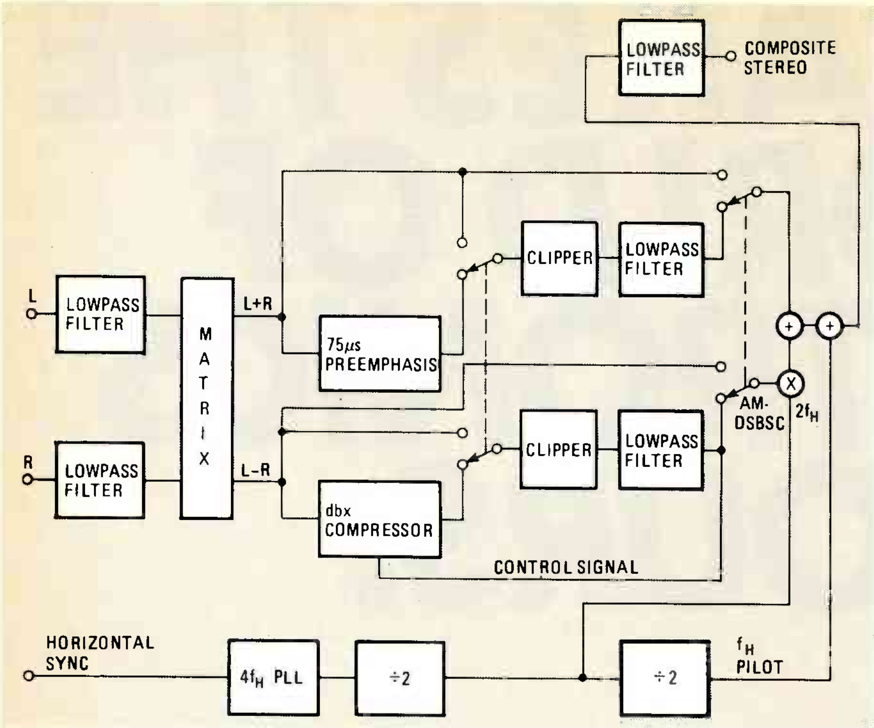


FIG. 2—MTS STEREO IS GENERATED in a manner similar to that of standard broadcast FM. MTS differs from broadcast FM in that it uses *dbx* noise-reduction, and the standard TV horizontal-scan frequency to generate the pilot tone.

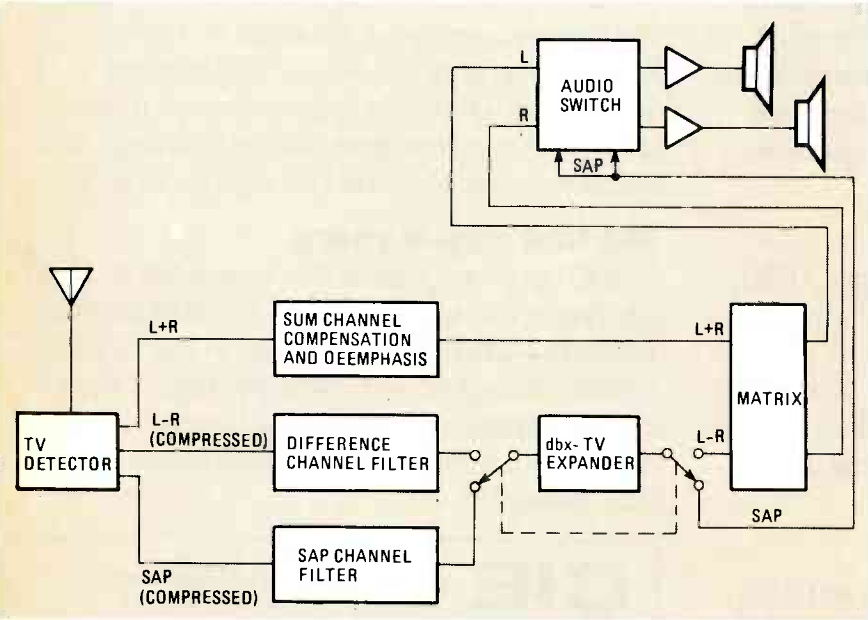


FIG. 3—THE ORIGINAL LEFT- AND RIGHT-CHANNEL AUDIO SIGNALS are recovered in the matrix decoder after filtering and de-emphasis of both L + R and L – R, and after expansion of the L – R signal by the *dbx* unit.

fication. (Note that the block diagram in Fig. 3 includes a SAP decoder, which our stereo adapter does not offer.)

If you're wondering how the original channels can be extracted from the sum and difference signals, examining the following equations should clear things up;

$$(L+R)+(L-R) = 2L$$

$$(L+R)-(L-R) = 2R$$

In other words, we can restore the left channel by adding the sum and difference signals, and we can restore the right channel by subtracting the difference signal from the sum signal. At that point all we have to do, in order to provide usable stereo-TV signals, is provide power amplification. So how can we extract the left- and right-channel signals?

Circuit description

The schematic of the stereo-TV decoder is shown in Fig. 4. Assume for now that it is connected to a proper source of composite audio. We'll show you how to do that in a minute.

The composite input signal is preamplified by transistor Q1 and is then coupled to the high-pass filter composed of C3, C4, R6, and R7. The filtered audio is then passed to IC1, an MC1310P "Coilless Stereo Demodulator." That IC is normally used to demodulate broadcast-band FM signals, but by changing the frequency of its on-board VCO (*V*oltage *C*ontrolled *O*scillator) slightly (from 19 kHz to 15.734 kHz), we can use that IC to detect stereo-TV signals.

A block diagram of the MC1310P is shown in Fig. 5. Notice that the components connected to pin 14 control the VCO's frequency, hence the pilot-detect and carrier frequencies. For use in an FM receiver, the VCO would run at four times the 19-kHz pilot frequency (76 kHz), but for our application, it will run at four times the 15.734-kHz pilot frequency of stereo TV, or 62.936 kHz.

The MC1310P divides that master VCO signal by two in order to supply the 31.468 kHz carrier that is used to detect the L – R audio signal. The L – R signal undergoes normal FM detection, and at that point we've got two audio signals: L + R and L – R. The *decoder* block in the IC performs the addition and subtraction to produce the separate left and right signals.

Referring back to the schematic in Fig. 4, R10 and C10 form a de-emphasis network that compensates for the 75-μs pre-emphasis that the left channel underwent; R12 and C11 perform the same function for the right channel. Now we've completely restored the original audio signal—almost.

You'll recall, in Fig. 3, the *dbx* expander circuit. We have provided no *dbx* expansion because *dbx* IC's haven't been released for general distribution. (They're available only to licensed OEM's.) So to provide some noise reduction (which will be necessary if you live in a less-than-ideal reception area), what we can do is connect our adapter to a non-*dbx* noise-reduction system. Alternatively, we can connect our adapter to a stereo system with a built-in noise reduction system. *(Another possibility would be to connect the stereo-TV decoder to the experimental compander discussed in the November, 1985 issue of* ***Radio-Electronics****—Editor.)*

None of those solutions is perfect, so the stereo TV you'll receive is less than ideal. However, we'll get no stereo TV at all if we don't start building an adapter—so let's do it now!

Construction

Since we're not dealing with very high frequencies, the adapter can be built in just about any convenient manner. A PC board will simplify construction, though, so we've included a foil pattern in "PC

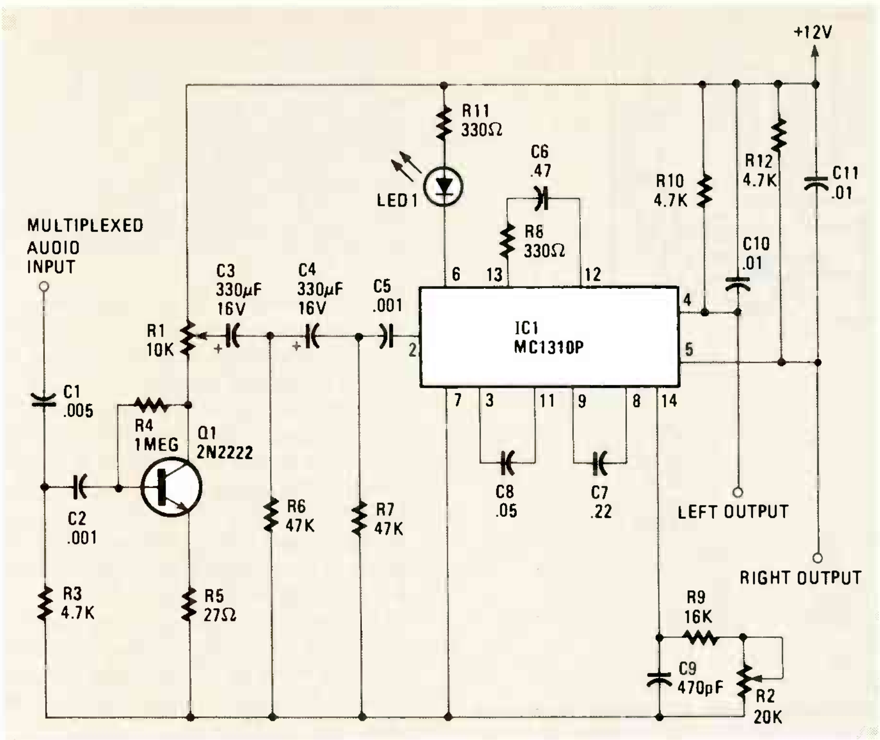


FIG. 4—THE CIRCUIT OF OUR MTS ADAPTER is quite simple, as shown here. The transistor provides a little pre-amplification for the IC (an MC1310P), which decodes the left and right audio channels.

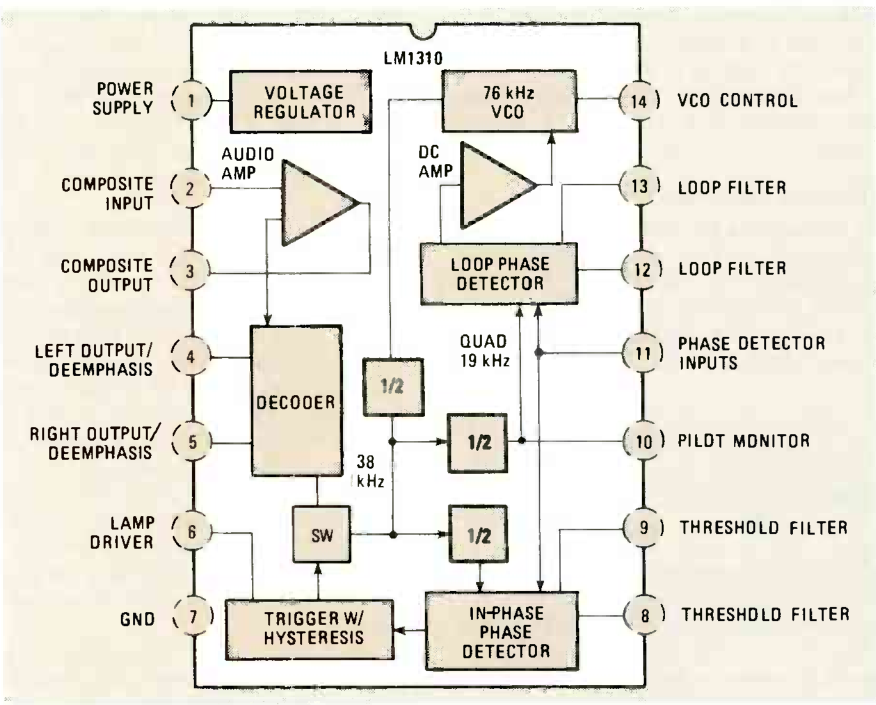


FIG. 5—THE MC1310P WAS DESIGNED FOR BROADCAST-FM decoding, but the stereo-TV pilot tone and carrier can be generated by altering the IC's VCO frequency from its nominal 76-khz value.

Service." You can also buy a PC board and a kit of parts; see the Parts List for more information.

Use the parts-placement diagram in Fig. 6 and the photo in Fig. 7 as a guide for mounting all components. Use a socket for IC1. Be sure to orient Q1 correctly, and don't apply too much heat to the transistor.

In Fig. 7 you'll notice a small board to the right of the main PC board. That's a 7812 regulator circuit that supplies 12-volts DC for the circuit. The schematic of that circuit is shown in Fig. 8. The foil pattern for the power-supply board is also shown in "PC Service," and the parts-placement diagram is shown in Fig. 9. For our prototype, we used a small wall-mount transformer to supply AC to the power supply.

PARTS LIST—MAIN BOARD

All resistors ¼-watt, 5% unless otherwise noted.

R1—10,000 ohms, audio taper, PC-mount, trimmer potentiometer
R2—20,000 ohms, linear taper, PC-mount, trimmer potentiometer
R3, R10, R12—4,700 ohms
R4—1 megohm
R5—27 ohms
R6, R7—47,000 ohms
R8, R11—330 ohms
R9—16,000 ohms

Capacitors

C1—0.005 μF, ceramic disc
C2, C5—0.001 μF, ceramic disc
C3, C4—330 μF, 16 volts, electrolytic
C6—0.47 μF, ceramic disc
C7—0.22 μF, ceramic disc
C8—0.05 μF, ceramic disc
C9—470 pF, ceramic disc
C10, C11—0.01 μF, ceramic disc

Semiconductors

IC1—MC1310P or LM1310 or XR1310 "Inductor-less" FM stereo demodulator
Q1—2N2222
LED1—Standard red LED

Note: A kit containing the main PC board and all parts that mount on it is available for $30.00 plus $1.50 for shipping and handling. Order from Del-Phone Industries, Inc., P. O. Box 150, Elmont, NY 11003. New York residents must add applicable sales tax.

When you've got the PC boards assembled, check them over carefully for solder bridges between adjacent pads and traces on the PC board. And make sure that all polarized components—IC1, Q1, LED1, the electrolytic capacitors—are installed correctly. When everything looks OK, it's time to align and install the adapter.

Alignment

You'll need an audio oscillator and a frequency counter to align the adapter. Connect the frequency counter to the oscillator and adjust the oscillator for a frequency of exactly 15.734 kHz at about ½-volt p-p. Then connect the output of the oscillator to the input of the adapter, and apply power. Adjust trimmer potentiometer R1 to its center position, then adjust trimmer potentiometer R2 until LED1 illuminates. If you have trouble getting the LED to light up, adjust R1 to allow more signal to get through to IC1.

If you don't have an audio oscillator and a frequency counter, you can align the adapter by connecting your adapter to a source of composite TV audio, as described below, and then tuning in a local station that you know is broadcasting in stereo. With the adapter connected to your stereo system, and R1 set in the center of its range, slowly adjust R2. Watch for the LED to light up, and then adjust R1 and R2 for best received audio.

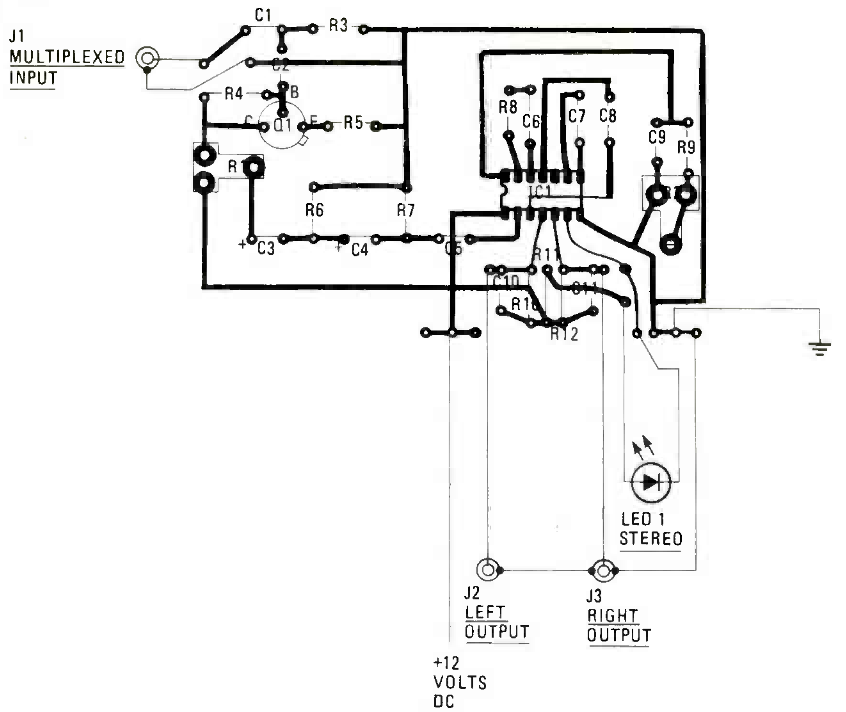


FIG. 6—THE STEREO-TV DECODER'S COMPONENTS are located on the PC board as shown here.

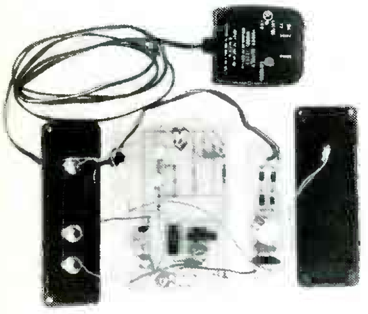


FIG. 7—YOUR STEREO-TV DECODER'S PC BOARD should look like this after all components are mounted.

That completes alignment! What we did was simulate the 15.734-kHz pilot signal with the audio oscillator. When the adapter is properly connected to a VCR or TV that is receiving a stereo signal, the LED will light up to indicate that a stereo signal is being received—just as the STEREO indicator on a standard FM receiver does.

Adapter installation

Connecting the adapter to a source of composite audio is potentially the most difficult part of this project. We'll describe five different possibilities.

Don't get any ideas about using the earplug output of your TV, VCR, or radio.

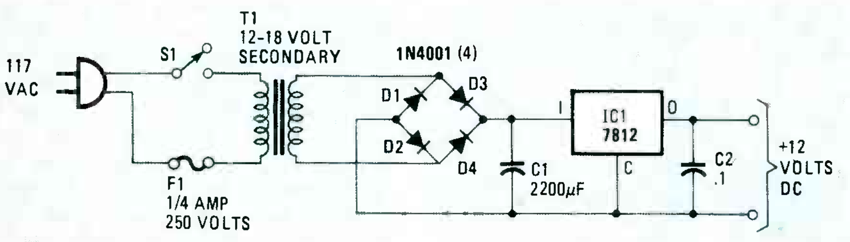


FIG. 8—THIS POWER SUPPLY provides plenty of power for the stereo-TV decoder.

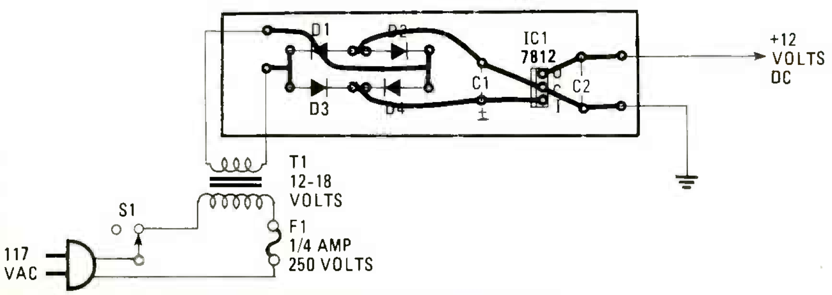


FIG. 9—PARTS PLACEMENT diagram for the power supply board.

PARTS LIST—POWER-SUPPLY

IC1—7812 12-volt, 1-amp regulator
D1–D4—1N4001 power rectifier
C1—2200 µF, 25 volts, electrolytic
C2—0.1 µF, monolithic

Other components

F1—¼-amp, 250 volts
J1, J2, J3—RCA phono jack
S1—SPST, miniature toggle
T1—12–18-volt wall-mount transformer

First, there will be too much distortion—you have to pick up a low-level signal. Second, the output will not contain the proper composite signal.

VCR connection—You *may* simply be able to connect the adapter to the audio output on the back of your VCR. Unfortunately, the adapter will not operate correctly with most VCR's because many manufacturers filter out the necessary signals and leave only the main channel. But it's certainly worth a try.

External-TV connection—If you purchased a TV recently, you may be in luck. If your TV has an stereo output jack, just connect the input of your adapter to that jack.

Internal-TV connection—**Warning**—Don't attempt this sort of connection unless you are sure you know what you are doing and you have complete documentation for your TV. The high voltages in your TV are hazardous to your health, and the health of your adapter! Remove the back of your TV and solder a shielded cable to the output of your set's audio detector. Connect the other end to the adapter.

Internal-VCR connection—**Warning**—Don't attempt this sort of connection unless you are sure you know what you are doing and you have complete documentation for your VCR. One mistake could be very expensive! As with the previous method, locate the audio detector IC. Then solder one end of a shielded cable to that point. Connect the other end to the audio input of the adapter.

Radio connection—If you have a table or portable radio that can receive TV audio, *carefully* connect one end of a shielded cable to the audio detector's output. Connect the other end to the adapter's input.

Whichever method of installation you choose, connect the outputs of the adapter to your stereo amplifier's (or receiver's) auxilliary inputs and fine-tune the alignment.

Conclusions

Stereo TV is still new, so even though many programs are now recorded in stereo (such as *Johnny Carson* and *Miami Vice*), not all stations are equipped to broadcast stereo audio. For a partial listing, check the back issues of **Radio-Electronics** mentioned above, or call your local TV stations. **R-E**

Walkman AMPLIFIER

Build this versatile amplifier and get "home stereo" sound from your Walkman*-type cassette player or radio. It has many other applications, too!*

PORTABLE *WALKMAN*-TYPE STEREO CASsette players and radios are great for entertainment on the go, but sometimes it would be nice if they could be used to give full stereo sound—like a home hi-fi. Well, when used with the small, high-performance stereo amplifier described in this article, those units are capable of doing just that. In addition, thanks to the inclusion of a pair of preamplifier stages, the amplifier can be used with low-level inputs such as microphones, turntables, and electric guitars. It can even be wired up as a tiny PA system.

About the circuit

Figure 1 shows the schematic for the basic *Walkman* amplifier. It is designed around a National LM380 audio power amplifier IC. The gain of that low-cost IC is internally fixed so that it is not less than 34 dB (50 times). A unique input stage allows input signals to be referenced to ground. The output is automatically self centering to one half the supply voltage. The output is also short-circuit proof with internal thermal limiting.

With a power supply between 9 and 15 volts, and a minimum 8-ohm load, a heat sink is generally not required for the design shown. If you choose to build the circuit using the PC board shown in our PC Service section, a very small amount of heat sinking is provided by that board's design; the copper tracks act as thermal fins. Although that does not normally represent enough heat sinking if the IC is to be extended to its maximum capability, with this design and the limited parameters that the circuit operates within, that heat-dissipation scheme should prove sufficient. With a maximum supply of 15 volts and an 8-ohm load, the output is around 1.5-watts-per-channel. The input stage is usable with signals from 50-mV to 500-mV rms.

If the amplifier is to be used with a source other than a personal stereo, such as a phonograph or an electric guitar, some type of preamplifer is required. A suitable circuit is shown in Fig. 2. In that circuit, two 741 op-amps have been configured as input amplifiers. Their input stages have been referenced to a common point—half the supply voltage. That voltage is derived from a voltage divider made up of R1 and R2, two 2.2K resistors. The gain of each of the 741's has been fixed at 21 by the input resistors (R3, R4) and the feedback resistors (R9, R10). Input capacitors, C1 and C2, are used to filter out any DC component from the input signal.

With a power supply of 12 volts, the quiescent current drawn by the total system is 30 to 35 mA. Under driven conditions, the drain could increase to 300 mA or more.

Building the amplifier

While the circuit can be built using any construction technique, we recommend using a PC board. A suitable design is shown in our PC Service section (elsewhere in this magazine). The parts-placement diagram for that board is shown in Fig. 3. Note that the board has been designed to accommodate both the power amplifier of Fig. 1 and the pre-amplifier of Fig. 2. All inputs and outputs of both amplifier stages have been made accessible for maximum flexibility.

As with any project, the first step is to make sure that you have all of the parts on hand. One source for a complete kit of parts is given in the Parts List. Otherwise, you should be able to get most, if not all, of the parts from your favorite distributor.

Begin construction by installing all of the resistors, excluding the two potentiometers. Next, install the IC's. We realize that that order of construction is a bit unconventional, but because of the large size of the electrolytics that flank some of the IC's, it is easier to perform the steps in that sequence.

Once the IC's are in place, the capacitors should be installed. Be sure to note the polarity of the electrolytics and install them correctly.

The only connections left are the volume controls, R15 and R16, the input wiring, and the connection to the power supply. The potentiometers are panel-

*Adapted from a story that originally appeared in Dick Smith's "Fun ways into Electronics, Volume Three."

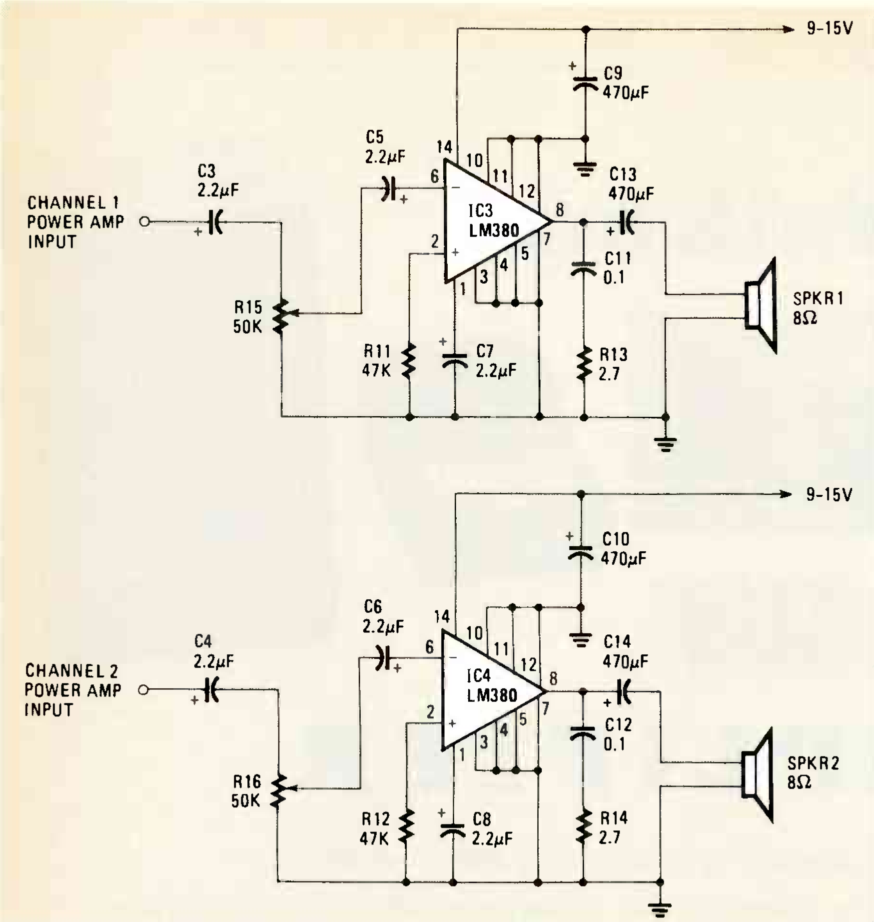


FIG. 1—THE *WALKMAN* AMPLIFIER. With this simple circuit you can use your personal stereo to drive standard 8-ohm speakers.

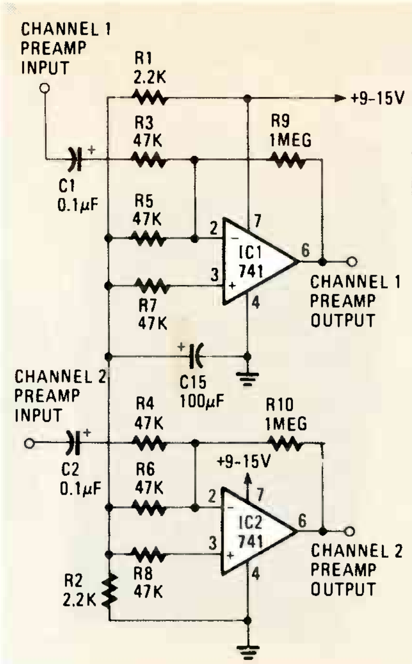


FIG. 2—THE PREAMP. If you wish to amplify low-level signals, such as the output of a turntable, the signal will first have to be fed to the preamp shown here.

mount units; they are mounted on the front panel of whatever case you house the circuit in, and they are connected to the board via jumpers.

The input wiring scheme is dictated by how you use the system. If you are using the amplifier with a *Walkman*-type stereo to drive a pair of 8-ohm speakers, only the power amplifier stage is used. If the input is a microphone, turntable, etc., the preamplifer stage will also need to be used. We'll look at the appropriate wiring schemes in more detail when we discuss the various applications for the amplifier.

Once you've checked your work for accuracy, and you're satisfied that there are no solder bridges, etc. on the board, power can be applied to the circuit. The unit requires at least 9 volts at 200 mA, and will work with power supplies of as high as 12 volts. Obviously, using a 12-volt supply will result in higher levels of audio output. Suitable power supplies are available from a number of sources, including the one mentioned in the Parts List.

Using the amplifier

Normally, those miniature *Walkman*-type personal stereos can only be used with headphones. But if the power amplifier stage of the circuit is used, 8-ohm speakers can be driven from those units.

Figure 4 shows the input wiring scheme that is followed when the unit is used as a personal-stereo amplifier. Note that only the power-amp stage is used; no connections are made to the preamp.

The amplifier is connected to the personal stereo via the stereo's headphone jack. Thus, the input to the amplifier must be connected to a miniature stereo phono plug as shown. Note the two 33-ohm resistors connected across each channel. Personal-stereo outputs are designed to feed headphones, not amplifier/speaker

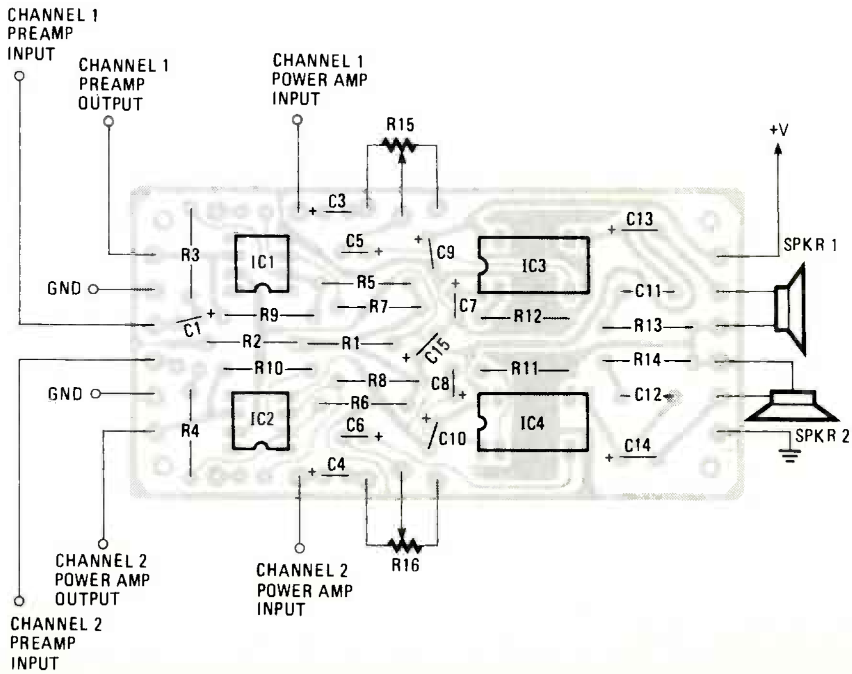


FIG. 3—PARTS-PLACEMENT DIAGRAM. Both the power amp and the preamp circuits are contained on this board.

combinations. Thus, those resistors are included in the input for impedance matching. Alternately, if the stereo has two headphone output sockets, as most do, you can leave one set of phones connected to the unit. Then, the 33-ohm resistors are not necessary.

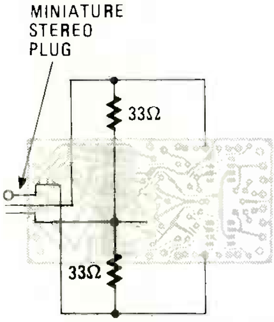


FIG. 4—USE THIS INPUT WIRING SCHEME when using the circuit to amplify the signal from a personal stereo. The 33-ohm resistors are used for impedance matching with the personal stereo's headphone output.

If the input is to be a microphone, turntable, or any other low-level source, the preamplifier stage must be used. In that case, the signal source is input to the preamplifier, and the output of the preamplifier is fed to the power amp. If that is done, input signals ranging from 3.5-mV to 100-mV rms can be accepted.

By using the twin output stages in a "bridge" mode, the output power can be approximately doubled (to 3 watts). If that is done, the circuit can be used as a mini PA amplifier.

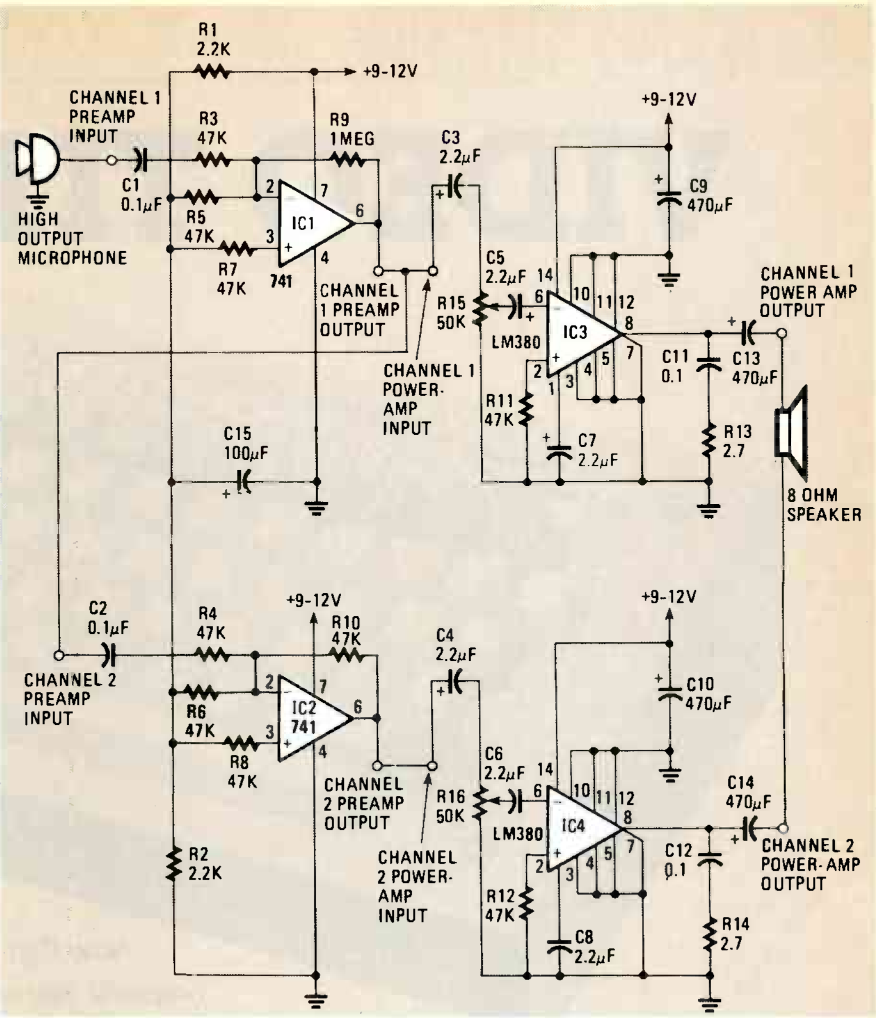


FIG. 5—THE CIRCUIT can be used as a small PA amplifier if it is wired up as shown here. The output of this circuit will be about 3-watts.

