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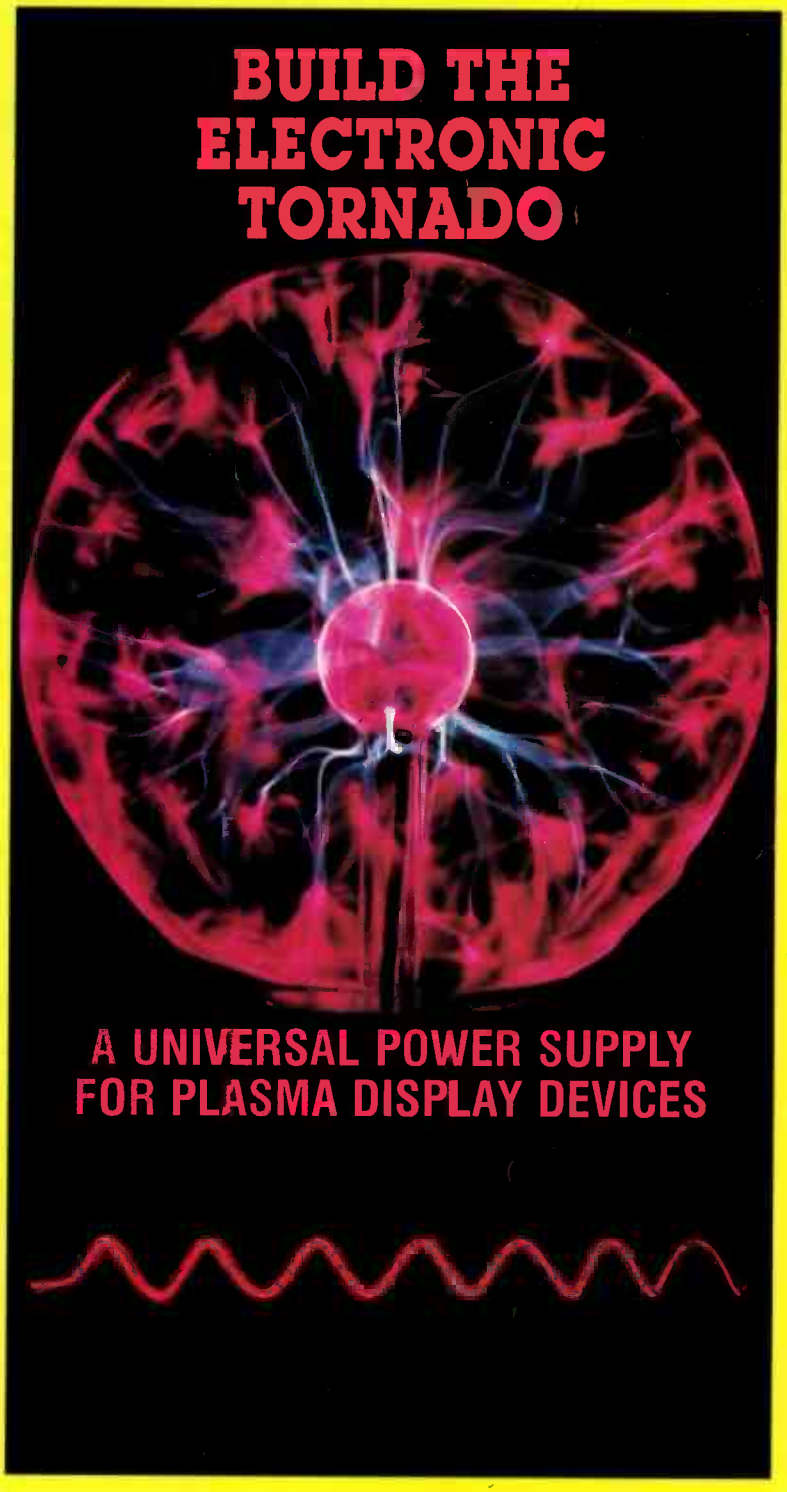

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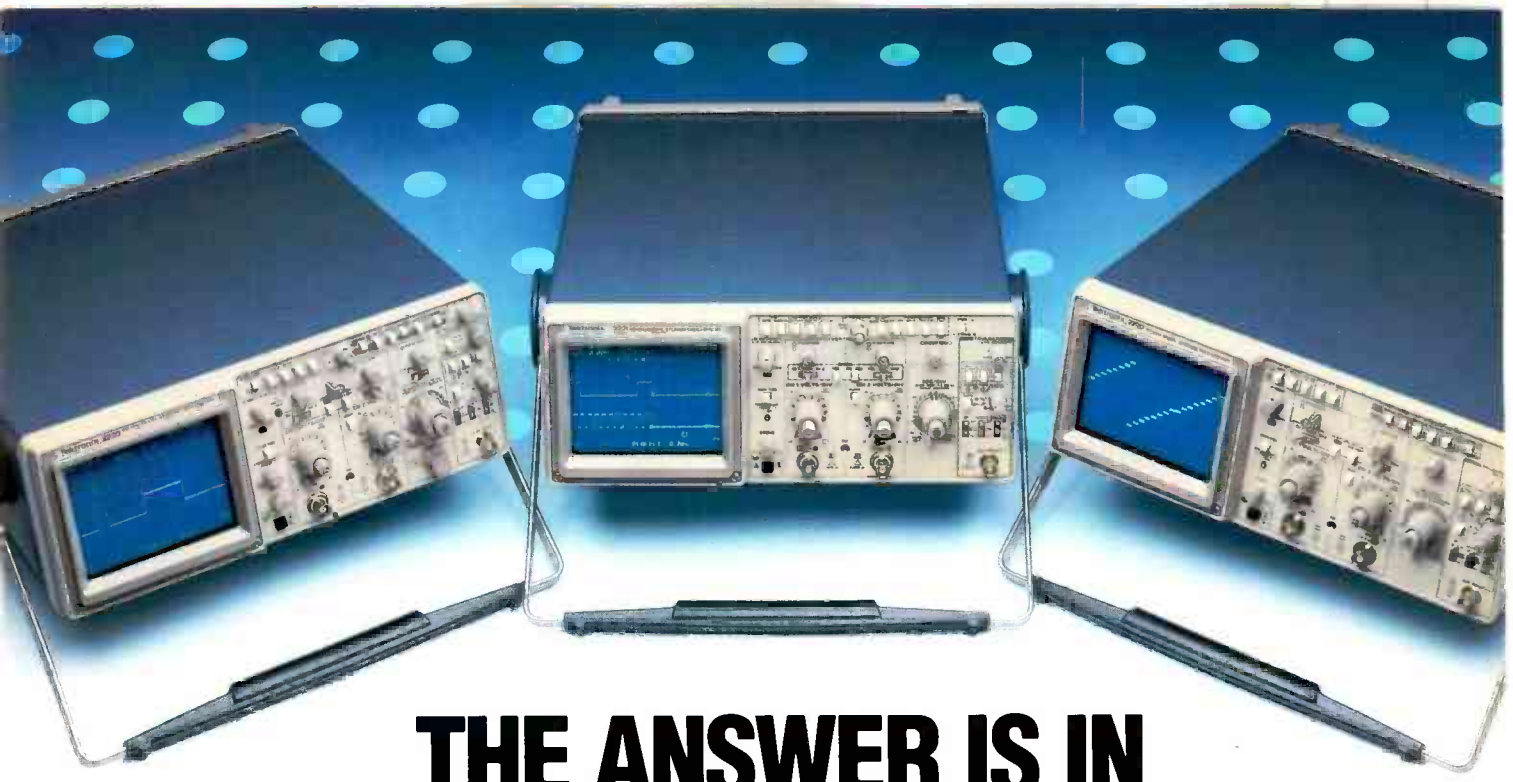

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Digital storage display accuracy enhances your confidence in measurements. And all you have to do is push a button for *real-time* display analysis.

Compare the 2230, 2221 and 2220 to each other—and all others. The new 2221 offers such advanced features as CRT readout and measurement cursors. For even more performance and flexibility, there's the 100 MHz, dual time base 2230 with optional battery-backed memory for saving up to 26 waveform sets. And if it's economy you want, choose the 60 MHz 2220 with many of the same features at an even lower cost.

Features	2230	NEW! 2221	2220
Analog/Digital Storage BW	100 MHz	60 MHz	60 MHz
Maximum Sampling Speed	20 MS/s	20 MS/s	20 MS/s
Record Length	4K/1K (selectable)	4K	4K
Peak Detect	100 ns	100 ns	100 ns
Save Reference Memory	One, 4K Three, 1K	One, 4K	One, 4K
Vertical Resolution	8 bits 10 bits (AVG mode) 12 bits (AVG mode over the bus)	8 bits 10 bits (AVG mode)	8 bits
CRT Readout/Cursors	Yes	Yes	No
GPIB/RS-232-C Options	Yes ($750)	Yes ($500)	Yes ($500)
Battery-Backed Memory (save 26 waveform sets)	Yes (inc with GPIB/RS-232-C)	No	No
Price	$4995	$3995	$2995

With each scope you can capture events as narrow as 100 ns at any sweep speed thanks to Tek's proprietary peak detect mode. View events prior to or following a trigger event with pre/post trigger. Store waveforms into 4K records. Automate measurements with optional GPIB and RS-232-C interfaces. And output direct to a printer or plotter.

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March 1988

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Vol. 59 No. 3

BUILD THIS

TECHNOLOGY

CIRCUITS AND COMPONENTS

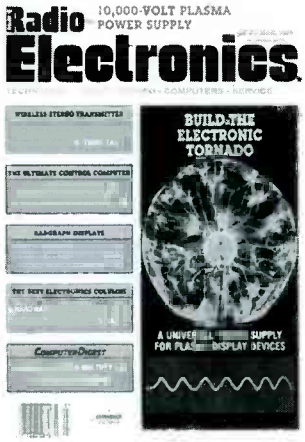
DEPARTMENTS

PAGE 87

PAGE 54

AND MORE

ON THE COVER



Plasma displays and other unusual lighting devices are all the rage. In the past, to get one of those displays for your home or business meant spending somewhere around $200. But not anymore! This month, **Radio-Electronics** presents an inexpensive high-voltage supply that's designed to power almost any type of plasma display. It can also be used to drive other innovative lighting devices such as travelling wave tubes and "Devil's Furnaces." To find out more about the power supply and how to use it, turn to page 43.

COMING NEXT MONTH

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Add move-theater sound to your home-video set up.

Radio Electronics ADVANCED CONTROL SYSTEM
Construction details for the CPU module.

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CIRCLE 71 ON FREE INFORMATION CARD

EDITORIAL

Consumer electronics for the consumer

The consumer-electronics industry doesn't always have its priorities in the right order. If it did, every cable-TV company and TV-set manufacturer would have adopted the EIA standard for a baseband interface between TV sets and peripheral devices. Who needs it? You do! Everyone does!

The industry has no excuse for not knowing how important the standard is. Consumers are making it rather clear what they want. Simply look at the VCR—one of the most successful consumer-electronics products ever. Why is the VCR so successful? Because it provides the ability to time-shift programs and it allows you to watch one channel, while taping another.

Or does it?

Just ask any consumer who has just bought the latest-model VCR with a cable-ready tuner who is upset because he can't tape HBO (which is scrambled by his cable system) while he watches a local news show. How do you tell him that his 6-event timer is of no use if he wants to tape more than one scrambled channel?

Granted, as a reader of **Radio-Electronics**, you would be capable of rigging something up to allow you to tape what you want. But the resulting jumble of patch cords and switch boxes would only be a compromise, not a solution. And don't forget: The great majority of consumers—on whom the success of the electronics industry depends—don't even know how to program their VCR's properly.

The EIA standard (IS-15) for a baseband (audio/video) interface between TV receiving devices and peripherals would answer many of the problems if it were embraced by the industry.

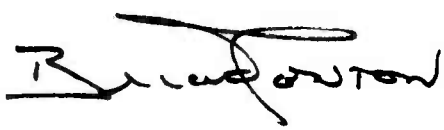
The interface would be implemented as a 21-pin connector that would accept and supply composite video, audio, and RGB video. Any new video device could simply be plugged into the connector, and it would work—no hassles.

From a technical standpoint, the most important feature of the interface is that TV receiver's AGC or *A*utomatic *G*ain *C*ontrol would be placed under the control of any signal descrambler. Instead of being connected to its own video detector, the receiver's AGC comparator would be connected to the decoder. It would be the decoder's responsibility to supply the voltage level at which sync tips would have been if they were not suppressed.

The benefits of such an interface would be many. For example, cable-program suppliers could reduce the cost of their decoders, because there would be no need to duplicate the tuning, IF, and remote-control functions. For that reason, they should be the ones to introduce the EIA connector on all of their cable boxes. After all, it is their signal scrambling that is causing most of the current problems.

The real winner would be the consumer, who would be able to make full use of the features that are offered by his cable-ready equipment. He could use his TV's or VCR's remote as they were intended to be used, and use the timer functions to record any scrambled channels.

The introduction of Super VHS has thrown a monkey wrench into the standard because S-VHS compatible equipment requires separate chromanance and luminance signals. That could be overcome, if only the members of the industry would cooperate a little better.