To use the circuit for such an application, the speaker is connected across the active output points of each amplifier as shown in Fig. 5. Let's look at that circuit in a little more detail.

In that circuit, the channel-1 preamp is used as an input stage with a gain of 21; it can accept inputs ranging from 3.5 to 100 mV. The channel-2 preamp, however, has been modified (compare the circuit to the one shown in Fig. 2). Now, the gain of that stage has been reduced to unity by changing the feedback resistor, R10, to 47K. That stage now acts as an inverter. That satisfies the requirements of the bridge output; that is, one input is positive-going while the other is negative-going. In other words, the inputs to the output (power amp) stages are 180 degrees out of phase. That provides twice the voltage swing across the 8-ohm load for a given supply, thereby increasing the output power by a factor of four over that of a single stage.

The key factor limiting the amount of power that that circuit can deliver to the load is power dissipation. Because of that, we have limited the power supply to a maximum of 12 volts. That, as previously stated, will result in a maximum power output of about 3-watts rms. To obtain more power you could attach a heatsink bent from a piece of copper 1.5" on a side. Bend two wings up at a 30° angle, leaving a ¼-inch strip down the center. Glue the center—wings up—to the output IC's with epoxy.

Note that in the dual configuration, both volume controls need to be adjusted equally to control the output. **R-E**

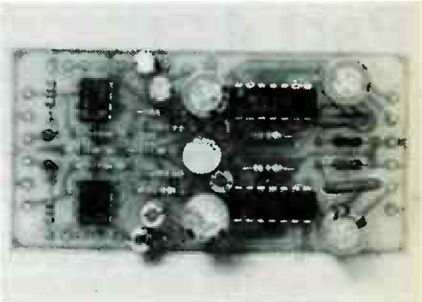


FIG. 6—FOUR IC's comprise this simple, yet versatile amplifier. A single-channel amp with double-power output can be configured.

PARTS LIST

All resistors ¼ watt, 10%, unless otherwise noted
R1, R2—2200 ohms
R3–R8, R11, R12—47,000 ohms
R9, R10—1 Megohm
R13, R14—2.7 ohms
R15, R16—50,000 ohms, potentiometers, audio taper
Capacitors
C1, C2—0.1 μF, 16 volts, tantalum
C3–C8—2.2 μF, 16 volts, electrolytic
C9, C10, C13, C14—470 μF, 16 volts, electrolytic
C11, C12—0.1 μF, ceramic disc
C15—100 μF, 16 volts, electrolytic
Semiconductors
IC1, IC2—741 op-amp
IC3, IC4—LM380 audio amplifier
Miscellaneous: PC board, speaker, hook-up wire, etc.

The following is available from Dick Smith Electronics, Inc., PO Box 8021, Redwood City, CA 94063: Kit of all components, including PC board, but excluding speakers and power supply (K-2667) $14.95 plus $3.00 shipping. A 12V, 500 mA power supply (M-9555) is available for $6.95, plus $3 shipping ($1 if ordered with the amp. California residents must add 6.5% sales tax. Orders outside U.S. must remit U.S. funds and include $5 for shipping.

VIDEO TITLER

Now that you have your video titler working properly, you can make it even more versatile by interfacing it with a home computer.

JACK FLACK

Part 4

WHEN WE LEFT OFF last time, we promised that we'd look at the software that controls the video titler. So we'll start off with an overview of the titler's operating system, and then we'll look at how you can interface the titler with several popular home computers. Since we'll be referring back to things we described in the previous three installments (November and December 1985, and January 1986), you might want to have them on hand.

The titler's software, which is contained in IC19, a 8K×8 EPROM, basically performs three functions: It initializes the video-display processor (VDP), it polls the keyboard, and it manipulates the VDP and the video RAM in response to keyboard inputs. Figure 18 is a flowchart of the operating system that fills in some of the details. If you'd like an even closer look at the software, a source listing is available for a nominal fee. See the Parts List for more details.

One of the best features of the video titler is its versatility. For example, you can even change its character font by burning a new EPROM. We'll be the first to admit that burning a new EPROM is not the easiest way to change a font—especially if you don't have an EPROM burner. Fortunately, there's an easier solution: Interface the titler with another computer.

Why interface?

It might seem strange to go through all the trouble to design a special video-titler computer and then turn off its microprocessor so that it can become another computer's peripheral device. It's really not that strange, though.

Interfacing the titler with a home computer lets us take advantage of all the advanced features available on the computer for the cost of a simple interface adapter. And when you consider how the prices of home computers have dropped, it begins to make a lot of sense. When you realize that interfacing a computer to the titler will let you create and superimpose sophisticated animation, interfacing the titler to a computer begins to make even more sense.

The interface circuit

Figure 19 shows the pinout of the video titler's expansion/interface port, and Fig. 20 is a schematic of the interface circuit for four popular computers: the IBM *PC*, Apple *II*, Commodore *64*, and *TRS-80 Color Computer*. Other computers can be interfaced with the titler as long as you have similar signals available on the expansion port.

The main functions of the interface circuit are to buffer the titler's data and address lines and to provide compatible connectors for each computer. But even more important, the interface circuit allows the VDP to be mapped into the host computer's memory (or I/O) address space so that the host computer can access the VDP's registers and the video RAM by using PEEK and POKE commands (or OUT and INP commands in an IBM *PC*.)

Unfortunately, we don't have the space here to discuss all the signals used in the interface circuit. You can consult the literature available on your particular computer for more information on the bus signals used in the interface. However, if you're not interested, rest assured that if you follow the interface schematic, and use all the correct addresses in your programs, you don't really need to understand all of the theory.

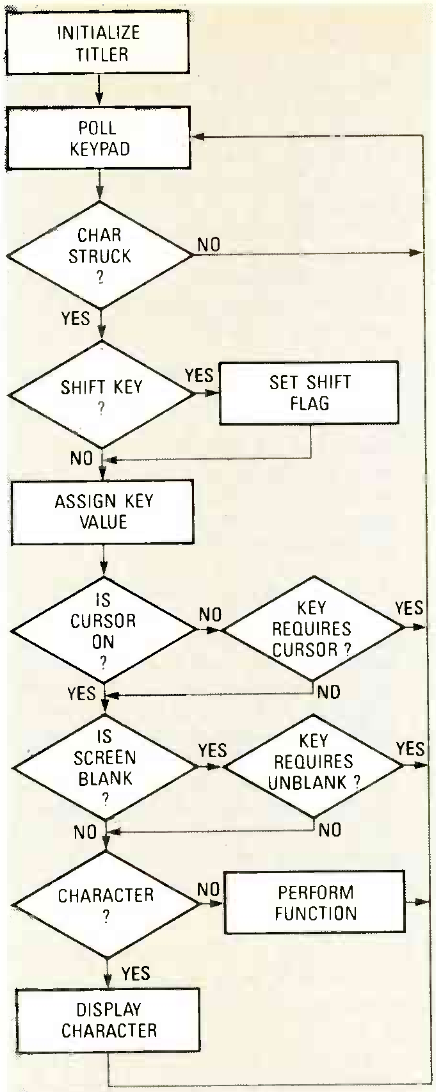


FIG. 18—THE OPERATING SYSTEM of the titler has three basic functions. It initializes the VDP, polls the keyboard, and responds to the keyboard inputs.

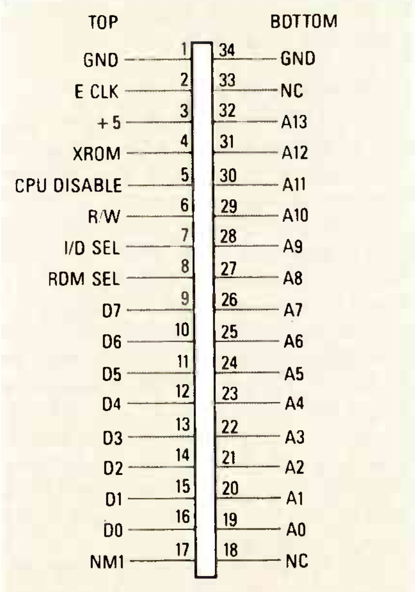


FIG. 19—THE EXPANSION-PORT PINOUT. A 34-conductor ribbon cable is the best way to connect to the card edge.

Building the interface

The interface is considerably easier to build than the titler, but there are several points worth mentioning. While you can build the interface circuit on a prototyping board, custom circuit boards are being developed by the supplier of the video titler's main board. (See the Parts List.) We suggest you contact them for information on price and availability.

If you use a prototyping board, be careful when you route the power-supply connections. If you accidentally route +12, −5, or −12 volts back through one of the titler's bus lines, you're almost certain to lose a few IC's. Carefully check for shorts on the card edge with an ohmmeter. If you use a ribbon cable to connect the interface board to the titler, be sure to mark the top side of the connector to remind you not to plug it in upside down.

When you have the interface circuit complete and you're ready to try it out, remember these rules: Always turn off the computer and the titler before plugging the cards and cables in. And when you power up, always turn the titler on first!

The VDP

Before we start controlling the titler with a host computer, we have to study what we're really going to control: the VDP. The interface allows the VDP to be mapped into the memory (or I/O) address space of the host computer. You can then write BASIC programs to access the VDP's registers and the video RAM by using PEEK and POKE commands (or OUT and INP in an IBM *PC*.)

The VDP is an extremely versatile device that provides a number of features that make it easy to create and manipulate screen images. The VDP is also an extremely complex device; if you plan to do any serious work, you'll want to get your hands on Texas Instruments' *Video Display Processors Programmers Guide* (TI No. SPPU004), which is available from Texas Instruments, P.O. Box 809066, Dallas, TX 75380-9066.

Figure 21 shows how the VDP image is made up of 35 separate planes: 32 *sprite planes*, a *pattern plane*, a *backdrop*, an *external video plane*, and a *black plane*.

The planes are arranged into priorities so that images appearing on the lowest-numbered plane will show on the screen. In other words, when two or more planes contain images at the same place on the screen, the plane with the highest priority is displayed. That makes it easy to simulate 3-D effects, where objects appear to move in front of other objects or images. The "0" sprite plane has the highest priority, the "1" sprite plane has the second highest, etc. The external-video plane has the lowest priority.

VDP modes

The VDP can operate in four modes: *graphics mode I*, *graphics mode II*, *multicolor mode*, and *text mode*. Each mode is table-driven and requires the video RAM to be configured differently. In the titler, only graphics mode II is used. That mode gives you the greatest control over pixels and colors.

Table 3 shows the format of data transferred to the VDP registers and video RAM, and the appropriate addresses to use in your BASIC programs. As you can see in the table, two- and three-byte (step) operations are required, as a rule, to transfer data. For example, to write to one of the VDP registers, you must first send the register data, followed by a control byte that tells the VDP that the previous byte was register data. A "1" in the *Most Significant Bit* (MSB) of the second byte transferred establishes that. The three *Least Significant Bits* (LSB's) of the second byte are used to select the register.

Writing to and reading from the video RAM is done in a somewhat similar manner. The eight LSB's of the video RAM address are sent in the first byte. The second byte transferred tells the VDP that a video RAM address is being set up. (A "0" in the MSB does that.) The second MSB of the second byte transferred tells whether a read (0) from video RAM or a write (1) to video RAM will occur. The remaining 6 bits of the second byte provide the 6 MSB's of the video RAM address. Once the 2 byte set-up has occurred, you can write to or read from video RAM.

One convenient feature of the VDP is that you can read from or write to successive locations in video RAM without further set-up. The video RAM address within the VDP is auto-incrementing

PARTS LIST

Capacitors
C1—10 µF, 50 volts, electrolytic
C2–C5—0.1 µF, ceramic disc
Semiconductors
IC1—74LS245 octal 3-state driver
IC2—74LS367 hex buffer
IC3—74LS00 quad 2-input NAND gate
IC4—74LS30 8-input NAND gate

Miscellaneous: 34-conductor ribbon cable and card-edge connector, prototype board (or custom PC board for your computer), etc.

Note: IC3 and C4 are not used for Apple interface. IC4 and C5 are used only for IBM PC interface.

The following are available from Micro-Video-Technology, P.O. Box 76, Chattanooga, TN 37343: Custom etched and drilled interface PC board, $25.00. (Specify your computer when ordering.) Source listing of titler's operating system, V1.0, $4.00 plus $2 shipping and handling.

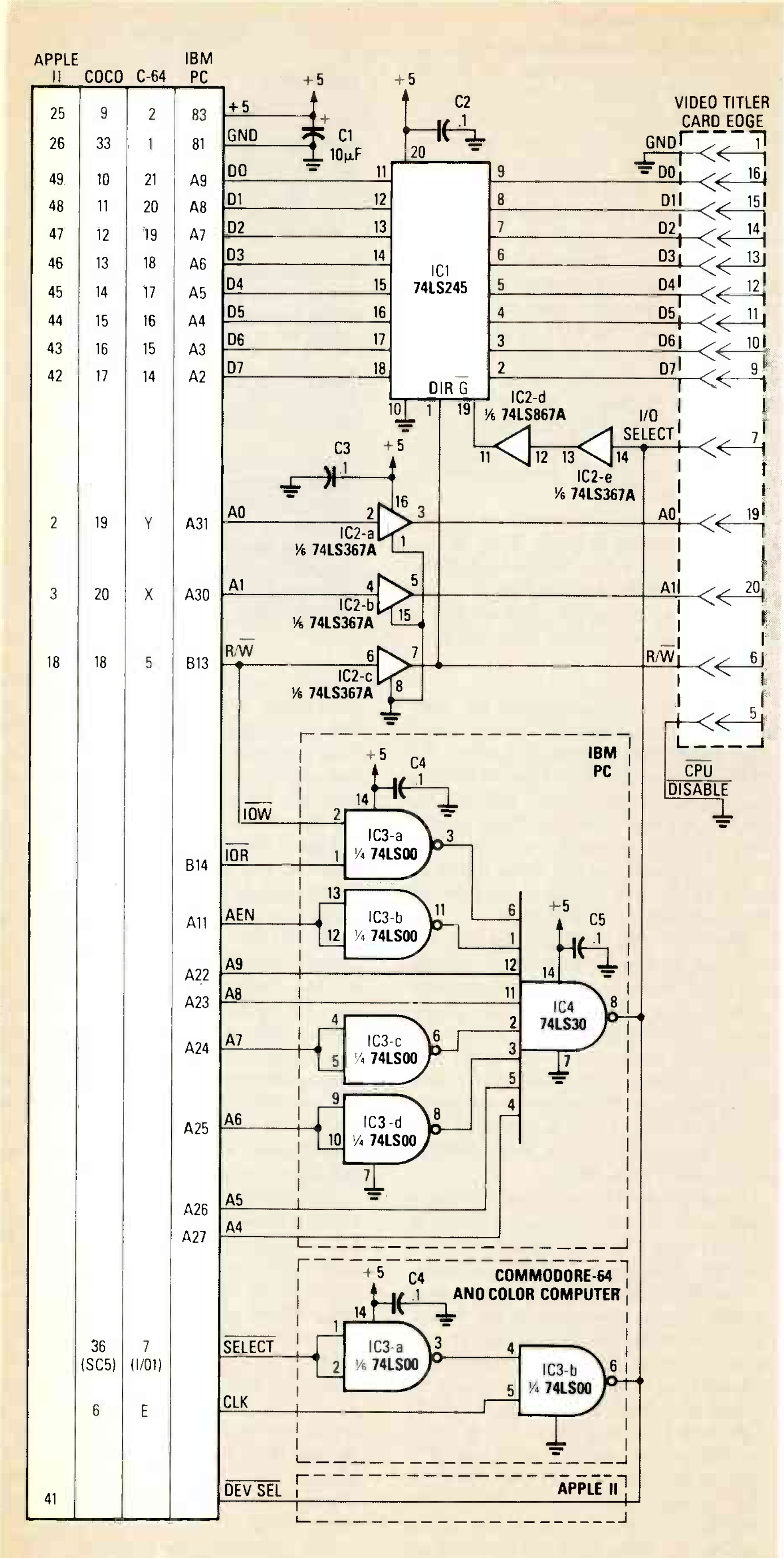


FIG. 20—THE INTERFACE CIRCUIT. The proper bus connections are shown for four popular computers. Note that all the components shown are not needed for all computers. Build the version that's appropriate for your system.

VIDEO TITLER ORDERING INFORMATION

The following are available prepaid from Micro-Video-Technology, P.O. Box 76, Chattanooga, TN 37343: Main PC board, $40.00. Programmed EPROM (V2.0), $25.00. Custom keyboard, $80.00. Custom enclosure, $40.00. All switches, jacks and connectors, $30.00 TMS9128 VDP, $30.00. Partial kit (includes all of the above) $250. Tennessee residents must add applicable sales tax.

The following are available from JDR Microdevices, 1224 South Bascom Ave., San Jose, CA 95128 (800) 538-5000: All components—except those available from Micro-Video Technology—$69.95 plus $2.50 for shipping. California residents must include applicable sales tax.

The following is available from MFJ Enterprises, Inc., 921 Louisville Road, Starkville, MS 39759: Complete titler, assembled and tested with 1 year unconditional guarantee, $599.95 plus $6 shipping. (Return if not satisfied within 30 days for refund, less shipping.) (800) 647-1800 (orders only) (601) 323 5869 (information and Mississippi orders). MasterCard and Visa accepted. Mississippi residents must add applicable sales tax.

and—as long as subsequent operations are consistent with the set-up (read or write)—you can zip through memory very quickly. You must, however, recognize certain timing requirements of the asynchronous data transfer. Depending on whether the VDP is actively displaying pixels (as opposed to vertical and horizontal periods), it can take as much as 8 microseconds to transfer data. Therefore, as a precaution, time delays should be included in your software.

VDP registers

The VDP registers are used to select one of the four modes and to configure the video RAM accordingly. Registers contain several other parameters which determine the size of sprites, blank the screen, and invoke the external-video mode. Figure 22 shows a typical way to initialize those registers for graphics mode II.

Generally, only three registers are updated after initialization. The external video flag (EV) in register 0 (bit Ø) determines when the VDP is in the external-video mode. (1 = external video on; Ø = external video off). Bit 6 of register 1 blanks and unblanks the screen. (Ø = blank; 1 = unblank). The four LSB's of register 7 determine the border color.

You need to remember that the VDP registers are "write-only" so you'll probably want to retain the register data in variables to keep track of them.

TABLE 3—TRANSFERRING DATA TO VRAM AND THE VDP

Operation	TRANSFERRED DATA MSB 7	6	5	4	3	2	1	LSB 0	"BASIC" statement	ADDRESS FOR STATEMENT Apple II*	C64	COCO	IBM PC
Write to VDP register													
Byte 1 data write	D7	D6	D5	D4	D3	D2	D1	D0	POKE/OUT	49281	56833	65345	817
Byte 2 register select	1	0	0	0	0	RS	RS	RS	POKE/OUT	49281	56833	65345	817
Write to VRAM													
Byte 1 address setup	A7	A6	A5	A4	A3	A2	A1	A0	POKE/OUT	49281	56833	65345	817
Byte 2 address setup	0	1	A13	A12	A11	A10	A9	A8	POKE/OUT	49281	56833	65345	817
Byte 3 data write	D7	D6	D5	D4	D3	D2	D1	D0	POKE/OUT	49280	56832	65344	816
Read from VDP status register													
Byte 1 data read	D7	D6	D5	D4	D3	D2	D1	D0	PEEK/INP	49281	56833	65345	817
Read from VRAM													
Byte 1 address setup	A7	A6	A5	A4	A3	A2	A1	A0	POKE/OUT	49281	56833	65345	817
Byte 2 address setup	0	0	A13	A12	A11	A10	A9	A8	POKE/OUT	49281	56833	65345	817
Byte 3 data read	D7	D6	D5	D4	D3	D2	D1	D0	PEEK/INP	49280	56832	65344	816

*ADD (SLOT# × 16)

TABLE 4—VDP COLOR CODES

Color	Color Codes (Hex)
TRANSPARENT	0
BLACK	1
MEDIUM GREEN	2
LIGHT GREEN	3
DARK BLUE	4
LIGHT BLUE	5
DARK RED	6
CYAN	7
MEDIUM RED	8
LIGHT RED	9
DARK YELLOW	A
LIGHT YELLOW	B
DARK GREEN	C
MAGENTA	D
GRAY	E
WHITE	F

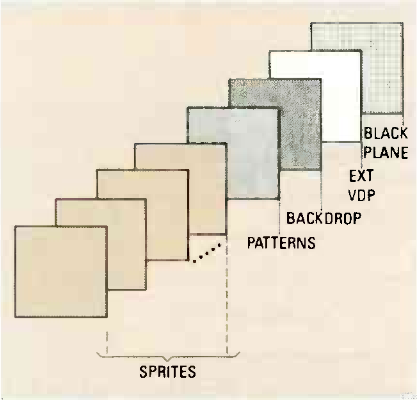


FIG. 21—THE VDP IMAGE PLANES are arranged here in the order of their priority.

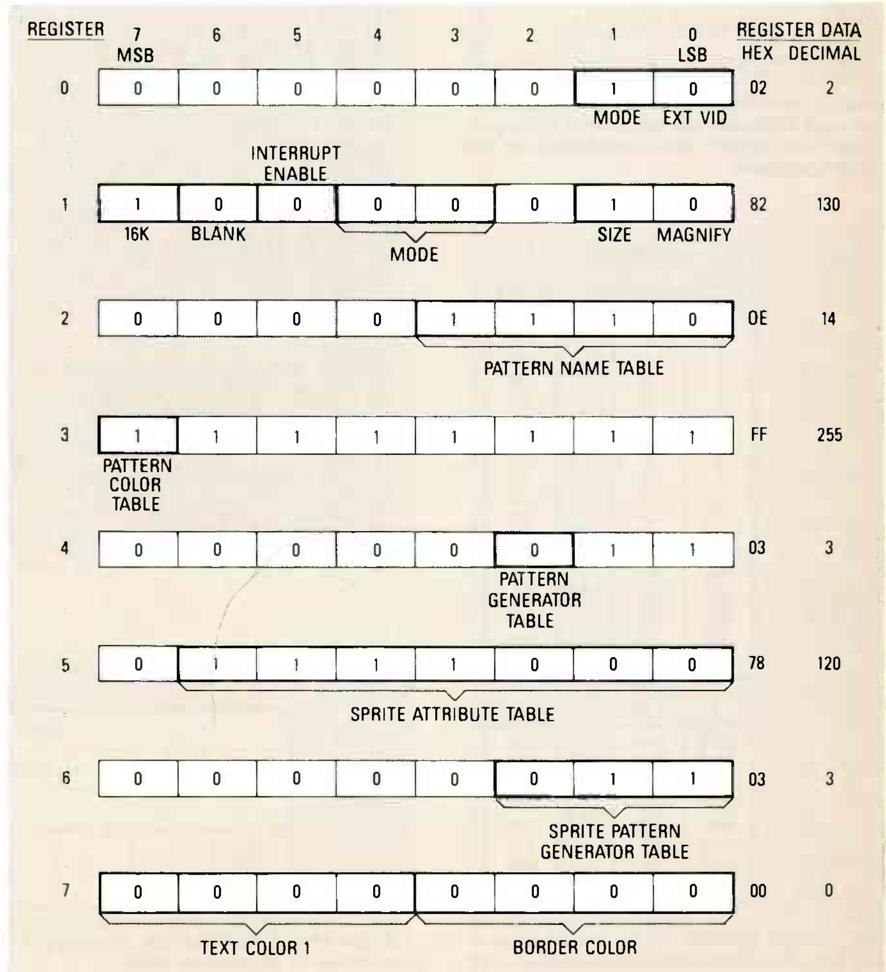


FIG. 22—THE VDP REGISTERS are initialized by the titler's software, and can be updated through the interface, if desired. For the most part, they are not registers in the microprocessor sense, but are used by the VDP to compute addresses for the various name, attribute, color, and pattern tables.

Figure 23 shows how the video RAM is mapped under Graphics Mode II. Portions of the addresses of the beginning of each area are loaded (by the system software's initialization routine) into the appropriate VDP register during initialization. They coincide with the base address register values in Fig. 22.

In graphics mode II, a 256 × 192-pixel screen is actually made up of 768 8-bit × 8 *patterns*. Figure 24 shows how those patterns are arranged in 24 rows of 32 patterns per row. Although the pattern definitions could be located almost anywhere in

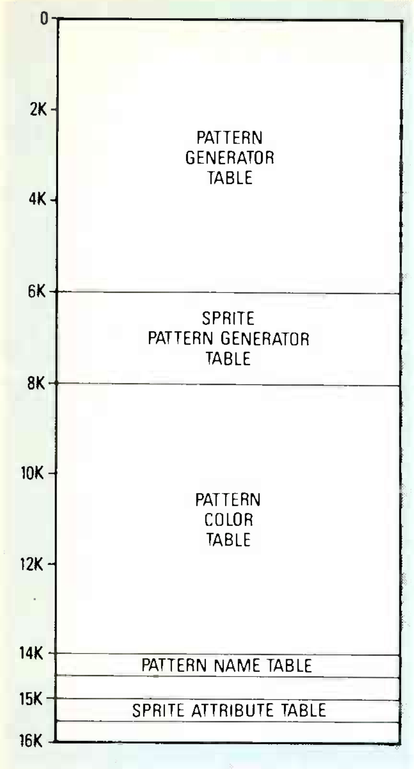


FIG. 23—VIDEO RAM MEMORY MAP. Portions of the base addresses are loaded into the appropriate VDP register upon initialization by the system software.

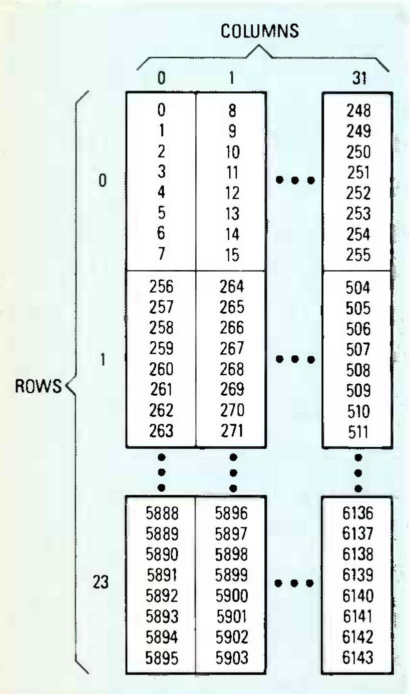


FIG. 24—THE SCREEN DISPLAY is made up of 768 8-bit × 8 patterns arranged as 24 rows of 32 patterns.

TABLE 5

```
100 REM THIS SAMPLE PROGRAM PRODUCES SIMPLE
110 REM ANIMATION WITH THE TITLER.
120 REM (SMALL MAN WALKING ACROSS THE SCREEN)
130 REM FOUR FUNCTIONS ARE DEMONSTRATED:
140 REM -VDP INITIALIZATION,
150 REM -TYPE "B" TO INCREMENT BORDER COLOR,
160 REM -TYPE "E" TO ENTER/EXIT EXT. MODE,
170 REM -ANY OTHER KEY RESTARTS THE MAN.
180 REM IT IS DESIGNED TO RUN ON A
190 REM TRS-80 COLOR COMPUTER.
200 REM THE FOLLOWING MINOR CHANGES
210 REM ARE NECESSARY TO RUN
220 REM THIS PROGRAM ON OTHER COMPUTERS:
230 REM C-64: V0=56832,V1=56833,
240 REM CHANGE LINE 1100 TO "GET A$".
250 REM IBM PC: V0=816,V1=817, CHANGE ALL
260 REM "POKE" STATEMENTS TO "OUT".
270 REM APPLE II: V0=49280+(SLOT X 16),
280 REM V1=49281+(SLOT X 16).
290 V0=65344:REM VDP PORT,MODE 0
300 V1=65345:REM VDP PORT,MODE 1
310 REM INITIALIZE VDP REGISTERS
320 DATA 2,0,130,1,14,2,255,3,3,4,120,5,3,6,0,7
330 FOR I=1 TO 8
340 READ D:POKE V1,D
350 READ R:POKE V1,R OR 128
360 NEXT I
370 R0=2:R1=130:R7=0
380 PRINT "VDP REGISTERS INITIALIZED"
390 REM CLEAR VRAM
400 PRINT "CLEARING VRAM(1 MINUTE)"
410 A=0:GOSUB 1310
420 FOR I=1 TO 16384
430 POKE V0,0
440 NEXT I
450 PRINT "VRAM CLEARED"
460 REM INITIALIZE VDP NAME TABLE
470 REM IN BIT MAP FORMAT
480 A=14336:GOSUB 1310
490 FOR I=1 TO 3
500 FOR J=0 TO 255
510 POKE V0,J
520 NEXT J
530 NEXT I
540 PRINT "NAME TABLE INITIALIZED"
550 REM INITIALIZE SPRITE ATTRIBUTE TABLE
560 A=15360:GOSUB 1310
570 FOR I=1 TO 32
580 POKE V0,208
590 FOR J=1 TO 3
600 POKE V0,0
610 NEXT J
620 NEXT I
630 PRINT "SPRITE ATTRIBUTES INITIALIZED"
640 REM LOAD SPRITE PATTERN TABLE
650 REM WITH 3 WALKING-MAN PATTERNS
660 A=6144:GOSUB 1310
670 REM SPRITE 0,1ST PATTERN
680 DATA 1,3,3,3,1,3,3,5,15,3,3,7,7,14,12,6
690 DATA 192,160,224,192,128,192,240,248
700 DATA 192,192,240,112,96,48,0,0
710 REM SPRITE 4,2ND PATTERN
720 DATA 1,3,3,3,1,3,3,7,3,3,3,7,14,12,8,0
730 DATA 192,160,224,192,128,192,224,160
740 DATA 192,192,192,192,192,192,192,96
750 REM SPRITE 8,3RD PATTERN
760 DATA 1,3,3,3,1,3,3,5,5,3,3,7,5,3,3,3
770 DATA 192,160,224,192,128,192,192,160
780 DATA 160,192,224,224,129,129,0,128
790 FOR I=1 TO 96
800 READ D:POKE V0,D
810 NEXT I
820 PRINT "SPRITE PATTERNS LOADED"
830 REM SET UP RED LINE ON SCREEN
840 REM FOR MAN TO WALK ON
850 REM USE 20TH PATTERN ROW,
860 REM ADDRESS=(ROW X 256)+(COLUMN X 8)
970 REM PATTERN 1ST THEN COLOR
880 RW=20:CL=0
890 A=(RW*256)+(CL*8):GOSUB 1310
900 FOR I=1 TO 256
910 POKE V0,255
920 NEXT I
930 REM COLOR IS NEXT,COLOR ADDRESS IS 8192
940 REM HIGHER THAN PATTERN,COLOR RED/TRANSP.
950 A=(RW*256)+(CL*8)+8192:GOSUB 1310
960 FOR I=1 TO 256
970 POKE V0,96
980 NEXT I
990 REM SETUP SPRITE 0 WITH
1000 REM VERTICAL LOCATION AND BLUE COLOR
1010 A=15360:GOSUB 1310
1020 DATA 142,0,0,4
1030 FOR I=1 TO 4
1040 READ D:POKE V0,D
1050 NEXT I
1060 REM UNBLANK SCREEN
1070 R1=(R1 AND 191)OR((NOT(R1 AND 64))AND 64)
1080 POKE V1,R1:POKE V1,1 OR 128
1090 PRINT "SCREEN UNBLANKED"
1100 A$=INKEY$
1110 IF A$="" THEN 1100
1120 IF A$<>"E" THEN 1160
1130 R0=(R0 AND 254)OR((NOT(R0 AND 1))AND 1)
1140 POKE V1,R0:POKE V1,0 OR 128
1150 PRINT "TOGGLE EXT.MODE":GOTO 1100
1160 IF A$<>"B" THEN 1210
1170 R7=(R7 + 1)AND 15
1180 PRINT "INCREMENT BORDER COLOR"
1190 POKE V1,R7:POKE V1,7 OR 128:GOTO 1100
1200 REM START OF MAN WALKING
1210 PRINT "ANIMATION INITIATED"
1220 FOR I=0 TO 250 STEP 2
1230 FOR J=0 TO 8 STEP 4
1240 A=15361:GOSUB 1310
1250 POKE V0,I:I=I+2
1260 POKE V0,J
1270 NEXT J
1280 NEXT I
1290 PRINT "ANIMATION COMPLETED"
1300 GOTO 1100
1310 REM SUBROUTINE TO SETUP VDP
1320 REM FOR "WRITE" OPERATION
1330 A2=INT(A/256):A1=A-(A2*256)
1340 POKE V1,A1:POKE V1,A2 OR 64
1350 RETURN
```

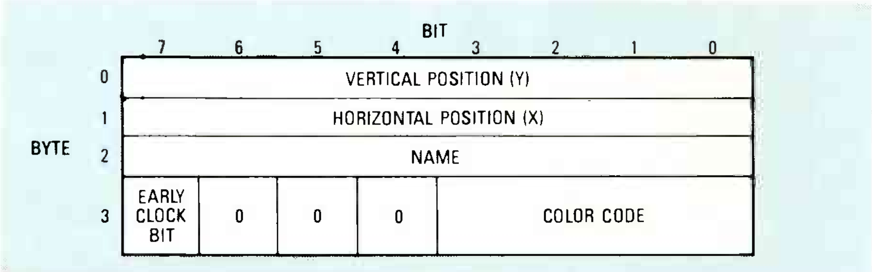


FIG. 25—SPRITE GENERATION. One entry of the sprite attribute table is shown here. There are 32 4-byte entries in the attribute table.

video RAM, it is easier to arrange them in the order that they appear on the screen. That way, the addresses of the pattern bytes can be computed with a simple algorithm. The equation that can be used to compute the relative address of the first byte of each pattern is: ROW × 256 + (COLUMN × 8).

To fully define a pixel on the screen, the pattern byte is not enough—a color byte is needed as well.

The color information is stored in much the same way as the patterns. The address of the color byte, however, is exactly 8192 bytes higher than the pattern byte. The most significant nibble of the color byte defines the color of the "1" bits in the pattern byte, and the least significant nybble defines the color of the "Ø" bits in the

continued on page 78

"Heat-Proofing" your Projects

Cool down your hot projects with the devices discussed here!

VAUGHN D. MARTIN AND BILLY W. DAVIS

Part 2

IN JANUARY WE learned about the analogy between heat and electricity; we also learned how to calculate the sizes of heatsinks and forced-air cooling systems. We'll continue this month by discussing some interesting ways of dissipating heat, and several new means of temperature sensing and heat injection. We'll conclude with a discussion of the vortex tube, an old, yet recently revitalized device used for heat dissipation.