BRIAN C. FENTON
Managing Editor

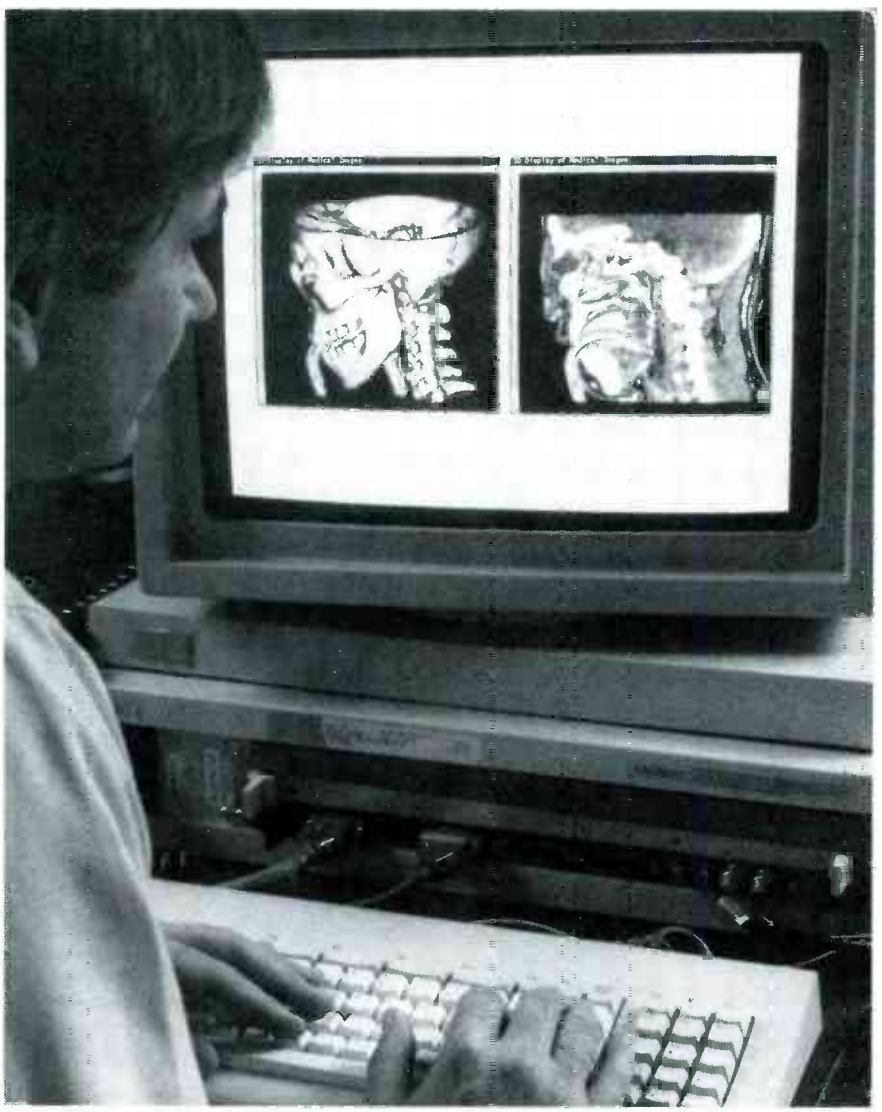
WHAT'S NEWS

Three-dimensional images made from CAT scans

Computer software that makes exceptionally sharp three-dimensional images of a patient's head or body from *C*omputed *T*omography (CT) X-ray scans was reported by General Electric scientists at the recent meeting of the Radiological Society of North America held in Chicago.

A physician can easily manipulate those three-dimensional images, turning them this way or that, or "cutting" into the organ being imaged at any angle to view portions of the inside and outside simultaneously on the computer display.

The program allows a physician to plan an operation by identifying underlying structures via computer simulation. Changes in the images can be made in just about five seconds.



INSIDE AND OUTSIDE VIEWS of the same section of the head of a patient (who is being sedated through a tube inserted in his mouth) are being watched by GE scientist William Lorensen.

To start the process, the G-E *CT-9800 Quick* scanner typically takes 50 cross-sectional X-ray "slices" of the head or the body organ to provide the building blocks from which the picture is assembled. The basic block is a cube about a millimeter on a side, known as a volume element, or "voxel." Each voxel is formed by a set of four points located on two adjacent CT scans.

Two new algorithms—sets of mathematical instructions—work on the cubes. One set is called "marching cubes," the other "dividing cubes." The "marching-cubes" set breaks up the entire scan into cubes and identifies those that contain at least a part of the object's surface; the "dividing cubes" set seeks to learn whether the surface of the organ being scanned is inside or outside of each cube. With that information, the program can present a sharp three-dimensional image, made by manipulating some four million voxels.

Sales of video products set records in late 1987

1.9 million color-TV sets were sold to dealers last October, a 6.9% increase over October 1986, reports the Electronic Industries Association (EIA). Monochrome TV-set sales also jumped, with factory sales of 456,000 units (a 32% increase over the previous October), and projection TV-set sales were up 19% over the same month in 1986.

More than 1.5 million VCR's were sold to dealers in October, up 9.3%, and camcorder sales were up by 26.4%. **R-E**

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FEATURES:
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Seiko Watch/PC (IBM)	B-618-100883		$48	$5.00	
Seiko Watch/PC (Comm.)	B-618-100891		$48	$5.00	
Seiko Watch/PC (Apple IIE)	B-618-100909		$48	$5.00	
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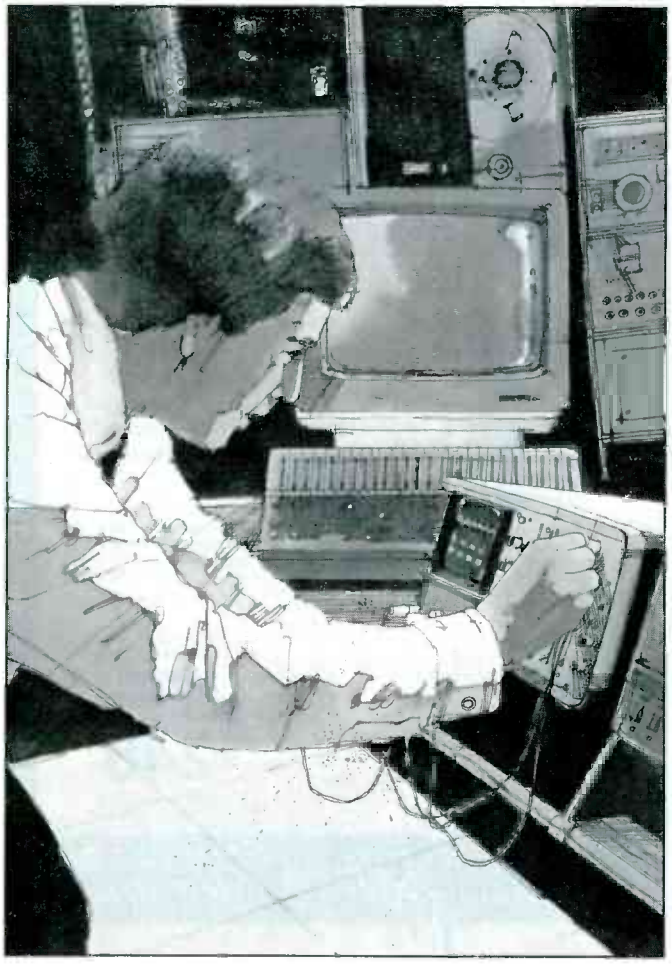

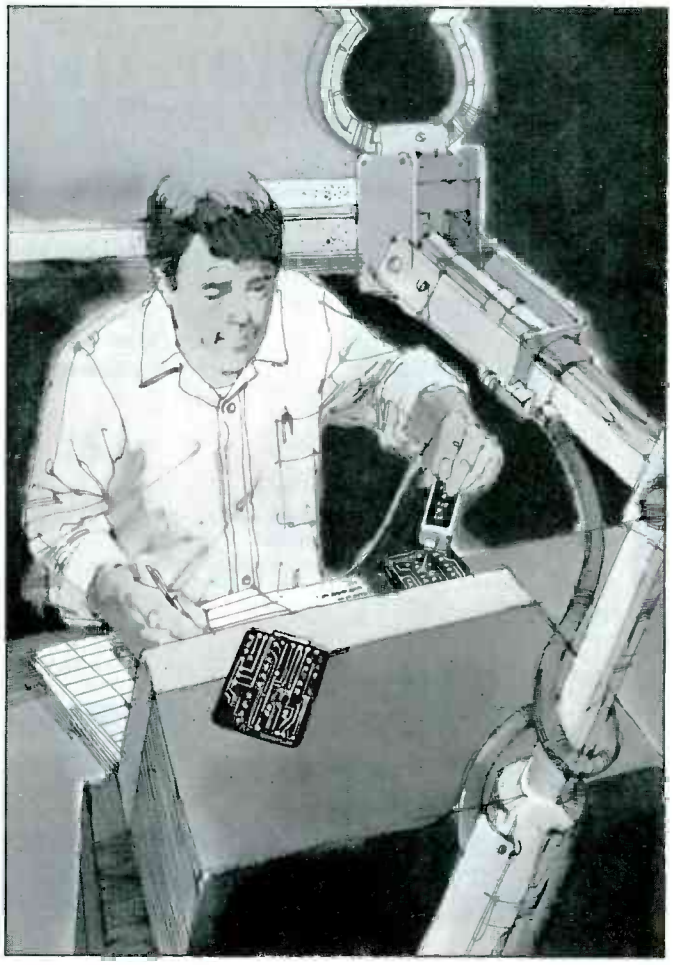

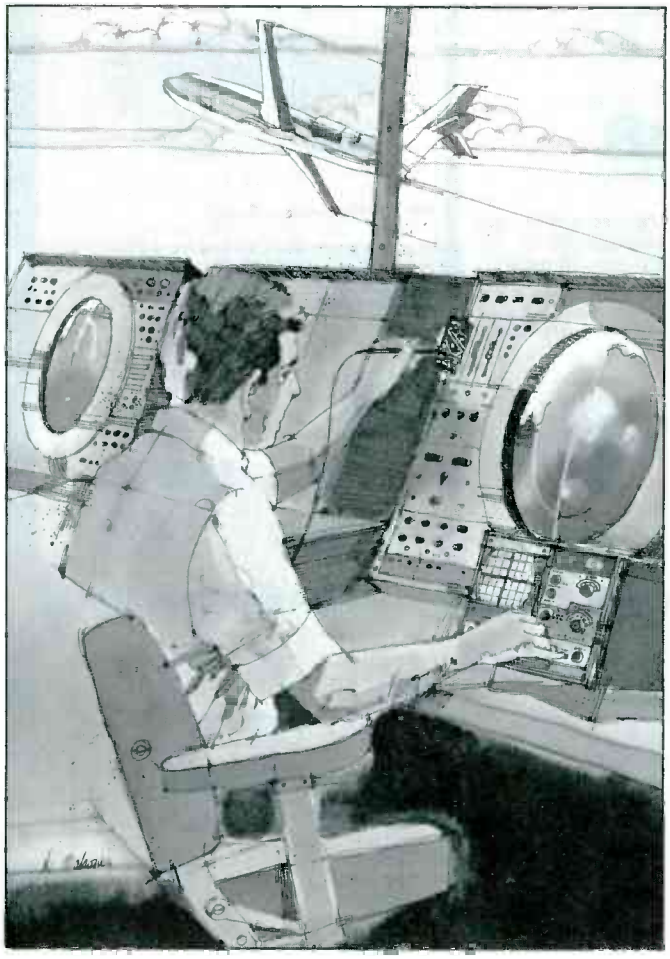

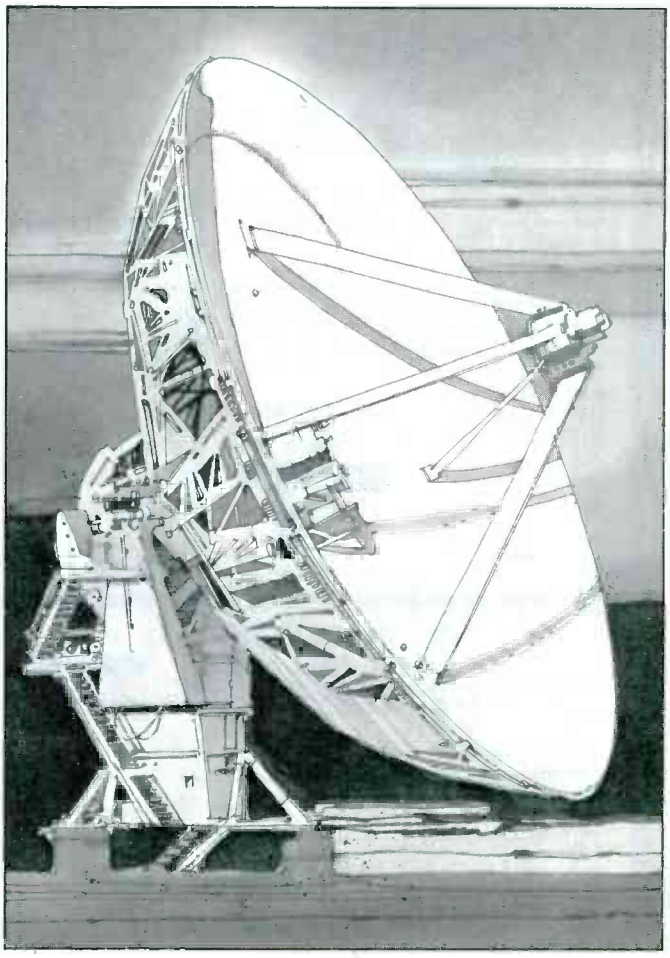

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VIDEO NEWS

DAVID LACHENBRUCH,
CONTRIBUTING EDITOR

• **VCR ownership breaks 50%.** Last year saw two major landmarks in video: more than 50% of U.S. households owned at least one VCR, and just about the same percentage were wired for cable TV. That's according to the A.C. Nielsen Co., which reported that a July 1987 survey showed that 50.9% of U.S. homes had VCR's and that 49.5% are now wired for cable. America's top VCR markets are Anchorage and Fairbanks Alaska where 70.6% and 69.1%, respectively, of households owned VCR's as of May 1987. The July survey showed that Las Vegas was third with 63.4%, followed by San Francisco-Oakland, Sacramento-Stockton, Los Angeles, Washington D.C., and Salt Lake City, all with penetration above 60%.

• **Video Telephones.** Commercially available videophones that send monochrome slow-scan pictures over standard telephone lines could begin to be a significant product category this year. The first "consumer-priced" model, introduced in the United States by Mitsubishi, carries a suggested list price of $399, as opposed to the previous model aimed at the business market at $1,450. Mitsubishi's *VisiTel* has a built-in video camera with ⅔-inch pickup and a 4½-inch monochrome monitor. It attaches to any telephone line with a standard modular plug. The system paints a complete picture in 5½ seconds and automatically stores the last three images for recall. Since the image is transmitted half duplex, voice and video can't be sent at the same time. The company estimates it will sell 100,000 to 150,000 consumer videophones in the U.S. this year and up to 500,000 in 1989.

It won't be all clear sailing for videophones, however. The new product is getting off to the same kind off start as many other consumer electronic products—in the middle of a dispute over standards. Mitsubishi's standards are backed by Panasonic and NEC, which are developing their own compatible phones. But there is formidable competition on the way from Sony and Nippon Telephone & Telegraph (NTT), which have their own non-compatible system that is said to be cheaper but requires a longer time to send a picture. We may see a repeat of the Beta-VHS wars.