Thermoelectric devices

Heatsinks, fans, and blowers are not the only devices that can be used to dissipate heat. Thermoelectric devices may also be used for that purpose, particularly when it is necessary to cool a small area, or even just one critical component. There are four physical phenomena that give rise to the thermoelectric effect:

- The Seebeck effect is the EMF (electromotive force) that arises when two dissimilar conductors are coupled, and each is maintained at a different temperature. That is the fundamental principle by which thermocouples operate.
- The Thomson effect is the heating or cooling that arises in a homogeneous conductor when an electric current passes in the direction of the temperature gradient.
- The Joule effect occurs when an electric current passes through a conductor that is isothermal (i.e., that maintains the same temperature throughout), and heat, called Joule heat, is generated.
- The Peltier effect describes the effect an electric current has as it travels through the junction of two dissimilar materials: When current flows in one direction, cooling occurs; when current flows in the opposite direction, heating occurs.

The Peltier Effect is probably the most useful in power-supply design (and in

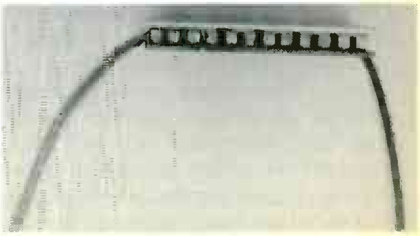
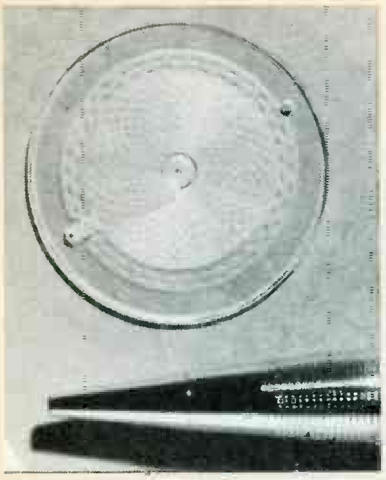
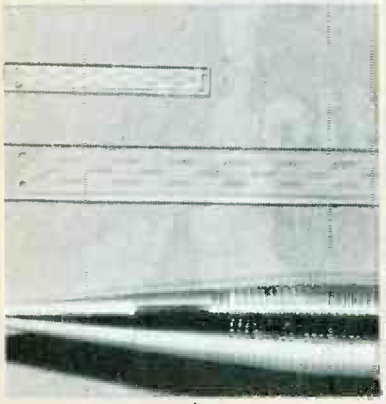


FIG. 8—PELTIER DEVICE dissipates heat in proportion to the amount of current flowing through the device.



a



b

FIG. 9—JOULE-THOMSON micro-refrigerator can cool a device to the temperature of liquid nitrogen in one second.

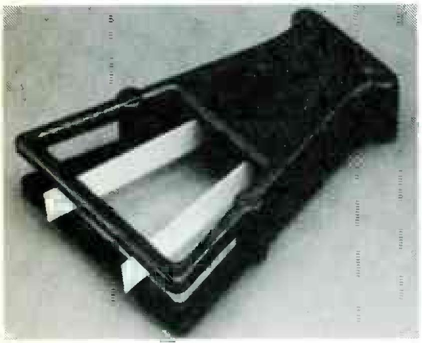


FIG. 10—PIEZO-ELECTRIC FAN can cool a small area much more efficiently than a regular fan.

electronics generally) because of its ability to literally draw heat away from a semiconductor. Several companies today produce Peltier cooling devices, such as that shown in Fig. 8. A Peltier device may be directly attached to the surface of a heat-producing semiconductor. Heat is drawn away from the semiconductor in proportion to the current passing through the Peltier device. Devices like the one shown cost about $15 in sizes large enough to cool a TO-3 power transistor.

Another interesting thermoelectric device is the Joule-Thomson cooler; two versions of that device are shown in Figs. 9-*a* and 9-*b*. That "micro-miniature refrigerator" cools infrared and millimeter-wave detectors down to 77°K, the temperature at which nitrogen becomes liquid, can cool a device to 80°K in just one second.

The piezoelectric fan

Another interesting cooling device is the piezoelectrically-driven fan, like that shown in Fig. 10. That device, manufactured by Piezo Electric Products (212 Durham Ave., CN-15, Metuchen, NJ 08840), is available in both 50- and 60-Hz. and 220- and 117-volt models. The device is used for spot cooling, and it consumes about 1/15 the power of a fan that provides the same cooling effect. The piezo fan has high reliability because of the flexible metal blades laminated to thin-sheet piezo-ceramic elements, as shown in Fig. 11. Mechanical distortion of the piezo elements results when an AC voltage is applied across them; that is what causes the blades to "flap." The highly-focused air streams produced are responsible for the unit's exceptional efficiency: the fan can move 20 CFM, but uses only 0.36 watts of power.

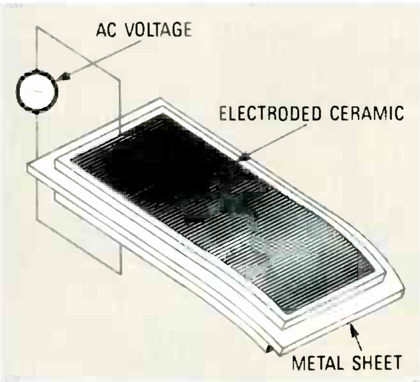


FIG. 11—ALTERNATING CURRENT causes each blade of the piezo fan to distort in turn.

The heat pipe

Heat pipes range in size from furnace liners and smokestacks to pipe-cleaner size objects. As shown in Fig. 12, a heat pipe is a sealed metallic tube that contains highly compressed gas. The highly pressurized and conductive tube can equally and uniformly distribute heat; it operates by principles of both condensation and evaporation. Heat-pipe manufacturers claim that the temperature difference between the object being cooled and its surroundings may be reduced to less than 1°C.

A small heat pipe may fit beneath two adjacent rows of IC pins. If, for example, you had a circuit composed of a row of adjacent LED's, you wouldn't be able to use one of the more common heat ventilating devices, like the slip-on DIP heatsink shown above, because the heatsink would obscure the front of the display, and therefore render it useless. A heat pipe would be ideal in that situation; as shown in Fig. 13, several heat pipes may be attached to a single PC board. One end would be mounted beneath the LED's, and the other end could be coupled to a heatsink, to aid in heat dissipation. Another method of increasing heat dissipation is by fusing a "radiator" onto the condenser end, as shown in Fig. 14.

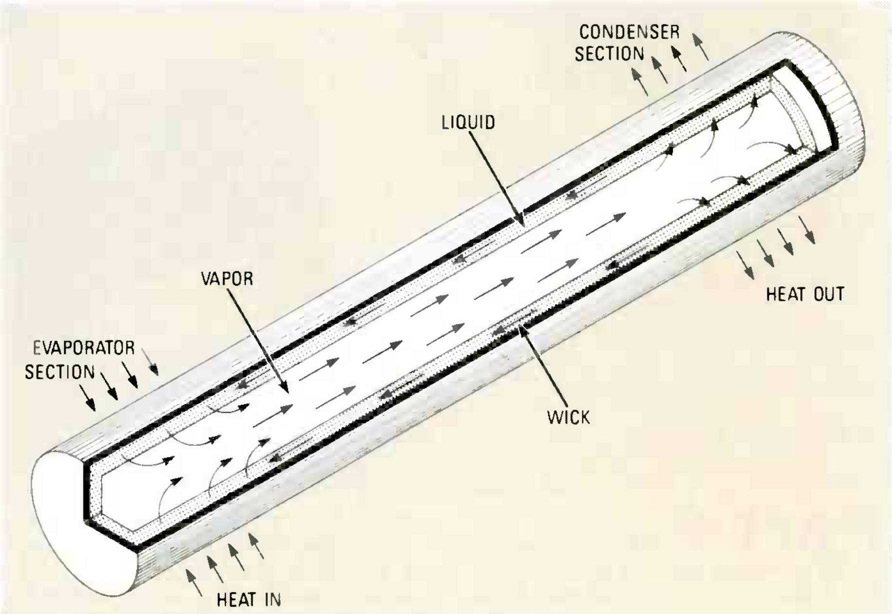


FIG. 12—HEAT PIPE is a sealed tube that is a highly-efficient conductor of heat.

Temperature indicators

A number of companies, including Omega (Box 4047, Stamford, CT 06907) and Telatemp (Box 5160, Fullerton, CA 92635), make paint-on and crayon-like indicators, like that shown in Fig. 15, which may be rubbed onto any surface

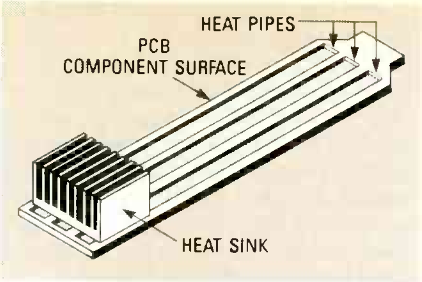


FIG. 13—HEAT PIPES may be coupled to a heat-sink for more efficient radiation of heat.

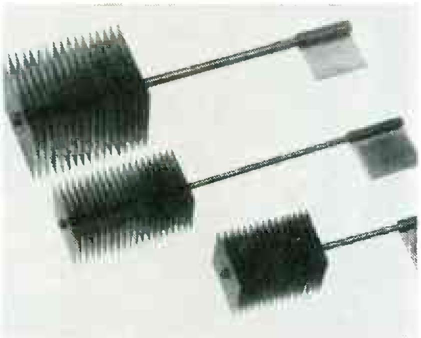


FIG. 14—RADIATING FINS may also be used for more efficient radiation of heat with heat pipes.

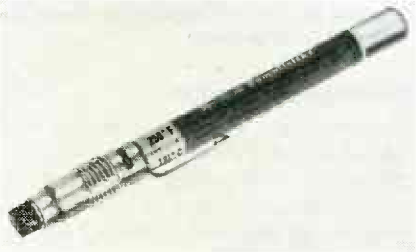


FIG. 15—THIS "TEMPILSTIK"™ changes color at 121°C.

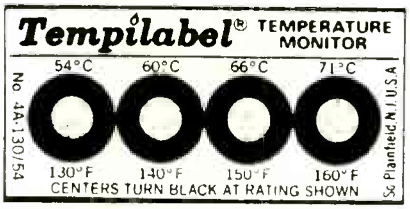


FIG. 16—THIS "TEMPILABEL"™ provides separate indicators that change color at temperatures ranging from 54°C to 71°C.

whose temperature is to be monitored. There are also stick-on temperature indicators, like those shown in Fig. 16, that are specifically designed to be attached to TO-3, TO-66, and DIP devices.

Those indicators function by changing color when the temperature reaches a pre-specified value. They come in two types. The traditional throw-away types change color permanently when the temperature reaches the trip point; they are unable to return to their former color when temperature later drops.

That unfortunate "rachet" effect has been overcome by an LCD- (Liquid Crystal Display) type temperature indicator. Those indicators do not use nematic crystals; rather, they use cholesteric crystals, which, by the way, come from the cholesterol in lamb's wool and cuttlefish. Those LCD indicators cost about four dollars each, and they may have as many as seven colors, each of which indicates an increment of 5 °C. There are larger indicators based on the same principle that can cover whole power supplies or printed-circuit boards.

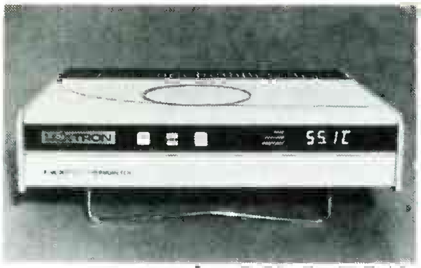


FIG. 17—LUXTRON'S *FLUOROPTIC* THERMOMETER has both analog and digital outputs for peripheral devices.

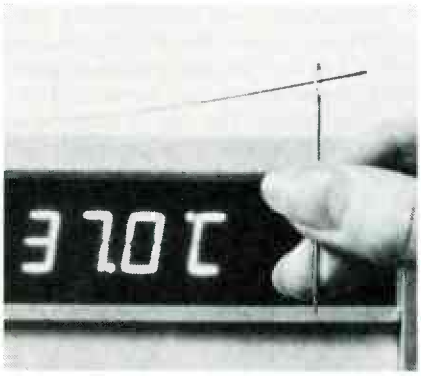


FIG. 18—A RARE-EARTH *FLUOROPTIC* PROBE can pass through the eye of an needle.

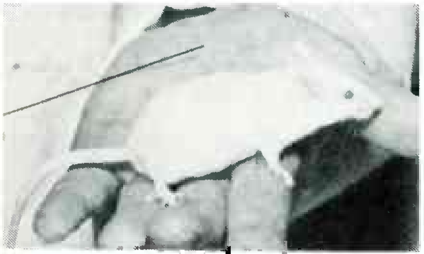


FIG. 19—A *FLUOROPTIC* PROBE can also pass directly into a biological research specimen.

Fluoroptic measurement

Liquid-crystal indicators are handy, but sometimes we need a more accurate indication of temperature than they can provide. Infrared sensors, for example, can provide a highly accurate measurement of temperature. Unfortunately, however, they must have an unobstrlucted line-of-sight to the object whose temperature is being measured. That makes it difficult—or impossible—to measure the temperature of hard-to-access locations.

To overcome that line-of-sight requirement, Luxtron (1060 Terra Bella Ave., Mt. View, CA 94043) has introduced the *Fluoroptic* Thermometer shown in Fig. 17. That device senses temperature by using slender optical fibers, like the one shown in Fig. 18. The *Fluoroptic* probe allows temperature to be determined to an accuracy of 0.1°C over the range of −50°C to +200°C.

The instrument includes a built-in digital LED display, and separate analog and digital outputs for operating strip-chart recorders, CRT displays, digital printers, or control instrumentation. A measurement time of one-fourth second, one second, or four seconds is switch-selectable. The *Fluoroptic* probe has several characteristics that make it especially useful in measuring temperature:

- The probe does not heat up from microwave or RF fields, nor does it distort or perturb the heating field.
- The probe is not conductive electrically or thermally.
- The long, smooth sensor is easily inserted into the body of a research specimen, as shown in Fig. 19.
- The probe is sheathed with a highly inert jacket that ensures chemical neutrality, and that also allows the probe to be gas-sterilized, or to be sterilized in an

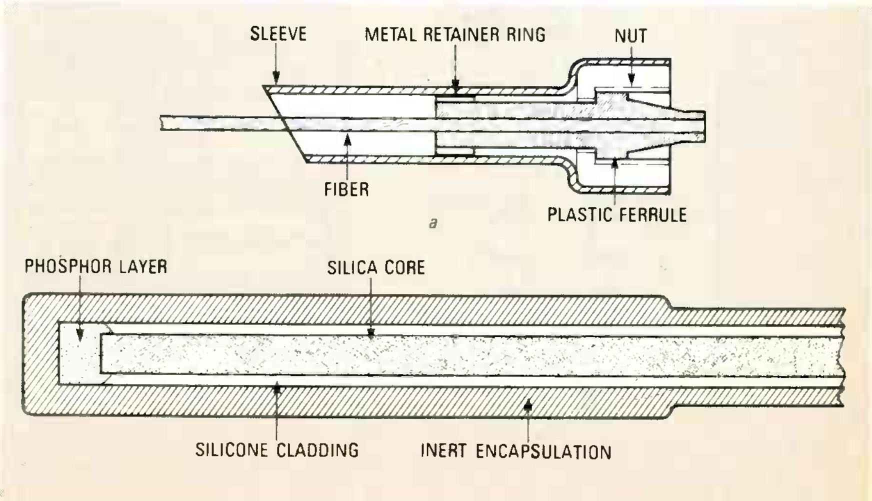


FIG. 20—THE CONNECTOR END OF THE *FLUOROPTIC* PROBE is shown at a, and the sensing end at *b*.

autoclave (an instrument that uses high-pressure steam to accomplish sterilization).

- The probe's low thermal inertia allows readings to be obtained in seconds.
- Calibration is intrinsic to the phosphor used. Probes need not be calibrated individually, and, since temperature is determined by comparing the relative intensities of different colors, the system is immune to changes in illumination that might otherwise be interpreted as changes in temperature.

The *Fluoroptic* probe

The probe shown in Fig. 20 has a diameter of approximately 0.7 mm, and it contains a small amount (10 micrograms) of europium-activated gadolinium oxyzulfide (a rare-earth phosphor) affixed to its end.

A high-intensity tungsten-halogen lamp sends ultraviolet (UV) light along the fiber to the tip of the sensor, where that light excites the phosphor. That excitation causes visible light to be emitted, and that light returns to the instrument via the same fiber. Then, as shown in Fig. 21, that light is sent by a beam splitter through two separate optical channels where the two wavelengths of interest are isolated by filters and detected by silicon photodiodes. The signals from the photodiodes are amplified, averaged, and converted to digital signals. The averaging time is switch-selectable.

The system microprocessor calculates the ratio of the two averaged signals, and determines the corresponding temperature from a look-up table stored in read-only memory (ROM). The microprocessor formats the temperature data for the front-panel display, the analog output, and the RS-232C output.

The factor that limits the length of the transmission fiber is the amount of excitation-radiation that is dissipated due to transmission losses in the fiber itself. Existing fibers can extend to 100 meters. Longer fibers—into the kilometer range—could be manufactured if the phosphor were excited by visible (blue) radiation, or by electrons, or by alpha particles from radioactive materials contained within the sensor. Now that we've got some idea of how the *Fluoroptic* system works, let's see what can be done with it.

Applications

To maintain a safe and efficient power-distribution system, the electric-power industry monitors the temperature of generators, transformers, and power-distribution equipment. The use of thermocouples and thermistors is generally not practical, because their outputs may be affected by the high-intensity electrical and magnetic fields that are present. *Fluoroptic* probes are not affected by those fields, and they may provide an easy solution to what has been a tough problem.

Fluoroptic technology can also be used to implement a non-contact sensor. In such a system, a spot of phosphor is affixed to a rotating machine. Then an optical fiber (or a fixed-lens system) senses the temperature of the rotating part from a distance. Corrective measures, if necessary, can then be taken.

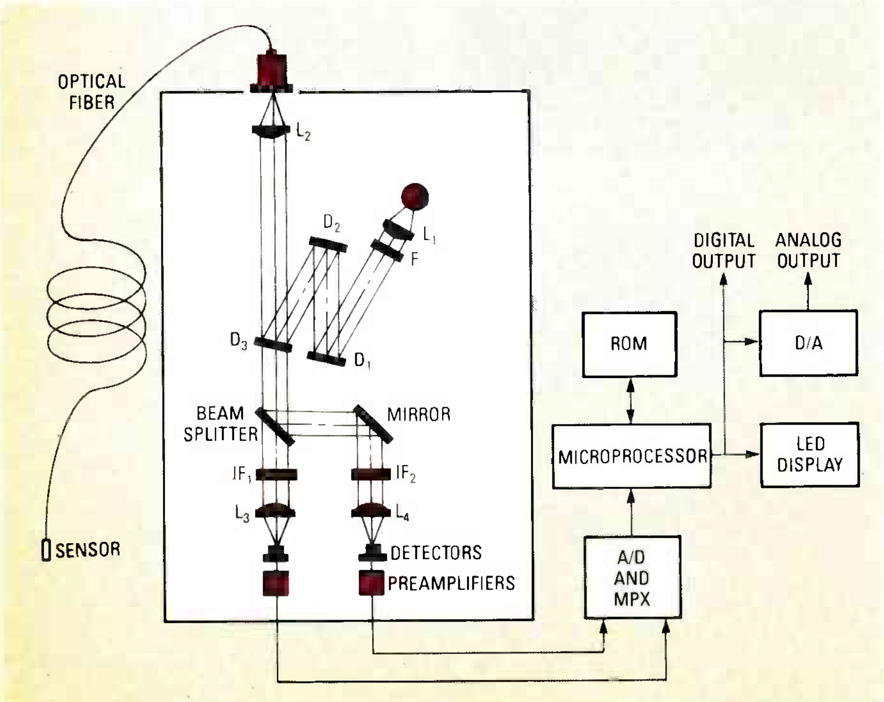


FIG. 21—BLOCK DIAGRAM OF THE *FLUOROPTIC* THERMOMETER is shown here. Note that a single optical fiber transmits excitation energy to the probe as well as the resultant signal from it.

Other possible applications include microwave food processing, lamination of wood, forming of plastics, cancer therapy, and anywhere that an accurate, non-contact measurement of temperature must be made. The ultimate development in non-contact sensors might be the throw-away sensor. Possible uses include phosphor sensors painted directly on microwave food pouches, and phosphor beads packaged for use in clinical chemistry.

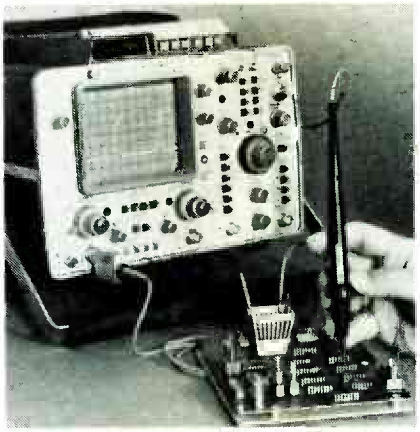


FIG. 22—SEMICONDUCTOR HEAT-SENSOR provides DC-voltage output that is directly proportional to temperature.

Direct-contact probe

Admittedly, *Fluoroptic* temperature measurement is a fairly exotic method of measuring temperature, so probes that rely on direct contact to measure temperature are still useful in many applications. The device shown in Fig. 22, a Hewlett-Packard (3000 Hanover Street, Palo Alto, CA 94304) model *10023A*, is a semiconductor device that produces an output voltage that is directly proportional to the temperature it senses. The device is connected to a DVM whose display provides an indication of temperature directly either in degrees Fahrenheit or in degrees Celsius.

Heating probe

You can use a small, hand-held probe not only for measuring temperature, but also for controlling it. For example, MTI (Micro-Technical Industries, 23666 Birtcher Dr. B, Lake Forest CA 92630) markets several "Thermo-probes" for the test-bench and the production-line, as shown in Fig. 23. Those probes allow you to heat—in circuit—specific transistors, IC's, or other electronic components, without using expensive, cumbersome ovens or heat chambers.

The bench model applies heat that is accurate to +3°C over the range of +25°C to +250°C, and the production model achieves the same accuracy over the range of +25°C to +225°C. A reliable, solid-state controller continuously monitors the probe's temperature and regulates that temperature to the value set by the control knob. It takes 35 to 40 sec-

FIG. 23—THERMO-PROBE CAN SUPPLY PRECISELY-CONTROLLED TEMPERATURE. The production-line model is shown here; a test-bench model is also available.

FIG. 24—VORTEX TUBE has no moving parts, yet it is a very efficient cooling device.

onds, depending on the model, to bring the probe to the specified setting from ambient temperature. Tips are available that fit most common electronic components; custom tips are also available.

The vortex tube

Now let's switch gears and return to talking about heat dissipation, and, in particular, the mostly unknown vortex tube, an example of which is shown in Fig. 24. Unlike traditional cooling devices, the vortex tube uses no electricity or water, and it creates no vibration or EMI (*E*lectro*M*agnetic *I*nterference). The vortex tube has no moving parts, and it requires only a source of clean, compressed air to produce powerful cooling effects. The vortex tube operates on the principle that, when a compressed gas expands through an orifice, the gas cools.

The vortex tube was discovered by French physicist Georges Ranque. However, upon describing his discovery to a French scientific society, he was met with disbelief. Several years later, Rudolph Hilsch, a German scientist, discovered Ranque's work; Hilsch subsequently revived interest in the device. It is interesting to note that vortex tubes made of pure silver were found in German laboratories by the Allies at the end of World War II. Their intended use was never discovered!

The basic operating principle of the vortex tube is illustrated in Fig. 25-*a*, and an exploded view of an actual vortex tube is shown in Fig. 25-*b*. High-pressure air is forced through the inlet to the generator. That air then enters the body assembly, where it loses pressure as it expands and attains a velocity near the speed of sound.

That low-pressure, high-velocity air then enters the hot tube. The air does not enter the cold tube because the opening to the hot tube is larger than the opening to the cold tube (the diaphragm). Centrifugal force then keeps the air near the inside surface of the hot tube as it moves toward the control valve at the end.

By the time that hot air reaches the valve, it has a pressure that is less than the exit pressure at the nozzles, but that is greater than atmospheric pressure (assuming that the cold outlet at the opposite end of the tube is at atmospheric pressure). The pressure just inside the control valve is always greater than the cold outlet pressure.

The position of the control valve determines how much air leaves at the hot end. For proper hot-cold separation, the valve must allow only part of the air to escape. The remaining air is then forced through the center of the hot tube, the generation chamber, and finally the diaphragm, after which it exits at the cold outlet.

The original stream of air in the hot tube did not travel through the center of the tube because of the centrifugal force of the pressurized inlet air. That is how the path for the inner stream is created. And that, in conjuction with the pressure difference between the control valve outlet and the cold outlet, is the reason that there are two distinct spinning streams, one inside the other, that move in opposite directions through the hot tube.

Now that we understand how air flows through the vortex tube, let's examine the reason why the hot air becomes hot and the cold air becomes cold. As we said, the outer ring of air moves through the vortex tube toward the hot end, and the inner core of air moves toward the cold end. Both streams of air are rotating in the same direction. More important, both streams of air are rotating at the same angular velocity. That is because intense turbulence at the boundary between the two streams locks them into a single mass, so far as rotational movement is concerned.

The proper term for the inner stream

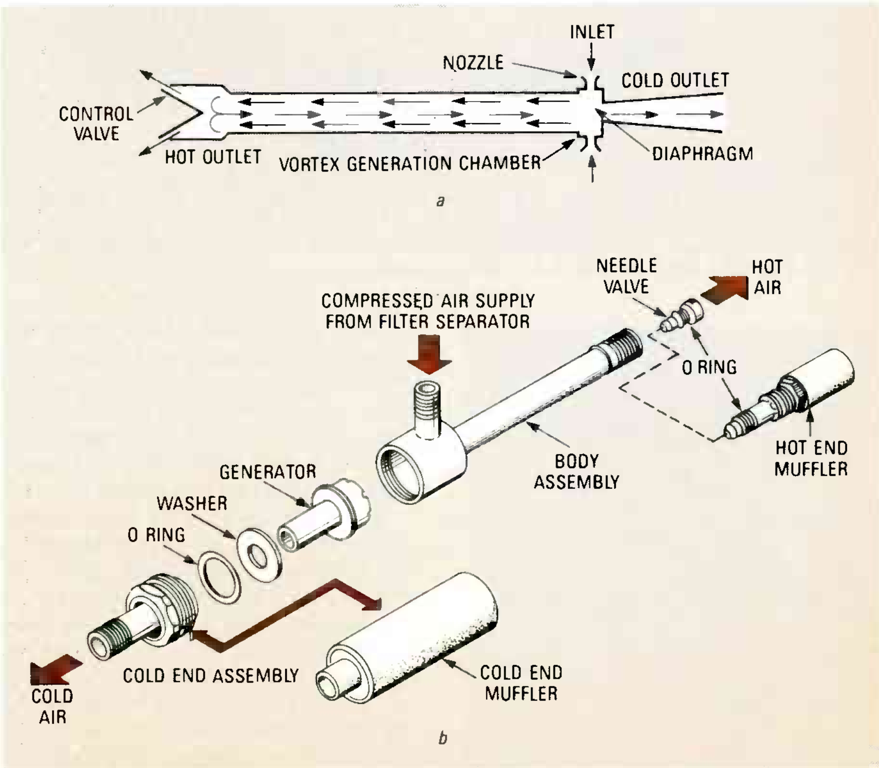


FIG. 25—VORTEX TUBE'S PRINCIPLE OF OPERATION is shown at *a*, and an exploded view of an actual vortex tube is shown at *b*.

would be a *forced vortex,* which is distinguished from a *free vortex,* in that the rotational movement of a forced vortex is controlled by an outside influence rather than by the principle of the conservation of angular momentum. In the case of the vortex tube, the outer (hot) stream forces the inner (cold) stream to rotate at a constant angular velocity.

By contrast, angular momentum is conserved in, for example, a bathtub whirlpool, which is a free vortex. The linear velocity of any particle in a free vortex is inversely proportional to its radius. So, in moving from a radius of one unit to a drain at a radius of 1/2 unit, a particle *increases* its linear (tangential) velocity by a factor of *two.* In a forced vortex with constant angular velocity, linear velocity *decreases* by *half* as a particle moves from a radius of 1 unit to a drain at a radius of 1/2 unit.

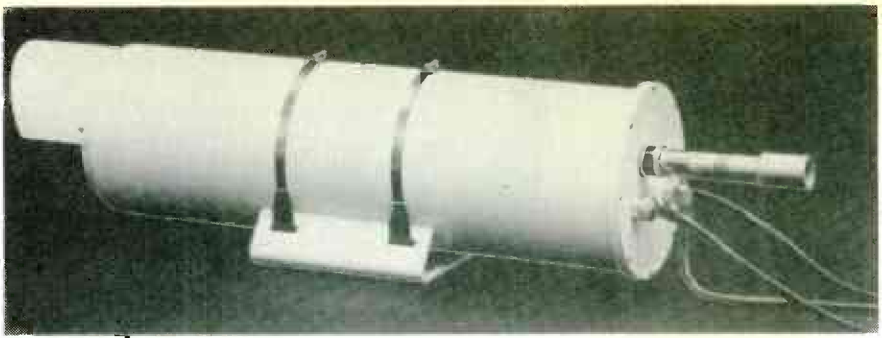


FIG. 28—INDUSTRIAL TV CAMERA is cooled by a vortex tube. This camera can operate in environments with temperatures as high as 200°F.

Therefore particles enter the drain of a free vortex with four times the linear velocity of a forced vortex. Kinetic energy is proportional to the square of linear velocity, so particles entering the drain of a forced vortex have 1/16th the kinetic energy of a free vortex.

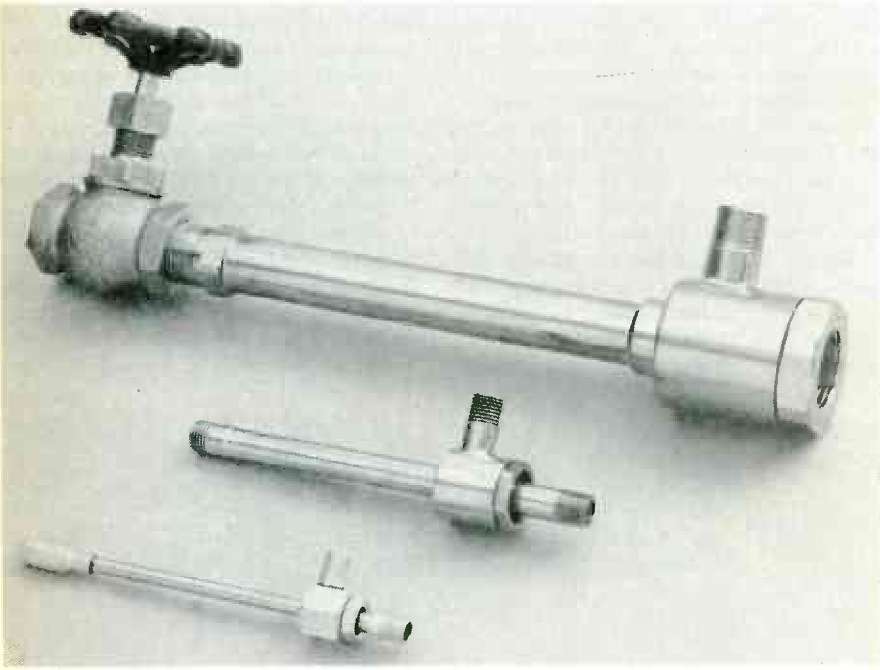


FIG. 26—VORTEX TUBES come in several different sizes.

FIG. 27—A THERMOSTAT may be an integral part of a vortex tube.

Where does that excess energy go? Therein lies the secret of the vortex tube. That energy leaves the inner core as heat! And that heat is transmitted to the outer air stream. So why isn't the outer layer heated by the same amount that the inner layer is cooled, leaving no net cooling effect?

Keep in mind that the outer stream's rate of flow is always greater than that of the inner stream, since part of the outer stream is discharged at the hot valve. If the amount of heat leaving the inner stream equals the amount of heat gained by the outer stream, the temperature drop of the inner stream must be greater than the temperature gain of the outer stream because its mass rate of flow is smaller. And that is the origin of the vortex tube's surprising cooling ability.

Real-world vortex tubes

Several examples of actual vortex tubes are shown in Fig. 26. Tubes of various sizes can be useful in providing different amounts of cooling. Some vortex tubes have built-in mechanical thermostats, as shown in Fig. 27. Vortec Corporation (10125 Carver Road, Cincinnatti, OH 45242) manufactures a number of different vortex tubes, and that company sells several kits for experimenting with them.

A commercial application of a vortex tube is shown in Fig. 28. The device shown is an industrial television camera that can be used without damage in environments with temperatures as high as 200°F. The air coupled through the hoses connected to the front of the housing provides the vortex cooling effect.

Conclusions

We have covered a lot of ground in this two-part article on heat and electronics. Last month we examined ways of controlling heat in electronics devices, particularly semiconductors. As we learned, heat flows by means of conduction, radiation and convection; all three must be taken into account when designing heat-ventilating systems. The analogy between the flow of heat and the flow of electricity allows heatsink area and air-flow requirements to be calculated easily.

This month we have examined several new devices that provide creative solutions to difficult heat-flow problems, and we mentioned several modern methods of temperature indication. We then discussed Luxtron's *Fluoroptic* thermometer and several probes used for both sensing heat and controlling it. To bring things to a close we then discussed vortex tubes in depth.

We hope that, by applying what you have learned here, your next design—whether it be a 7805 regulator circuit or a high-current power supply—should function much better.

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Repairing Compact Disc Players

Compact disc players are the most exciting development in audio in years. In this article we'll show you how those devices work, and how you can repair them when something goes wrong.

JOHN LENK

Part 5 PREVIOUSLY, WE'VE covered many different types of CD-player failures, and their likely causes. But there are still a few that we haven't looked at. Let's pick up where we left off.

4. Pickup does not focus properly. Figure 29 is the troubleshooting diagram. When play first begins, the focus actuator coil receives a focus up-down (FUD) signal from IC301 through IC101 and IC102. Those FUD pulses move the focus actuator up and down two or three times as necessary to focus the beam on the disc. Once focus is obtained, a focus-ok (FOK) signal is generated by IC601 and applied to both IC301 and IC[illegible]01. If IC301 does not receive an FOK signal after two or three tries, it shuts the system down and play stops (turntable off, pickup moves to inner-limit). On most players, that also occurs if there is no disc in place.

If focus is obtained, the focus error (FER) signal from IC601 is applied to the focus actuator through IC101 and IC102. The FER signal keeps the pickup focused on the disc. On most players, when the pickup reaches the outer limit, focus is lost, the FOK signal is removed, and IC301 shuts down the system.