• **A new/old brand name.** A major new brand of TV sets, VCR's and stereo equipment has been introduced in the United States. It's Philips, the dominant brand in Europe, which is sold in many countries throughout the world, but, with a few exceptions, never in the U.S. (**Radio-Electronics** December 1987). The first Philips line is an upscale group of large-screen direct-view monitor-receivers and projection TV sets, audio components, and VCR's, introduced by North American Philips, which now is completely owned by Philips of the Netherlands. The first video products look familiar because they strongly resemble similar ones previously introduced under the Magnavox brand, which is also owned by North American Philips. Company officials say, however, that that is only a temporary condition and promise that the Philips line will be "innovational."

• **Projection progress.** A projection TV screen that also serves as a flat loudspeaker has been introduced in Japan by Matsushita, parent of Panasonic. Matsushita set its computers to work and developed a reflective lenticular screen for displaying video pictures, measuring 70 inches diagonally, with woofers, midrange speakers, and tweeters built right into the screen's surface using the "*A*udio *F*lat *S*peaker" (AFS) principle developed by Matsushita. The screen in its own cabinet is three inches deep and weighs about 220 pounds, including the supporting stands.

In Denmark, meanwhile, a major manufacturer of translucent screens for rear-projection TV sets announced that it has developed a giant version, to be available in sizes as large as 120-inches, diagonal measurement. Scan Screen of Copenhagen, supplier to many U.S. projection-TV systems, says the new screens have wide viewing angles, and good brightness and contrast. Scan Screen's previous largest size was 67 inches. It's now also developing an in-between size of 82 inches.

HANDHELD DIGITAL IC COMPARATOR/ TESTERS FEATURE 20 CHANNEL LOGIC MONITOR

B&K-PRECISION's Model 550 and 552 IC Comparator Tester/Logic Monitors test IC's by comparison to a known good reference in one simple operation. As logic monitors, they simultaneously indicate the logic states of up to 20 IC pins. They test most 14 to 20 pin, 54 and 74 Series TTL (Model 550) or 4000 and 74C Series CMOS (Model 552) devices. Both models are available from distributors at $395. Contact your local distributor or: B&K-PRECISION, Maxtec Int., 6460 W. Cortland St., Chicago, IL 60635. (312) 889-9087.

LOGIC/PULSER PROBES HELP LOCATE DIGITAL FAULTS IN LAB OR IN FIELD SERVICE

B&K-PRECISION now offers logic and pulser probes to fill the needs of engineers and technicians. The DP-21 is a 20 MHz probe that also displays pulse presence and logic status. Both LED and audible logic state indicators are featured. The DP-31 pulser probe can be used alone or with a logic probe or scope. It produces a 10μS pulse at 0.5 or 400 PPS rates and features an external square wave and synchronizing terminal. Both probes are multi-family compatible. The DP-21 is $32. The DP-31 is $33. Contact your local distributor or: B&K-PRECISION, Maxtec Int., 6460 W. Cortland St., Chicago, IL 60635. (312) 889-9087.

NEW COMPARATOR ADDS IC/COMPONENT TESTING TO SCOPE

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NEW COMPONENT TESTER LOCATES FAULTS ON UNPOWERED BOARDS IN FIELD OR PLANT

The new Model 540 component tester is an extremely cost effective, highly flexible trouble-shooting aid that can assist in rapidly locating faults on unpowered boards. Faults can be traced to the component level without specific circuit knowledge. Individual components can also be tested. Test results are displayed as a curve on a built-in CRT display. Curve tracing allows matching of components. Two channels allow production testing against known good boards. Ideal for field service or production testing. $995. Contact your local distributor or: B&K-PRECISION, Maxtec Int., 6460 W. Cortland St., Chicago, IL 60635. (312) 889-9087.

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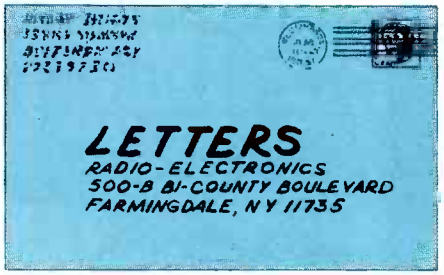
LETTERS



AUDIO SCRAMBLING SYSTEM

I've needed a secure communications system for years, and your "Audio Scrambling System" (January 1988 **Radio-Electronics**) is the only device I've found that didn't cost megabucks. But I've had some trouble getting it going. Were there any circuit changes?

I need several units, so I want to purchase pre-made PC boards. Where can I buy them? The article stated that there was a source for PC boards in the parts list, but it wasn't there.

TIM CATLIN
Chicago, IL

If your project used a PC board made from our template there is no circuit change. If you built the circuit using Fig. 5 in January as a reference, however, make the following corrections: Delete the connection between IC4-a, pin 2 and IC4-d, pin 12. Add a connection between IC4-a, pin 13 and IC4-d pin 12. The schematic should then be correct.

An etched and drilled PC board is available postpaid for $8.00 from Wavelink Laboratories, P.O. Box 199, Trumbull, CT 06611. Connecticut residents must add appropriate sales tax.—Editor

THE BLUE BOX

Herb Friedman's article, "The Blue Box and Ma Bell," (**Radio-Electronics**, November 1987) may be interesting reading for many people who need to study simpler circuits. It also reflects on a time when the latent computer hacker was a phone-phreak. Please let me add a few details.

The Red Box that he describes was really a Black Box. The Red Box

FIG. 1

was a 2.2-kHz pulsed oscillator for imitating the "new" tones generated by single-slot pay phones. If all you wanted was free calls, that was the safest, surest way. The real reason why the phone company had coronaries over Blue Box use was due to its almost limitless control over the trunk lines. It rivaled the power some hackers get by intentionally logging into a secured computer system.

Please note that it was necessary to send a 2.6-kHz tone to disconnect from the central office at the end of the call route. Only then did you send the multi-frequency tones. Ma Bell also took care to use a different *Touch-Tone* pad matrix so that the oscillators could not just be re-tuned. Centralized Automatic Message Accounting (*CAMA*) was common knowledge.

The criminal element utilized the technical prowess of phone-phreaks with a device called the "Cheese Box," which tied two phone lines together. The criminal called one number (reserved for him only) and waited for someone to call the other, public number. The box connected them automatically. All calls to the Cheese Box came through free through Black Box technology. Nobody but true phreaks and the curious used Blue Boxes, because Ma Bell's fury against that particular box was well recognized.

Technical information in this letter came from papers published by the Youth International Party Line between 1972 and 1974. Regards to all who remember.

H.M.S.
New Jersey

MORE BLUE BOX

I read Herb Friedman's article, "The Blue Box and Ma Bell," (**Radio-Electronics**, November 1987) with considerable interest. Long a reader about phone-phreaking (not a practitioner), the story contained enough of the specifics to make the technique clear to me without explaining how to build a Blue Box. As the article mentioned, toll-phreaking can be detected and traced (using AMA) much more readily with today's ESS series CO switches.

Back in 1974 I subscribed to a publication called *Telephone Electronics Line*. After receiving six or seven issues of this modest little monthly, lightning struck in the form of a threatening letter from Pacific Bell noting that they had seized the publishers, their equipment, and their subscriber list! As a subscriber, I was put on notice that if I ever entertained thoughts of phreaking, I would be prosecuted to the full extent of the law.

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Actually, my sole goal then was adding an extension phone or two to my house phone—which, as you know, was illegal at that time. A simple method of escaping detection was to disconnect the bell. For ring detectors, there were circuits utilizing light-sensitive resistors coupled to NE-2's, along with transistor-actuated relays. Due to their isolation and high impedance, they were undetectable by the local switchman. How times have changed!

Thanks for a great article!

CLIFFORD C. BARBER
Arlington Heights, IL

A SPECIAL THANK YOU

You probably get a lot of "thank you for a great magazine" letters, but this is a special one. I'm not just thanking you for a good publication, but for producing a magazine that helped make me what I am today.

I've subscribed to **Radio-Electronics** since 1978, when I was in eighth grade. I've carefully read each issue and built many of the projects. They were my motivation to learn about transistors, op-amps, lasers, and computer technology. I played with the 76477 sound generator. I build a robot. I learned to program in BASIC. **Radio-Electronics** inspired me to learn and do *so much*!

That interest in electronics took me to college, where I just completed a degree in Electrical Engineering (analog design). Looking back, I remember "first" courses—like an introduction to transistor amplifier design—where most of the other students had to ask questions like "Excuse me, Professor, but what's the emitter again?"

Years of reading and doing, experimenting and hacking, had laid down for me a basic, practical foundation of knowledge which made it easier to learn the more rigorous theoretical material to come. Almost none of my peers had any experience. Only one even knew the resistor color code! I had it easy.

Finally, the extra practical experience I gained in part from reading **Radio-Electronics**, combined with my college theoretical background, has made me a more de-

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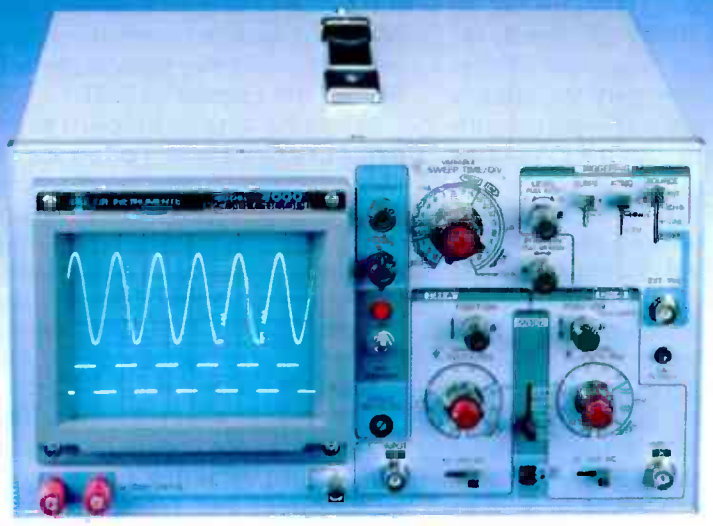

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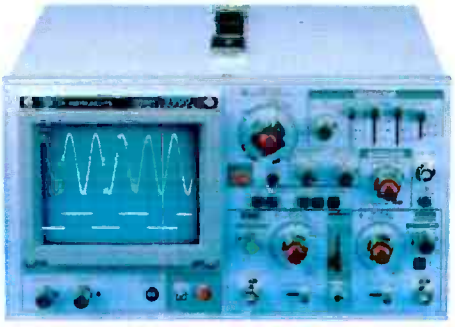

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sirable—and saleable!—engineer to industry. Managers would be willing to kill to find good engineers with *practical* experience. They're few and far between, straight out of college.

If you're a **Radio-Electronics** reader, surely you already know that you're learning practical electronics with each issue. If you're a student who's planning to go to a four-year college for a degree, I promise you've already made the best start. Keep reading, doing, and learning, and you'll be far ahead of the rest!

Thanks again to everyone on your staff for a great magazine.
DAVE JENNINGS
Venice, CA

R-E ROBOT PARTS

We have been following the "R-E Robot" construction series and must congratulate you on the time and effort which have obviously been put into that project.

Part 11 (**Radio-Electronics**, October 1987) refers to Sprague Electric Company's UDN2952W for the servo driver of Fig. 4. Unfortunately, due to manufacturing difficulties (ground connection at pin 4) we had to discontinue that device this past June. Happily, the redesigned part, UDN2954W, is available. In addition to slightly reduced cost and improved performance, the new part includes a few added features—adjustable current trip and internal PWM current control.

The rather high value (1 ohm) for your current-sensing resistor, R11, equates to a typical motor current of less than 850-mA, *including* the worst-case startup current. That agrees with your text. At that low current rating, the UDN2952B dual in-line package, or the now preferred UDN2953B would be much more economical. With the new UDN2953B/54W, R11 would have to be only 0.29 ohms for an 860-mA load current.
F. RAYMOND DEWEY, *Technical Information Coordinator*
Sprague Electric Company
Worchester, MA

MORE THANKS FOR SMT

I want to thank you for your timely presentation on surface-mount components in the November 1987 issue of **Radio-Electronics**. I am involved in training for a major manufacturer of state-of-the-art mobile communications products, and I've personally witnessed the change to SMT.

When training technicians to repair our equipment, I often spend at least as much time familiarizing the technician with surface-mount repair as I do with troubleshooting electronic circuitry. In future training sessions, I will refer to the November issue to aid in breaking down the usual initial resistance to a new technology.

For today's electronic technician, a thorough knowledge of surface-mount soldering and removal techniques, and typical failures encountered, will go a long way toward solving most electronics problems in a minimum amount of time.
JIM W. MARION
NEC America, Inc. **R-E**

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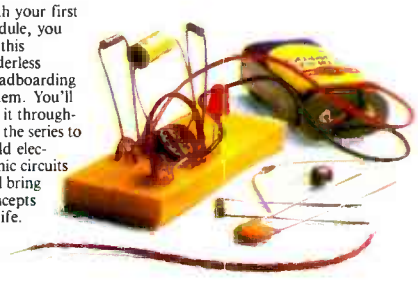

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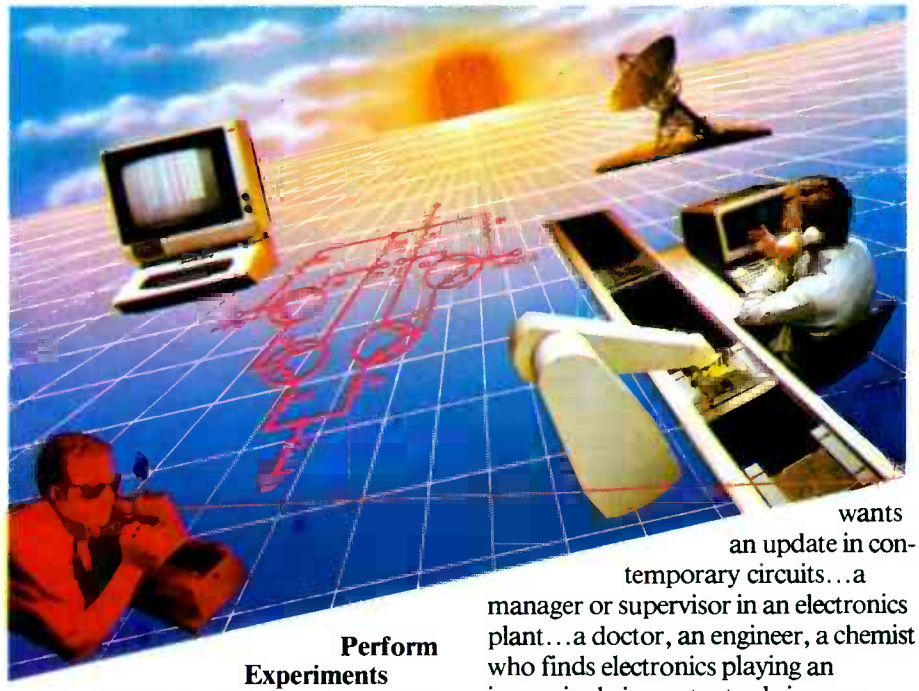

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EQUIPMENT REPORTS

Technology Marketing Inc. PC Weather Pro

A computer-controlled home weather station

CIRCLE 39 ON FREE INFORMATION CARD

MANY ELECTRONICS PROFESSIONALS and hobbyists have interests that go beyond electronics and computers. One of the more common is weather monitoring and forecasting. If you, too, want to know more about the weather than what you can learn by simply looking out the window or turning on a radio, then you'll love the new *PC Weather Pro* from Technology Marketing Inc. (400 Kruse Way Place, Bldg. 2, Suite 120, Lake Oswego, OR 97035, 503-635-3966).

PC Weather Pro is a combination of hardware and software that monitors and tracks local weather conditions and reports them on your PC-compatible computer. You can monitor and record indoor and outdoor temperatures, wind speed and direction, wind chill, barometric pressure, and rainfall. And you can set things up to be virtually automatic. So although you still may not be able to do anything about the weather, at least you'll know what the weather is doing to you!

The *PC Weather Pro* system con-

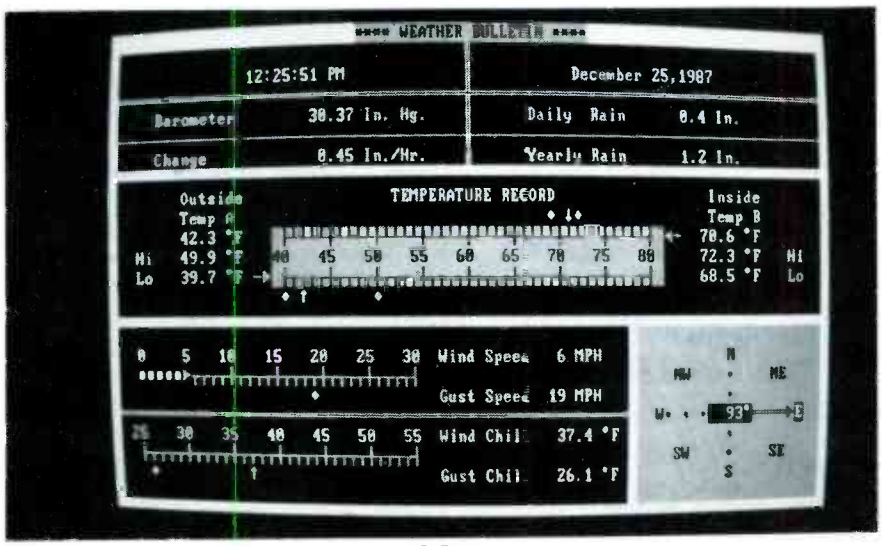

FIG. 1

sists of an anemometer and wind vane to report wind speed and direction, two temperature probes, and a rain sensor. Those items are attached by cables to a half-slot plug-in circuit card for a PC-compatible computer. An AC adapter, and a 5¼-inch floppy disk that contains the *PC Weather Pro* display software are also included with the system.

Installation

Getting *PC Weather Pro* up and running is relatively straightforward. Installing the anemometer/wind-vane assembly is the most difficult part—because it's usually done more than 20 feet in the air, above the peak of the rooftop, so that buildings and trees, etc. won't interfere with the proper and accurate measurement of the wind. We would strongly recommend hiring someone to carry out the installation if you are not equipped with the proper tools or experience. Even if you are properly equipped, it's still a good idea to have a helping hand. Besides the obvious safety advantages, it will be much easier to calibrate the wind vane if you have a helper.

The anemometer, which is usually the least accurate part of any home weather station, is factory calibrated to ensure accuracy within ±1 mph. The wind vane, however, is calibrated by the user during the installation procedure. If calibrated correctly, it is accurate to within ±1 degree.

The rain sensor is usually mounted near the anemometer and wind vane, away from any obstructions, and in an area where falling leaves won't cause any problems. The sensor is a tipping-bucket type. Whenever one-tenth of an inch of water enters the funnel, a small "bucket" inside the unit tips over, emptying the water, and tripping a small switch.

The cables supplied with the wind assembly and the rain sensor are 40 feet long, and extension cables are available to lengthen the cables to over 200 feet.

Two temperature probes are included with *PC Weather Pro*, each with an 11-foot cable. Typically, one sensor is mounted indoors, and the other outdoors. Mounting the temperature probes is not too dif-

ficult, because the probes don't have to be installed on the roof, and they can be calibrated easily indoors, before they are installed. (The calibration is performed using boiling water and ice water as temperature references.) Of course, the outdoor probe still requires a cable run, and the proper mounting place is critical for meaningful measurements.

The PC board is installed in your PC just like any other expansion card. A solid-state pressure transducer, which is the barometric sensor, is located on the board.

Once the sensors are mounted and the board is installed in the computer, the cables from the anemometer, the wind vane, the rain sensor, and the two temperature probes are routed and plugged into the appropriate jacks on the rear of the card. The AC adapter is also plugged into the card; it keeps the on-board real-time clock running even when the computer is turned off.

PC Weather software

The PC Weather software is the user interface to the instruments. It's a menu-driven, memory-resident program that is very easy to use. The main menu offers 11 main functions. For example, choosing D will display a weather-data summary screen, such as that shown in Fig. 1.

Each of the functions shown in that summary—BAROMETRIC, RAINFALL, TEMPERATURE, and WIND—has its own, more detailed, screen. For example, the WIND bulletin shows the present, high, and average wind speed in mph, kph, knots, meters/sec, feet/sec, the time that the high wind speed was recorded, and the present and lowest wind-chill recorded.

Other selections available from the main menu include an ALARM menu, a PLOT menu, and an OPTIONS-SET menu.

From the ALARM menu, you can set an on-board piezoelectric buzzer to sound when a certain condition is met. For example, you could set the alarm to sound when the wind speed rose over 30 mph, or when the indoor temperature dropped below 50°F. The alarms will sound even when the comput-

continued on page 42

NEW PRODUCTS

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VISUAL TELEPHONE Mitsubishi Electric Sales America has announced the *VisiTel*, the first still-frame visual telephone designed specifically for home use. The unit features a built-in video camera and a 4.5-inch monitor. It allows the user to send and receive freeze-frame black-and-white video "snapshots" over standard telephone lines. The *VisiTel* works in tandem with any home telephone equipped with a modular phone plug. Easy to hook up, the unit simply plugs into a standard AC outlet and the home phone jack.

The user is in control of the outgoing image at all times. To send an image, the user simply positions himself in front of the camera, reviews the image on the screen, and pushes a *send* button to transmit the image to another *VisiTel* user. Transmissions take only 5 seconds and as many transmissions as desired can be made. Normal telephone rates apply to all calls.

The *VisiTel* will automatically store the last three received images for ready recall. Those images can be reviewed at will by pressing a *view/pose* button.

The *VisiTel* has a suggested retail price of $399.00.—**Mitsubishi**, Visual Telcom Division, 3350 Scott Boulevard, Building 49, Santa Clara, CA 95054.

LCD BARGRAPHS. Triplett's new line of LCD bargraph meters have both AC and DC measurement capabilities. The l6-style line has an optional AC average signal-conditioning card that allows direct hookup of the meter, eliminating the need for external filtering. A 5-amp AC direct card is also optional, for feeding 5 amps AC or 600 volts rms directly into the meter.

In addition to the AC capabilities, there is a meter-relay option on the model *320-WS* and the model *420-WS*, which feature front-end programmability. Triplett has taken the TTL output from a standard meter and fed it to a comparator section to initiate the meter relays. The end user can then turn external circuits on and off through the relay contacts.

While most of the meters in the line can be customized by Triplett, VU designs are offered as finished meters. The VU meter fits into audio/video-monitoring equipment and meets standard VU ballistics.

The bargraph draws 500 μA from a 5-volt power supply. The backlit models use 5-volt DC bulbs, which require approximately 250 mA per bulb. Additional specifications include: accuracy of plus or minus 1% of scale; a maximum response time of 200 ms; linearity of plus or minus ½ segment; input impedance of 1 megohm, and an operating temperature of 0° to 50°.

CIRCLE 11 ON FREE INFORMATION CARD

Prices on the new LCD bargraphs range from $110.00 to $135.00 for the standard meter; $200.00 to $250.00 with meter relay; $150.00 to $175.00 with the 5-amp AC direct card, and $110.00 to $135.00 for the VU meter.—**Triplett Corporation,** One Triplett Drive, Bluffton, OH 45817.

CALL-BACK CONTROLLER. Black Box offers a controller that, when installed between a modem and a telephone-company interface, provides total protection against unauthorized dial-up access to a serial computer.

CIRCLE 12 ON FREE INFORMATION CARD

Preprogramming of access codes and corresponding telephone numbers into the *Call-Back* controller allows only users with valid access codes to be "called back" at their assigned numbers. Even if a hacker *did* break the access code, the controller would divert dial-up access to a preprogrammed phone number. That alerts the user to the fact that someone has broken the first access code to the system and is trying to break into his or her files.

The *Call-Back* controller is available either as 1-line (price $450.00) or 2-line (price $695.00) units.—**Black Box Corporation,** P. O. Box 12800, Pittsburgh, PA 15241.

SUPER-VHS CAMCORDER. JVC's *GF-S1000HU* uses its new format with full-size S-VHS cassettes, which have 6-hour recording capability. It incorporates the new ⅔-inch field-storage CCD image sensor with 360,000 effective picture elements (pixels); the image sensor achieves horizontal resolution of 450 lines and contributes to the 8-lux low-light sensitivity. It also incorporates the Super Double-Azimuth 4-head system that further enhances the picture quality in both SP and EP modes.

To match the Super-VHS pictures, the Depth-Multiplex sound-recording system has a more than 80-dB dynamic range and frequency response of 20 to 20,000 Hz. In recording, the *GF-S1000HU* detects whether an S-VHS or regular VHS cassette had been loaded and automatically switches to the appropriate mode; manual override also enables regular VHS recording on S-VHS tape. In playback, it automatically detects the mode in which the recording was made and switches the circuitry accordingly. Those recordings can also be played back on decks of the corresponding format.

The *GF-S1000HU* is priced at $2495.00.—**JVC,** 41 Slater Drive, Elmwood Park, NJ 07407.

CIRCLE 13 ON FREE INFORMATION CARD

LASER PRINTER. The Sharp Electronics' model *JX-9300* is a six-page-per-minute compact laser printer that allows users to take

full advantage of the graphics generated by much of today's software. It offers 300 × 300 dpi resolution, and the standard 396K memory is expandable to 1.5M. Resident typefaces are the Courier and line-printer fonts, both available in bold, condensed, pica, elite, and italic. Other fonts can be added through downloading or plug-in font cartridges.

CIRCLE 14 ON FREE INFORMATION CARD

A single paper tray holds up to 100 sheets of plain paper; a legal-size tray is optional, and a manual insert slot allows letterhead, overhead transparencies, and other special sheets to be fed as needed. The model *JX-9300* is priced at under $2400.00.—**Sharp Electronics Corporation,** Sharp Plaza, Mahwah, NJ 07430.

PHONO CARTRIDGES. Shure Brothers has a new line of phono cartridges, the VST Special Edition Series.

CIRCLE 15 ON FREE INFORMATION CARD

The model *VST V* (left in photo) features a "Micro-Ridge" tip geometry for exceptional high-frequency reproduction, and Shure's exclusive "Dynamic Stabilizer". That assembly acts as a shock absorber to help make warped records playable again, while reducing arm-cartridge resonance and eliminating static. The model *VST V* is priced at under $200.00.

CIRCLE 187 ON FREE INFORMATION CARD

CIRCLE 110 ON FREE INFORMATION CARD

Now from NRI comes the first course of its kind . . . anywhere!

Learn to use, program, and service today's digital electronic music equipment as you build your own computer-controlled music center

Now NRI puts you at the heart of the most exciting application of digital technology to date! With NRI's new at-home training in Electronic Music Technology, you get hands-on experience with the equipment that's revolutionizing the music industry—Atari ST Series computer with built-in MIDI ports, Casio CZ101 digital synthesizer with advanced MIDI capabilities, and ingenious MIDI software that links computer keyboard to synthesizer keyboard—all yours to train with and keep.

This year, over $1.5 *billion* worth of digital electronic music instruments—keyboards, guitars, drum machines, and related equipment—will be sold in the U.S. alone. Who's buying this new-tech equipment? Not just progressive musicians and professional recording technicians, but also thousands of people who have never touched a musical instrument before. And there's good reason why.

Something called MIDI (Musical Instrument Digital Interface) has suddenly transformed musical instruments into the ultimate computer peripherals . . . and opened up a whole new world of opportunity for the person who knows how to use, program, and service this extraordinary new digital equipment.

Now NRI's breakthrough Electronic Music Technology course puts you at the forefront of this booming new technology with exclusive hands-on training built around a MIDI-equipped computer, MIDI synthesizer, and MIDI software you keep.

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The opportunities are unlimited for the person who's trained to take advantage of today's electronic music phenomenon. Now you can prepare for a high-paying career as a studio technician, sound engineer, recording engineer, or road technician . . . even start your own new-age business providing one-stop sales and service for musicians, technicians, and general consumers alike. Or simply unleash your own musical creativity with the breakthrough training and equipment only NRI gives you.

Only NRI Gives You an Atari ST Computer, Casio Synthesizer, and Innovative MIDI Software You Train With and Keep

The Atari ST Series computer included in your course becomes the heart of your own computer-controlled music center. With its tremendous power, superior graphics capabilities, and built-in MIDI interface, the 16/32-bit Atari ST has almost overnight become the computer of choice for today's most knowledgeable electronic musicians.