If you suspect problems in the automatic focus (AF), install a disc, select play, and check that the pickup moves up and down two or three times, and then settles down. If not, check the laser (and adjust the laser if necessary). Then make a quick check of the lens actuator coils. Here's how:

Measure the resistance of focus and tracking coils with an ohmmeter. Typically, the resistance of the focus coil is about 20 ohms, while the resistance of the tracking coil is 4 ohms. Actual resistance depends on the pickup. However, if you get an open, a short, or a resistance that is way off, the actuator is suspect. On some players, you can see a slight movement of the actuator when the ohmmeter is connected to the coils.

If the coil appears good, and the problem can not be corrected by adjustment, check the focus servo as follows.

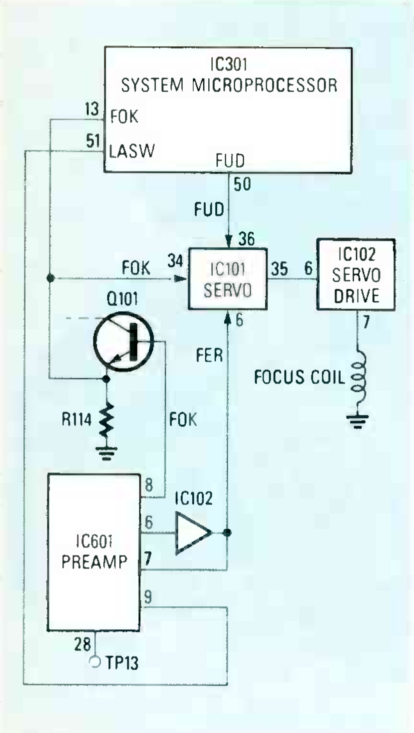


FIG. 29—THIS DIAGRAM should be used to help track down the cause of focusing problems.

If the FUD pulses are not present just after PLAY is selected, suspect IC301. Check for pulses at pin 50 of IC301, pins 35 and 36 of IC101, pins 6 and 7 of IC102, and at the coil.

Next, check for FOK signals at pin 34 of IC101, pin 13 of IC301, and pin 8 of 601. (If the FOK signals are not present, IC301 should shut the system down.) If the FOK signals are absent at pin 8 of IC601, suspect IC601, or possibly the four pickup photodiodes. Also, the FOK signal is not generated unless the LASW signal is applied to pin 9 of IC601.

Next check for FER signals at pins 6 and 7 of IC601. If FER signals are present at pin 6, but not at pin 7, suspect IC102. If FER signals are absent at pin 6, suspect IC601, or possibly the photodiodes.

If you suspect the signal/focus photodiodes, monitor the EFM signal at TP13 (TDET). If EFM is good, it is reasonable to assume that all four photodiodes are good.

5. Pickup does not track properly. Figure 30 is the troubleshooting diagram. In most players, it is very difficult to separate tracking and focus servo problems. For example, unless there is an FOK signal applied to IC101, the tracking error (TER) signal does not pass to the tracking actuator. Both the focus and tracking servos use the laser beam as a source of error signal (although different photodiodes are used). To make it worse, TER is also used by the pickup motor as a fine speed control (that takes place in IC101). If TER is lost, both the radial tracking coil and the pickup motor have no control signals. Either condition can produce symptoms of improper tracking.

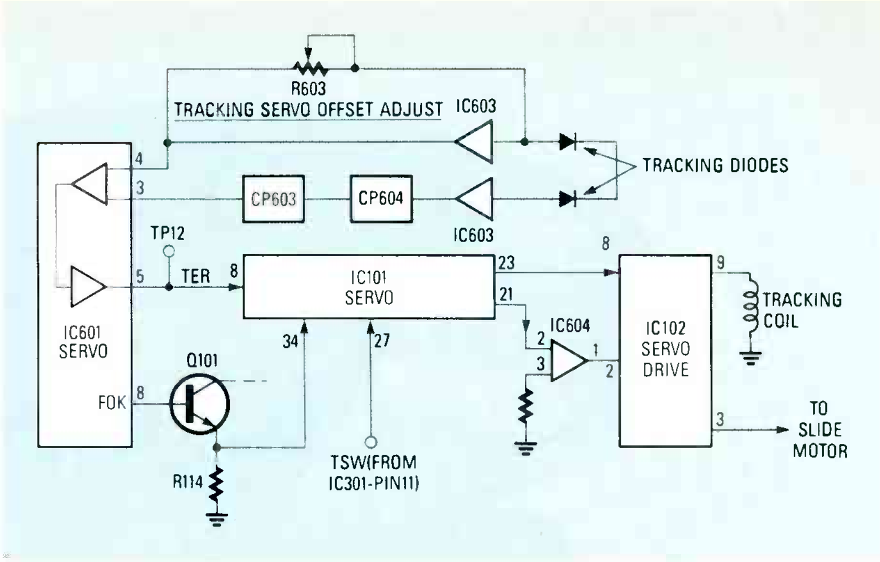


FIG. 30—BEFORE DECIDING that the servo IC (IC101) is bad, be sure that that all of the inputs to that device are okay (consult the service manual for the player for more details).

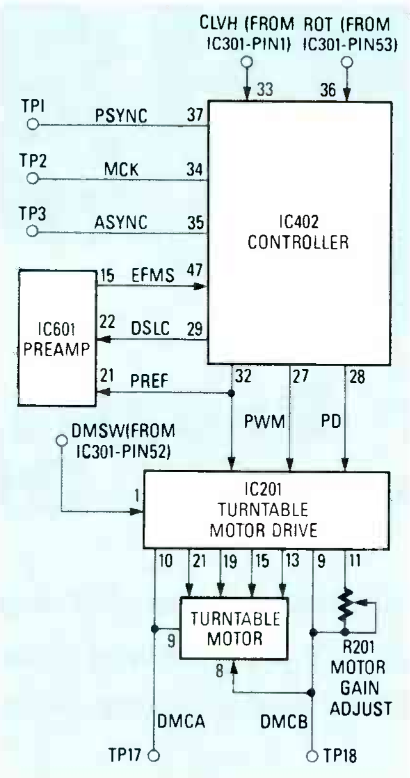


FIG. 31—WHILE IT'S EASY to tell whether or not a turntable motor is working at all, it is more difficult to determine whether or not it is working correctly. If not, use this diagram to find the cause.

First try to correct any tracking problems with adjustment. Next, make a quick check of the tracking actuator coil. Then see if the pickup moves to the inner limit when power is first applied. (That confirms that the pickup motor, reset circuit, and the basic servo is good.) If the motor and coil are good, and adjustments do not correct the problem, check the following:

Trace the TER signal from its source to the tracking actuator coil and pickup motor. (Note that TER is not applied to the pickup motor in all players.) If the TER signal does not reach IC102, IC101 is usually at fault. However, before you pull IC101, remember that IC101 must receive a number of signals before TER can pass. Two such signals are FOK and TSW. (In some players, the TER signals are also analyzed for errors in IC101.) If FOK or TSW are absent or abnormal, or if there are excessive errors in the TER signals, IC101 is cut off and TER signals do not pass. So always check the signals and voltages at the pins of IC101 (using the service manual values) before you decide IC101 is bad.

6. Disc motor (turntable) does not rotate properly. Figure 31 is the troubleshooting diagram. It is easy to tell if the turntable is not spinning, and you can usually pin down the cause of such total failure. For example, you can easily check for DMCA and DMCB drive signals to the motor windings. The problem is not quite that simple if the motor rotates, but you are not sure of the correct speed (especially since the motor speed is constantly changing). You must rely on waveform measurements and adjustments. So the first step in disc motor circuit troubleshooting is to perform the adjustments. However, before you decide there is a problem in the disc motor control circuits, consider the following.

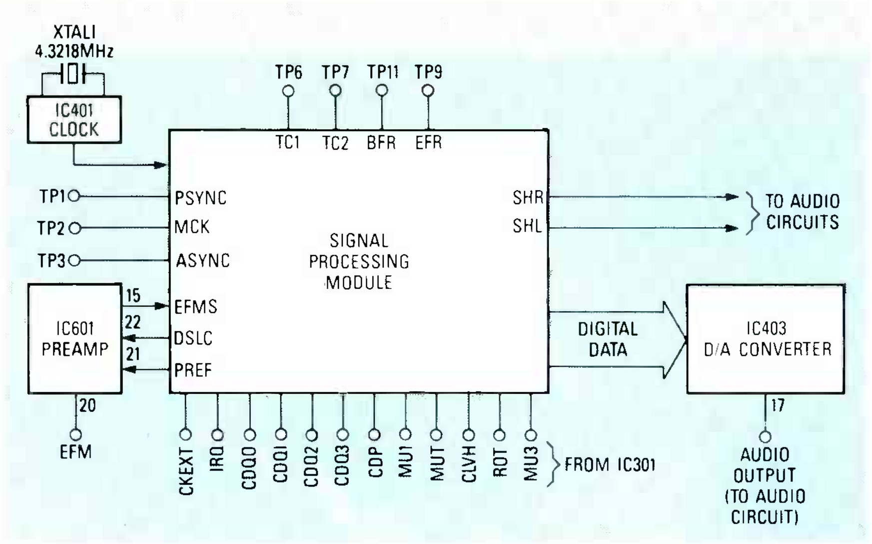


FIG. 32—A FAULTY signal-processing module can cause a variety of audio and motor-control problems.

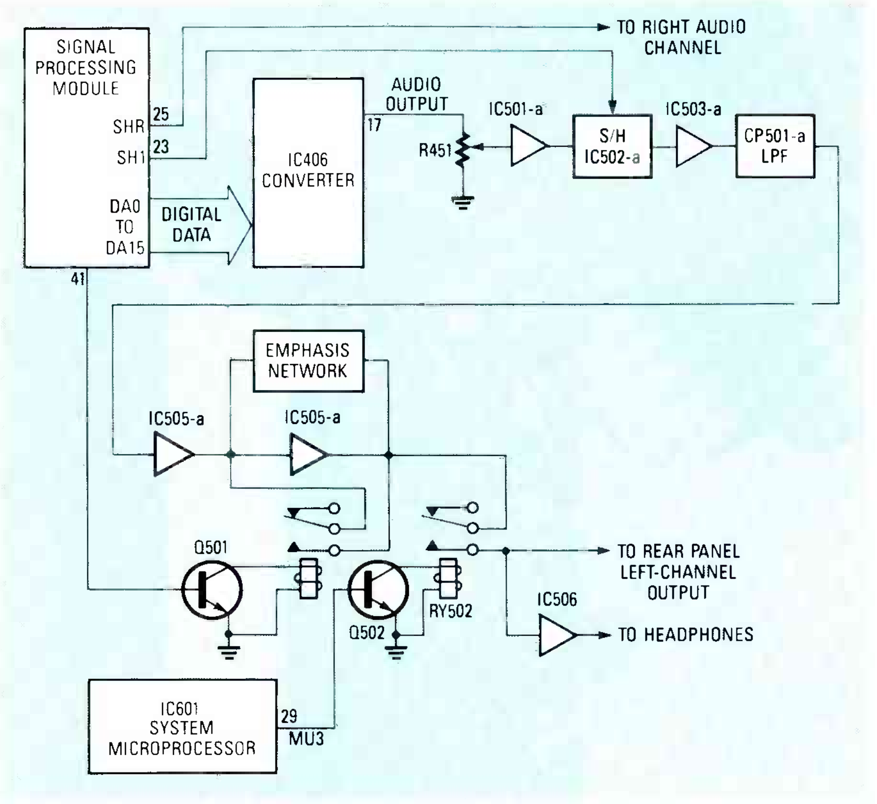


FIG. 33—WHEN TROUBLESHOOTING the audio circuits, be sure to check for an erroneous muting signal from the microprocessor. Such a signal can prevent the audio signal from reaching the unit's outputs.

The DMSW, CLVH, and ROT signals must come from the system microprocessor, IC301, before IC402 will apply disc motor signals to IC201. In most players, if IC301 does not get an FOK (and possibly a TOK signal) from the focus and tracking circuits, the DMSW, CLVH, and ROT signals are set to prevent IC402 and IC201 from passing the PREF, PWM, and PD signals to the motor. Typically, both DMSW and CLVH are made low to turn on the disc motor when PLAY is selected; and ROT goes low about one second later. If all three signals remain high after PLAY is selected, check for FOK and TOK to IC301. If only one of the three signals is abnormal, IC301 is most likely at fault.

If you get the DMCA and DMCB drive signals, and the motor is turning (indicating that DMSW, ROT, and CLVH signals are good), but you are unable to set the output levels as described, check all of the waveforms associated with disc motor control as follows:

Check PWM, PREF, and PD from IC402. If any are absent or abnormal, suspect IC402. Next, trace the signals between IC201 and the motor. Suspect IC201 if any or all signals are abnormal. If all signals appear to be normal (check the service manual for waveforms and amplitude), suspect the disc motor (probably the Hall elements, but possibly the windings).

Also note that PREF is applied to IC601, along with the DSLC signal from IC402, to form the EFMS signal, which is returned to IC402. If EFMS is absent, IC402 does not produce PREF, PWM, and PD signals. If EFMS is absent, you will also have several other problems. You can make a quick check of EFMS by comparing the signals at TP1 (PSYNC) and TP3 (ASYNC) using a dual-trace scope; both signals should be synchronized. If not, or if either signal is missing, suspect IC402.

In any player, the disc-motor control circuits are closely related to the signal processing circuits. A failure in signal processing can appear as a failure in disc motor control. So if you are unable to locate a problem in the disc motor, check the signal processing circuits.

7. Signal processing circuit problems. Figure 32 is the troubleshooting diagram. A failure in signal processing can cause a variety of failure symptoms in both audio and disc-motor control circuits. Likewise, a failure in system control can appear as a failure in signal processing. From a practical standpoint, there is no sure-fire way to tell if the problem is in signal-processing, system-control, disc-motor, or audio signals. However, there are checks that will help pin down the problem.

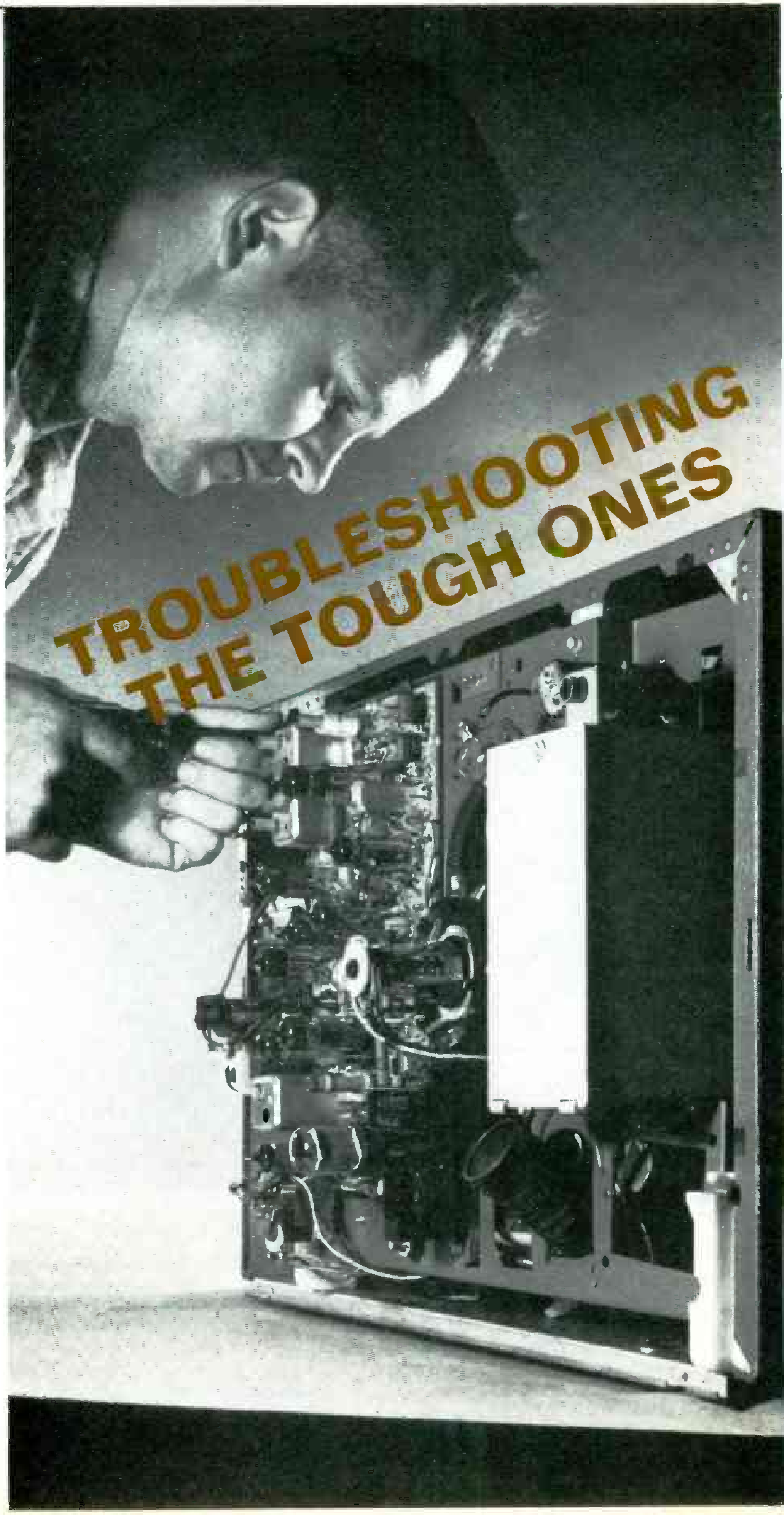
First off, check for audio at the D/A converter output (pin 17 of IC403). You should get both left and right-channel low-level audio. If you get no audio at that point, suspect signal processing. If there is measurable audio at that pin, the problem is likely in the audio circuits.

Next, if there are excessive audio dropouts, and the front-panel indications are not normal, the problem is likely in signal processing. Check all of the waveforms to and from the signal processing circuits shown in the service literature. Pay particular attention to the following (using Fig. 32 as a guide).

Check for a 4.3218-MHz signal at TP2 (MCK) of the signal-processing module. If that signal is missing, suspect the clock, IC401, as well as the signal-processing module itself. Check TP1 (PSYNC) and TP2 (ASYNC) for 7.35-kHz signals. The ASYNC should be present only during PLAY, but PSYNC should be available in both STOP and PLAY.

Make certain that PREF and DSLC are supplied to IC601, and returned to the signal-processing module as squarewave EFMS signals. If EFMS is missing, check

continued on page 78



TROUBLESHOOTING THE TOUGH ONES

ONE OF THE MOST ATTRACTIVE FEATURES of TV servicing is its similarity to detective work. One picks up a clue, and then forms a theory. He then follows that theory to its ultimate conclusion. If, along the way, he finds that the direction he's going in is not bringing him closer to a solution, he studies the case again, picking up another clue that may take him in a different direction. Like a good detective, if the technician stays with the "case" long enough, he will eventually "catch the culprit." Some may feel that the preceding metaphor streteches the point a bit, but anyone who's been faced with a particularly difficult troubleshooting problem will tell you that it is appropriate. Let's look at a few examples.

Some TV troubleshooting problems can drive even an experienced technician crazy.

FRANK A. SALERNO

A change in direction

Our first example deals with a Zenith 19CC19Z chassis with an open 2.7-amp fuse. When a new fuse was installed, and the set turned on, the 19CG3 damper-tube plates began to glow red. That, of course, meant that the tube was drawing heavy current. The plug was quickly pulled, but not before the fuse had blown again.

Some preliminary checks revealed that the 24-volt Zener diode, CR212 (see Fig. 1), was shorted. That diode is supposed to keep the 24-volt supply at a constant level. That finding lead to the theory that, since there was no 24 volts, the horizontal oscillator became disabled, causing excessive current flow through the output tube, resulting in an overheating damper tube.

Confidently, the Zener diode was changed and the set turned on. Naturally, the 19CG3 began to glow red again, and in short order, the fuse blew. Oh, yes, the new Zener was also gone. With that, the set was taken to the shop.

Once there, the first step was to see what was going on in the 24-volt supply. After removing the Zener, a voltmeter was clipped to the 24-volt line. At turn-on, the meter read 24 volts and continued to do so until the tubes warmed up and began to conduct. As the damper developed its first blush, the meter moved up to 26 volts. As the glow deepened, the meter moved higher and higher. At 32-volts, the plug was yanked to prevent any further damage.

It was obvious that we would need to follow a different path to track down the cause of the failure. Our tests revealed that it was not the 24-volt supply that was draining the output circuit. Instead, something in the damper circuit was driving up the 24-volt line. Investigating further, a low resistance reading from the 19CG3 cathode to ground turned up a shorted pincushion transformer. What was apparently happening here was that the saturated current in the main B + supply created a higher AC input to the 24-volt supply. A new transformer corrected the problem.

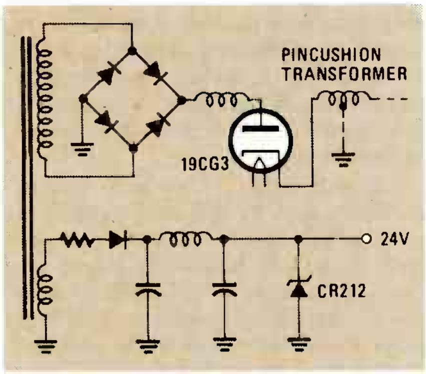


FIG. 1—THE 24-VOLT ZENER, CR212, in this set was repeatedly blowing. The cause turned out to be a shorted pincushion transformer.

Short picture

A Sony KV1201 demonstrated that the smoke and the fire can sometimes be in two different places. The set lacked vertical size, showing just a third of the picture across the screen; no foldover, no distortion—just a short picture. The first step, of course, was to take voltage measurements. Those measurements showed just the opposite of what was expected. The voltages on the collectors of both the driver and the bottom output transistors were almost twice what they should have been. That seemed odd since in a case of insufficient sweep you would expect lower than normal voltages, not higher than normal ones. Nevertheless, tracing back to the source of those two voltages led to the regulated 130-volt supply, which was also reading high. The cause was a shorted regulator transistor.

Putting in a new regulator brought these questionable readings back to normal, but it had no effect on the picture size. Considering what we've just said, that was not too surprising a result.

Next, an oscilloscope was used to take measurements around the driver and output transistors. The measurements matched those called for on the schematic: 115-volts p-p at the driver collector and 125-volts p-p at the input to the deflection yoke. Yet, though those two readings were fine, the picture was far from it.

Suddenly, a thought occurred. It was true that the two key waveforms viewed before were right on the button, but those tests were performed with both the height and linearity controls cranked up to their maximum. Where was the reserve power? It was time to take a closer look at the oscillator. That stage is independent of the two controls. Sure enough, though the schematic called for 4.5-volts p-p at the collector, the reading there was only 2.5-volts p-p. DC voltage at the collector should have been 13; the reading was 7. Tracing those voltages back led this time to the 18-volt scan-derived supply. It was low, and for good reason—the 18-volt rectifier was open (see Fig. 2).

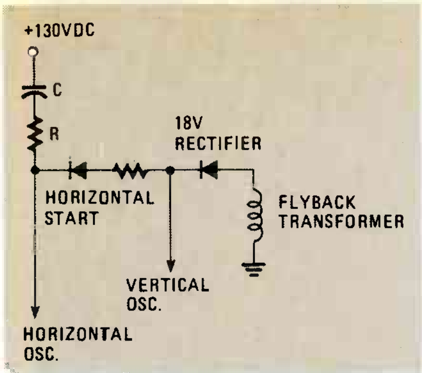


FIG. 2—THE OUTPUT OF THE 18-volt rectifier is used to keep the horizontal oscillator running after turn on.

Briefly, the scan-derived supply works like this: At the moment that the on-off switch is turned on, a voltage pulse that is sufficient to get the horizontal oscillator going is generated. The output transistor then amplifies the oscillator signal, causing the flyback transformer to generate high voltage pulses. Several of those pulses are tapped off the flyback and rectified. Those rectified voltages are then used to supply power to different sections of the receiver.

The 18-volt rectifier is a critical component in this case because its output is fed back to the oscillator to sustain operation. Without that 18 volts, the oscillator will not operate because the pulse that gets it going in the first place is there only at turn on.

The wayward capacitor

Our next case deals with an RCA CTC97 whose horizontal frequency was way off, causing a loss of sync. While that could be caused by an oscillator problem, there is another possibility. In many RCA models, when there is an excessive high voltage condition, an overvoltage protection circuit goes into conduction and throws the oscillator off. The circuit is put there to satisfy HEW regulations limiting X-ray exposure. Should the high-voltage (nominally about 26 kilovolts) go too high, causing excessive radiation, the circuit renders the TV inoperable.

To isolate the cause of the problem, the protection circuit needs to be disabled. That is done by shorting point A (see Fig. 3) to ground. If doing so restores the horizontal sync, it is safe to assume that the set is in overvoltage shutdown. In the case under discussion, sync was not restored, so the oscillator circuit itself was suspect.

Using that magnificent piece of test equipment in a can, circuit cooler, the AFC transistor was sprayed. Instantly, the picture slid into place. A replacement transistor was installed, the set was tested for a day, and then delivered.

As you might guess, two days later the set was back. In the shop, the same routine was followed. After first clearing the protection circuit, the AFC transistor was sprayed with circuit cooler and again, without a moments's hesitation, the picture locked right in. This time, a direct RCA replacement was used.

After two days of testing and two more days in the customer's home, the set was back a third time. Now, though, the AFC transistor was not so compliant. Instead, it seemed that everything had become temperature sensitive. This was one of those times that circuit cooler would not do the trick.

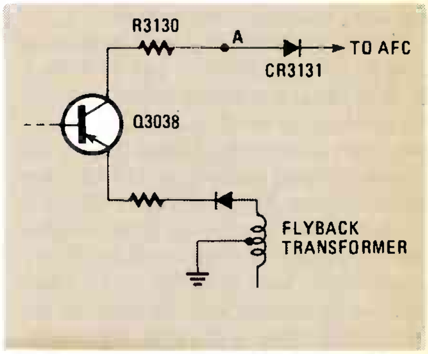


FIG. 3—THIS SHUT-DOWN CIRCUIT cuts off operation in the event of an excessive high-voltage condition.

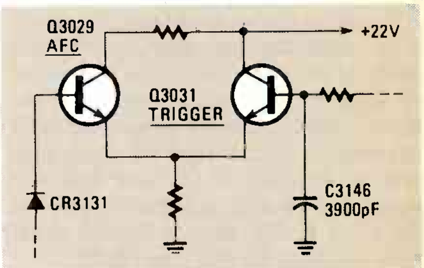


FIG. 4—THROUGH TRIAL AND ERROR, capacitor C3146 was found to be the one that most affected frequency. Replacing it cured the problem.

Instead, it was time to resort to the process of elimination. Studying the schematic, those capacitors that would most affect frequency were singled out. By bridging each one in turn with a separate low-valued unit, the most critical one was found to be C3146 (see Fig. 4). As that was as good a place to start as any, that capacitor was replaced. The set has worked fine ever since. **R-E**

CD SERVICE

continued from page 75

for high-frequency EFM signals at pin 20 of IC601.

Check all signals (ROT, CLVH, etc.) between IC301 and the signal-processing module as shown in Fig. 32. It is not practical to analyze the waveforms of those signals. However, if you can view a data stream on each line with a scope, it is reasonable to assume that the signal is correct. If one or more of those signals is missing, suspect IC301, the signal-processing module, or both. Remember that a signal from IC301 can depend on a signal from the signal-processing module, and vice versa. So you may have to replace both the IC and the module to find the problem. Also remember that IC301 may not produce the required signals unless FOK, TOK, etc., are applied to it.

Before you pull the signal-processing module, check TP6 (TC1) and TP7 (TC2). Both of those test points (which indicate the accuracy of the C1- and C2-decoding processes within the signal-processing module) should produce a 7.35-kHz signal during stop, but then drop to 200 Hz or less when PLAY is selected. If not, suspect the signal-processing module. Next, check TP11 (BFR) and TP9 (EFR) which indicate the accuracy of the sync and detection functions within the signal-processing module. During PLAY, BFR should always be zero, except during groove skipping. During PLAY, EFR may produce a signal, but at a frequency below 50 Hz.

8. Audio circuit problems. Figure 33 is the troubleshooting diagram. The first check of the audio circuits is to monitor the output of the D/A converter (pin 17 of IC406). Next, check the sample-and-hold SHR and SHL signals from the signal-processing module. If the SHR and SHL signals are present, and there is audio at pin 17 of IC406, trace the audio signal from IC406 to the rear-panel jacks.

Also look for any muting or emphasis signals from the system microprocessor, IC601, and/or the signal-processing module. For example, if MU3 from IC601 is low, Q502 does not conduct, and RY502 remains open. That prevents audio from passing to the output.

Operating problems

We will not go into programming and operating problems in this article. Such problems usually start with the system microprocessor, or possibly the front-panel wiring. For example, if you press PROGRAM, REPEAT,, etc., and the player does not respond properly, check that the system microprocessor is receiving the command from the front-panel switch or button. If not, check the switch and wiring. If the command is received, suspect the system microprocessor. **R-E**

VIDEO TITLER

continued from page 66

pattern byte. Table 4 lists the color codes.

Sprites

Sprites are generated using two tables: the *sprite attribute table* and the *sprite pattern generator table*. The sprite attribute table can contain 32 entries; each entry requires 4 bytes of information. Those 4 bytes are shown in Fig. 25.

The vertical position (Y) of the sprite, which has a value from 0 to 191, is referenced to the upper left pixel. If a value from −31 to −1 is placed in the vertical-position byte, the sprite will appear to bleed down from the edge of the border. A value of 201 (DØH) in the vertical position will blank out the sprite. The horizontal position (X) of the sprite, which has a value from 0 to 255, is also referenced to the upper left pixel.

The color of the "1" bits in the pattern are determined by the least significant nybble of byte No. 3 of the *sprite attribute table*.) The "0" bits in the pattern are always transparent. If the MSB of byte No. 3 is set, the entire sprite will shift 32 pixels to the left to allow the sprite to bleed in from the left border.

Byte No. 2 of the sprite attribute table contains the name (relative address) of the sprite pattern map (which is stored in the sprite pattern table). The sprite pattern map requires 32 bytes to define each sprite.

Sample BASIC program

Now that you know the basics of the VDP and sprites, you can write a BASIC program to manipulated a VDP image. The listing in Table 5 is a sample BASIC program that will help you understand how to do it. The program initializes the VDP in Graphics mode II with the register data in Fig. 22. Video RAM mapping is shown in Fig 23.

The program loads sprite data for three 16 × 16-pixel sprites into the sprite pattern table. And three sprites are manipulated in such a way that a man appears to run across the screen.

As you may have already realized, there are a variety of things to do once the VET and home computer are connected. Your imagination is the only limit. The best approach is to experiment with PEEKs and POKEs to create images. Use the program we presented as a base and expand it as you learn more about how the VDP works.

The titler can really dress up your home videos and be a tremendous outlet for creativity. With the help of the Texas Instruments *VDP Programmers guide* that we mentioned earlier, and a little experience, you can superimpose images that you never thought possible. **R-E**

PC SERVICE

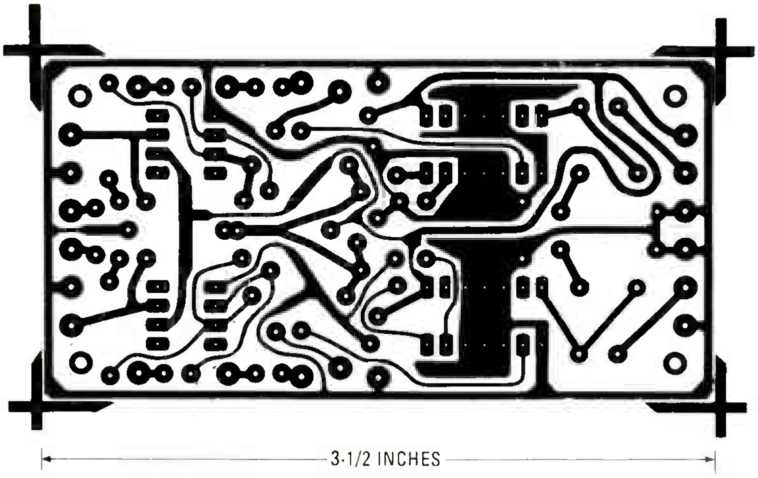
One of the most difficult tasks in building any construction project featured in **Radio-Electronics** is making the PC board using just the foil pattern provided with the article. Well, we're doing something about it.

We've moved all the foil patterns to this new section where they're printed by themselves, full sized, with nothing on the back side of the page. What that means for you is that the printed page can be used directly to produce PC boards!

Note: The patterns provided can be used directly only for *direct positive photoresist methods.*

In order to produce a board directly from the magazine page, remove the page and carefully inspect it under a strong light and/or on a light table. Look for breaks in the traces, bridges between traces, and in general, all the kinds of things you look for in the final etched board. You can clean up the published artwork the same way you clean up you own artwork. Drafting tape and graphic aids can fix incomplete traces and doughnuts, and you can use a hobby knife to get rid of bridges and dirt.

An optional step, once you're satisfied that the artwork is clean, is to take a little bit of mineral oil and carefully wipe it



GET ROOM-FILLING SOUND from your walkman-type player with our easy-to-build amplifier. The board for the project, which begins on page 59, is shown here.

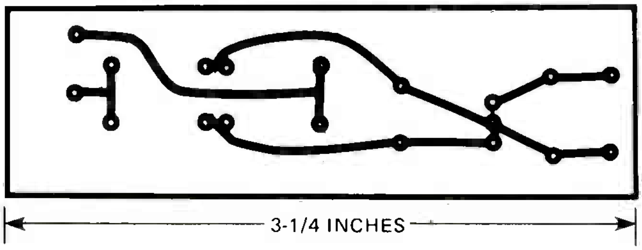
PC SERVICE

across the back of the artwork. That helps make the paper transluscent. Don't get any on the front side of the paper (the side with the pattern) because you'll contaminate the sensitized surface of the copper blank. After the oil has "dried" a bit—patting with a paper towel will help speed up the process—place the pattern front side down on the sensitized copper blank, and make the exposure. You'll probably have to use a longer exposure time than you are probably used to.

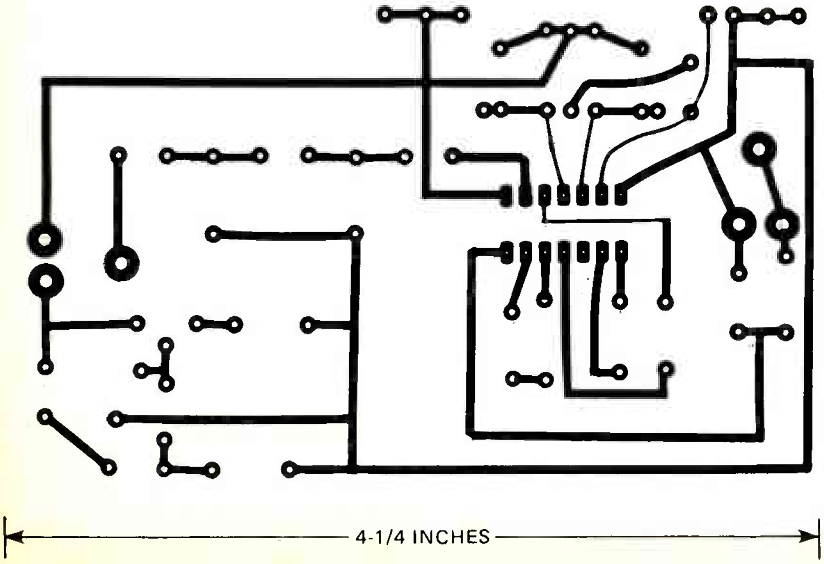
We can't tell you exactly how long an exposure time you will need but, as a starting point, figure that there's a 50 percent increase in exposure time over lithographic film. But you'll have to experiment to find the best method for you. And once you find it, stick with it. Don't forget the "three C's" of making PC boards—care, cleanliness, and consistency.

Finally, we would like to hear how you make out using our method. Write and tell us of your successes, and failures, and what techniques work best for you. Address your letters to:

Radio-Electronics
Department PCB
500-B Bi-County Blvd.
Farmingdale, NY 11735



USE THIS BOARD for the power supply required by our stereo-TV decoder.



HEAR YOUR FAVORITE TV SHOWS in stereo with our stereo-TV decoder. The main board is shown here; the story begins on page 51.

SATELLITE TV

BOB COOPER, JR.
SATELLITE TV EDITOR

It's Kate—bar the door!

EVER SINCE THE BIRTH OF HOME SATELlite TV in 1979, there has been a persistent problem with the quality of TVRO products. The victim has usually been the consumer, but dealers have certainly suffered, too. And the reason is simply that equipment often fails to work as it should.

That problem has been getting worse, recently, since a number of semi-important equipment suppliers have collapsed. Collapses like that leave consumers with no factory-supported warranty service. So, to protect themselves, TVRO dealers have been requesting that receiver and actuator suppliers provide at least a schematic diagram for every unit they sell.

But many manufacturers have resisted honoring those requests; apparently, they fear that valuable trade secrets might leak out if schematics were distributed on a widespread basis. But withholding schematic diagrams offers no real protection. Any marginally-talented circuit copier would need no schematic, and the amateurs who do require schematics pose no real market-share threat.

Now dealers have reached the point where they are demanding schematics from OEM's if the dealers are going to handle that OEM's products. Some dealers have been burned so many times by collapsing OEM's that they simply won't handle a new product unless they're provided with a schematic and some basic service information. And that is understandable.

Problem components

Antenna actuators have been the source of most product failures through the years. By the actuator, I'm referring to both the motor drives that mount at the antenna to "jackscrew" the dish through the satellite orbit belt, and the indoor controller that gives the actuator directions about when and where to move.

FIG. 1

TVRO dealer "Starter Kit" available

Bob Cooper's *CSD Magazine* has arranged with a number of TVRO equipment suppliers to provide a single-package of material that will help introduce you to the world of TVRO dealership. A short booklet written by Bob Cooper describes the start-up pitfalls to be avoided by any would-be TVRO dealer, in addition, product data and pricing sheets from prominent suppliers in the field are included. That package of material is free of charge and is supplied to firms or individuals in the electronics service business as an introduction to the 1984/85 world of selling TVRO systems retail.

You may obtain your *TVRO Dealer Starter Kit* free of charge by writing on company letterhead, or by enclosing a business card with your request. Address your inquiries to: *TVRO STARTER KIT, P.O. Box 100858, Fort Lauderdale, FL 33310.* That kit *not* available to individuals not involved in some form of electronics sales and service.

Typically, those two parts are sold together, but they are seldom built by the same manufacturer. Most actuator builders concentrate their talents on the controller and go to outside sources (like Saginaw) to acquire the linear-actuator portion. The controller and the actuator are then integrated in the field by the installing dealer, who connects the motorized jackscrew between the fixed and the moving portions of the dish—the post mount and the reflector surface, respectively.

There has never been an attempt to standardize that connection, so every designer creates his own installation scheme. And the problem is compounded for the dealer by the wide variety of antennas, no two of which has the same mounting scheme.

We see the importance of the actuator-dish interconnection scheme when an antenna system is subjected to severe pressure from wind, rain, and ice. There are about 50 manufacturers of home-style TVRO antennas, but only a handful of those manufacturers publish wind-tunnel test data for their antennas, and those tests are often conducted using non-comparable techniques. The bottom line is that the antenna is a major portion of a TVRO system's cost, but the structural strength of most commercially-sold devices is unproven.

The big blow

A late-season storm, Hurricane Kate, originated north of Puerto Rico in mid-November, 1985; Kate provided us with some interesting data on the strength of several antenna-mount systems.

For more than six years, this writer has been conducting extensive TVRO-systems research in a little-known former British colony, the Turks and Caicos Island. Hurricane Kate cut directly across that isolated island with winds between 105 and 110 miles per hour for more than 4½ hours. Our antenna test range had 25 operating antennas before the storm hit. Most antennas suffered extensive damage; only 2 of those 25 antennas, shown in Fig. 1, functioned normally after Kate had gone. We learned several things from that storm, including:

- Antenna mounts are the weak link in present antenna designs. Dealers who have been pushing antenna manufacturers to produce light-weight mounts out of thin material have been asking for the wrong thing.
- A well-designed, properly-installed mesh antenna takes a beating better than a solid antenna. However, a poorly-designed, improperly-installed mesh antenna will suffer damage just as extensive as will a solid type.
- Motor drives—neither the older linear-actuator style nor the newer horizon-to-horizon direct drives—cannot provide the required "braking power" to keep an antenna from moving in hurricane-force winds.
- Metal fatigue (caused by antenna parts being "beaten to death" when supports break and allow the antenna to free-wheel in the storm) may be the least-understood element in antenna failure. One-inch steel bolts and ¼-inch-thick steel washers are simply sheared off after being beaten repeatedly against other antenna parts.

Several years ago, one supplier of mesh-style antennas—Paraclipse—conducted wind-tunnel tests with their twelve-foot antennas. The wind turbines produced winds greater than hurricane force (over 75 miles per hour), and then, to properly simulate actual conditions, thousands of gallons of water were poured into the wind turbines. A handful of antenna suppliers copied those tests, and all reported that their antennas had passed those tests. Paraclipse created an advertising campaign that highlighted the rigors of their testing, but that campaign graciously neglected to pan some of the solid metal and fiberglass antennas that failed those tests. I won't be so generous.

Two that passed

As we said above, when Kate headed away from the Turks and Caicos, we found that only two antennas (out of 25) still worked properly. More than half of those that were totally destroyed; most of the others were eventually put back into service after replacement parts arrived.

The two fully-operational antennas after the storm were both Paraclipse models: a 16-footer and a 9-footer. Both antennas have substantial mounts—not simple pipe mounts—and both have horizon-to-horizon drives. And that drive mechanism is significant.

The idea behind the horizon-to-horizon drive is that, rather than pushing or pulling on the dish with an in-line jackscrew, the dish is driven from one horizon (east) to the opposite horizon (west) with a chain, belt, or hydraulic gear system.

The linear actuator allows the dish to cover only about 50% of the Clarke Orbit Belt. The linear actuator, then, has finite limits: typically, when the dish is nearly straight up (due south) at one end of the range of travel, and close to the western horizon when the dish is at the opposite end of travel.

Linear actuators typically have a continuous-gear threaded rod that is driven by a small, often plastic, gear wheel. Under the extreme pressure of a hurricane, the dish can actually force the threaded rod to turn, even though no electricity is applied to the motor. When the linear actuator is pushed to one end or the other, wind pressure continues and all its force is absorbed by the gear-wheel teeth.

The gear teeth then break off, so the antenna is free to flap in the wind. It flaps back and forth, eventually breaks off, and then slams into the ground, the post mount, or the concrete pad, where it is usually destroyed. When the storm ends, the antenna has been beaten to a pulp; and the motor system, the mount, and everything else associated with the antenna are all unrepairable.

We had four horizon-to-horizon antennas operating before the storm. Two of those not only survived, but were still accurately aimed when the storm moved on. Of the other two, one (a 20-foot ADM) survived with only minor damage to the hydraulic drive system. As best we can reconstruct, the hydraulic system acted as a high-tension safety brake on the motor drive. Even under 100-mile/hour winds, it only allowed the 20-foot solid antenna to slip gradually across the belt.

Our fourth horizon-to-horizon antenna was totally destroyed because a part of the concrete-pad anchoring system failed. That allowed the antenna to break loose and flip backward in the winds. Once it had been ripped from the concrete pad, the antenna beat itself to death on that pad.

Other antennas also failed through no fault of their own. A sixteen-foot heavy-duty (USS) fiberglass antenna, for example, failed because we apparently selected an anchoring system that was weaker than the antenna's mount. The winds simply got behind and under the antenna and literally pried it out of the concrete pad by yanking the lag bolts out of the concrete.

Looking back, those 3-inch long × ¾-inch-diameter "lags" should have been ¾-inch bolts imbedded into the concrete pad at least 12 inches with rebar (steel) supports attached to the heads of the bolts.

Next month we'll share some conclusions on antenna integrity with you; we'll also make some recommendations on how you can protect yourself from antenna failure when your antenna is subject to severe winds and other heavy loading conditions. **R-E**

SERVICE CLINIC

Voltage regulators

JACK DARR
SERVICE EDITOR

BY MURPHY'S LAW, "ANYTHING THAT can go wrong will go wrong," and voltage regulators are no exception. Most solid-state sets have voltage regulators, so we've got to be able to troubleshoot them. Fortunately, voltage regulators aren't really complicated, so they're easy to fix by following standard troubleshooting procedures and the hints I'll give below.

A regulator can be a single IC, or it can be built from discrete components. Either way, it's easy to check if it's working properly. Assuming that the input voltage is correct, all you have to do is measure the regulator's output voltage. If it isn't exactly what the schematic calls for, you've got trouble. If you measure no output voltage, another component may have shorted the output line, so don't automatically assume that the regulator is bad.

If the output appears to be shorted, disconnect the regulator's output from the rest of the circuit and then measure the regulator's output voltage. If it's not what it should be, the regulator is almost certainly bad. But if that voltage *is* what it's supposed to be, connect a low-value power resistor across the output, and then measure the voltage. If it's still within specifications, the regulator's OK, and something else in the circuit must be gumming things up.

To get an overall idea of how well your regulator does its job, plug your TV into a Variac. Then monitor the regulator's output voltage as you vary the line voltage from 90- to 125-volts AC, the usual range of line-voltage variation. If your regulator holds the voltage constant over the whole range—connected to the load or not—it's probably good, so your troubles must be elsewhere!

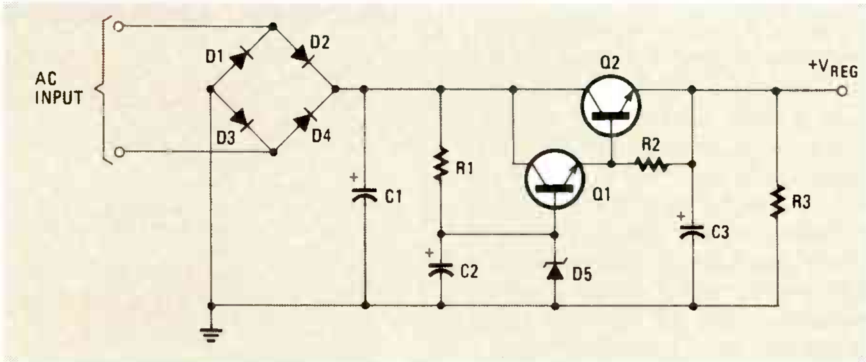


FIG. 1

However, if the regulator follows the line-voltage variations, your trouble is in the regulator circuit, so you'll have to troubleshoot it. And that means you'll have to know how it works.

Any voltage regulator—discrete or integrated—is really quite simple. It uses a power transistor as a "pass element," and a small-signal transistor as a "sense" element. The sense element monitors the output voltage, and if that voltage drops below a reference value, the sense transistor feeds more base current to the pass transistor, and that increases output voltage. Sophisticated power supplies disable output if the load tries to draw too much current.

As shown in Fig. 1, D5 is a Zener diode that provides a reference voltage for sense transistor Q1. That transistor controls the current fed to Q2's base, hence Q2's collector-emitter current, which indirectly controls output voltage.

To troubleshoot a 3-terminal regulator (like the ubiquitous 7805), about all you can do is measure input and output voltages. To troubleshoot a discrete voltage regualtor, measure the DC voltage on every terminal of every transistor in the circuit. If a transistor has the same voltage on its base, emitter and collector (or any two of those terminals), it's almost certainly shorted! Replace it and retest the circuit. A leaky transistor can really mess up the whole circuit, so check all transistors for leakage. Leakage in the pass transistor is especially troublesome.

Symptoms

What would cause you to suspect a bad voltage regulator? Parasitic oscillation, too much gain, or too little gain can all be traced to a faulty voltage regulator. You're liable to get oscillation or too much gain if the regulator's output voltage is too high; on the other hand, too little gain might be caused by an output voltage that is too low. Try the Variac test; the output should remain steady; that's what the regulator is for!

Look for a component in the regulator that doesn't act in a normal fashion. For example, in normal operation the voltage at Q2's base should vary, but not the voltage at its emitter. If you suspect the pass transistor, check it, especially for shorts and leakage. You'll probably have to remove the transistor from the circuit to make a valid test.

Another problem you might run into is a bias resistor that has drifted off-value. Or the Zener diode (or other voltage reference) may have gone bad. How do you check a Zener diode? It's easy: just measure the voltage across it. If that voltage is not what the schematic calls for, the diode is probably bad. Replace it with one that has the correct voltage rating and measure the voltage across it again. You'll find Zener diodes with values ranging from a few volts all the way up to 115 volts. Be sure to get the correct value, or you'll have more problems than you started with.

Another potential problem component in a voltage regulator is a voltage-dependent resistor (VDR). If the voltage across a VDR is correct, the VDR is probably OK, but if it's incorrect, try a new one.

All in all, regulators aren't too hard to fix. Use the procedures recommended above, and, above all, *think* about what the problem could be. You'll figure it out! **R-E**

SERVICE QUESTIONS

WHAT A YOKE!

In an RCA CTC-76, I've got what looks like a yoke problem, and it's intermittent, of course! The raster gives a keystone effect: narrow at the bottom; wide at the top. But it never stays on screen long enough to trace it. Rapping the chassis above PW400, which is the motherboard for the vertical and horizontal circuit boards, makes it disappear. I soldered all of the mounting points; we had trouble with bad grounds in several of those chassis. No luck. One symptom guide suggests it may be R404, a 100K resistor in the base circuit of the error amp, Q404. That resistor is a flameproof type, and I always thought that those were supposed to open—not change in value or go intermittent ! What do you think?—P. H., Herndon VA

I've never seen any part that *couldn't* be intermittent! Try replacing it and see what happens!

SIMPLE CURE FOR BURNT RESISTOR?

I've got a Sears 564.417700400. Resistor R250 burns up as soon as power is applied to the set. I've replaced several parts without help. Any ideas?—H. J., Castalia, OH

Yes. A resistor burns up because there's too much current flowing through it. Since it burns up before anything else has a chance to warm up and draw current, it probably has the full B+ across it, so the short must be on the load side. Maybe it's a solder-bridge, or even a wiring short somewhere. In any event, the cause of the problem should be easy to find. **R-E**

ANTIQUE RADIOS

Early radio history

RICHARD D. FITCH
CONTRIBUTING EDITOR

LAST TIME, WE BEGAN OUR LOOK AT THE early history of radio. This month we'll move into the 20th century and finish up that discussion.

The 20th century

There were many important inventions in the early part of this century. Crystal detectors—the first semiconductor diodes—were invented in 1906. The two-electrode tube was invented by Fleming (in England, where the device was, and still is, known as a valve) in 1904, and the triode (also called an audion) was invented by de Forest in this country in 1906. Actually, neither Fleming nor de Forest invented the first electronic tube. Sir William Crookes, a British electrical engineer, built an experimental tube in 1870. There were probably ten experimental tubes that preceded the Fleming valve, although the names of their inventors are lost forever. So, in the minds of many, Fleming receives credit for being first.

The United States Navy was one early radio pioneer. As far back as 1907 the USN had a radio station at Anacostia. Music and official messages were broadcast to the U.S. fleet on world tour in 1907. However, the Navy had been communicating with amateurs for many years, possibly as far back as 1900–1902.

Regular broadcast stations were a reality in Europe before they were in the U. S. Radio broadcasting was demonstrated at the Dutch Trade Fair in 1919. Many radio components had to be imported.

The roaring '20's

Before 1920, amateurs and experimenters always built their own radios. They talked, listened, or both to anyone who was on the air. Imagine the thrill of an early experimenter when he made contact with another experimenter, or heard a foreign broadcast. Kids who grow up these days taking radio and TV for granted can hardly appreciate that thrill.

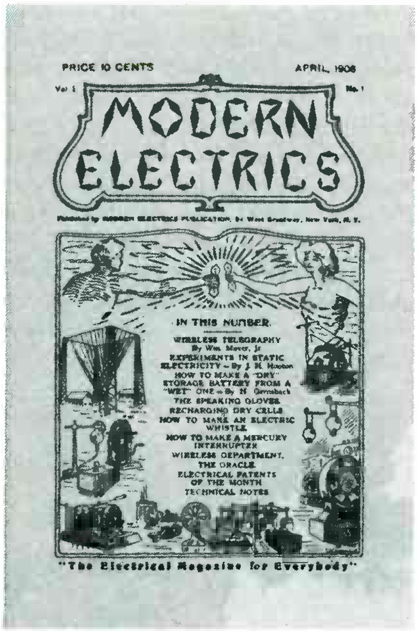


FIG. 1

I think it's fair to say that broadcast radio got its biggest boost in the 1920's, when Westinghouse station KDKA in Pittsburg broadcast election results. Of course, irregular broadcasts were already present, else there would have been no need for a commercial station. Before those historic broadcasts, many radios were purchased just to hear music broadcast by Dr. Conrad.

By the 1930's regular broadcasts were well established. Many of the technical problems that had plagued early broadcast radio were being eliminated. Radio was well commercialized, and politicians were beginning to recognize that radio was a powerful propaganda medium.

Technical innovations

By 1921 alternatives to the inevitably annoying earphones were found. For example, a megaphone was placed over an earphone, and—instant loudspeaker. Improvements in tube construction did much for the quality of both transmitters and receivers. Also, power increased throughout the 1920's, and a dramatic improvement in microphone quality also helped signal quality. The importance of acoustics in the station's studio was recognized and given as much importance as purely electronic matters.

At the receiving end, the automatic volume control (AVC) circuit made its appearance. And the increased use of standard AC power was a big help to radio manufacturers. Problems with hum were overcome, and more and more sets developed all of the required voltages (A, B, and C supplies) from the standard "light socket."

Oldtimers tell me that radio stations had to go off the air when an S.O.S., or other emergency, was broadcast from a ship at sea. Those stations had to monitor ship traffic on nearby frequencies so that their regular broadcasts wouldn't interfere.

Regulating agencies

Arbitrating interference prob-

VOL. 3 NO. 3 March 1986

COMPUTERDIGEST

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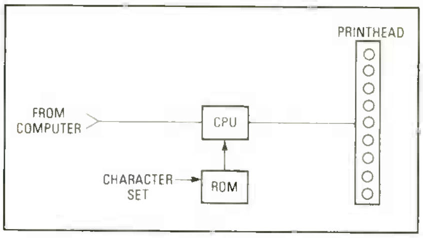
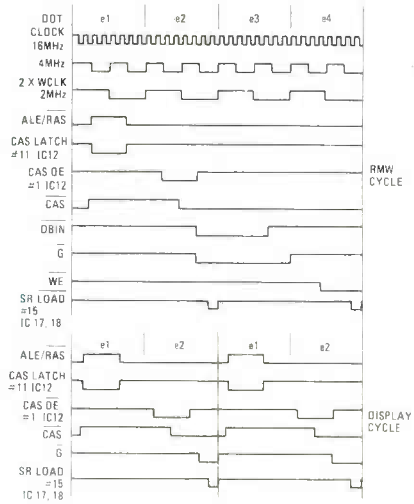


See Page 8

Vol. 3 No. 3 March 1986



See Page 14

ON THE COVER

Hold the cover of this issue to your ear. Do you hear anything? Well, maybe the new P5 Printer from NEC really isn't that quiet, but at 48 dba in the quiet mode, it's got to impress you! See page 8 for more printer info.

COMING NEXT MONTH

What's actually required in the way of preventive maintenance for your computer? It's all spelled out in an informative article. We'll have an article on Packet Radio. And you'll find part 3, the finale, for the Grafex-32.

EDITORIAL

You've got to sacrifice...

■A friend of mine recently put his old IBM Selectric out to pasture and bought his first computer to use for word processing. He got a keyboard, a monitor, a printer and a modem along with a dual-disk drive. Now he was all set. As a professional author, he could do all his inputting on the computer, get a hard-copy printout, and shoot the copy in via modem to his publisher. His output increased, and he was very happy about the whole thing.

His wife, like so many people who aren't familiar with computers, actually resented this electro-mechanical interloper. All she knew about computers was that they were good for "playing games" and this one wasn't even used for playing games. She saw absolutely no value in the computer for herself. No value whatever.

One morning, she was on the phone with a friend who offered to give her a new and lengthy recipe. "Wait," she said, "I'll get a pencil and write it down."

Her friend, now faced with a long period of slowly reciting a dull recipe spoon-by-spoon over the phone, asked "Doesn't your husband have a computer?" She said he did, but she didn't know how to use it. The friend came over at once.

It took a quick call to my friend at his office to get the necessary password and some simple instructions, and they went into the room where the computer was, turned it on and booted up. "When the phone rings, just push this, okay?" and the friend left.

A minute later, the phone rang, the button was pressed, and the printer ran off the recipe. The last line read "Now pick up the phone." My friend's wife did so, and was told by her friend to wait, she'd be right over.

A lot of practical information was exchanged, and now my friend's wife sees the computer more as a friend than an enemy. She's got a bookful of her pet recipes stored on disk. On another disk she's got the kids' medical and school records. She keeps records of periodic car maintenance, and the computer has made her so efficient, she doesn't know how she ever got along without it until now.

A lot of the advertisers talk about their computers being "user friendly." But before anybody—or anything—can be friendly, it's got to be introduced.

Byron G. Wels

Byron G. Wels
Editor

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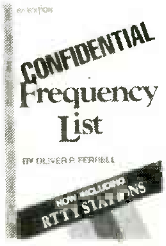

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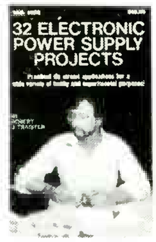

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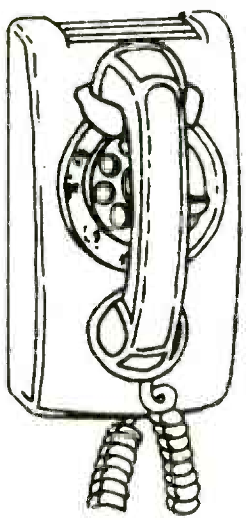

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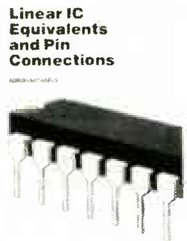

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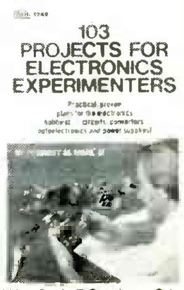

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SOFTWARE REVIEW

The Little Black Book.

■Actually, there would really be no need for this product... No need at all. Provided that you could as easily slip your entire computer into your breast pocket. But short of that, you're going to find The Little Black Book from Cygnet Technologies (1296 Lawrence Station Road, Sunnyvale, CA 94089 (800) 621-4292) the handiest peripheral you've bought for your computer since you decided to add a monitor!

This is an idea whose time has come.

Chances are that one of the first things you thought to do was put your telephone directory into your computer. Now you can run a printout of that directory on ordinary computer printout paper, cut on the dotted lines, and staple the info into this 400-entry directory which fits in a shirt pocket. Lose it, and all you need to do is print out a new one. Each of the entries offers name, address, phone number and notes; you can define up to 30 entry categories and you can use multiple entries for cross-referencing. Let's see you do *that* with your ordinary address book!

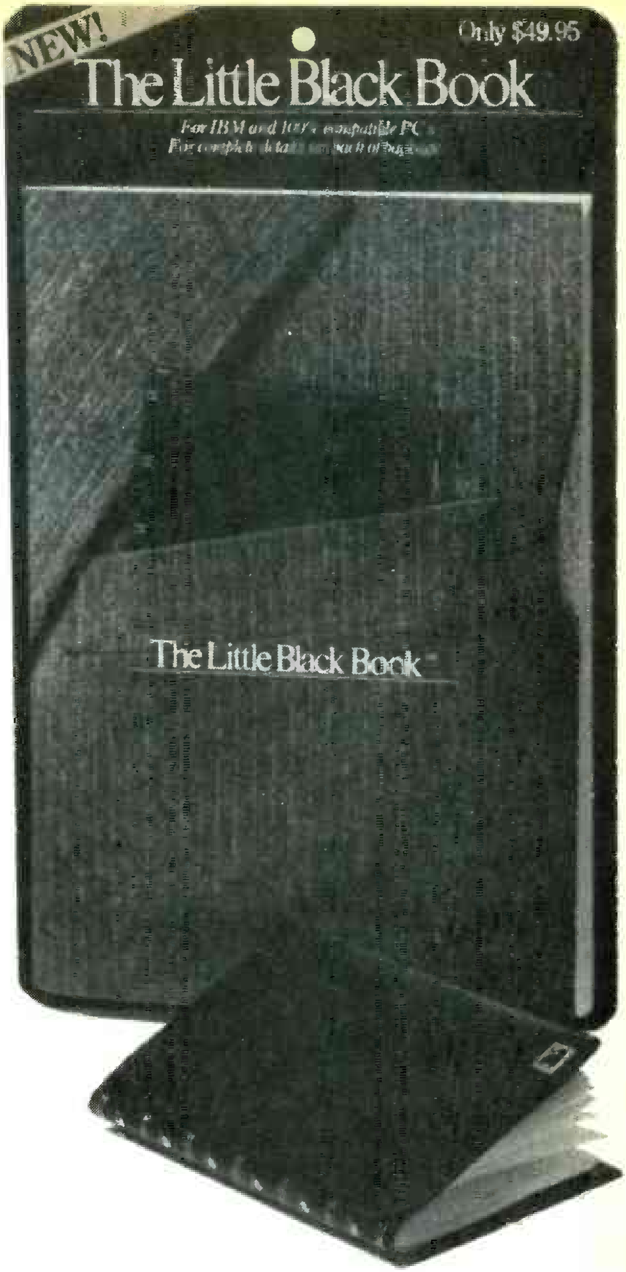
You say you aren't satisfied? You say you want more for your money? Tell you what we're gonna do. In addition to printing out your personal telephone directory, the software will—get this—automatically dial telephone numbers including access codes to your own long-distance dialing system! The optional dialer board is available at an additional cost of $70.

Let's be practical. An executive on-the-go will certainly need one of these, but when you hear about some of the applications to which they're being put, you wonder how business ever got along without them. Take the New York based sales manager with a staff of far-flung salesmen all over the country. He simply bought additional book covers, one for each salesman, and has his secretary update the regional leads that come in each month. These are sent to the men in the field who add them to their own books.

The system, complete with a nicely packaged book cover, the software, all you need, works with IBM's and compatibles, Lotus 1, 2 and 3, Symphony, and most PC/DOS programs. It's yours for only $50. That's right, I said fifty bucks.

Uniform

For the most part, the oft-occurring changeover from CP/M to MS-DOS machines is a smooth one. One reason for that is the fact that most of the popular software for the older format is also available for the IBM and its compatibles. In fact, the data files created by the CP/M versions of word processors, spreadsheets, datas bases and the like are almost always compatible with the MS-DOS versions of that



software. But, the disk formats are not.

In the past, the process of transferring your CP/M-software generated data files to MS-DOS disks has been a tedious and primitive one. Now, thanks to a new piece of software, that job is as simple as inserting your CP/M disk into your IBM's drive.

That new software, called Uniform, enables your MS-DOS machine to directly read and write disks from almost any of the popular CP/M formats, and to initialize a blank disk in the CP/M format of your choice. That means data files created by a CP/M machine can be used directly by an MS-DOS machine and vice-versa.

The software is easy to use; menus, prompts and easy-to-understand messages guide you through. Once invoked to select a disk format, you simply use the MS-DOS commands (COPY, etc.) and software with which you are familiar. Also, no modification of your hardware is needed.

For more information, contact Micro Solutions, Inc. 125 S. Fourth Street, DeKalb, IL 60115.

ALL ABOUT PRINTERS

What you see may NOT be what you print!

Herb Friedman

■With few exceptions printers rarely are 100% compatible with any modern personal computer. Even when the printer has the same marque as the computer it's a good bet it won't print all the characters and symbols shown on the screen. Manufacturers often upgrade or modify the characteristics of their latest models to accommodate the features of the most recent software or hardware fad. While every printer must print the ASCII characters represented by ASCII codes 32 through 126—those we call "the character codes"—outside this range anything goes. Some computers create block graphics in response to ASCII codes above 126, others use the above-126 ASCII codes for a separate Italics font, still others use the above-126 codes for a complete set of international characters and Greek and math symbols, and others use the codes for partial international character sets.

Then there are the ASCII codes below 32—what are called "the printer control codes." While the line feed (LF), carriage return (CR) and back space (BS) are virtually standard, the remaining codes are used for whatever the manufacturer selects: Some use them for conventional printer controls, others employ some of the under-32 codes for graphic symbols such as the four playing card suits, the international male and female symbols and musical notes; anything at all.

Few printer buyers realize that "What they see ain't what they print" until it's too late. For example, two of the most famous, best-selling printers cannot reproduce the graphics and characters above ASCII 126 produced by the IBM and IBM-compatible personal computers, although one printer can be retrofitted to provide some of the upper-ASCII characters. In the home-and family category, no known non-proprietary printer can reproduce all the graphics of the Commodore 64, and any conventional printer used with the Apple II familly of computers must use shifted graphics because the conventional Apple printer interface has a seven-bit printer output, which limits the ASCII codes to 126.

In order to get around inherent printer limitations and be able to reproduce any character or symbol, some of the very latest printer designs—such as certain models from Epson and Panasonic—provide a user RAM area in which the user can store user-created or custom-designed characters.

Characters in ROM

All matrix printers are controlled by a microprocessor. As shown in Figure 1, a simplified functional diagram of a matrix printer, the microprocessor receives either serial or parallel data from the computer which it compares with a character set stored in ROM. For each conventional ASCII code there is a matching character or control function stored in ROM. (The codes for which no ROM character is provided are generally ignored by the printer.) The microprocessor also controls the movement of the print

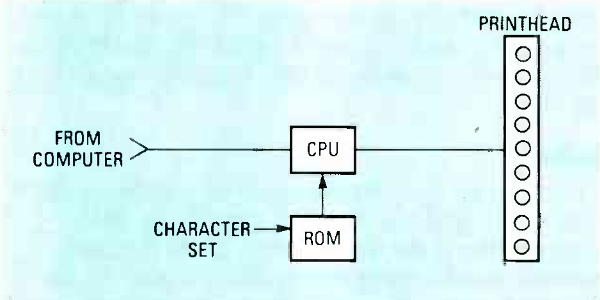


FIG. 1—THE BASIC MATRIX PRINTER drives the print head using a character set that is entirely within ROM. There is no way to modify the inherent characters or substitute user created characters.

head and the firing order of the print head wires that imprint the dots from which the characters are formed. The print head of most modern low cost printers employ 9 wires, of which up to 7 are used to create the characters (all 9 might be used for graphics). The extra wires are needed in order to create the descenders for lowercase characters such as the "p" "g" and "q." Figure 2 shows how the printer's CPU shifts from the seven upper to the seven lower wires in order to create upper and lower case characters in the Epson FX+ printer. Each character is created in a matrix 9 dots high and 6 dots wide. The dots represent the actual firing of the wires as the head is moved from left to right across the paper. If the head had only 7 wires the lowercase characters would be shifted upwards and lack descenders, as they did in the earliest of personal computer printers. Also note from Figure 2 that in some instances the dots are printed not in a column but on the "line(s)" between the column: It is possible to print a total of nine dots in a matrix only six dots wide. The very last column is not normally used for characters because it provides the spacing between characters.

The required ASCII code, head movement and the firing sequence of the wires for each character are programmed into the ROM along with the printer functions and cannot be changed. The printer will print only the character for which it is programmed even if the computer uses the same ASCII code for a different character, symbol or graphic. For example, if a particular printer has the same Italic character set as the Epson FX+ printer only the Italic characters will be generted by printer codes higher than 161. If the computer outputs an ASCII 234, which is the printer's lowercase Italic "j," the printer will print the "j" even though the same ASCII 234 code is recognized by the computer as the omega symbol. As far as the computer is concerned it is outputting the Omega symbol displayed on the screen, but as far as the printer is concerned the computer is sending an Italic "j."

But because a matrix printer's characters are created by individual dots it's possible to custom design any kind of character, symbol or graphic, even a complete character set from ASCII 00 to ASCII 256. All that's required is some way to supercede the ROM-based character set. This is accomplished, as shown in Figure 3, by driving the print head from a RAM buffer—user-programmable memory—rather than from the ROM. When the print is made the characters will be those of the programmable RAM rather than those of the ROM.

Ram permits the user to create a custom design for any or all ASCII codes, or to store one or more characters from the ROM character set and customize only specific ASCII codes. The CPU can either drive the matrix printhead from the ROM character set, or it can drive the print head from the RAM buffer. The ROM/RAM switching, the programming of RAM with custom characters, and the selection of ROM characters to be emulated in RAM are under software control, and can be entered either as direct statements, or as part of a BASIC program, or in certain select instances as a printer control code (the RAM/ROM switching) from within an applications program.

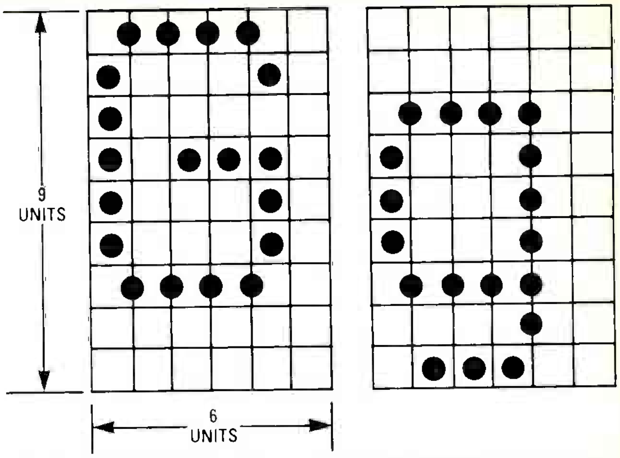


FIG. 2—THE CONVENTIONAL MATRIX PRINTER employs a 9-wire head even though only 7 wires are used for each character. The two "extra" wires are needed for lower case descenders, such as the "tail" shown on the lower case "g." Notice that the dots can be printed in a column or between columns. The extreme right hand column is left free for conventional characters because it provides the space between adjacent characters.