The Casio CZ101 digital synthesizer, also included in your training, is the perfect complement to your Atari ST. The polyphonic, multitimbral CZ101—which stores up to 32 voices internally—"communicates" with your ST computer through MIDI, bringing life to virtually any sound you can imagine.

Plus, you get ingeniously designed MIDI software that opens up amazing new creative and technical possibilities . . . you actually build your own 4-input audio mixer/amplifier . . . and you test the electronic circuits at the core of today's new-tech equipment with the hand-held digital multimeter included in your course.

No previous experience necessary—in electronics or music!

No matter what your background, NRI gives you the skills you need to take advantage of today's opportunities in electronic music technology.

With your experienced NRI instructor always available to help, you master the basics of electronic theory step by step, gaining the full understanding of electronics that's now so essential for technicians and musicians alike. You move on to analyze sound generation techniques, digital logic, microprocessor fundamentals, and sampling and recording techniques . . . ultimately getting first-hand experience with today's explosive new technology as you explore MIDI, waveshaping, patching, sequencing, mixing, special effects, and much more.

Plus, even if you've never been involved with music before, NRI gives you enough basic training in music theory and musical notation to appreciate the creative potential and far-reaching applications of today's electronic music equipment.

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The other two cartridges in the VST Series are the model *VST III* (right in photo) and the model *VST III-P,* (center in photo) sister units that both feature the distortion-reducing Shure hyperelliptical tip. The model *VST III,* designed for standard ½-inch headshell mounting, shares the Dynamic Stabilizer design with the model *VST V,* while the model *VST III-P* is optimized for P-mount applications. The model *VST III* and the model *VST III-P* are priced in the $100.00 range.—**Shure Brothers Incorporated,** 222 Hartrey Avenue, Evanston, IL 60202-3696.

HF TRANSCEIVERS. Kenwood offers two new models: the *TS-140S* (shown) and the *TS-680S*. The model *TS-140S* is an all-band, all-mode, 100-watt HF transceiver with a general-coverage receiver section. The model *TS-6805* is an all-band, all-mode 100-watt HF transceiver that includes a ten-watt, six-meter section.

CIRCLE 16 ON FREE INFORMATION CARD

Both models feature a programmable band marker that is particularly useful for staying within the limits of one's ham license and prevents out-of-band operation, and a Morse-code beeper status indicator.

Other features include dual digital VFO's, 31 memory channels (10 of which can store, receive, and transmit frequencies separately for repeater or cross-band operation), programmable scanning, and automatic selection of USB or LSB, and more.

The model *TS-140S* has a suggested retail price of $899.95; the suggested retail price of the model *TS-680S* is $999.95.—**Kenwood,** 2201 E. Dominguez Street, Long Beach, CA 90810.

VIDEO COMMAND CENTER. The Video Link *Cockpit II* is a IR remote "unifier" that includes two aimable infrared turrets. Those rotatable turrets allow the amplified infrared signals to be directed anywhere in the user's room, and allow the device to be placed in the most convenient location for simplified operation.

The *Cockpit II* is a table-top unit that stores several remote controllers in a molded tray. A solid-state amplifier is built in to boost the infrared signals' strength, for additional convenience, and also for flexibility.

CIRCLE 17 ON FREE INFORMATION CARD

The *Cockpit II* has a suggested retail price of $49.95.—**Video Link,** 12950 Bradley Avenue, Sylmar, CA 91342. **R-E**

COMMUNICATIONS CORNER

HERB FRIEDMAN,
COMMUNICATIONS EDITOR

Hybrid networks make signals invisible

AS DIGITAL SIGNALS BECOME INcreasingly more intertwined with the common telephone system, a device you're more likely to run across in both the design and maintenance of a communications system is the *hybrid network*, which is often called a *hybrid coil*. Those of you who are up on your telephone technology are certain to recognize that the hybrid network is part of the common telephone, where it's called the *induction coil*. Others, who enjoy listening to call-in radio and TV programs, will certainly recognize it as the device that allows the studio audio to be mixed with the telephone signal, without having the station's audio system break into howling caused by positive feedback. And if you didn't know how the caller and callee were mixed without feedback, you'll find out now, because this month's subject is the hybrid network. (And those of you who are amateur radio operators and are familiar with, and have cursed the hybrid-network telephone patch, will also find out why your particular patch sounds so bad.)

The reason we're getting into hybrid networks, which is really part of the telephone system and broadcast call-in equipment, is because it is absolutely necessary for interleaving digital data and communications into the dial-up tele-

phone. Long-haul circuits require distortion-free amplification to get signals error-free from one part of the country to another. Normally, the amplification is provided in the connecting wires between central offices, or within the signal equipment. For example, a single pair of wires carries your voice or digital data to a central office, but between central offices—where the amplification is done—there are actually two pairs of wires: one for the transmitted signal, the other for the received signal.

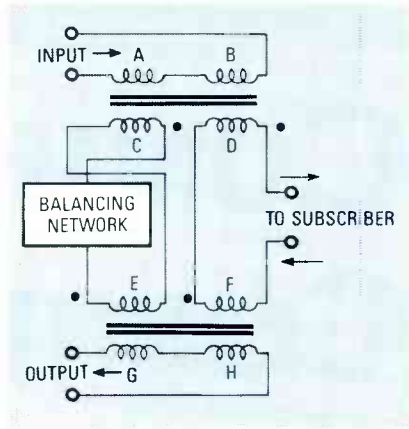

FIG. 1

Two inputs, one output

Figure 1 shows a *communications hybrid network*. It's described as a communications hybrid because it is completely different from the audio-mixing hybrid network found in movie- and TV-production studios. Everything we say this time out refers only to a communications hybrid that resembles Fig. 1.

Notice that there are actually two transformers, T1 and T2. They might be individual units, as they often are in an inexpensive hybrid phone patch, or they might both be enclosed in a single metal "can," as they are in a telephone.

Let's assume that the hybrid shown in Fig. 1 is the one at your local telephone office. Signals—analog or digital—from a distant source are fed into the INPUT and eventually exits at the SUBSCRIBER terminals, which are in turn connected to the wires that connect to your home telephone.

Signals originating in your home pass into the subscriber connections and exit via the network's output. No signal on the subscriber line can exit from the network's input, nor can any signal on the input or output mix or crosstalk with each other.

The entire system depends on phase coherence throughout the network, which is accomplished by the device labeled BALANCING NETWORK. That is simply a "black box" whose reactance and resistance exactly matches that of the subscriber circuit from the network to the telephone equipment.

Phase matching

Notice that T1 and T2's four secondary windings are identified by a dot that indicates their phasing. The hybrid network won't work if the phasing is incorrect.

Now let's follow some signals through the hybrid network. Assume that a signal is applied to the input. Its current flows through primary windings A and B, inducing current in windings C and D. The current flowing in B induces a current that flows through D, F, and Z_L (the load); so the input signal appears at the load.

The current through F induces a current in H. Meanwhile, the input current through C also flows through E and the balancing network, which is a mirror image of Z_L. The current through E induces a current into G, which is exactly the same value but 180° out of phase with the current induced in H; so the current in G cancels the current in H and, in result, no part of the input signal appears at the hybrid's output.

Now let's work the other way. A signal originates at the subscriber's input, causing current to flow in D and F. F induces a current in H that also flows through G and on to the output. The current in G induces a current in E that flows through the balancing network and also C.

Winding C induces a signal in A which is equal to and 180° out of phase with the signal induced by the subscriber signal from D to B, so that no part of the subscriber signal appears in the network's input.

It's magic

That's the whole magic of hybrid networks. "Aha," you say, drawing your .357-magnum pen and getting set to write in and protest our taking a three-day subject (in school) and converting it into a few paragraphs, "if hybrids keep the input from the output, why do we hear ourselves when we speak into the telephone?"

That's a matter of psychology. Back in the early days of telephones, people could not hear what they said—the transmitter and receiver were isolated—so they tended to shout, louder, and Louder, and LOUDER. After a while, the telephone people decided to feed back a small part of the transmitted signal (from the telephone's microphone) into the receiver (earphone) so the user could hear that the equipment was, in fact, working properly. The feedback is called *sidetone*. **R-E**

AUDIO UPDATE

Debunking audio myths.

LARRY KLEIN,
AUDIO EDITOR

ANY AREA OF HUMAN CONCERN INEVitably creates its own peculiar collection of half-truths, illusions, confusions, and eventually, myths. Mythology prevails when rational scientific answers are not available, not understood, or not respected because they don't account for subjectively-observed phenomena. And, in particular, I shouldn't overlook those myths that are deliberately promoted as an aid to selling a product. Since mythology has frequently been used to promote high-fidelity equipment, let's take a close look at some of the most popular of the current audio myths.

TABLE 1
WHAT THE EAR HEARS

Increase in power	Decibels	Effect on listener
2	+3 dB	Barely discernible
4	+6 dB	Definite increase in volume
10	+10 dB	As if the volume level was doubled

Myths and legends

• **Sound quality is a matter of taste:** The idea behind this hogwash is that everyone hears differently, and therefore, there are legitimate differences in sonic taste. I can illustrate the flaw in that argument by setting up an imaginary experiment. Suppose that I were to make a perfect tape recording of the sound of the cover of this issue of **Radio-Electronics** being shredded by the blades of an electric fan. When played back over a perfect audio system, the tape will sound identical to the original when heard by *any* given pair of ears. Some listeners might prefer the sound of some other magazine being shredded, but that's not the point. In other words, we are all listening to the same objective reality, and even though each of us samples it somewhat differently, our ultimate reference standard is the original live sound.

Of course, due to age, accident, or lack of training, not all of us hear equally well. For example, if someone's hearing cuts off at about 8 kHz, he or she is probably is not going to hear the difference between two sound components, one of which has a peak at 12 kHz and the other a dip at 12 kHz. But since the hearing of most listeners is good to perhaps 15 kHz (particularly at the higher volume levels), the prudent equipment designer tries to provides a flat response to at least that frequency, and usually substantially higher.

Taste *is* a factor when dealing with subtle nuances of sound. I define "nuance" as the sort of sonic differences that might occur between two good seats in the same concert hall. Such differences are a legitimate matter of taste. But a preference for boomy bass or shrill, peaky treble (achieved by setting the bass and treble controls for maximum boost) is not a matter of taste; rather, it indicates a lack of taste. Time and experience will frequently—but not always—help moderate such inclinations.

• **I don't have a trained ear, so I don't really need a good system:** That statement is most often heard from an older person. A psychologist on the lookout for hidden messages would probably find: 1) "I don't want to spend a lot of money;" 2) "Don't embarrass me with a lot of technical gobbledygook that I don't understand." My response (without gobbledygook) is that as one becomes accustomed to the sound of a quality audio system, the ability to appreciate good sound improves. It would therefore be a mistake to put money in a low-quality system that will ultimately prove unsatisfactory.

If you have a friend to whom you want to demonstrate the value of high-fidelity sound, you can easily provide a bit of the "ear training" he says he lacks. Play a *good* recording of the kind of music he likes, first with the treble turned down to simulate the performance of a typical low-cost system, and then with a *flat* response. Depending on the kind of music being played, you could point out the newly-audible presence of the higher harmonics ("overtones" might be a better word), or the improved naturalness in the sound of the tambourine, castanets, etc.

• **Sensitivity is the most important FM tuner rating:** It may be, but only if the user is in the distant deep-fringe area of the desired stations, and in any case, a better antenna will usually do more to reduce background hiss than an extra microvolt of tuner sensitivity. For most listeners, multipath noise and distortion, and "breakthrough" from other stations, are the more pressing problems. To what degree you will suffer from the effects of multipath and breakthrough is determined not by sensitivity but by the a tuner's performance in the areas of *Capture Ratio*, *AM Rejection*, and *Alternate-Channel Selectivity*.

• **A receiver that plays loudly with the volume control barely cracked open has lots of power:** A sports car that surges away from a standing start by a mere touch on the accelerator may indeed have enormous power reserve. But an analogous performance by an amplifier has nothing to do with power; it simply means that the amplifier's volume control has been selected for a "fast" taper, probably in the hope of creating a false impression of "greater" output power. Although such a volume control provides more signal with less rotation than a control having a conventional "audio" taper, its action has no bearing on the *total* amount of power available from the amplifier.

• **The bigger the magnet in a woofer, the better its performance:** It is true that all other factors being equal, the greater the magnetic flux in the voice-coil gap of a speaker the greater its efficiency. However, too large a magnet for a given design will result in *decreased* bass output compared to a woofer with a smaller magnet of appropriate size. The reason is that the heavier magnet overdamps the voice coil and inhibits woofer-cone movement at the low frequencies.

The use of a large speaker in a box too small for the speaker will—for different reasons—also produce less bass.

• **Amplifiers with "Lateral Feedback" are superior to those with "Gamma-Plus" circuits:** I've invented "Lateral Feedback" and "Gamma-Plus" as typical examples of an advertising/promotional effort to create sales-enhancing myths. In the years that I worked as an editor, I wondered why so many manufacturers of perfectly fine products seemed compelled to paint their lilies with gimmicky claims. Now that I'm spending some of my time helping manufacturers and advertising agencies wield the paint brush, I can appreciate the problem: How do you differentiate this year's product from that of your competition—and from your own products of last year?

During the time when a component-category is undergoing rapid evolution, it's not too difficult to build a significant advance in performance or features into succeeding models. But genuine competitive advantages are very hard to come by when a product category has matured. That's when we begin to hear about "Lateral Feedback" to eliminate "side-slip" distortion, "Gamma-Plus" circuits, etc. If all that makes you nervous, be reassured that the vast majority of the gimmicks do no harm, even if they do no good and aren't very meaningful.

• **A 100-watt amplifier can play twice as loud as a 50-watt amplifier:** That is a tough myth to dispel because, on its face, it seems so logical; but as shown in Table 1, the human ear does not respond linearly to increases in power. A doubling of power (a 3-dB increase) is audible, but is certainly not heard as "twice as loud."

Psychoacousticians have found that for a sound be perceived as twice as loud, an increase of 10-dB (or 10 times the power) is required. But since the *average* output level of a stereo system reproducing typical program material ranges from 0.25 watt to perhaps 10 watts, the occasional need for 10-times the power remains within the capabilities of many systems. Things only begin to get hairy (or fuzzy) when the listener is driving the amplifier into clipping by trying to play program material having a wide dynamic range through medium- to low-efficiency speakers. The solutions for the loss in clarity, openness, and low-bass impact can be found in either a new amplifier with at least 6 dB (4 times) the power of the existing amplifier, or speakers with 3 to 6 dB greater efficiency—or both. **R-E**

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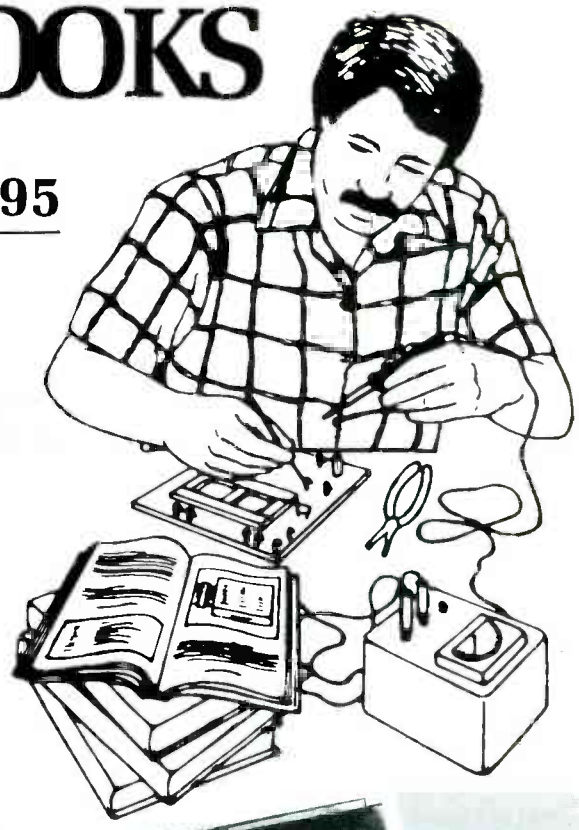

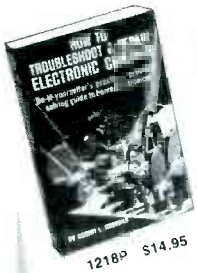

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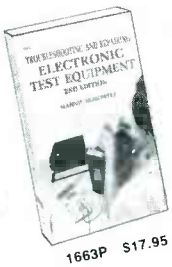

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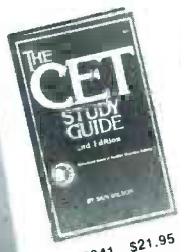

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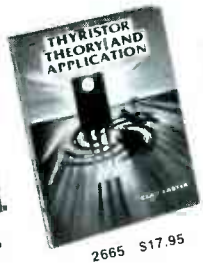

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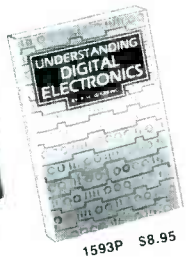

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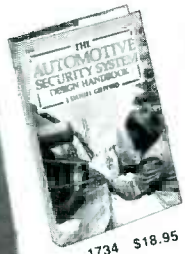

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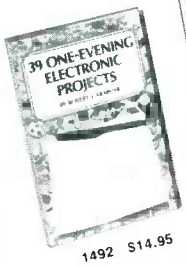

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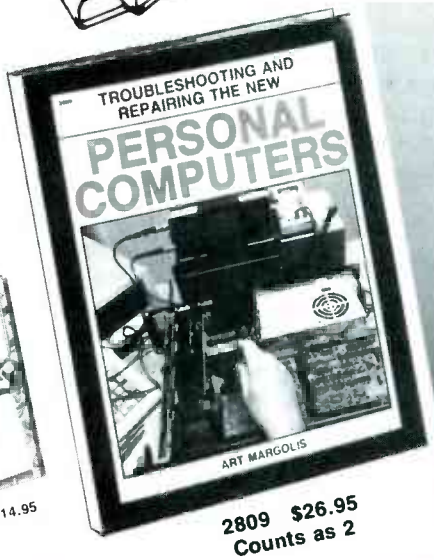

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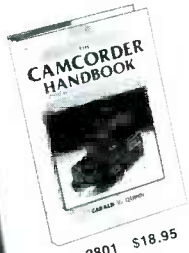

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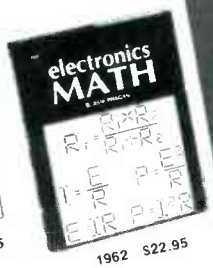

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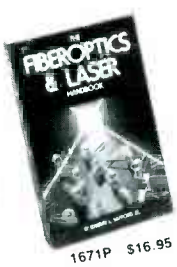

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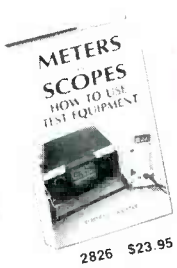

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continued from page 25

er is turned off thanks to the AC power supply.

The PLOTTING function allows you to plot on screen (or on a graphics printer using the PC's print-screen function) the data that has been gathered and logged for a given day. Data can be logged and stored on disk automatically. Once a file is opened, data is stored once every 30 minutes. Of course, to write to disk, the computer has to be running.

Memory registers on the *PC Weather Pro* board store maximum temperature, wind speed, etc., but they are not stored to disk.

In operation

In use, we found the *PC Weather Pro* hardware to work without a hitch—once we got it installed. We ran into a few problems during installation that were cleared up with a new troubleshooting guide. While that new troubleshooting manual was very clear and well written, the basic installation, operation, and software reference guides were not well thought out. The necessary information is in them, but not always easy to find. But our major complaint with the manuals is not the information they contain, but what they leave out.

For example, there is no mention of the format of the data that is logged to disk. So while it is possible to use the supplied software to look at plots of various functions on a particular day, there is no automatic way to look at longer trends. To be truly useful, the software should allow you to look at longer-term trends, to help with future forecasts.

To be fair, the people at Technology Marketing seem more than willing to help out wherever they can. And, although it we didn't get to see it before press time, they are about to release a full tool and utility kit that answers our complaints. Among other features, the utility kit will allow you to port the data logged by *PC Weather Pro* to such programs as *dBase* or *Lotus*.

Since the software runs in the background (in a "terminate and stay resident" mode), you can expect occasional problems with other memory resident software. Interestingly enough, we didn't run into such problems. We did, however, run into a compatibility problem with a word processor.

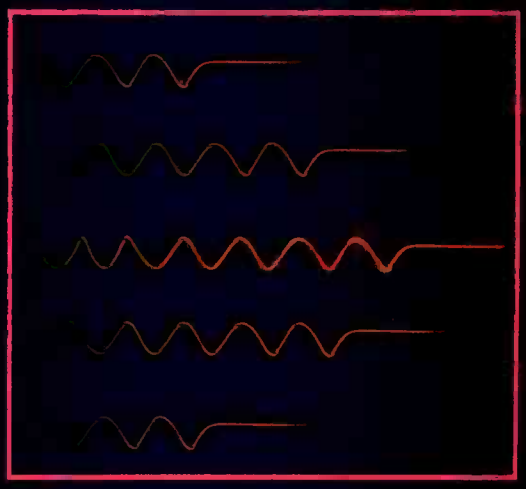
Despite those negative points, we were very pleased with *PC Weather Pro*. We've been waiting a long time for someone to integrate weather sensors with the data-logging capabilities of a computer, and Technology Marketing, Inc. has done a fine job.

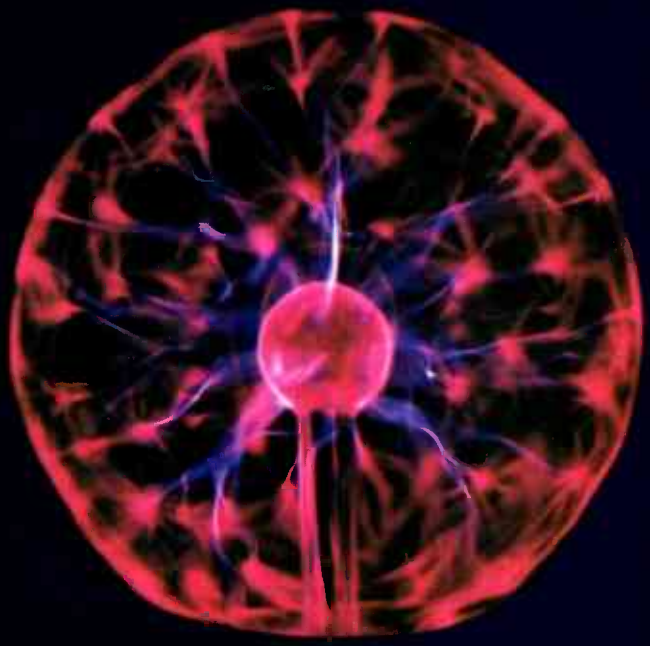
PC Weather Pro costs $575. A lower-cost version, which does not include the rain gauge and comes with a simpler software package (that doesn't offer data logging or plotting) is available for $375. Those prices really stand out when *PC Weather Pro* is compared to other systems on the market that offer similar functions—but cost ten times more. **R-E**

BUILD THIS

ELECTRONIC TORNADO

PLASMA DISPLAY POWER SUPPLY





A universal power source for an Eye-of-the-Storm-like display, and other unusual plasma and neon lighting devices.

ROBERT IANNINI

You no longer need to go to a local discotheque to see the latest in unusual lighting effects. Whether it's an Eye-of-the-Storm-like display, a Devil's Furnace, or travelling-wave neon lamps, you can now buy them for your own home at the larger department stores and high-tech boutiques. Only problem is, they usually cost big bucks—in the neighborhood of $200; but you can certainly can build them for much less if you have the special kind of power supply that's needed. And that's where our universal plasma power supply comes in: it can drive all three kinds of displays—you simply connect the desired display device to the universal plasma power source.

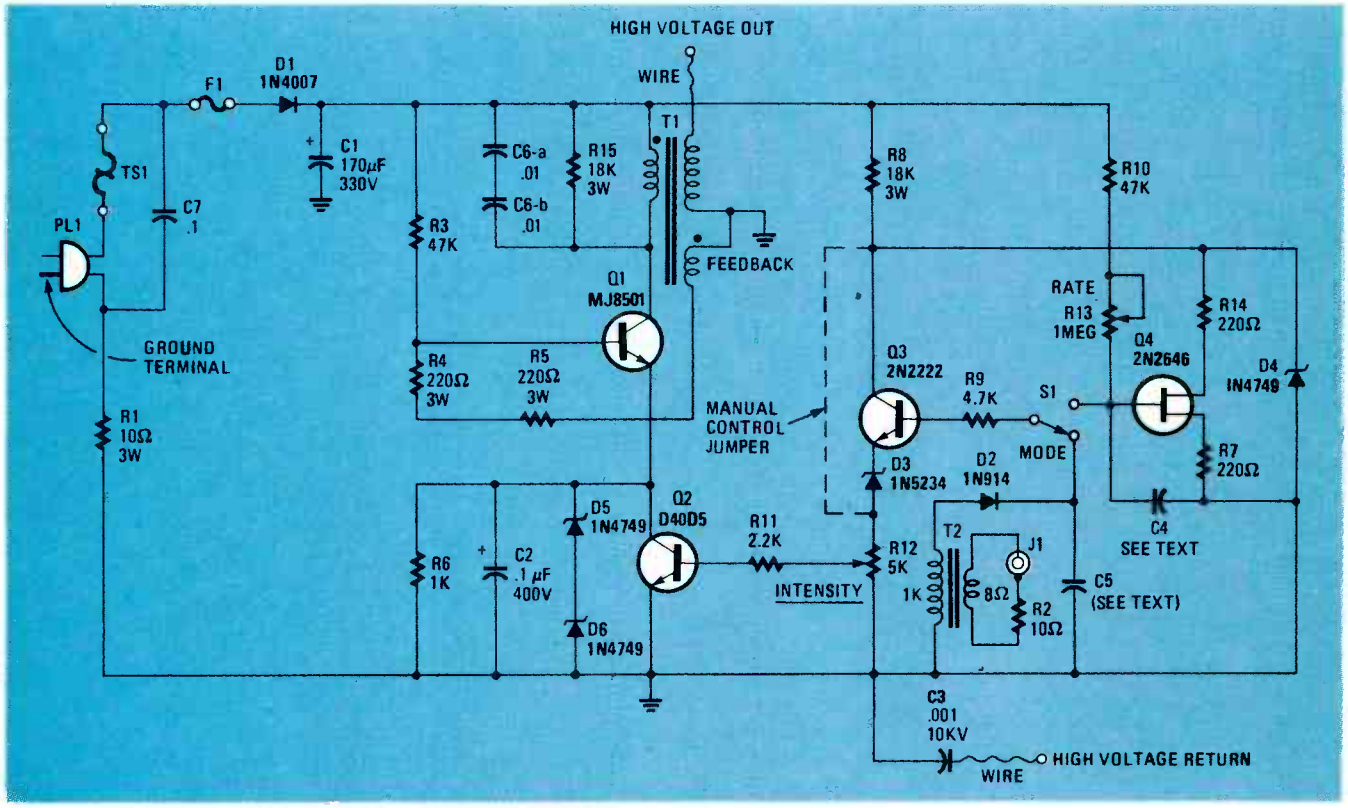


FIG. 1—THE POWER SOURCE USES A COMMON GROUND so make certain PL1 is a polarized linecord plug. The dashed line indicates a shorting jumper that's only installed if the device is to be used only for powering a plasma bulb.

Fire in your hand

For those of you unfamiliar with discotheque lighting, we'll take time out to explain. An Eye-of-the-Storm-type plasma device is a glass bulb that surrounds a small golf-ball-size core. When powered, red and blue streamers resembling flashes of lightning emanate from the ball to the globe. If you move your fingers over the globe the streamers follow your fingers and appear to burst and mushroom at your fingertips.

A Devil's Furnace is also a globe but there is no central ball. Streamers of flame-tipped lightning flow upward from the base and follow the curvature of the globe. As you move your hand or fingers over the globe the Devil's Flame follows them and "explode" against the bulb.

A travelling-wave or tracing neon lamp is a lighting device that illuminates slowly from end to end, then extinguishes, then repeats the cycle. The time it takes for total illumination of the tube and the repetition rate are determined by the characteristics of the power source.