Let's illustrate printer programming using the ASCII 234 code previously discussed. If we wanted to substitute the Omega character for the Italic "j" we could program the entire ROM-based character set except for ASCII 234 to load into the RAM and then load a user-generated ASCII 234 representative of Omega (Ω) from the computer using a short BASIC program. As long as power to the printer wasn't interrupted it would print an Omega in response to an ASCII 234. Or, we could program the entire ROM character set from ASCII 00 through 126 into ROM, and then program only the custom designed ASCII 234. The printer would ignore all ASCII codes higher then 126 except for ASCII 234.

The user-designed characters must fit within what is called the "matrix" of the printer, which is simply a box representing all the dot positions that can be used to create a character. In the Epson FX+ printer the matrix is 9 x 11, meaning 9 vertical dots by 11 horizontal dots, as shown in Figure 4. Confused? No, there is no error in Figure 4. As we explained earlier in Figure 2, the dot matrix is 9 x 6, but dots can be printed between the columns; in effect, the matrix is 9 x 11. (Also as mentioned earlier, as a general rule the extreme right column is never used for the character because it is the minimum space needed between characters, but there is nothing to prevent the user from employing the column for special graphic effects or double-width characters.)

For example, Figure 5 shows how RAM programming can be used to create a customized font (type face) or individual characters. The FX+ printer is factory supplied with the Roman character set: The straight-sided characters we recongnize as "computer printing." Figure 5A shows how the Roman "E" is generated: Notice the dots are located precisely within the matrix boxes. Let's assume that the user prefers to

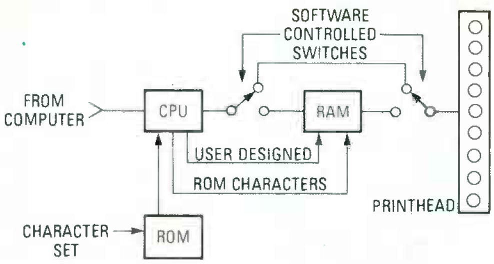


Fig. 3—A PRINTER THAT ACCOMODATES user-designed characters can print using either the ROM characters or from a RAM that is programmed with characters either downloaded from the computer or from the ROM. The RAM can accommodate any kind of ROM/download intermix.

have the printing more closely resemble the characters of a conventional typewriter, what is called NLQ, meaning "near letter quality." The distinction between the characters is serifs or rounded corners, and the user could custom design and program the printer with a substitute character set resembling conventional pica characters, such as the letter "E" shown in Figure 5B. If the user wanted to modify only the shape of the letters but not the numerals or punctuation symbols he could load the new upper and lower case letters into RAM along with the numerals and punctuation form the ROM roman character set. With the printer's CPU programmed to operate from RAM the printout would contain NLQ letters and Roman numerals and punctuation. A complete NLQ character set for letters, numerals and punctuation could be designed and loaded into RAM. It is even possible, as shown in Fig 5C, to program a graphic symbol such as the Omega.

Generally, we try to use whatever we can of the ROM characters. Designing a custom character set is not a one-evening project. The characters are created by a BASIC program: An individual character requires an attribute statement that positions the character in the 9 x 6 matrix, and a data line for each row. The data lines

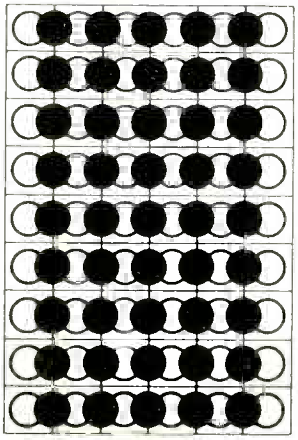


FIG. 4—CUSTOM-DESIGNED CHARACTERS are formed from a 9 x 6 matrix which actually provides 11 columns of dots. The characters are created by firing any of the indicated dots, however adjacent white and dark dots cannot be used; the printer will ignore an indicated dark dot if the immediate adjacent dot is white.

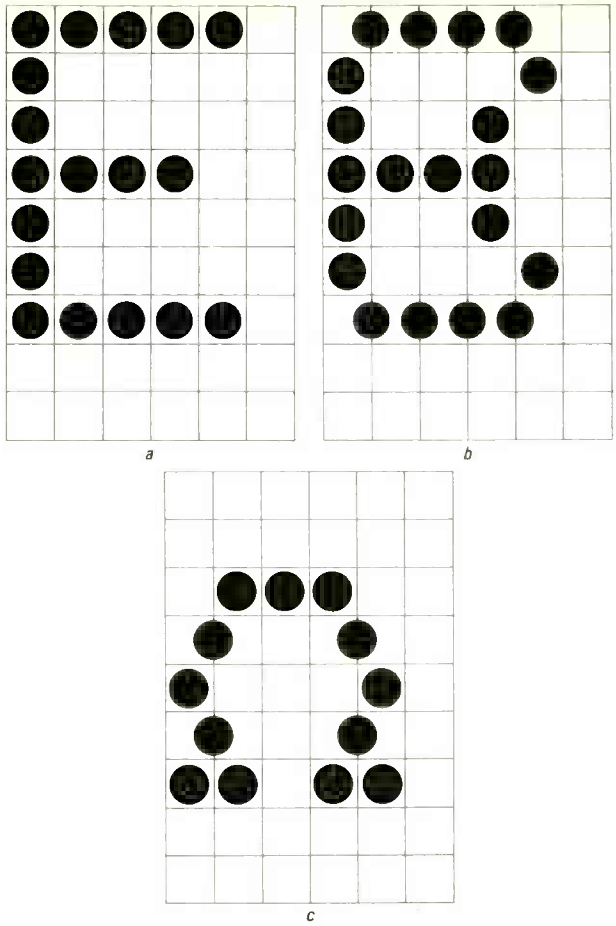


FIG. 5A—THE CONVENTIONAL ROMAN CHARACTER has straight sides and looks "computerized." This is how a dot matrix printer creates the Roman "E."

FIG. 5B—THE 'NLQ"TYPE CHARACTER—which resembles typewriter characters—can be created by the user and downloaded into RAM as a substitute for the Roman characters. This is how a user-created NLQ "pica" character might be created. Although full NLQ printing is attained by multistriking in such a way that the spaces between the dots are literally filled in, the basic character is created from individual dots.

FIG. 5C—SINCE THE CUSTOMIZED CHARACTERS are created from dots almost anything is possible. This is the pattern for Omega, the symbol we use to indicate resistance.

represent the byte value for each column of dots, and since there are nine possible columns for each character it would take considerable time and debugging tocustom design no more than a handful of characters. It is probably less time and trouble to purchase a program that automatically downloads an NLQ or IBM-compatible character set(s).

While there is software available for some commonly-used non-programmable matrix printers that generates custom character sets through the printer's dot addressable function, the printing process itself tends to be s-l-o-w because each letter might require several passes of the print head. On the other hand, printers having custom characters programmed into RAM have no loss in throughput because the printer doesn't know whether it's printing ROM-based internal or RAM-based custom characters.

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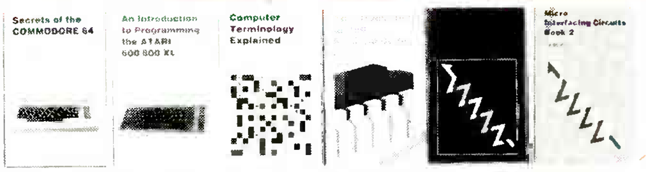

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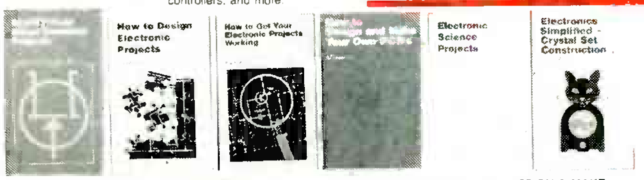

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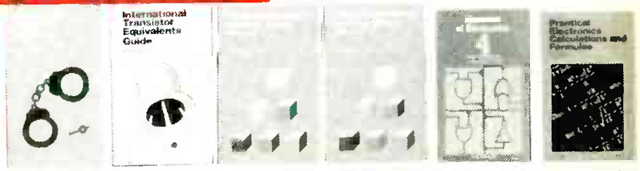

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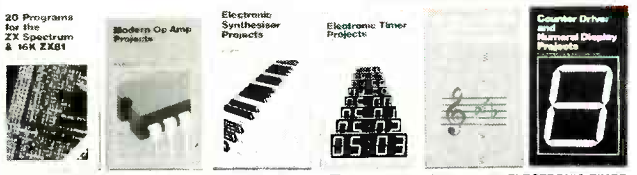

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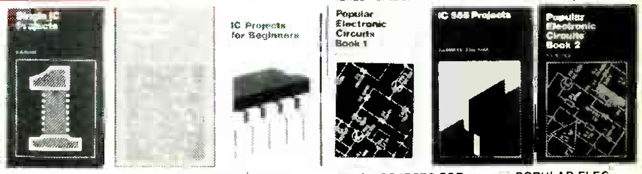

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FREQUENCY COUNTER FOR YOUR C-64

A new use for your light pen.

Ralph Neal

■After building the light pen described in the June, 1985 edition of **ComputerDigest**, I began thinking of possible uses for it. One idea, was as an optical tachometer for measuring the speed of rotating objects such as fans or motors. The program presented here is the result. Using this program and a light pen compatible with the Commodore C-64, you can measure the rotational speed of most objects.

The program was originally written in Assembly Language and later converted to data statements to make the program easier to type into the computer. Unfortunately, there is one drawback to this. Without the source code, it is difficult to see how the program functions. However, we'll explain.

```
5 REM* OPTICAL TACHOMETER *
10 PRINT"♥"
20 POKE 53281,1
30 FOR I=32768 TO 32971
40 READ X
50 POKE I,X
60 NEXT I
70 SYS32768
80 DATA169,1,141,255,3,173
90 DATA24,208,9,2,141,24
100 DATA208,32,172,128,169,48
110 DATA141,255,4,141,0,5
120 DATA141,1,5,141,2,5
130 DATA141,3,5,169,72,141
140 DATA5,5,169,26,141,6
150 DATA5,169,0,133,162,162
160 DATA4,24,164,162,192,59
170 DATA176,109,32,150,128,189
180 DATA255,4,109,255,3,157
190 DATA255,4,201,58,208,234
200 DATA233,10,157,255,4,202
210 DATA189,255,4,105,0,157
220 DATA255,4,201,58,208,213
230 DATA233,10,157,255,4,202
240 DATA189,255,4,105,0,157
250 DATA255,4,201,58,208,195
260 DATA233,10,157,255,4,202
270 DATA189,255,4,105,0,157
280 DATA255,4,201,58,208,177
290 DATA233,10,157,255,4,202
300 DATA189,255,4,105,0,157
310 DATA255,4,201,58,208,159
320 DATA233,10,157,255,4,202
330 DATA173,0,220,41,16,208
340 DATA249,173,0,220,41,16
350 DATA240,249,96,165,162,208
360 DATA252,76,16,128,162,0
370 DATA189,186,128,157,50,4
380 DATA232,224,17,208,245,96
390 DATA70,82,69,81,85,69
400 DATA78,67,89,32,67,79
410 DATA85,78,84,69,82,96

READY.
```

How the program works

If it were not for the fact that computers are very-fast adding machines, this system would only work at low frequencies. We take advantage of the computer's speed by having it count the number of times the light pen is activated per second. At the point where the second has ended, the program stops counting and displays the count to the screen for about two seconds. After this, all values are zeroed and the count begins again as sensed by the light pen.

Obviously, timing is everything if this system is to function properly. And all of the timing is accomplished by use of the Jiffy Clock, which is an interrupt-driven clock. The computer keeps a continuous count of the number of times interrupts occur and stores this count at memory locations 160 - 162. However, of these three memory locations, we are concerned only with location 162. This location is updated every 1/60th of a second. All we have to do to check to see if a second has passed, is compare this location with the number 60. When memory location 162 reaches 60, the program stops counting and jumps to a time-out subroutine. This subroutine continuously checks the same memory location (location 160) for a value of zero. This value will *only* be obtained after the count in memory location 162 has passed 255. Once the value in location 162 is equal to zero, the program jumps to the start and is again ready to record events detected by the light pen.

First connect the light pen to joystick port 2. Then turn on the computer and load the program listed. When run, the program should clear the screen and turn the background of the monitor to white. A simple test to check out the program, is to place the light pen against the screen of the monitor. A value of 60 should appear on the screen if the program is functioning properly. (The value may fluctuate between 59 and 61 on some monitors.)

There are some limitations to this program. From tests conducted, it would appear that the limiting readable frequencies are about 10,000Hz. At this frequency, the optical tachometer reads about 9650Hz, some 450Hz from true value.

BUILD THE GRAFEX-32 PART 2

RAY DAHLBY

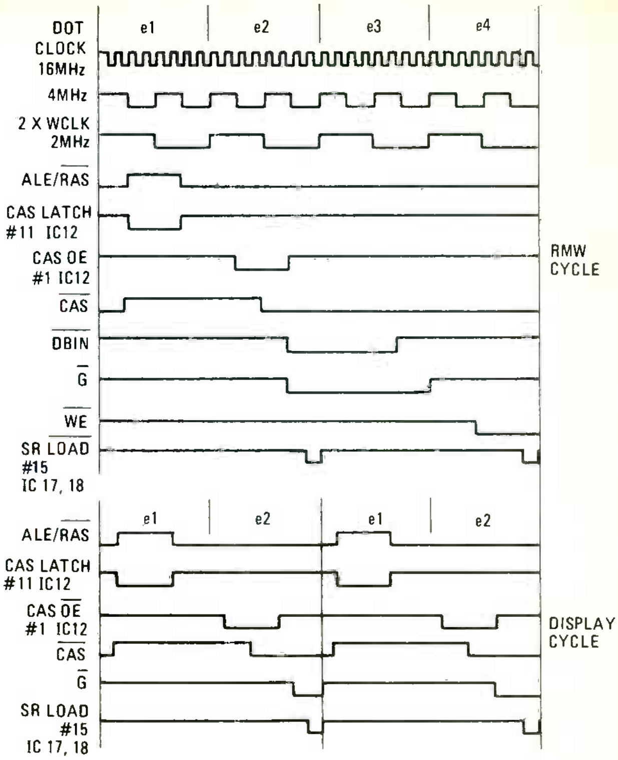


FIG. 3—TIMING DIAGRAM illustrates timing steps and sequences. See text for further information.

This article, begun in February is continued here.

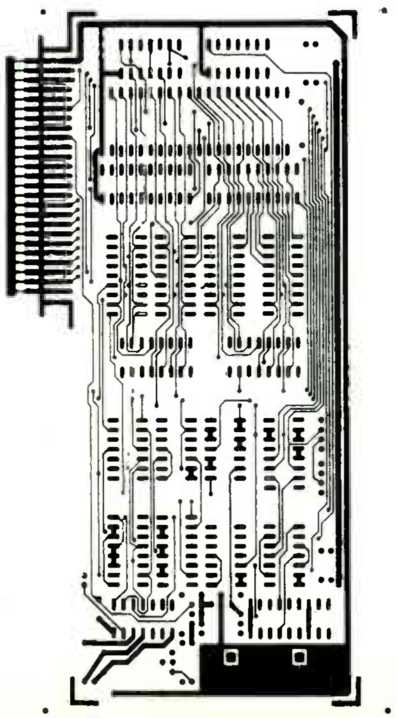
A 7220 display cycle requires 2-2Xwclk cycles and a RMW cycle requires 4-2Xwc1k cycles. The sequence of events which takes place during a RMW cycle is outlined below. The four 2Xwc1k intervals are referred to as e1, e2, e3, and e4 as per the timing diagram, Figure 3.

The intervals description follows:

e1—The 7220 begins to output the display memory address on the 16 AD lines; ALE goes low to indicate this address is valid. This signal (also called RAS) strobes the low 8 address bits into the display memory and latches the high 8 address bits into the CAS latch, IC12.

e2—The 7220 tri-states the AD lines and DBIN goes low to indicate that a RMW cycle is in progress. The CAS latch OE pin is brought low to present the 8 column address bits to the display memory and then, the CAS line is brought low to strobe this address into the display RAM chips. The G pin of the memory is brought low to allow the read data to be presented to the 7220. The read data is loaded into the video shift registers.

e3—The 7220 reads the 16 bit data from the display



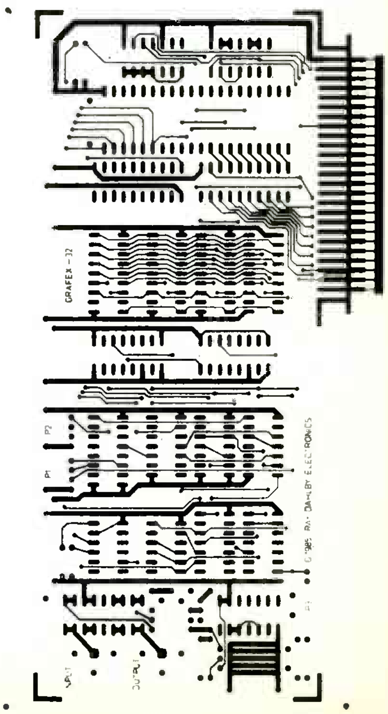
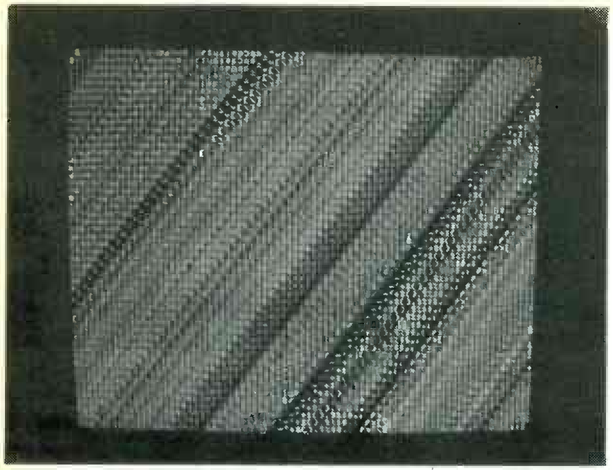
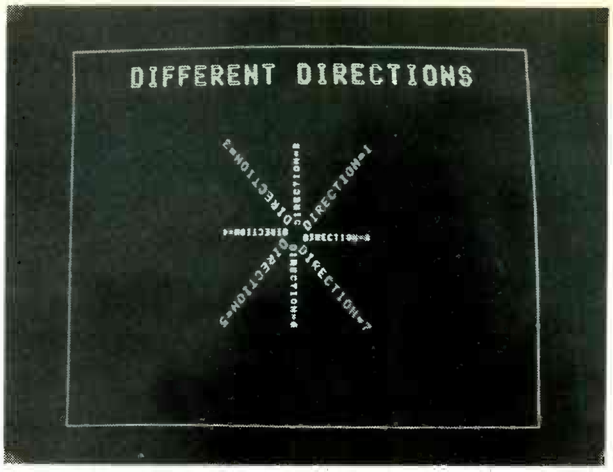


FIG. 4—PRINTED CIRCUIT BOARD is shown half size for those who wish to make their own. Due to space restrictions, board had to be reduced 50%. Be sure to have these drawings photographically enlarged 200% before making board. Component side is shown at left.



BARBERPOLE EFFECT OF 80 columns by 50 rows of text. The character set is made from a 5 x 7 dot matrix in an 8 x 8 box. This set includes the complete 128 character ASCII set.



THE EIGHT DRAWING DIRECTIONS. The display was produced by writing the string "DIFFERENT DIRECTIONS" at a magnification factor of 2, then writing it again with the x and y starting position shifted by 1 pixel and the mode set to complement.

memory and performs the modifications.

e4—The G pin of the memory is brought high to tri-state the RAM data lines, the 7220 presents its modified data onto the AD lines, the memory WE is brought low to write the modified data back into the display memory. The modified data is loaded into the video shift registers.

The two 2Xwc1k intervals which make up a display cycle are outlined below. Again, e1 and e2 refer to the 2Xwc1k intervals labelled on the timing diagram.

e1—The 7220 begins to output the display memory address on the 16 AD lines; ALE goes low to indicate this address is valid. This signal strobes the low 8 address bits into the display memory and latches the high 8 address bits into the CAS latch, IC12.

e2—The 7220 tri-states the AD lines and DBIN stays high to indicate that a display cycle is in progress. The CAS latch OE pin is brought low to present the 8 column address bits to the display memory and then, the CAS line is brought low to strobe this address into the display RAM chips. The G pin of the display memory is brought low to allow the read data to be presented to the video shift registers. The read data is loaded into the video shift registers.

Notice that the video shift registers are loaded with new data every two 2Xwc1k interval regardless of whether the 7220 is executing a display cycle or a RMW cycle. In the case of a RMW cycle, the data loaded into the shift registers will not correspond to valid screen data and will cause visible glitches if the 7220 is allowed to access the screen RAM during active video intervals. The 7220 has a provision which allows RMW cycle to take place only during the blanked Vsync and Hsync intervals preventing a disturbed screen display while drawing is in progress. Although the video shift registers are still loaded during RMW operations, these cycles are restricted to the approximately 30% of the time when the screen is blanked, preventing the false data from being seen.

When two or more boards are installed in a system, they are daisy-chained together by means of the expansion connectors, P1 and P2. These connectors carry the 16 MHZ dot clock and the 7220 video sync signals from the board designated to be the master, to the slave boards. The jumper on P3 is installed only on the board acting as the master. When initiallized by software, the slave 7220's synchronize their timing with the master so that all of the 7220's run in phase with each other. In this way, three Grafex boards installed in a system can each drive one gun of an RGB color monitor. The composite sync is carried on the video for those monitors capable of accepting sync on the green input. RGB monitors having external synchronization inputs can be driven from one of the expansion connectors of a Grafex board. Specific information explaining the use of three Grafex boards with RGB monitors is included with the color software package available from my company. Please check with the source mentioned at the end of this article for price and delivery information. Figures 4 and 5 provide necessary information should you prefer to fabricate your own boards.

Programming the 7220

After power up, the 7220 must be initiallized by a series of commands and parameters to configure it for the type of display desired. Usually, these commands and parameters are stored in a table which the initialization routine can refer to and then pass to the 7220.

The path for information flow between the host microprocessor and the 7220 is the first-in first-out (FIFO) buffer internal to the 7220. Commands and parameters and loaded into this buffer by the host and removed at the other end by the GDC's command processor. Care must be taken by the programmer to avoid overflowing the FIFO buffer with data faster than the GDC empties it. For this purpose, the GDC has a status register containing bits which indicate when the FIFO buffer is full or empty and also when data is ready

TABLE 1

Address	Read	Write	Video Relay
CON0	Status Register	Parameter	Apple Video Displayed
CON1	FIFO	Command	
CON2	Status Register	Parameter	Grafex Video Displayed
CON3	FIFO	Command	

to be read by the host microprocessor. Referring to Table 1, the status register can be seen to be mapped into the Apple's expansion slot area and can be read at any time. Other bits in this register indicate the state of the Vsync and Hsync video timing counters to allow smooth scrolling and other effects needing software synchronization to the video field rate.

The first command issued after power up is the Reset command. This command is interpreted by special hardware ahead of the FIFO to ensure that the internal registers, FIFO buffer, and command processor of the GDC are reset to their idle state prior to the initialization commands and parameters which follow. Normally, it is a good idea to check the status register for a FIFO FULL condition before each byte is output. On power up, the flags in the status register are not meaningful, so the RESET command must be issued before attempting to read the status register or load other commands and parameters into the GDC.

A typical initialization program is shown in Listing 1.

Listing I

```
:L

IO        EQU  $FE
          ORG  $0300
          LDA  #$F2        ;SLOT7
          STA  IO
          LDA  #$C0
          STA  IO+1
INIT      LDX  #00
LOOP      LDA  TABLE1,X
          LDY  TABLE2,X
          STA  (IO),Y
          INX
          CPX  #30
          BNE  LOOP
          RTS
TABLE1    DFB  $00,$1F,$26,$04,$1A
,$0B,$1E,$C8,$40,$6F,$47,$28,$70,
$00,$00,$00,$19,$4B,$00,$C0,$00,$
46,$00,$78,$FF,$FF,$23,$4C,$10,$6
B
TABLE2    DFB  1,0,0,0,0,0,0,0,0,1
,1,0,1,0,0,0,0,1,0,0,0,1,0,1,0,0,
1,1,0,1
```

GRAFEX-32 Power and Ground Pin-outs

	+5volts	ground
IC1	40	20
IC2	14	7
IC3	14	7
IC4	14	7
IC5	14	7
IC6	14	7
IC7	14	7
IC8	14	7
IC9	14	7
IC10	16	8
IC11	20	10
IC12	20	10
IC13	9	18
IC14	9	18
IC15	9	18
IC16	9	18
IC17	16	8
IC18	16	8
IC19	16	8
IC20	16	8

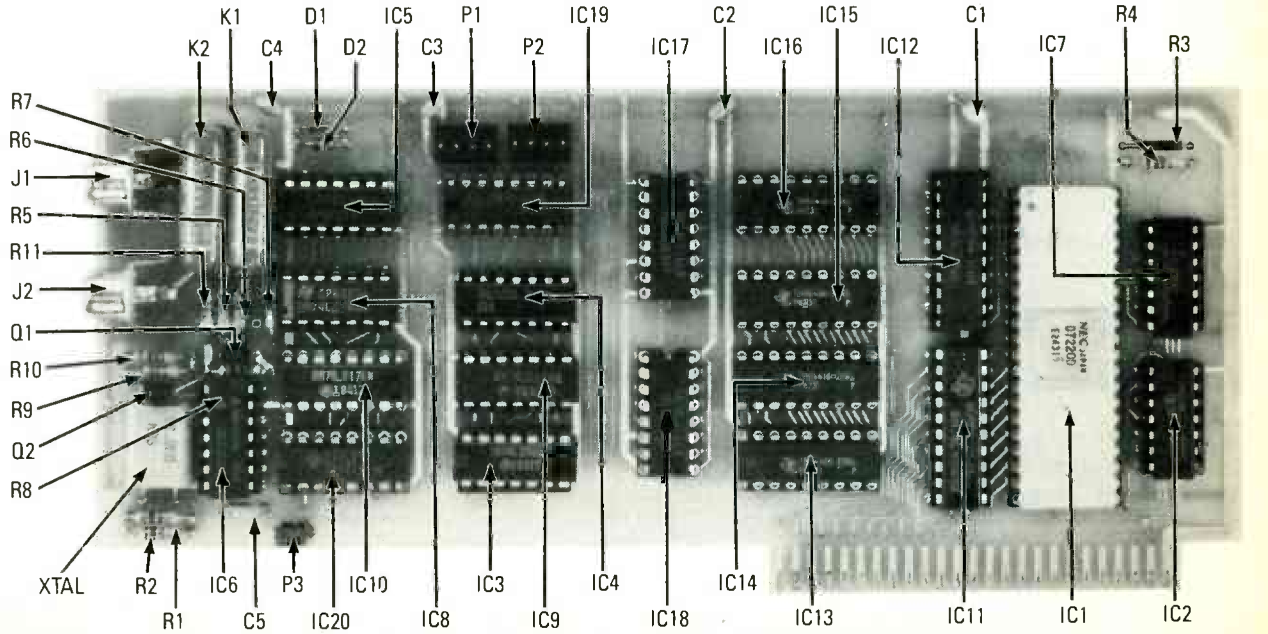


FIG. 5—PARTS PLACEMENT is shown above. No components are mounted on reverse side of board.

Listing II

```
:L

IO       EQU   $FE
         ORG   $0300
         LDA   #$F2        ;SLOT7
         STA   IO
         LDA   #$C0
         STA   IO+1
         JSR   FIFO        ;MAKE SURE FIFO IS EMPTY
         LDY   #01
         LDA   #$49        ;CURSOR COMMAND
         STA   (IO),Y
         DEY
         LDA   #00
         STA   (IO),Y
         STA   (IO),Y
         INY
         LDA   #$4A        ;MASK COMMAND
         STA   (IO),Y
         DEY
         LDA   #$FF
         STA   (IO),Y
         STA   (IO),Y
         INY
         LDA   #$0F        ;SYNC COMMAND
         STA   (IO),Y
         DEY
         LDA   #$0F        ;FAST MODE
         STA   (IO),Y
         LDX   #$00
LOOP     LDY   #01
         LDA   #$4C        ;FIGS COMMAND
         STA   (IO),Y
         DEY
         LDA   #$02
         STA   (IO),Y
         LDA   #$FF
         STA   (IO),Y
         LDA   #$3F
         STA   (IO),Y
         INY
         LDA   #$22        ;WDAT MODE
         STA   (IO),Y
         DEY
         LDA   #$FF
         STA   (IO),Y
         STA   (IO),Y
         JSR   FIFO        ;MAKE SURE FIFO IS EMPTY
         INX
         CPX   #$01        ;CHANGE TO #$04 FOR 128K
         BNE   LOOP
         RTS
FIFO     LDY   #00
WAIT     LDA   (IO),Y
         AND   #$04
         BEQ   WAIT
         RTS
```

Table II
Video Parameters

Active Line =	40µs
HFP =	7µs
HBP =	12µs
HSYNC =	6µs
Total Line Time	64µs
Active lines per video field =	200 lines
VFP =	30 lines
VBP =	16 lines
Vsync =	16 lines
Total lines per field =	262 lines

Video field rate = 1/64µs × 262 lines) = 59.637 Hz

This sequence configures the GDC to generate 640 by 400 interlaced video with the video timing parameters given in Table II. The GDC is designated as master, dynamic RAM refresh is enabled, and transparent mode is selected (the GDC is allowed to draw only during blanked screen intervals). Also the entire screen is defined as a bit-mapped graphics area with the screen window set to the top of memory. When this program is run, the 7220 begins outputting video to the system

Listing III

```
:L

IO       EQU   $FE
         ORG   $300
         LDA   #$F2        ;SLOT7
         STA   IO
         LDA   #$C0
         STA   IO+1
         JSR   FIFO        ;MAKE SURE FIFO IS EMPTY
         LDY   #01
         LDA   #$23        ;WDAT MODE
         STA   (IO),Y
         LDA   #$78        ;PATTERN RAM
         STA   (IO),Y
         DEY
         LDA   #$FF
         STA   (IO),Y
         STA   (IO),Y
         INY
         LDA   #$49        ;CURSOR COMMAND
         STA   (IO),Y
         DEY
         LDA   #$81
         STA   (IO),Y
         LDA   #$17
         STA   (IO),Y
         LDA   #$00
         STA   (IO),Y
         INY
         LDA   #$4C        ;FIGS COMMAND
         STA   (IO),Y
         DEY
         LDA   #$40
         STA   (IO),Y
         LDA   #$03
         STA   (IO),Y
         LDA   #$00
         STA   (IO),Y
         LDA   #$63
         STA   (IO),Y
         LDA   #$00
         STA   (IO),Y
         LDA   #$63
         STA   (IO),Y
         LDA   #$00
         STA   (IO),Y
         LDA   #$FF
         STA   (IO),Y
         LDA   #$3F
         STA   (IO),Y
         LDA   #$63
         STA   (IO),Y
         LDA   #$00
         STA   (IO),Y
         INY
         LDA   #$6C        ;FIGD COMMAND
         STA   (IO),Y
         RTS
FIFO     LDY   #00
WAIT     LDA   (IO),Y
         AND   #$04
         BEQ   WAIT
         RTS
```

CRT monitor from the random power-up data in the display memory.

A screen clear sequence is shown in Listing 2. This sequence clears the entire 32,768 bytes of display memory to zeroes in under 16 ms, or less than the time required for one video field. This routine can be modified to clear 128K bytes of display memory by changing the indicated line to: CPX #$04.

A final sequence of commands and parameters, shown in Listing 3, draws a rectangle in the center of the screen with the dimensions of 100 vertical pixels by 100 horizontal pixels.

That's all the space for now. We'll conclude this article next month.

lems and other regulating functions were performed by the Department of Commerce, and, later, by the Federal Radio Commission (the FRC), the forerunner of our present-day FCC. The FRC was started by an act of Congress in 1927, and the FRC began life with a group of technically knowledgeable commissioners who had many problems with politicians who wanted to control—or abolish—the FRC. And the tremendous growth of radio meant that the FRC had all it could do just to keep up with technical problems.

Among its many other responsibilities, the FRC regulated the use of language that might be considered profane. To a degree, the FRC could punish persons or stations for infractions of the rules. Criminal violations were referred to the Department of Justice.

Cracking down on pirate (unlicensed) stations was another of the FRC's tasks. Dozens of pirate stations were creating interference with licensed stations. By the 1930's, the FRC was already handling hundreds of cases per week, all of which were related to radio regulations.

Stations were assigned their place on the dial according to several criteria, including type of programming and power output. For example, in 1921, the Department of Commerce assigned music and entertainment stations to 360 meters. Agricultural and meteorological (weather) reports were assigned to 485 meters. During the next few years, stations were assigned by their power output. Lower-powered stations were placed on the 230-330 meter band. Later, the broadcast band was lowered to 200 meters.

There were about 15,000 to 20,000 amateur radio operators (hams) operating in the United States in those early days. Those operators and experimenters were an asset to the industry as well as to the country, and the government always encouraged their efforts. Unfortunately, many of their contributions to the development of radio remain anonymous.

Patent-infringement suits were being solved in the 1930's, and that meant that more superheterodyne receivers could be built. Of course, suits and bankruptcies continued on through the 1930's and into present times.

Other early influences

This column is devoted mostly to radio. But closely intertwined with the development of radio was, of course, TV. The earliest radio experimenters were just as interested in being able to send visual as aural messages. Some of those ideas go back as far as the 1700's, when experimenters believed that transmitting images would be easier than transmitting sound!

The editors of early radio publications deserve much credit for advancing the state of the radio art, as well as for fostering interest in radio. Actually, the radio magazines, and their learned editors, were probably the most reliable sources of information for early radio enthusiasts. Complete schematics, explanations of the latest circuits, photographs, and sources for parts were often published in those magazines.

In the early 1900's almost all home-built receivers were built from information contained in a radio magazine. With the coming of commercially-built sets, many of those magazines disappeared. Of course, not all radio publications fell by the wayside. And among the survivors were the publications by Hugo Gernsback. Starting with *Modern Electrics* (see Fig. 1) in 1908, *Radio Craft* in the 1920's, and *Gernsback's Educational Library*, in the 1930's, Gernsback's publications were, and still are, a vital source of information for radio enthusiasts and people interested in all facets of electronics.

Haves and needs

I have sent many personal replies assisting fellow collectors. If you still need antique radio parts or information, try one of the following:

Antique Electronic Supply Co. (1725 W. University, Temple, Arizona 85281) is a good source of tubes, parts, and books. The Vestal Press Ltd., (Box 97, 320 N. Jenson Road, Vestal, New York 13850) also has a good supply of books and manuals. **R-E**

DRAWING BOARD

ROBERT GROSSBLATT,
CIRCUITS EDITOR

Z80 demo program

LAST MONTH, WE SHOWED YOU A DEMonstration program for our simple Z80 circuit. This month, we'll finish up the demonstration program, and then see if we can put our Z80 circuit to work.