Since the power source for a travelling-wave neon lamp is the most complex, that's the one we'll describe—so that you get the option of using all three devices. The circuit that determines the speed of end-to-end illumination determines the brightness range of the plasma globes, while the repetition-rate circuit for the neon tube can be easily bypassed for full-time plasma-tube display.

The usual power

The usual way to power neon and cold-cathode gas discharge tubes is to use a high-voltage, current-limited transformer operating at 60 Hz that is connected to both ends of the tube; an approach that only allows the full discharge length to be simultaneously energized. Sequential energizing of the display is therefore impossible, and any display motion must be simulated by using individually-segmented discharge tubes, each having a connection to an individual source of power. Timing and power-control circuits determine the distribution of power to the individual segments of the tube.

In our universal power supply, instead of 60 Hz, we substitute high-frequency energy of approximately 20 kHz as the power source, which makes it possible to excite and re-energize the tube's gas via a connection to only one end of the tube. That is made possible by the capacitance between the ionized gas and the surroundings, which produces a low enough reactive impedance so the high-frequency energy can cause plasma ignition.

Since ignition depends on the capacitance of one end of the tube to its surroundings, it allows the ignited plasma display to travel along the tube, creating a defined bright and dark band. The degree or type of travel-effect can be a pre-programmable event that determines where the plasma ignition will start, causes the ignition to travel steadily to the end of the tube, and then repeats the electrical effect; thereby creating the visual effect of *handwriting* or *tracing*

Varying voltage levels such as those from the output of a radio or audio amplifier can also be used to vary the tracing effect or the plasma-lighting discharge-effect in step with the sound amplitude. That creates bizarre and dazzling special effects.

How it works

Refer to Fig. 1. The 117 volts from the AC powerline passes through

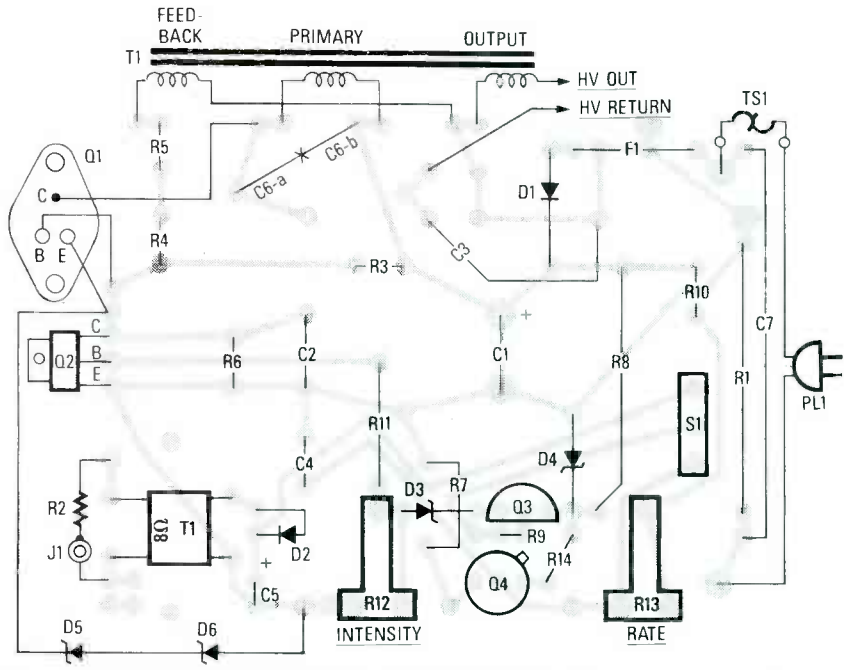


FIG. 2—THE CURVED LINES IN THIS PARTS LAYOUT indicate components that span across other components. That is possible because most of the small-size parts are end-mounted. Capacitor C7 can be placed on top or under the PC board.

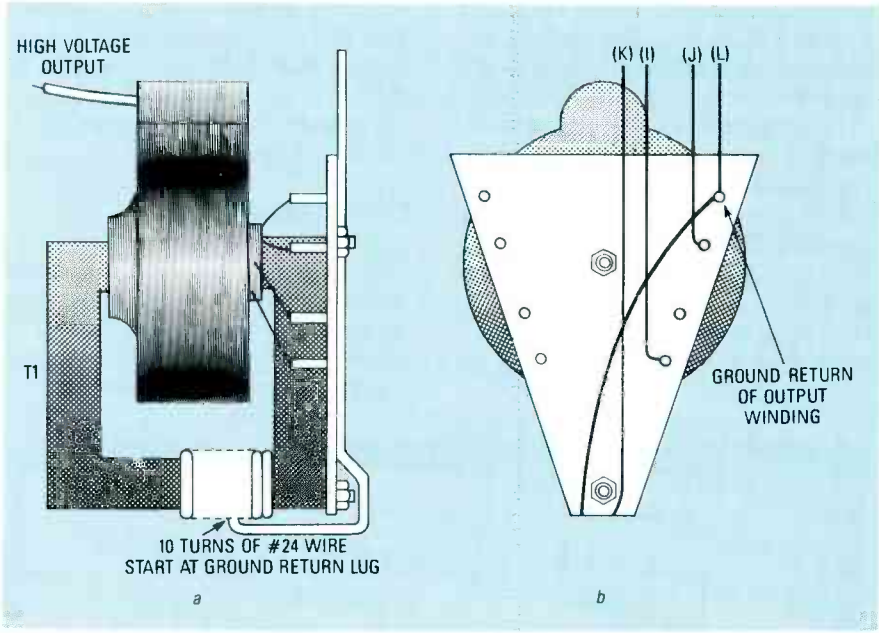


FIG. 3—THE FEEDBACK WINDING, as shown in *a*, is wound directly over T1's core. Its leads, as shown in *b*, are routed under T1's mounting plate. The letters in *b* that identify the wires are the same as those used by the manufacturer; they match the connections shown in Fig. 5.

through thermal safety switch TS1 (which is mounted on the device's heat sink), is rectified by diode D1, and filtered by capacitor C1. Resistor R1 limits the surge current of D1 and C1. Fuse F1 is a *slo-blo* type that allows C1 to charge, yet opens (at 1 amp) if a catastrophic fault exists in the circuit. Thermal switch TS1 turns the device off when the temperature of Q1 exceeds 200°F. (It is necessary when operating the unit in a high-powered mode, or may be required to comply with local electrical codes.) The rectified voltage across C1 is approximately 160-volts DC.

Transistor Q1 is connected as a Hartley-type oscillator. It is biased into conduction when base current is first applied through R3. Feedback to Q1's base is obtained by a tertiary feedback winding on T1 that is in-

PARTS LIST

Resistors
R1—10 ohms, 3 watts
R2—10 ohms, ¼ watt
R3, R10—47,000 ohms, 1 watt
R4, R5—200 ohm, 3 watt, wirewound
R6—1000 ohms, 1 watt
R7, R14—¼ watt
R8, R15—18,000 ohms, 3 watt, wirewound
R9—4700 ohms, ¼ watt
R11—2200 ohms, ¼ watt
R12—5000-ohm trimmer potentiometer
R13—1-Megohm trimmer potentiometer

Capacitors
C1—170 µF, 330 volts, electrolytic
C2, C7—0.1 µF, 400 volts, paper
C3—.001 µF, 10 kV, ceramic,
C4—220-1000 µF, 25 volts, electrolytic (see text)
C5—1 µF, 50 volts, electrolytic
C6-a, C6-b—0.01 µF, 1 kV, polypropylene (see text)

Semiconductors
Q1—MJ8501, NPN high voltage transistor
Q2—D40D5, NPN power transistor
Q3—2N2222, NPN transistor
Q4—2N2646, UJT transistor
D1—IN4007 rectifier diode
D2—IN914 small-signal diode
D3—1N5234, Zener diode
D4–D6—1N4749, Zener diode

Other components
F1—1-amp, *slo-blo* fuse
J1—Phono jack
PL1—Polarized power plug
S1—SPDT PC-mounting slide switch
TS1—Thermal switch
T1—Ferrite transformer (see text)
T2—Miniature audio transformer, 8-ohm primary, 1000-ohm secondary

Miscellaneous: Printed circuit materials, insulating board, TO-3 mounting kit, 6-32 nylon screw and nut, mica washer, insulated alignment tool, wire, solder, sheet aluminum, cabinet, etc.

Note: The following parts are available from: Information Unlimited, PO Box 716, Amherst, NH 03031: An etched and drilled PC board ($5.50): Transformer T1 ($29.50): 0.01 µF, 1 kV, polypropylene capacitor ($2 each): A complete kit containing T1 and all other components as well as the enclosure ($59.50). Add 5% of the total order for for postage and handling.

Plasma globes and custom neon tubes are available from Strattman Design, 791 Trement St. No. E517, Boston, MA 02118. Tel. 617-266-8821. Write or phone for specific information and prices.

phase with T1's primary winding. The positive feedback is what causes Q1 to oscillate. Base current is limited by resistors R4 and R5.

The resonant frequency of T1 is such that the circuit oscillates at a frequency of approximately 20–25 kHz. A resonating capacitor, C6, tunes the primary of T1 to a smooth, soft waveform, while R15 provides the load impedance that is sometimes necessary when the supply powers very small display tubes and globes.

Since the power supply uses a ground circuit that is common to the AC powerline, capacitor C3 is provided to prevent a hazardous condition should polarized line-cord plug PL1 be defeated.

The gain of Q1 determines the output voltage. The gain is controlled by the conductance of transistor Q2, which is determined by the bias applied to Q2's base through the INTENSITY control, R12. Diode D3 prevents any offset voltage that may occur at the beginning of the turn-on cycle from turning on Q2. Capacitor C2 bypasses any high-frequency signal that might be developed across Q2, while Zener diodes D5 and D6 limit Q2's instantaneous collector-emitter voltage to 48 volts.

The control signal applied to Q2's base—which determines the instantaneous system-output voltage—is determined by the ramp voltage produced by unijunction-transistor oscillator Q4. The period of the ramp is determined by capacitor C4 and the setting of the RATE control, R13. The value of C4 should be in the range of 220–1000 μF. A mid-value of 500 μF is suggested as an initial value. Although 500 μF probably will work out best for most applications, you can experiment to determine the exact value for the kind of display that you prefer.

The ramp voltage is applied through the MODE switch, S1, to emitter-follower Q3, which serves as a buffer-amplifier whose relatively high input impedance isolates C4 from variable resistor R12. The voltage produced by Q3 across R12 corresponds to the ramp voltage, thereby providing a relatively linear change in Q1's power output.

Proper biasing of Q2 by R12 is the point of conduction just as the ramp voltage starts to increase. That provides a minimum or zero tube or globe display that steadily increases as the ramp waveform builds. If R12 is adjusted for a "hold off" bias so Q2's conduction does not start until the ramp is well underway, the overall period of the output voltage, and therefore the display, is reduced.

Audio control

An audio signal can be substituted for the ramp control voltage by setting S1 so that Q3's base connects through R9 to D2 rather than to C4. An audio signal, say from a transistor radio, that is applied to J1 will then provide the control signal for Q2, and the system's output voltage will more or less correspond to the amplitude of the audio signal.

Normally, resistor R2 isn't necessary unless the audio signal is so strong that it swamps the unit and produces an output that appears to be *on* most of the time. You only have to install R2 if R12 has little effect on the output when audio is used as the control signal.

As a general rule, the 1-μF capacitor specified for C5 in the Parts List will be satisfactory, but you can experiment with different values to get the plasma or neon display you prefer.

If you have no need for either automatic ramp control by Q4, or audio control via J1, then you can install the shorting jumper indicated in Fig. 1 by the dashed line connecting R8 to R12. With the jumper installed, the brightness of a plasma-bulb display, or the brightness and maximum length of a neon display is determined only by R12.

The display

The plasma arc—the visual display—is created by the electric current flowing through the gas in the tube. In a plasma bulb, the gas can be argon, neon, krypton, or any combination thereof. The colors generated are determined by the specific kind and ratio of gasses. In a neon tube the gas is, of course, neon. When electric current is applied to the gas, the atoms become energized to a level where both electrons and positive-charged atoms are produced. They emit light spontaneously upon returning to their initial energy state. As the electric current is reduced, the display shortens because there is insufficient energy to cause further ionization. Increasing the ionization energy causes the end of the display in a neon tube to lengthen because there are a greater number of free charges. In simple quantitative terms, the number of charges produced in the tube is directly related to the input energy. A smaller-volume tube would theoretically produce a longer discharge for a given ionization energy and vice versa. (That explanation neglects the change in the dynamic impedance of the system due to a change in the volume of gas.)

Construction

Although we provide details for construction of the universal plasma power source prototype shown, keep in mind that a complete kit that includes the cabinet and all prefabricated metal parts is available from the

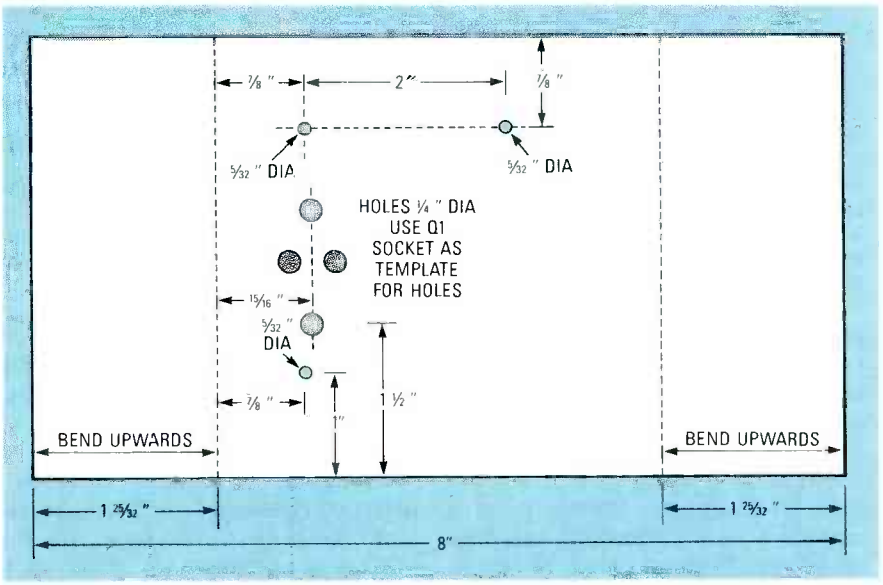


FIG. 4—THIS IS THE TEMPLATE for the metal frame. The holes for Q1 should correspond to the particular socket you use.