TABLE 1—EXAMPLE PROGRAM

Line	Address	Op Code	Source Code	Comments
1	ØØØØ	AF	XØR A	Zero the Accumulator
2	ØØØ1	26 ØF	LD H,ØF	Set the display number
3	ØØØ3	2E AØ	LD L,AØ	Set the loop counter
4	ØØØ5	7C	LD A,H	Load the Accumulator
5	ØØØ6	D3 FF	OUT (FF),A	Send it to the latch
6	ØØØ8	C3 11 ØØ	JP ØØ11	Go to delay subroutine
7	000B	25	DEC H	Decrement port count
8	ØØØC	2D	DEC L	Decrement loop counter
9	000D	C2 05 00	JP NZ 0005	Do again if not zero
10	ØØ1Ø	76	HALT	End of the program
11	0011	11 83 8B	LD DE,8B83	Preset the delay loop
12	ØØ14	1B	DEC DE	Decrement the counter
13	ØØ15	C2 14 ØØ	JP NZ ØØ14	Jump back if not zero
14	ØØ18	C3 ØB ØØ	JP ØØØB	Return if finished

Odds and ends

There are only two other things to talk about: the way instructions are printed and the way the program ends.

You probably noticed that, in the Op Code column in Table 1, the addresses in lines 6, 9, and 13, and the data in line 11 appear to be written backwards. To avoid getting into a lot of messy details, you'll just have to accept the fact that that's the way it's done. The reason isn't really all that important—certainly it's not as important as remembering that it is done. Your reference book may give you the answer, but unlike programming tricks, if the answer isn't there, the book is not necessarily bad. Not all micprocessors use that low-high format, either; so be careful.

About ending the program: Since all it does is to count from fifteen down to zero, we could either have it go on forever or stop after a number of runs. Of course, we chose the latter, and the HALT instruction in line 10 ends the program. After that HALT executes, the only way to make the Z80 do anything useful is to reset it.

So get an EPROM burned and plug it in. With some LED's connected to the latch you should see the count go from F down to Ø ten times. You'll get tired of watching it after a while, but it'll be thrilling the first couple of times—and at least you'll know your circuit works.

Now that we have a working circuit, what else can we do with it? By adding a couple of things, we can make that circuit one of the most useful we've ever put together—seriously! The first addition is a keyboard, and the second is RAM. I know it sounds as if we're talking about building a complete computer, but that's not the case at all.

A keyboard could be located in the regular memory address space; doing that would make getting data as simple as reading an address. A better way to do it would be to set the keyboard up at a port address as we did with our output latch. Of course, you would access the keyboard with an IN instruction as opposed to the OUT instruction we use in the demo.

Any serious use of that circuit will require getting data in and storing it somewhere. Using the registers for storage is fine for a demo, but for any serious use, we need some RAM.

The first thing we need to decide when adding RAM to the circuit is where it will be located. Since the Z80 starts program execution at power-up (or reset) from address ØØØØ, it's a good idea to reserve low memory for ROM and high memory for RAM. A 2K EPROM might be addressed from ØØØØ to Ø7FF, and a 2K RAM might be addressed from F8ØØ to FFFF. In order to access that additional memory, as well as the keyboard, you'd have to do more decoding of the $\overline{RD}$, $\overline{WR}$, $\overline{MREQ}$, and $\overline{IORQ}$ lines, but that's not the real problem. As you might have guessed, the real problem is, once again, software.

But let's forget about that for a moment; let's imagine some of the spiffy things you could do with the sort of circuit we've just described:

- Look up values in a table.
- Control peripheral devices.
- Test routines for the EPROM.
- Build an intelligent keyboard.

So to get your creative juices flowing, we'll start another contest. The rules are simple. Attach a keyboard (with any number of keys) to our circuit, add some RAM, and write a program that makes the circuit do something useful—anything you want. Send me your designs, and I'll publish the best one that really works. I'll give you guest space in the column, and you'll get a free one-year subscription to **Radio-Electronics**, too. So get to work.

Memory wars

Before we begin our next adventure in circuitland, there are a few things I'd like to talk about. Although the news will be outdated by the time you read this, you should know that the so-called computer revolution has claimed its first major victim. On October 17, 1985, Mostek was closed down by its parent company, United Technologies. The reason that happened is complicated, but, in essence, Mostek was a casualty of the computer-memory war.

The mainstay of the Mostek product line was memory, and, as we all know, the Japanese have taken most of that market. By using more efficient manufacturing techniques (which consequently cut prices), Japanese semiconductor companies have captured close to 70% of the 64K market, and an astonishing 90% of the 256K market. And let's not forget that the major users of memory are all in the computer industry. When you put those two facts together, it's surprising that Mostek didn't go under even earlier.

The reason I mentioned that is as a lead-in to the subject of computers in general. The computer revolution has been with us for the last five or six years, and if the computer revolution were comparable to anything in recent memory, it would have to be the real-estate boom in Florida in the early 1970's. Computer manufacturers, peripheral manufacturers, magazine publishers, book publishers—and just about anything else you can think of—have all proliferated the past couple of years. But now we're beginning to see the bubble burst.

If you're a regular reader of the column you've probably noticed that I don't spend much time talking about computers. They're wonderful tools; I use one every day—but I also use my multimeter every day. The point is that a computer can do all sorts of great things for you, and you can learn a lot by taking one apart. But there's a lot more to electronics than CPU's, disk drives, and software.

Computers can be a tremendous help in designing circuits, but not all programs are available for all machines. I'd like to tell you about useful software packages that make life at the workbench a bit easier. In order to do that, however, I have to know which computers you people out there are using. Take a few minutes to drop me a postcard and tell me what kind of computer you use. Don't forget to include a list of the peripherals you have. I'll put all that stuff together and keep my eyes open for packages that you should know about. **R-E**

DESIGNER'S NOTEBOOK

More single-gate designs

ROBERT GROSSBLATT
CIRCUITS EDITOR

THINGS ARE HEATING UP IN THE ONE-gate contest again. I've received a big batch of new entries the past few weeks. This month, I'll pass along a couple of the better ones.

A few months back, you'll recall, we were looking for ways to get a negative voltage from a single-ended positive supply. At that time we built a charge-pump inverter from a 555 and a few discrete components. The circuit in Fig. 1 shows an even neater way to get a negative voltage from a positive supply. That design uses only a single inverter—and there's always an unused one in a circuit design. The circuit was submitted by Don, Bill, and John from the Companion Computer Company of Apex, North Carolina.

You can use just about any CMOS inverter for IC1-a, but a more powerful IC (like a 4049) will be able to supply more current. You may be able to parallel gates to increase current output, but that will change the operating frequency (which is set by R1 and C1) of the oscillator, hence the circuit's output voltage.

Diodes D1 and D2, along with capacitors C2 and C3, function as a voltage doubler. When IC1-a's output goes high, D1 is forward biased, so C2 begins to charge. At the same time, C1 charges up through R1. When C1 exceeds the inverter's turn on voltage, the output of IC1-a goes low. Since D2 is reverse biased with respect to C2, C2 has no way to discharge and a negative voltage appears at the output of the circuit.

The frequency of oscillation, in conjunction with the current drawn by the load, determines the

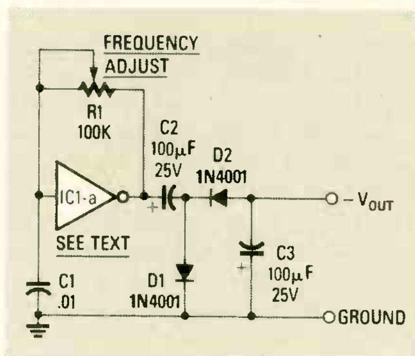


FIG. 1

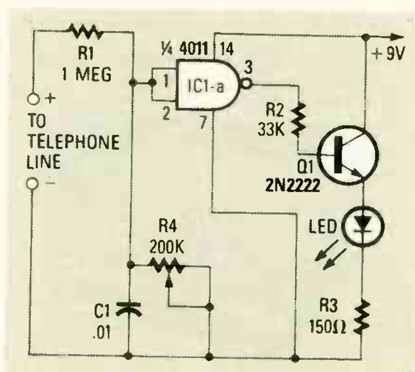


FIG. 2

output voltage of the circuit. Simulate your load with a resistor of the appropriate value, and then adjust R1 while monitoring the output with a voltmeter.

Our 555 circuit could provide about 60 mA, but a single CMOS inverter can't supply anywhere near the power of a 555. In fact, I'd be surprised if you could get more than 10 mA out of it. Even so, that circuit could save you a lot of grief when you discover that there's absolutely no way you can get an op-amp circuit working without a negative voltage.

As with any charge-pump circuit (including the 555 version), you can expect a lot of ripple. That's not necessarily a big problem, but you'll have to keep it in mind.

Off-hook indicator

Tim Frazer of Ormund Beach, Florida sent me the circuit shown in Fig. 2. He used a single 4011 NAND gate to build a neat indicator that illuminates when the telephone is off hook. Resistors R1 and R4 function as a voltage divider that scales the phone line's output voltage to a level the gate can handle. Tim says R4 should be adjusted so that the input to the gate is 7.0 volts when the phone is on hook, and 1.1 volts when it's off hook. When the phone is off hook, the output of the gate goes high, transistor Q1 turns on, and the LED lights up.

Tim also mentioned that the DC supply should be separated from the phone line and that the circuit shouldn't be powered directly from the loop.

In the meantime, here are a few suggestions to help you get a little more out of that circuit. First, you can drive the LED directly and eliminate R2, R3, and Q1. If the LED is too dim, use a 4049 instead of the 4011. Also you should use a high-efficiency LED.

By using a diode bridge at the input to the circuit, you won't have to worry about the polarity of the phone lines. The diodes will also help isolate the circuit from the phone line, so you won't have to worry about dropping the on-hook voltage to the point where the line is accidentally seized.

Thanks again to Tim and the gang at Companion Computers. You've earned your one-year subscriptions. **R-E**

COMMUNICATIONS CORNER

Cross-country networking

HERB FRIEDMAN
COMMUNICATIONS EDITOR

THE WAY IT'S TOLD IN THE POPULAR press—newspapers and magazines—we are rapidly on our way to becoming a "networked" nation. That means that we will be doing much, if not all, of our daily information gathering and disseminating via computer networks.

For example, a child writing a composition for school will no longer have to spend time doing research in the library; he'll simply dial up the library's electronic database from home, using a computer and a modem. Similarly, we'll no longer need skilled electronics technicians (or skilled technicians of any sort); they'll all be replaced by minimum-wage workers who can get all the information they need on-site by using a lap computer to access the office mainframe. Even your accountant will never have to drop by: He'll simply use the telephone and a modem to tap your computer for your business records.

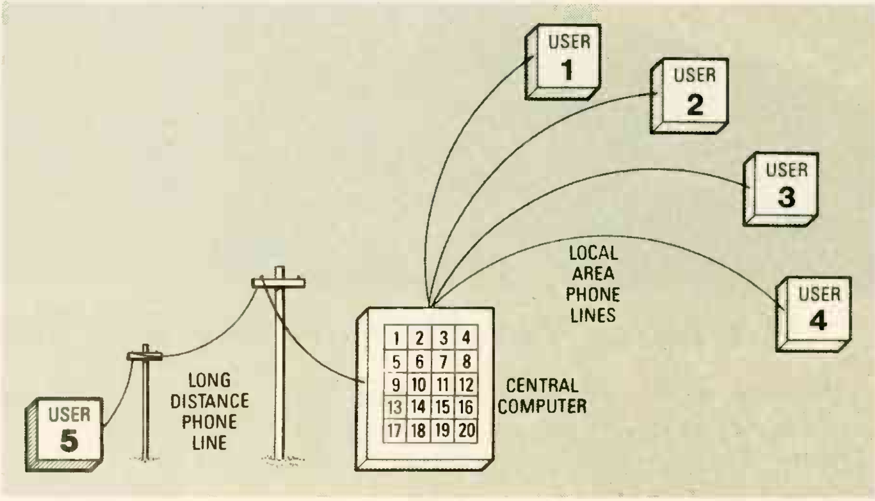


FIG. 1

Networking snags

Boy, does networking sound great! But that's just the problem: It *sounds* great. In actual fact, except for a few special-purpose applications (like getting trading data on stocks and bonds), general-purpose networking has been simply underwhelming.

The problem with networking is that it is often the most *inefficient* means of communication. At its best, networking is often slow, cumbersome, and inconvenient. Consider for a moment the skilled technician in the field: The knowledge in his head is accessible to him much quicker, and much more conveniently, than anything that can be sent to him by computer. If he does need reference material, he can often get it from a service manual much faster than from a computer database. That's because he can mark pertinent sections with small scraps of paper, and then flip through the book to find what he needs. With a computer, you can never keep track of where you are.

Even in the area of general-reference information sources, users have not rushed to embrace networking. Subscription rates to most services have been sharply reduced to attract subscribers, yet one of the most prestigious newspapers closed its on-line reference service for lack of use.

Even The Source and CompuServe, whose rates are reasonable, and who have experimented with many different kinds of databases, have a combined membership of only about 250,000 users, in spite of the fact that there are an estimated 10-million personal computers in homes, offices, and schools.

Or how about teletext, or videotext, or any other kind of "-text" service? Most have failed, or they survive only as an "add-on" to some other service like cable TV.

The reason for the lackluster interest in most networking is that it usually isn't a better way to communicate: It neither enhances the way we presently communicate, nor offers a new and more efficient means of exchanging information. Networking appears to be most successful when it is specifically designed, not as a substitute for the printed page, but as a totally new way to communicate, and when it provides general access to anyone, at any place, and at any time.

Enter MCI mail

The best example of that kind of thinking is MCI's Electronic Mail. MCI provides many different services, but from the communications point of view the most important feature is the electronic mailbox. Basically, electronic mail works as shown in Fig 1. MCI's central computer can be accessed by any personal computer—local or long distance—through the switched telephone network (the dial-up system). But instead of being routed to another party for voice communications, the user is connected to the computer's storage system, in which he may store a document—a note, a letter, or any text file—for automatic transmission at some later time.

The document might then be forwarded to a computer in another city where it would be printed and then delivered by messenger or by the U. S. mail. Alternatively, the user might select conventional electronic-mailbox service wherein the document would be stored in the addressee's "mailbox." When the addressee dialed up, he would be informed that your letter was waiting.

As far as the user is concerned your document is in his "mailbox," but actually that mailbox is computer memory just like other computer memory. When the addressee request his "mail," your document is moved from that memory to the user's computer terminal via the dial-up system.

At first glance, an electronic mailbox might appear as just another cute networking function with no real value, but think about it. How else could you easily step around time zones, or deliver an important document at an inconvenient time, or afford a personal FAX (facsimile) system?

Here in New York I can't start calling businesses on the coast until noon, and then my lunch hour gets tangled with their coffee breaks. We close at 5 PM; but that's the middle of the afternoon in California. And the middle of my work day is lunch hour out there. With electronic mail I simply don't have that problem. I send my message electronically, and it is "picked up" when convenient. If I need to send a message overseas I can use MCI's Telex service.

I can even use the electronic mailbox to exchange documents with other editors in my area. If the creative juices strike someone at 3 AM, he can "drop" his "copy" in my "mailbox" in the wee hours, and I can "pick up the mail" when the sun comes up.

But perhaps the nicest feature of electronic mail is simulated FAX. A major difficulty in electronic communications has always been the reproduction of tables and charts. With electronic mail, the receiving party gets an exact copy of the original document. We can send almost anything by electronic mail, as long as it can be represented by ASCII codes.

MCI's mail services are not networking in the true sense of the word, because they aren't performed in real time—meaning there is always a delay between the sending of a document and its receipt. Nevertheless, MCI accomplishes the real purpose of networking: convenient, unattended information exchange that is no more difficult to use than existing information services. R-E

STATE OF SOLID STATE

ROBERT F. SCOTT,
SEMICONDUCTOR EDITOR

Overvoltage protection

HIGH VOLTAGES STRIKE FEAR IN THE heart of circuit designers because damage by a high-voltage condition can easily cause erratic circuit operation or even catastrophic component failure. To protect circuits from overvoltage conditions, Motorola has introduced four new IC's that work with both positive and negative supplies. Those IC's sense the overvoltage condition and almost instantly "crowbar" (short circuit) the power-supply line; the dangerous voltage is thereby reduced before sensitive circuitry can be damaged. One nice feature of the new IC's is that an external capacitor may be used to program a delay between the onset of the overvoltage condition and the tripping of the crowbar. That delay provides noise immunity. The IC's also have circuitry that eliminates trip-voltage and temperature-drift errors due to SCR gate variations.

The MC34061 is a three-terminal device in a TO-92 plastic package. The basic MC34061 offers a ±2% trip-voltage tolerance. The corresponding figure for the MC34061/A is ±1%, and its other key parameters have been tightened. Other features of the MC34061 include:

- 200-mA SCR gate drive
- 2.5-volt sense voltage
- 250-mV hysteresis
- 4–41-volt supply voltage

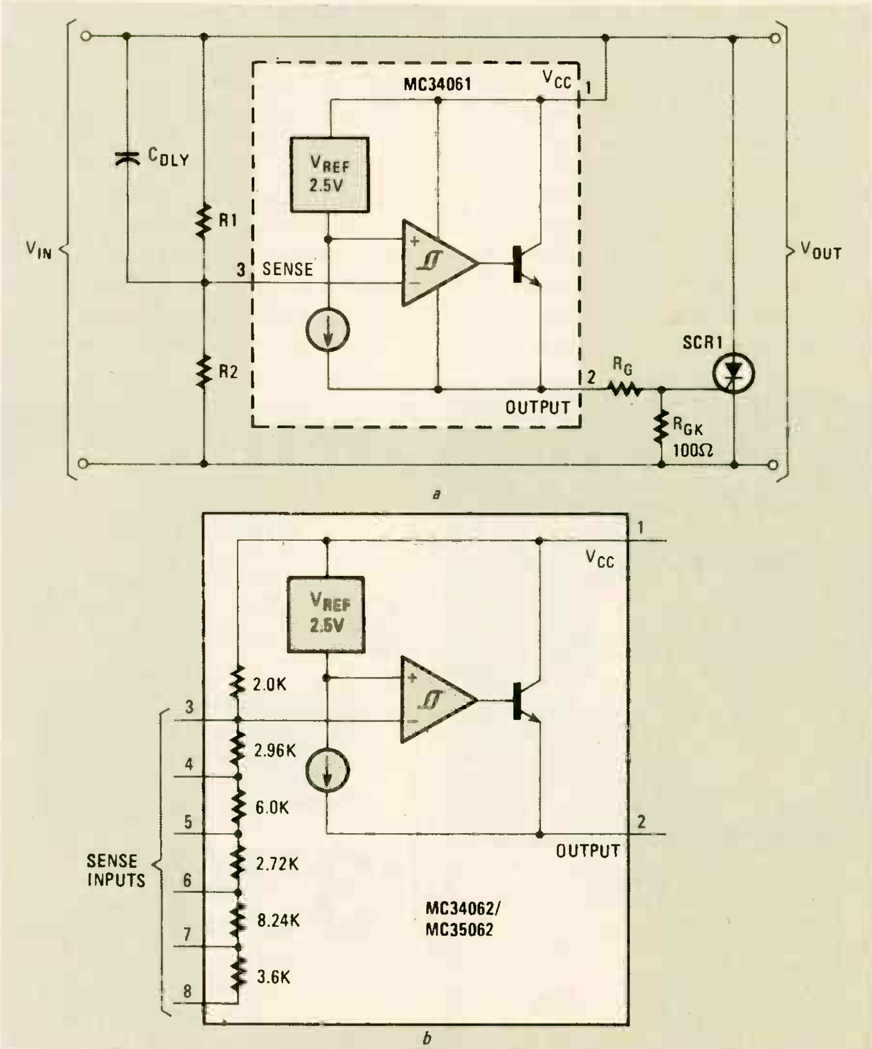


FIG. 1

A block diagram of the MC34061 is shown, along with a typical application, in Fig. 1-*a*. The voltage at the comparator's inverting input (pin 3) is ($V_{CC} \times$ R2)/(R1 + R2), while the voltage at the non-inverting input is $V_{CC} - 2.5$ volts. Therefore, the voltage divider (R1 and R2) sets the sense-trip level, and the comparator's output is a function of V_{CC}.

The trip voltage (V_{TRIP}) equals 2.5(R1 + R2)/R1. When V_{CC} is less than V_{TRIP}, the output transistor is *off*. When V_{CC} is greater, the output transistor is *on*.

In the *off* state, a small current (the sum of the reference- and comparator-supply currents) is available at pin 2. Resistor R_{GK} may be used to shunt that current away from the driven circuit. A value of 100 ohms reduces the off-state drive to about 60 mV.

In the *on* state, the device becomes a current source capable of saturating to within 2.0 volts of V_{CC}. So, if the device must drive a high-impedance load, you'll have to clamp the output to at least 3.0 volts below V_{CC}.

Resistor R_G should be connected in series with the SCR's gate when you use a power supply greater than eleven volts. That gate resistor limits the power dissipated in the IC to about two watts. It also protects the IC if the SCR fails. The data sheets for the MC34061 supply detailed information, including nomographs, on selecting an appropriate SCR and gate resistor.

The delay provided by capacitor C_{DLY} is a function of R1, R2, C_{DLY}, as well as the nominal supply voltage and the value of the overvoltage. The magnitude of the overvoltage condition determines the rate at which C_{DLY} charges up to the reference voltage (2.5 volts). So, for given values of R1, R2, and C_{DLY}, the delay decreases as overvoltage increases. The time (in milliseconds) may be found from this equation:

$$T_{DLY} = \frac{R1 \times R2 \times C_{DLY}}{R1 + R2} \times \ln\left(\frac{V_{CC} - V_{CC\,(NOM)}}{V_{CC} - V_{TRIP}}\right)$$

Motorola provides a nomograph that simplifies determining the time delay for various values of C_{DLY} at supply voltages ranging from 6.3 to 40 volts. In a typical 5-volt supply, R1 = 1.8K, R2 = 2.7K, V_{CC} = 5.0 volts, and V_{TRIP} = 6.25 volts.

The MC34062 and MC35062 are similar devices with built-in trip-point sensing. They come in eight-pin dual-in-line packages (DIP's). The MC35062U comes in a ceramic DIP and operates over the military temperature range of −55 to +125°C. The MC34062P1 (ceramic) and MC34062U (plastic) operate over the commercial temperature range of 0 to +70°C.

The MC34062 and MC35062 are very similar to the MC34061. They differ from it in that they include a built-in voltage divider, as shown in Fig. 1-*b*, that allows the user to program a trip voltage ranging from 3.5- to 40-volts DC. By connecting the input voltage to a single pin, an MC34062/MC35062 can trip at 5, 10, 12, 15, 24, or 28 volts. By inter-connecting pins, grounding them, or both, the user can select 120 other trip voltages ranging from 3.483 to 39.064 volts.

For more information contact your local Motorola representative, or write to **Motorola Semiconductor Products, Inc.,** P. O. Box 20912, Phoenix, AZ 85036.

DAC manual

The *CMOS DAC Application Guide* is a comprehensive 63-page guide to CMOS digital-to-analog converters (DAC's). It covers the theory, operation, and applications of DAC's. Also discussed is basic DAC circuit design, and the meaning of specifications like glitches, output-leakage current, and power-supply rejection.—**Analog Devices,** P. O. Box 289, Norwood, MA 02062. **R-E**

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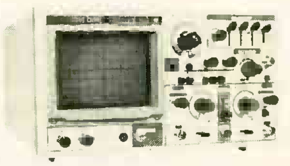

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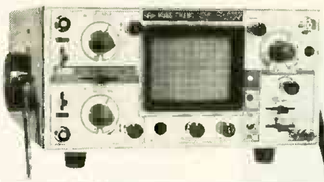

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Check transistors, diodes and LEDs with this professional quality meter. Other features include, decibel scale • 20K volt metering system • 3½" mirrored scale • polarity switch • 20 measuring ranges • safety probes • high impact plastic case

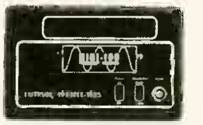
$19.95 test leads and battery included

NEW

RAMSEY D-4100 COMPACT DIGITAL MULTITESTER

Compact sized reliability and accuracy. This LCD digital multitester easily fits in your pocket, you can take it anywhere. It features full overload protection • 3½ digit LCD readout • recessed input jacks • safety probes • diode check function • 2000 hours battery life

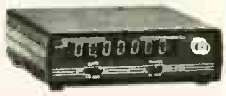
$22.95 test leads and battery included



MINI-100 FREQUENCY COUNTER

Features and capabilities of counters costing twice as much • compact • high sensitivity • low current drain • very accurate • leading zero blanking • field or shop use • 1 MHz to 500 MHz range • diode protected • 7 digit display

$99.95 BATTERY CHARGER NICAD BATTERIES AND AC ADAPTER INCLUDED



CT-70 7 DIGIT 525 MHz COUNTER

Lab quality at a breakthrough price. Features • 3 frequency ranges each with pre amp • dual selectable gate times • gate activity indicator • 50mV @ 150 MHz typical sensitivity • wide frequency range • 1 ppm accuracy

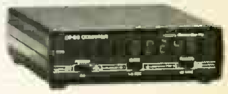
$119.95 wired includes AC adapter

CT-70 kit $99.95
BP-4 nicad pack 8.95

CT-50 8 DIGIT 600 MHz COUNTER

$169.95 wired

CT-50 kit $139.95
RA-1 receiver adapter kit 14.95



CT-90 9 DIGIT 600 MHz COUNTER

The most versatile for less than $300. Features 3 selectable gate times • 9 digits • gate indicator • display hold • 25mV @ 150 MHz typical sensitivity • 10 MHz timebase for WWV calibration • 1 ppm accuracy

$149.95 wired includes AC adapter

CT-90 kit $129.95
OV-1 0.1 PPM oven timebase 59.95
BP-4 nicad pack 8.95

CT-125 9 DIGIT 1.2 GHz COUNTER

$169.95 wired includes AC adapter

BP-4 nicad $8.95

MINI KITS—EASY TO ASSEMBLE, FUN TO USE BEGINNERS & PROS WILL HAVE A GREAT TIME WITH THESE KITS

FM MINI MIKE

A super high performance FM wireless mike kit! Transmits a stable signal up to 300 yards with exceptional audio quality by means of its built in electret mike. Kit includes case, mike, on-off switch, antenna, battery and super instructions. This is the finest unit available.

FM-3 Kit $14.95
FM-3 Wired and Tested 19.95

Color Organ

See music come alive! 3 different lights flicker with music. One light each for, high, mid-range and lows. Each individually adjustable and drives up to 300 W. runs on 110VAC.

Complete kit, ML-1 $8.95

Video Modulator Kit

Converts any TV to video monitor. Super stable, tunable over ch 4-6. Runs on 5-15V accepts std video signal. Best unit on the market! Complete kit, VD-1 $7.95

Led Blinky Kit

A great attention getter which alternately flashes 2 jumbo LEDs. Use for name badges, buttons, warning panel lights, anything! Runs on 3 to 15 volts. Complete kit, BL-1 $2.95

Super Sleuth

A super sensitive amplifier which will pick up a pin drop at 15 feet! Great for monitoring baby's room or as general purpose amplifier. Full 2W rms output, runs on 6 to 15 volts, uses 8-45 ohm speaker. Complete kit, BN-9 $5.95

CPO-1

Runs on 3-12 Vdc 1 watt out, 1 KHZ good for CPO, Alarm, Audio Oscillator. Complete kit $2.95

FM Wireless Mike Kit

Tansmits up to 300' to any FM broadcast radio, uses any type of mike. Runs on 3 to 9V. Type FM-2 has added sensitive mike preamp stage.

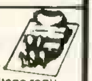
FM-1 Kit $3.95 FM-2 Kit $4.95

Whisper Light Kit

An interesting kit, small mike picks up sounds and converts them to light. The louder the sound, the brighter the light. Includes mike, controls up to 300 W, runs on 110 VAC.

Complete kit, WL-1 $6.95

Tone Decoder



A complete tone decoder on a single PC board. Features: 400-5000 Hz adjustable range via 20 turn pot, voltage regulation, 567 IC. Useful for touch-tone burst detection, FSK, etc. Can also be used as a stable tone encoder. Runs on 5 to 12 volts. Complete kit, TD-1 $5.95

Universal Timer Kit

Provides the basic parts and PC board required to provide a source of precision timing and pulse generation. Uses 555 timer IC and includes a range of parts for most timing needs.

UT-5 Kit $5.95

Mad Blaster Kit

Produces LOUD ear shattering and attention getting siren like sound. Can supply up to 15 watts of obnoxious audio. Runs on 6-15 VDC

MB-1 Kit $4.95

Siren Kit

Produces upward and downward wail characteristic of a police siren. 5 W peak audio output, runs on 3-15 volts, uses 3-45 ohm speaker.

Complete kit, SM-3 $2.95

60 Hz Time Base

Runs on 5-15 VDC. Low current (25ma) 1 min/month accuracy TB-7 Kit $5.50
TB-7 Assy $9.95

30 Watt 2 mtr PWR AMP

Simple Class C power amp features 8 times power gain. 1 W in for 8 out, 2 W in for 15 out, 4 W in for 30 out. Max output of 35 W, incredible value, complete with all parts, less case and T-R relay.

PA-1, 30 W pwr amp kit $22.95
TR-1, RF sensed T-R relay kit 6.95

Power Supply Kit

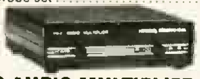
Complete triple regulated power supply provides variable 6 to 18 volts at 200 ma and +5 at 1 Amp. Excellent load regulation, good filtering and small size. Less transformers, requires 6.3V (a 1 A and 24 VCT. Complete kit, PS-3LT $6.95

DM-700 DIGITAL MULTIMETER

Professional quality at a hobbyist price. Features include 26 different ranges and 5 functions • 3½ digit, ½ inch LED display • automatic decimal placement • automatic polarity

$119.95 wired includes AC adapter

DM-700 kit $99.95
MP-1 probe set 4.95



PS-2 AUDIO MULTIPLIER

The PS-2 is handy for high resolution audio resolution measurements, multiplies Up in frequency • great for PL tone measurements • multiplies by 10 or 100 • 0.01 Hz resolution & built-in signal preamp/conditioner

$49.95 wired

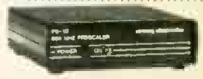
PR-2 kit $39.95

PR-2 COUNTER PREAMP

The PR-2 is ideal for measuring weak signals from 10 to 1,000 MHz • flat 25 db gain • BNC connectors • great for shifting RF • ideal receiver/TV preamp

$44.95 wired includes AC adapter

PR-2 kit $34.95



PS-10B 1.5 GHz PRESCALER

Extends the range of your present counter to 1.5 GHz • 2 stage preamp • divide by 1000 circuitry • super sensitive (50 mV typical) • BNC connectors • 1 GHz in, 1 MHz out • drive any counter

PS 10-B Prescaler $79.95
wired includes AC adapter

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Telescopic whip antenna—BNC plug	$ 8.95
High impedance probe, light loading	16.95
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Tilt bail, for CT-70, 90, 125	3.95

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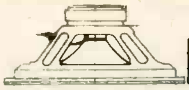

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RADIO tubes: 2A3, 45's, 50's, 211, 845. Western Electric tubes, amps, drivers, horns, speakers. **DAVID,** P.O. Box 832, Monterey Park, CA 91754, Tel:(818) 576-2642.

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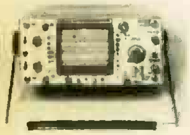
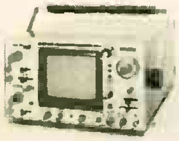
100 MHZ · 3 CH.



- Eight Trace Capability
- Alternate Triggering
- High Vertical Input Sensitivity
- Excellent Triggering Sensitivity

$1435

LBO 524L
35 MHZ · 2 CH.



- 500 uV Sensitivity
- Calibrated Delayed Time Base
- Alternate Triggering
- CH-1 Output

$890

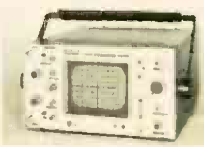
LBO-518	$1985
LBO-525L	$1156
LBO-524	$ 843
LBO-523	$ 759
LBO-513A	$ 399
LBO-310A	$ 259
LBO-5825	$3727

LBO 522
20 MHZ · DT

- 500 uV Sensitivity
- Variable Hold-off
- 8 x 10 cm Display
- Alternate Triggering

$589

LBO 514
15 MHZ · DT



- 1 mV Sensitivity
- 5" CRT
- 0.1 μs Sweep Speed
- X-Y Mode

$394

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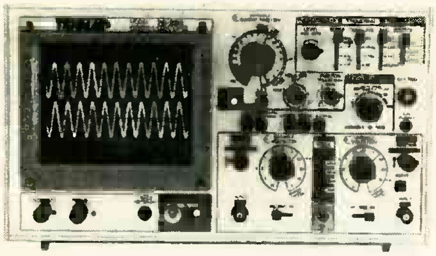
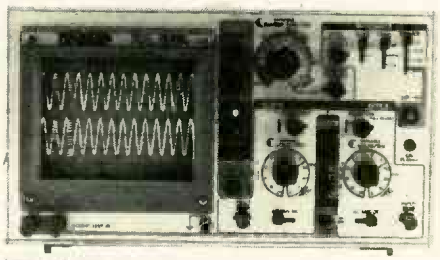


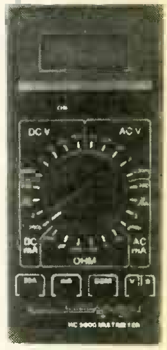
TENMA 35 MHZ Dual Trace Oscilloscope
- Two high quality 10:1 probes included
- For additional specifications see MCM Catalog #11

#72-330
$569.00 (ea)
2 YEAR WARRANTY



TENMA 20 MHZ Dual Trace Oscilloscope
- Two high quality 10:1 probes included
- For additional specifications see MCM Catalog #11

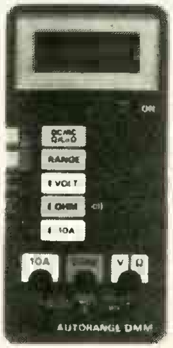
#72-320
$389.95 (ea)
2 YEAR WARRANTY



NEW

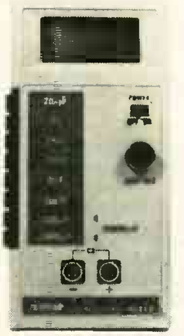
TENMA Rotary Dial DMM
■ 3½ digit LCD display ■ Rotary dial for rapid selection of functions and ranges ■ 20 amp AC-DC current ■ .1ohm resolution ■ Carrying case included

#72-075 $44.80 (ea)
$41.95 (2-up)
1 YEAR LIMITED WARRANTY



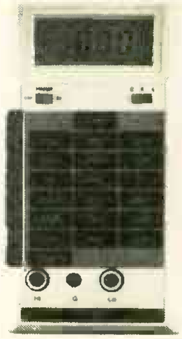
TENMA Autoranging Digital Multimeter
■ 3½ digit ■ Auto polarity ■ Low battery indicator ■ 10 amp AC-DC current ■ Continuity buzzer ■ 2¾" x 5¾" x 1⅜" ■ Carrying case included

#72-058 $49.80 (1-4)
$44.95 (2-up)
1 YEAR LIMITED WARRANTY



TENMA Capacitance Meter
■ Measures capacitors from 0.1pF to 19.999mfd ■ Accuracy 0.5% ■ Checks capacitors in and out of circuit ■ Carrying case included

#72-040 $59.80 (ea)
$54.95 (2-up)
1 YEAR LIMITED WARRANTY



NEW

TENMA Digital LCR Meter
■ Measures inductance, capacitance and resistance ■ L = 1 micro H to 200H, C = .1pF to 200 micro F, R = .01ohm to 20Mohm ■ Carrying case included.

#72-370
$149.95 (ea)
1 YEAR LIMITED WARRANTY

TENMA Combination Function Generator and Frequency Counter
■ 6 digit display ■ Output range: .2Hz to 2MHz seven ranges ■ Counter range .1Hz to 10MHz ■ 5-15 volt TTL and CMOS output ■ Wave forms: sine, triangle, square, pulse, and ramp.

#72-380
$219.90 (ea)
1 YEAR LIMITED WARRANTY

NEW

TENMA Frequency Counter
■ 8 digit LED display ■ Measurement range: 1HZ - 120MHz ■ High input sensitivity of 20mV RMS

#72-375 **$189.95** (ea)
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EQUIPMENT REPORTS

continued from page 28

feet above sea level, stations as far away as 35 miles could be heard using those antennas.

The *800XLT* is fairly free of birdies (self-generated spurious signals). As in other Uniden-Bearcat scanners we have used and evaluated, the birdies were primarily evident in the 40–50- and the 150–160-MHz range. However, in no instance did those present any kind of problem.

The *800XLT* offers some impressive specifications, especially for equipment of its type. While we won't go into detail here, those specifications compare favorably with those of some other communications-quality gear we've recently seen.

As to the unit's instruction manual, it is clear and concise. It easily leads you through the *800XLT*'s features, and it offers an extra bonus on its back page: a listing of popular frequencies to help the new scanner user get started. The manual's graphics were clear and illustrated the text quite well.

On the whole, the Uniden-Bearcat *800XLT* is an outstanding performer. If you're in the market for a scanning receiver with expanded frequency coverage, it should be placed near the top of your list. Undoubtedly, at a suggested list of $499.95, the *800XLT* isn't inexpensive, but you certainly get what you pay for. **R-E**

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TURBO SCREW-DRIVER (RECHARGEABLE) No. 988

New

The most perfect powerful multi-purpose tool for Workshop, Home, Hobby & Outdoor work....
Includes UL approval charger, Driver bits: 2 Regualar and 2 Philips.
Each set $30.00

CORDLESS SOLDERING IRON (RECHARGEABLE) No. 620

New

The most perfect handy, lightweight soldering iron for Workshop, Home, Hobby & Outdoor work....
Includes UL approval charger & cleaning sponge.
With build-in solder point illumination.
Each set $22.80

TALKING CLOCK — NEW FOR 86'

1. Talk: push button for voice announcement of time.
2. Read out: twelve hours system display for hour, minute, second (by colon flash), AM & PM.
3. Display: three display modes of time, alarm time & date.
4. Alarm: on/off switch with thirty seconds voice alarm.
5. Snooze: reminder voice alarm of thirty seconds after 4 minutes of first voice alarm.
6. Volume: two level of voice output.
7. Language available: English.

Mynah 8504 & Cockatoo 8502 .... $25.00 NOT A KIT!

LCD THERMOMETER CLOCK — NEW!

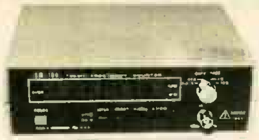
Features:
0.34" DIGITAL thermometer with Hi & Low temperature alarm function and 12 hours clock combination.
Measuring range: 0°F to 160°F or −20°C to +70°C.
Resolution reading: ±1.8°F.
Dimension: 3.2" × 0.86" × 2.08".
T-1 with In/Out Door sensor $20.00
T-2 with Fahrenheit/Celsius measuring . $18.00 NOT A KIT!

YAMATO 4001 3½ DIGITAL MULTIMETER

SPECIAL OFFER!

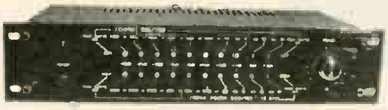
The YAMATO 4001 is a 3½ DIGIT COMPACT DIGITAL MULTIMETER, it employs FE type LCD, with large figures. Its ADVANTAGES: High accuracy in measuring. High impedance assures min. measuring error. One rotary switch allows fast & convenient operation. 26 measurement range enable wider application. Over-input indication & low battery life appears on display. LSI-circuit use provides high reliability and durability. Measurement possible even under strong magnetic field.
Not a KIT, assembled with tested $33.80

150MC UNIVERSAL DIGITAL FREQUENCY COUNTER SM-100



SM-100 is an accurate, easy-operated digital frequency counter. Few pieces of advanced, high technical LSI integrated circuit are used, thus, circuit structure is reliable. SM-100 can give you up to 8 digits of resolution for a wide frequency range of 10Hz to 150MHz. Besides, a memorize system is available, the last input digits can be held on the panel, as compare to the other or even observation.
Input sensitivity: KHz range 10Hz – 10MHz 50mVrms
MHz range 1MHz – 150MHz 40mVrms
Response time: 0.2 sec.
Hold: Hold the last input signal
Power supply: DC6V Battery or DC9V 250MA Adaptor
Assembled with Tested $99.00

TA-302 60W VERSATILE STEREO POWER BOOSTER



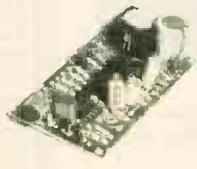
- OTL full transistorize and low distortion of SEPP circuit design, high output power and sound fidelity.
- With high and low input inpendance for selection, so it can match with all pre-amplifiers, low power of portable sound equipment, and all types of stereo recorder deck to use. It can boost 'walkman' type of radio and tape player, too.
- With 10 band colour LED power meter, output power can be easily defined. TA-302 is a versatile amplifier for both visual and listening enjoyment.

Assembled with Tested $60.00
Kit $50.00

SM-43 MULTIFUNCTIONAL LED D.P.M.

6 different kinds of usages with only one meter, high accuracy (±0.1%) (±1 digit), high input impedance, high anti-vibrating ability, the display reset to zero automatically when the input is 0V and employs 100PPM/C temperature compensating zener diode which improves the accuracy and stationary of the meter.
MEASUREMENT RANGE:
D.C. VOLTAGE: 1mV – 1000V
A.C. VOLTAGE: 1mV – 1000V
DIGITAL THERMOMETER: 0°C – 100°C
D.C. CURRENT: 1uA – 2A
CAPACITOR METER: 1pF – 2uF
FREQUENCY COUNTER: 10Hz – 20KHz
DIMENSION: 3¾" × 1⅞" × 4 1/16"
Kit $29.23
Assembled with tested $35.00

TY-38 SOUND OR TOUCH CONTROL SWITCH



When there is a sound input, the switch is on, otherwise the switch is off.
High precision timing circuit makes it possible to adjust delay from 0.5 second to 15 seconds.
Suitable for CB transmitter.
When touching plate is pressed, the switch is on, otherwise it is off.
High precision delay circuit is included.
Power supply: 9–16V DC.
Kit $10.00

PRACTICAL & DECORATIVE TWO-PIECE PHONE HT-10

- Ultra-slim desk top style.
- Last number memory redial.
- 10 memories function.
- Two colors available: Red & Gray.

FCC approved No. DEW7DH-15793-TE-R.
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REMIX your record yourself

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It uses 0.6" LED display panel so the display is more clear and readable.
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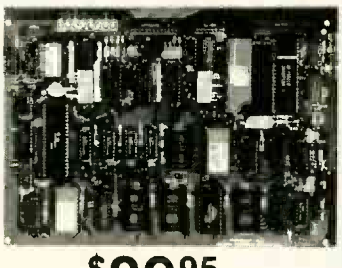

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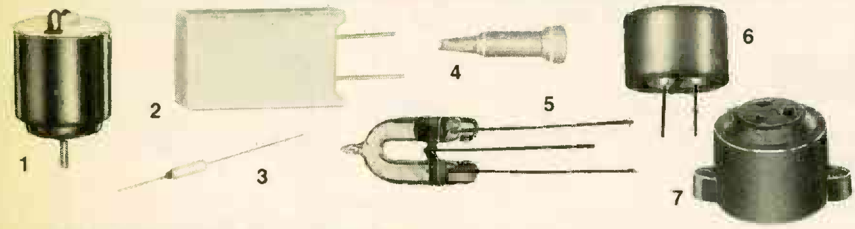

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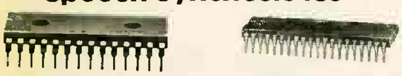

Note: ICs are supplied with data and circuit examples. All required extra parts are available through Radio Shack.

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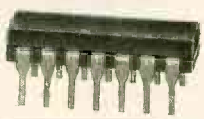

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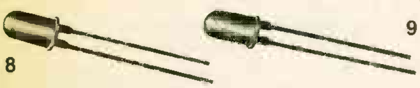

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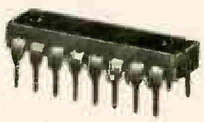

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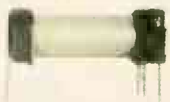

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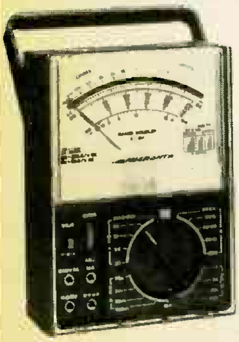

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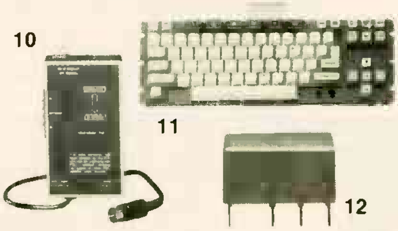

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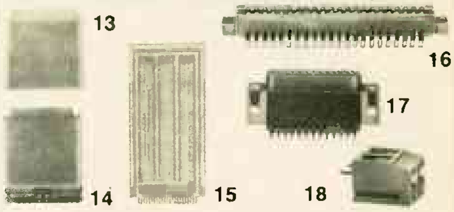

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Dual plus and minus 12Vdc open frame power supply. Can be used as 24Vdc @ 1.5 amp. INPUT: either 115 Vac or 230 Vac
Fully regulated computer grade supply.
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New, stereo cassette mechanism. Includes record/playback and erase heads, 2-12VDC motors, drive belts, pulleys, 3-12VDC solenoids, pinchwheels and other mechanical parts. These parts, used on other current model decks, would cost several times our selling price if purchased separately. Build your own audio or data recorder or use for spare parts. 5⅜" X 3½" X 3⅛".
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Two color coded terminals on a sturdy 2¾" x 3¾" bakelite plate.
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HM6116LP-2	2048x8	(120ns)(CMOS)(LP)	2.95
HM6264P-15	8192x8	(150ns)(CMOS)	3.89
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LP=Low power

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4164-150	65536x1	(150ns)(5V)	.99
4164-120	65536x1	(120ns)(5V)	1.95
MCM6665	65536x1	(200ns)(5V)	1.95
TMS4164	65536x1	(150ns)(5V)	1.95
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2732	4096x8	(450ns)(5V)	2.45
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2732A-2	4096x8	(200ns)(5V)(21V PGM)	3.95
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5V=Single 5 Volt Supply 21V PGM=Program at 21 Volts

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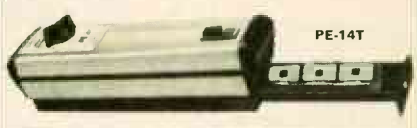

Model	Timer	Capacity Chip	Intensity (uW/Cm²)	Unit Price
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PE-14T	YES	9	8,000	$119.00
PE-24T	YES	12	9,600	$175.00

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8253-5	1.95
8255	1.69
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8259	1.95
8259-5	2.29
8272	4.95
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1.0 MHz

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6850	1.95
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6.144	1.95
6.5536	1.95
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10.0	1.95
10.738635	1.95
12.0	1.95
14.31818	1.95
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2.5	4.95
4.0	4.95
5.0688	4.95
6.0	4.95
6.144	4.95
8.0	4.95
10.0	4.95
12.0	4.95
12.480	4.95
15.0	4.95
16.0	4.95
18.432	4.95
20.0	4.95
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74LS00	.16	74LS165	.65
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74LS04	.16	74LS174	.39
74LS05	.18	74LS175	.39
74LS08	.18	74LS191	.49
74LS09	.18	74LS192	.69
74LS10	.16	74LS193	.69
74LS11	.22	74LS194	.69
74LS12	.22	74LS195	.69
74LS13	.26	74LS196	.59
74LS14	.39	74LS197	.59
74LS15	.26	74LS221	.59
74LS20	.17	74LS240	.69
74LS21	.22	74LS241	.69
74LS22	.22	74LS242	.69
74LS27	.23	74LS243	.69
74LS28	.26	74LS244	.69
74LS30	.17	74LS245	.79
74LS32	.18	74LS251	.49
74LS33	.28	74LS253	.49
74LS37	.26	74LS256	1.79
74LS38	.26	74LS257	.39
74LS42	.39	74LS258	.49
74LS47	.59	74LS259	1.29
74LS48	.69	74LS260	.49
74LS51	.17	74LS266	.39
74LS73	.29	74LS273	.79
74LS74	.24	74LS279	.39
74LS75	.29	74LS280	1.98
74LS76	.29	74LS283	.59
74LS83	.49	74LS290	.89
74LS85	.49	74LS293	.89
74LS86	.22	74LS299	1.49
74LS90	.39	74LS322	3.95
74LS92	.49	74LS323	2.49
74LS93	.39	74LS364	1.95
74LS95	.49	74LS365	.39
74LS107	.34	74LS367	.39
74LS109	.36	74LS368	.39
74LS112	.29	74LS373	.79
74LS122	.45	74LS374	.79
74LS123	.49	74LS375	.95
74LS124	2.75	74LS377	.79
74LS125	.39	74LS378	1.18
74LS126	.39	74LS390	1.19
74LS132	.39	74LS393	.79
74LS133	.49	74LS541	1.49
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74LS154	1.49	74LS688	2.40
74LS155	.59	74LS783	22.95
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74LS157	.35	81LS96	1.49
74LS158	.29	81LS97	1.49
74LS160	.29	81LS98	1.49
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74HC10	.59	74HC158	.95
74HC14	.79	74HC163	1.15
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74HC30	.59	74HC244	1.89
74HC32	.69	74HC245	1.89
74HC51	.59	74HC257	.85
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74HC85	1.35	74HC273	1.89
74HC86	.69	74HC299	4.99
74HC93	1.19	74HC368	.99
74HC107	.79	74HC373	2.29
74HC109	.79	74HC374	2.29
74HC112	.79	74HC390	1.39
74HC125	1.19	74HC393	1.39
74HC132	1.19	74HC4017	1.99
74HC133	.69	74HC4020	1.39
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74HCT04	.69	74HCT193	1.39
74HCT08	.69	74HCT194	1.19
74HCT10	.69	74HCT240	2.19
74HCT11	.69	74HCT241	2.19
74HCT27	.69	74HCT244	2.19
74HCT30	.69	74HCT245	2.19
74HCT32	.79	74HCT257	.99
74HCT74	.85	74HCT259	1.59
74HCT75	.95	74HCT273	2.09
74HCT138	1.15	74HCT367	1.09
74HCT139	1.15	74HCT373	2.49
74HCT154	2.99	74HCT374	2.49
74HCT157	.99	74HCT393	1.59
74HCT158	.99	74HCT4017	2.19
74HCT161	1.29	74HCT4040	1.59
74HCT164	1.39	74HCT4060	1.49

74F00

74F00	.69	74F74	.79	74F251	1.69
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74F04	.79	74F138	1.69	74F257	1.69
74F08	.69	74F139	1.69	74F280	1.79
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4042	.59	74C00	.29
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4044	.69	74C74	.59
4045	1.98	74C83	1.95
4046	.69	74C85	1.49
4047	.69	74C95	.99
4049	.29	74C150	5.75
4050	.29	74C151	2.25
4051	.69	74C161	.99
4052	.69	74C163	.99
4053	.69	74C164	1.39
4056	2.19	74C192	1.49
4060	.69	74C193	1.49
4066	.29	74C221	1.75
4069	.19	74C240	1.89
4076	.59	74C244	1.89
4077	.29	74C374	1.99
4081	.22	74C905	10.95
4085	.79	74C911	8.95
4086	.89	74C917	8.95
4093	.49	74C922	4.49
4094	2.49	74C923	4.95
14411	9.95	74C926	7.95
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7400/9000

7400	.19	74147	2.49
7402	.19	74148	1.20
7404	.19	74150	1.35
7406	.29	74151	.55
7407	.29	74153	.55
7408	.24	74154	1.49
7410	.19	74155	.75
7411	.25	74157	.55
7414	.49	74159	1.65
7416	.25	74161	.69
7417	.25	74163	.69
7420	.19	74164	.85
7423	.29	74165	.85
7430	.19	74166	1.00
7432	.29	74175	.89
7438	.29	74177	.75
7442	.49	74178	1.15
7445	.69	74181	2.25
7447	.89	74182	.75
7470	.35	74184	2.00
7473	.34	74191	1.15
7474	.33	74192	.79
7475	.45	74194	.85
7476	.35	74196	.79
7483	.50	74197	.75
7485	.59	74199	1.35
7486	.35	74221	1.35
7489	2.15	74246	1.35
7490	.39	74247	1.25
7492	.50	74248	1.85
7493	.35	74249	1.95
7495	.55	74251	.75
7497	2.75	74265	1.35
74100	2.29	74273	1.95
74121	.29	74278	3.11
74123	.49	74367	.65
74125	.45	74368	.65
74141	.65	9368	3.95
74143	5.95	9602	1.50
74144	2.95	9637	2.95
74145	.60	96S02	1.95

74S00

74S00	.29	74S163	1.29
74S02	.29	74S168	3.95
74S03	.29	74S174	.79
74S04	.29	74S175	.79
74S05	.29	74S188	1.95
74S08	.35	74S189	1.95
74S10	.29	74S195	1.49
74S15	.35	74S196	1.49
74S30	.29	74S197	1.49
74S32	.35	74S226	3.99
74S37	.69	74S240	1.49
74S38	.69	74S241	1.49
74S74	.49	74S244	1.49
74S85	.95	74S257	.79
74S86	.35	74S253	.79
74S112	.50	74S258	.95
74S124	2.75	74S280	1.95
74S138	.79	74S287	1.69
74S140	.55	74S288	1.69
74S151	.79	74S299	2.95
74S153	.79	74S373	1.69
74S157	.79	74S374	1.69
74S158	.95	74S471	4.95
74S161	1.29	74S571	2.95

VOLTAGE REGULATORS

TO-220 CASE

7805T	.49	7905T	.59
7808T	.49	7908T	.59
7812T	.49	7912T	.59
7815T	.49	7915T	.59

TO-3 CASE

7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49

TO-92 CASE

78L05	.49	79L05	.69
78L12	.49	79L12	.69

OTHER VOLTAGE REGS

LM323K	5V	3A	TO-3	4.79
LM338K	Adj	5A	TO-3	3.95
78H05K	5V	5A	TO-3	7.95
78H12K	12V	5A	TO-3	8.95
78P05K	5V	10A	TO-3	14.95

LINEAR

TL066	.99	LM733	.98
TL071	.69	LM741	.29
TL072	1.09	LM747	.69
TL074	1.95	LM748	.59
TL081	.59	MC1330	1.69
TL082	.99	MC1350	1.19
TL084	1.49	MC1372	6.95
LM301	.34	LM1414	1.59
LM309K	1.25	LM1458	.49
LM311	.59	LM1488	.49
LM311H	.89	LM1489	.49
LM317K	3.49	LM1496	.85
LM317T	.95	LM1812	8.25
LM318	1.49	LM1889	1.95
LM319	1.25	ULN2003	.79
LM320	see7900	XR2206	3.75
LM322	1.65	XR2211	2.95
LM323K	4.79	XR2240	1.95
LM324	.49	MPQ2907	1.95
LM331	3.95	LM2917	1.95
LM334	1.19	CA3046	.89
LM335	1.40	CA3081	.99
LM336	1.75	CA3082	.99
LM337K	3.95	CA3086	.80
LM338K	3.95	CA3089	1.95
LM339	.59	CA3130E	.99
LM340	see7800	CA3146	1.29
LM350T	4.60	CA3160	1.19
LF353	.59	MC3470	1.95
LF356	.99	MC3480	8.95
LF357	.99	MC3487	2.95
LM358	.59	LM3900	.49
LM380	.89	LM3909	.98
LM383	1.95	LM3911	2.25
LM386	.89	LM3914	2.39
LM393	.45	MC4024	3.49
LM394H	4.60	MC4044	3.99
TL494	4.20	RC4136	1.25
TL497	3.25	RC4558	.69
NE555	.29	LM13600	1.49
NE556	.49	75107	1.49
NE558	1.29	75110	1.95
NE564	1.95	75150	1.95
LM565	.95	75154	1.95
LM566	1.49	75188	1.25
LM567	.79	75189	1.25
NE570	2.95	75451	.39
NE590	2.50	75452	.39
NE592	.98	75453	.39
LM710	.75	75477	1.29
LM723	.49	75492	.79

H=TO-5 CAN, K=TO-3, T=TO-220

DATA ACQ · INTERFACE

DATA ACQ		INTERFACE	
ADC0800	15.55	8T26	1.29
ADC0804	3.49	8T28	1.29
ADC0809	4.49	8T95	.89
ADC0816	14.95	8T96	.89
ADC0817	9.95	8T97	.59
ADC0831	8.95	8T98	.89
DAC0800	4.49	DM8131	2.95
DAC0806	1.95	DP8304	2.29
DAC0808	2.95	DS8833	2.25
DAC1020	8.25	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	2.95	DS8837	1.65

IC SOCKETS

	1-99	100
8 PIN ST	.13	.11
14 PIN ST	.15	.12
16 PIN ST	.17	.13
18 PIN ST	.20	.18
20 PIN ST	.29	.27
22 PIN ST	.30	.27
24 PIN ST	.30	.27
28 PIN ST	.40	.32
40 PIN ST	.49	.39
64 PIN ST	4.25	CALL
ST=SOLDERTAIL		
8 PIN WW	.59	.49
14 PIN WW	.69	.52
16 PIN WW	.69	.58
18 PIN WW	.99	.90
20 PIN WW	1.09	.98
22 PIN WW	1.39	1.28
24 PIN WW	1.49	1.35
28 PIN WW	1.69	1.49
40 PIN WW	1.99	1.80
WW=WIREWRAP		
16 PIN ZIF	4.95	CALL
24 PIN ZIF	5.95	CALL
28 PIN ZIF	6.95	CALL
40 PIN ZIF	9.95	CALL

ZIF=TEXTOOL
(ZERO INSERTION FORCE)

EDGECARD CONNECTORS

100 PIN ST	S-100	.125	3.95
100 PIN WW	S-100	.125	4.95
62 PIN ST	IBM PC	.100	1.95
50 PIN ST	APPLE	.100	2.95
44 PIN ST	STD	.156	1.95
44 PIN WW	STD	.156	4.95

36 PIN CENTRONICS

MALE

IDCEN36	RIBBON CABLE	6.95
CEN36	SOLDER CUP	4.95
CEN36PC	RT ANGLE PC MOUNT	4.95

FEMALE

IDCEN36/F	RIBBON CABLE	7.95

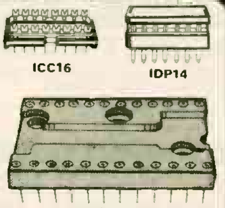
INTERSIL

ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	4.95
ICM7207A	5.95
ICM7208	15.95

DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS								
		8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
HIGH RELIABILITY TOOLED WW IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	---	.95	.95	---	---	---	1.75	---	2.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE BELOW


ICC16 IDP14 AUGAT 24ST

DIODES/OPTO/TRANSISTORS

1N751	.25	4N26	.69
1N759	.25	4N27	.69
1N4148	25/1.00	4N28	.69
1N4004	10/1.00	4N33	.89
1N5402	.25	4N37	1.19
KBP04	.55	MCT-2	.59
KBU8A	.95	MCT-6	1.29
MDA990-2	.35	TIL-111	.99
N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.25
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.49

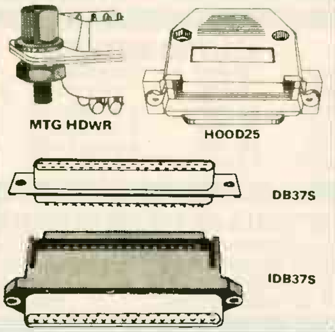
D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS					
			9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.82	.90	1.25	1.25	1.80	3.48
	FEMALE	DBxxS	.95	1.15	1.50	1.50	2.35	4.32
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	1.20	1.49	---	1.95	2.65	---
	FEMALE	DBxxSR	1.25	1.55	---	2.00	2.79	---
WIRE WRAP	MALE	DBxxPWW	1.69	2.56	---	3.89	5.60	---
	FEMALE	DBxxSWW	2.76	4.27	---	6.84	9.95	---
IDC RIBBON CABLE	MALE	IDBxxP	2.70	2.95	---	3.98	5.70	---
	FEMALE	IDBxxS	2.92	3.20	---	4.33	6.76	---
HOODS	METAL	MHOODxx	1.25	1.25	1.30	1.30	--	---
	GREY	HOODxx	.65	.65	---	.65	.75	.95

ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED.

EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR.

MOUNTING HARDWARE $1.00


MTG HDWR HOOD25 DB37S IDB37S

LED DISPLAYS

FND-357(359)	COM CATHODE	.362"	1.25
FND-500(503)	COM CATHODE	.5"	1.49
FND-507(510)	COM ANODE	.5"	1.49
MAN-72	COM ANODE	.3"	.99
MAN-74	COM CATHODE	.3"	.99
MAN-8940	COM CATHODE	.8"	1.99
TIL-313	COM CATHODE	.3"	.45
HP5082-7760	COM CATHODE	.43"	1.29
TIL-311	4x7 HEX W/LOGIC	.270"	9.95
HP5082-7340	4x7 HEX W/LOGIC	.290"	7.95

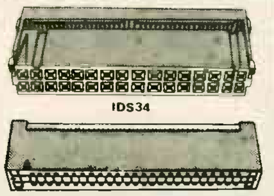
DIFFUSED LEDS

		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS					
		10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WW HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.79	.99	1.39	1.59	1.99	2.25
RIBBON HEADER	IDMxx	---	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	1.75	2.25	2.65	2.75	3.80	3.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE ABOVE


IDS34 IDE50

SWITCHES

SPST	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.50
DPDT	MINI-TOGGLE ON-OFF-ON	1.75
SPST	MINI-PUSHBUTTON N.O.	.39
SPST	MINI-PUSHBUTTON N.C.	.39
SPST	TOGGLE ON-OFF	.49
BCD OUTPUT 10 POSITION 6 PIN DIP		1.95

DIP SWITCHES

4 POSITION	.85	7 POSITION	.95
5 POSITION	.90	8 POSITION	.95
6 POSITION	.90	10 POSITION	1.29

HARD TO FIND "SNAPABLE" HEADERS

CAN BE SNAPPED APART TO MAKE ANY SIZE HEADER, ALL WITH .1" CENTERS

1x40	STRAIGHT LEAD	.99
1x40	RIGHT ANGLE	1.49
2x40	STRAIGHT LEAD	2.49
2x40	RIGHT ANGLE	2.99

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GOLD CONTACTS SPACED AT .1" CENTERS

5/$1.00

It was a pleasure to place an order with your people. I found the response pleasant and helpful and the answers prompt and correct. The delivery on my most recent order was fast, correct and well packed. I already had faith in the quality since my family has been using some of your products for several years with no problems.

Sincerely, J.D. Hattaway

RIBBON CABLE

CONTACTS	SINGLE COLOR		COLOR CODED	
	1'	10'	1'	10'
10	.18	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.36	3.20	.60	5.50
25	.45	4.00	.75	6.85
26	.46	4.10	.78	7.15
34	.61	5.40	1.07	9.35
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

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500ea: 3.0", 3.5", 4.0"

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- 6 AMP 120/240 VOLT

6 FOOT LINE CORDS

LC-2	2 CONDUCTOR	.39
LC-3	2 CONDUCTOR	.99
LC-HP	3 CONDUCTOR W/STD FEMALE SOCKET	1.49

MUFFIN FANS

3.15" SQ	ROTRON	14.95
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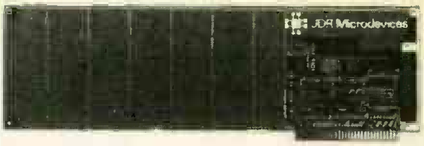
FR-4 EPOXY GLASS LAMINATE
WITH GOLD-PLATED EDGE-CARD FINGERS



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IBM
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IBM-PR1	WITH +5V AND GROUND PLANE	$27.95
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P100-1	BARE - NO FOIL PADS	$15.15
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P500-4	SINGLE FOIL PADS PER HOLE	$21.80
7060-45	FOR APPLE IIe AUX SLOT	$30.00

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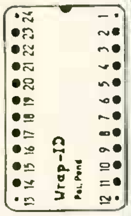
- SLIPS OVER WIRE WRAP PINS
- IDENTIFIES PIN NUMBERS ON WRAP SIDE OF BOARD
- CAN WRITE ON PLASTIC; SUCH AS IC #

PINS	PART#	PCK. OF	PRICE
8	IDWRAP 08	10	1.95
14	IDWRAP 14	10	1.95
16	IDWRAP 16	10	1.95
18	IDWRAP 18	5	1.95
20	IDWRAP 20	5	1.95
22	IDWRAP 22	5	1.95
24	IDWRAP 24	5	1.95
28	IDWRAP 28	5	1.95
40	IDWRAP 40	5	1.95

PLEASE ORDER BY NUMBER OF PACKAGES (PCK. OF)



ID WRAP 24

FRAME STYLE TRANSFORMERS

12.6V AC CT	2 AMP	5.95
12.6V AC CT	4 AMP	7.95
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25.2V AC CT	2 AMP	7.95

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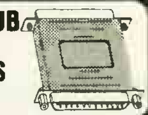
$7.95



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- FOR IBM PC-XT COMPATIBLE
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  -5V @ .5A, -12V @ .5A
- ONE YEAR WARRANTY


PS-IBM

PS-130 $99.95
- 130 WATTS
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- FOR USE IN OTHER IBM TYPE MACHINES
- 90 DAY WARRANTY


PS-130

PS-A $49.95
- USE TO POWER APPLE TYPE SYSTEMS
- +5V @ 4A, +12V @ 2.5A
  -5V @ .5A, -12V @ .5A
- APPLE POWER CONNECTOR


PS-A

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  -5V @ 1A, -12V @ 1A
- UL APPROVED
- ALUMINUM ENCLOSURE

PS-TDK $29.95
- +5V @ 4A, +12V @ 2A
  +12V @ 2.8A, -12V @ .30A
- 6.2" x 7.4" x 1.7", 1.6 LBS.

PS-11951 $29.95
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  +12V @ 1.5A, -12V @ 2A
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PS-SPL200

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TANTALUM

1.0µf	15V	.35	.47µf	35V	.45
6.8	15V	.70	1.0	35V	.45
10	15V	.80	2.2	35V	.65
22	15V	1.35	4.7	35V	.85
.22	35V	.40	10	35V	1.00

DISC

10pf	50V	.05	680	50V	.05
22	50V	.05	.001µf	50V	.05
27	50V	.05	.0022	50V	.05
33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
560	50V	.05	.1	50V	.12

MONOLITHIC

.01µf	50V	.14	.1µf	50V	.18
.047µf	50V	.15	.47µf	50V	.25

ELECTROLYTIC

RADIAL			AXIAL		
1µf	25V	.14	1µf	50V	.14
2.2	35V	.15	10	50V	.16
4.7	50V	.15	22	16V	.14
10	50V	.15	47	50V	.20
47	35V	.18	100	35V	.25
100	16V	.18	220	25V	.30
220	35V	.20	470	50V	.50
470	25V	.30	1000	16V	.60
2200	16V	.70	2200	16V	.70
4700	25V	1.45	4700	16V	1.25

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SIP	10 PIN	9 RESISTOR	.69
SIP	8 PIN	7 RESISTOR	.59
DIP	16 PIN	8 RESISTOR	1.09
DIP	16 PIN	15 RESISTOR	1.09
DIP	14 PIN	7 RESISTOR	.99
DIP	14 PIN	13 RESISTOR	.99

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WBU-T	1.38 x 6.50"	---	---	1	630	---	6.95
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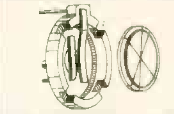

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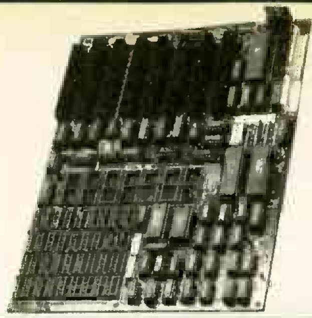

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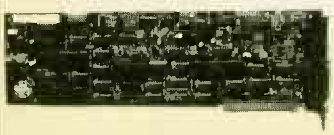

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LS112	*LS138	LS139	*LS14	*LS14	LS153	LS155	LS156	LS157	LS158	LS161	LS163
LS164	LS165	LS166	LS169	LS169	LS175	LS191	LS193	LS194	LS195	*LS20	LS221
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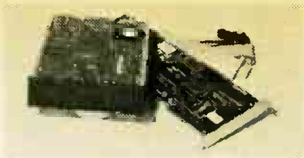

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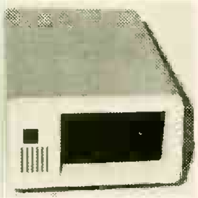

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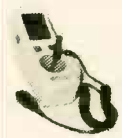

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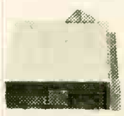

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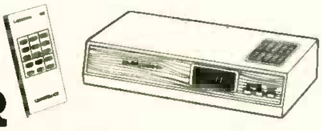

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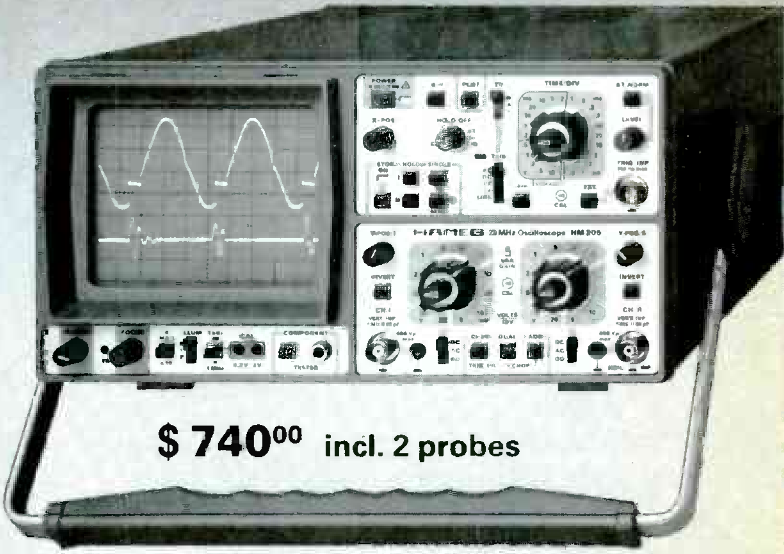

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