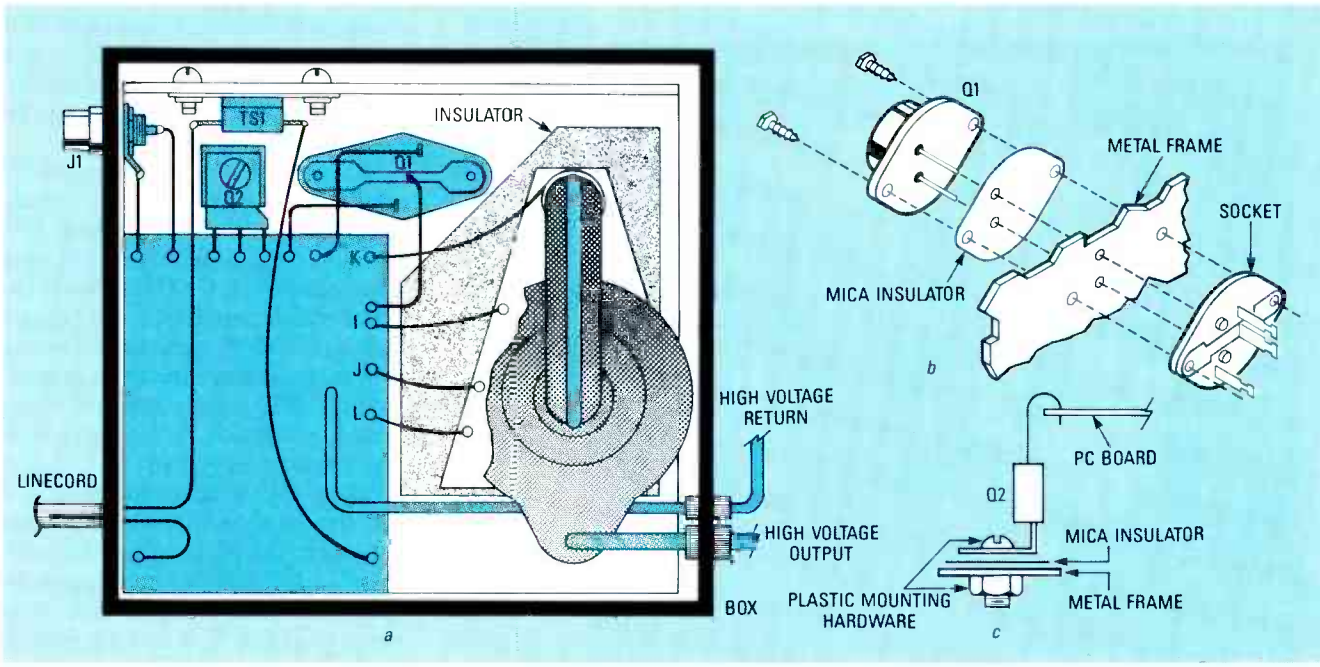


FIG. 5—THE ASSEMBLY ON THE METAL FRAME should correspond very closely to the view shown in *a*. Note in particular how the letter-identified wires from T1 connect to the PC board. If TS1's mounting screws interfere with the frame's installation in its cabinet, eliminate the screws and secure TS1 to the frame with epoxy cement.

source given in the Parts List, which is located on page 45.

The first step is to make the PC board using the template shown in PC Service. Then, using Fig. 2 as a guide, install all board-mounted components. But note that the components are mounted somewhat differently than usual: except for D1, D3, D4, and R1, all components are mounted on end; that is, they stand vertically on the PC board. Although Fig. 2 shows diodes D5 and D6 external to the board, they actually span across the board. They are positioned about ¾-inch above the board and are located between T1 and C4.

Note that although the leads from Q2 are soldered to the PC board, during final assembly Q2 will be folded downwards so it can be heat-sinked to a metal frame. Be sure to leave sufficient lead length—about ½-inch—so the fold can be made without stressing the leads or the board.

In reality, C6-a and C6-b do not exist. There should be only one capacitor, C6, a 0.005-μF, 1-kV tubular capacitor connected across T1's primary winding. Unfortunately, that value isn't among the easiest to locate, so you can substitute the more easily obtained series-connected 0.01-μF, 1-kV capacitors, shown in Figs. 1 and 2 as C6-a and C6-b. They are both end mounted, and are connected together at the top after they are installed on the board. Finish up by using an RTV type adhesive such as G.E.'s Silicon II to cement a sheet of insulating material to the underside of the PC board.

When the PC board is completed, you can set it aside and move on to transformer T1.

A feedback coil

Although the T1 specified in the Parts List is supplied completely assembled, it requires the addition of feedback coil, which, as shown in Fig. 3-*a*, is nothing more than 10 turns of No. 24 solid, insulated wire wound around T1's core. Bear in mind that if you substitute a different transformer for the model specified the required feedback winding might have more or less turns. Also, a substitute transformer should have a primary inductance between 2 and 3 mH. If your T1 has pin connections that interfere with its installation, simply cut them short.

Figure 3-*b* shows letter-coding for the connections of the particular model T1 specified in the Parts List. The letters only serve as a reference when assembling the project; more on that later. (The letters are the same as those used for identification by the kit supplier given in the Parts List.)

Take note that since T1's terminals extend through its own support bracket, they must be insulated from the metal frame that is used as a chassis. The insulation can be a strip of epoxy PC material from which the copper foil has been etched. (The insulator is supplied in the complete kit of parts.)

The frame

The metal frame chassis, which is called a *mounting plate* in the instructions packaged with the complete kit, also serves as the heat sink for Q1 and Q2, which is why thermal-switch TS1 is installed on the frame. If the frame gets excessively hot, TS1 opens and turns the power supply off. Since TS1 is self-resetting, it automatically restores power when the heat sink cools.

Figure 4 shows the measurements for a metal frame made from 1/16-inch aluminum. The indicated holes are for the mounting screws used for Q1, Q2, and T1. The precise layout of the diamond-pattern holes for Q1 will be determined by the particular kind of socket you use; but regardless of the kind or design of the socket, make Q1's holes ¼-inch, and deburr them with a knife or deburring tool before installing the socket.

Make certain you drill all holes before bending the side flanges upwards on the fold marks.

Figure 5 shows how the project is

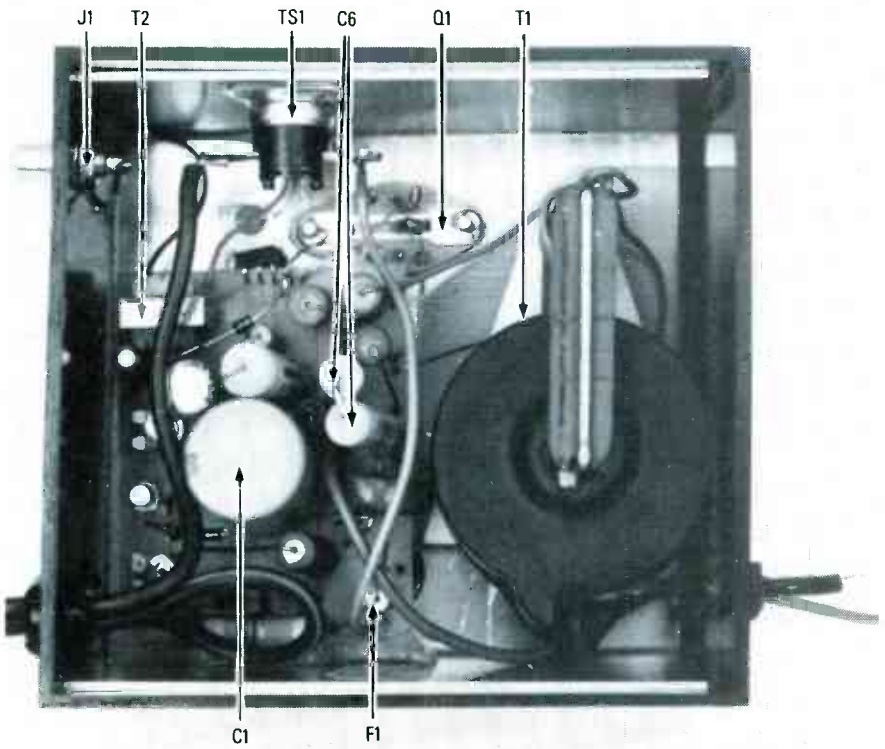


FIG. 6—THE ACTUAL PROTOTYPE. Notice that it is virtually a duplicate of the layout shown in Fig. 5.

assembled. Figure 5-*a* shows that TS1 is secured to the metal frame with screws and nuts. If you have somehow made the frame a smidgen oversize so the mounting screws prevent the chassis from being installed in its cabinet, you can eliminate the screws and use epoxy glue to cement TS1 to the chassis. Its location is not precise, but it should be reasonably close to the top of the enclosure (away from Q2).

Figure 5-*b* shows how Q1 is installed on the metal frame using an insulating socket. However, note from Fig. 5-*c* that Q2 does not use a socket; it is insulated from the frame only by a mica insulator, so a Nylon screw and nut must be used as the mounting hardware.

Finally, use RTV adhesive to cement the PC board to the metal frame. The board must be spaced off the frame because one end is lifted by Q2's mounting; use a stack of rubber grommets for the spacers.

The enclosure

Although the project should not be installed in an enclosure until tested, prepare the enclosure so it is ready as soon as the tests are completed. For safety, the (4½-inch wide × 4¾-inch long × 2¾-inch high) enclosure must be made of plastic; 3/32-inch thick will be ideal. (An appropriate enclosure is supplied with the kit.)

Fabricate a cover from perforated aluminum that will snap onto the top of the cabinet, but be certain to drill access holes for R12, R13, and S1 before bending the sides of the cover. Also, if you plan on using a plasma globe, assemble a base large enough to support the globe, and place the power supply within the base box.

Do not pre-size a plasma-globe base before you obtain the globe. Since plasma globes range in size from 7 to 22 inches, you must be certain the base has the proper dimensions to fully support the globe.

Checkout

Before applying power, very carefully check the insulation between the metal frame and the connections to Q1, Q2, and T1. Also, check for continuity between PL1's ground lug (the larger one) and the circuit's common (ground) point. Make certain the circuit ground is not connected to PL1's "hot" terminal.

Next, set R13 fully clockwise, R12 fully counterclockwise, and S1 so its handle points toward R10. Then connect T1's output lead to a neon tube, bank, or sign.

Plug the unit into a variable, current-metered AC supply, such as a metered variac. If that kind of equipment is unavailable we suggested connecting a 60-watt light-bulb ballast in series with the power cord. If there is a catastrophic failure in the device, the light bulb will turn on and drop the voltage at PL1 to a safe value.

Slowly turn the variac up to 120 volts and note that its ammeter should indicate only 50–60 mA. Also note that there should be only a faint glow in the neon tube. **CAUTION—if the meter reads excessive current, a fault exists that must be corrected to prevent severe circuit damage.**

Adjust R12 for a maximum sweep reading of 200 mA. At 200 mA a neon tube should energize out to 15 feet.

Adjust R13 counterclockwise and note that the neon sweep speed should increase to the point where it ceases.

Set S1 to its AUDIO input position. Connect a transistor radio's earphone output to J1 and note that the neon or plasma display intensity should respond to the audio sound level.

If everything checks out, install the unit in its enclosure, using strain relief clamps or devices where the line-cord, high- voltage, and high-voltage-return wires pass through the enclosure. Figures 6 and 7 show the completed protype unit.

Special Instructions

Although the unit can power up to 30 feet of neon tubing, best results are obtained by connecting 10–15-foot sections in parallel because maximum sweep travel is usually limited to 15 feet.

The high-voltage-return wire is intended for connection to the end of larger neon displays. It is not necessary for single electrode-ended tubes such as used for visual audio enhancement. Do not ground the high-voltage return if unused; simply tie-wrap the wire and make sure there are no exposed strands.

Do not allow the power-supply unit to run without being connected to a display tube or globe.

Neon displays

- Set R13 fully clockwise, R12 fully counterclockwise, and S1 to INTERNAL (so that Q3 is fed by Q4).
- Lay out the intended neon sign on a clear non-conductive bench. (Not necessary for pre-installed displays).
- Connect the high-voltage return (the ground wire) to the far end of display. Note that the wire is only

continued on page 82

Build REACTS:

THE RADIO-ELECTRONICS ADVANCED CONTROL SYSTEM

This month we take an in-depth look at the CPU board's circuitry.

H. EDWARD ROBERTS M.D.

Part 2 AS WE SAID last time, the REACTS 7000 uses an operating system that is compatible with the CP/M operating system. The version we use is an enhanced SB-80 from Lifeboat Associates. Special utilities have been added to the basic DOS (*D*isk *O*perating *S*ystem) in order to make robotics/control applications easy to implement.

A number of the systems commands are known as *intrinsic*—i.e. they are part of the basic system. Examples of intrinsic commands are: DIR, which lists the directory of a disk drive; DEL, which deletes files; SAVE, which saves files; and BATCH, which can be used to chain together a number of different commands. Of course, there are many more, but that gives you an idea of some of the commands if you aren't familiar with CP/M or MS-DOS.

Additionally, the operating system includes a number of utilities such as CONFIG, RBURN, and FORMAT, etc. Utilities are programs that have been added to the basic operating system. The following is an explanation of some of the utilities included with the REACTS DOS:

- CONFIG: Used to change different parameters of the DOS such as, disk-drive assignments, boot drive, serial-port parameters, I/O assignments, etc. If the changes are to be made permanent, a new boot PROM can be burned using RBURN described below.
- RBURN: is a utility that allows you to create a custom PROM disk on a 32K ROM. Using that utility, you can create a PROM disk as easily as you create a floppy disk.
- FORMAT: That allows the formatting of the REACTS 3.5-inch floppy disk if a disk controller and disk are included in the system.

That gives you some idea of what can be done with the CP/M operating system. There are a number of excellent books on CP/M for those who want to get more information. In addition, a detailed manual is included with the operating system sold by the source mentioned elsewhere in this article.

It is important to note that you don't have to have an operating sys-

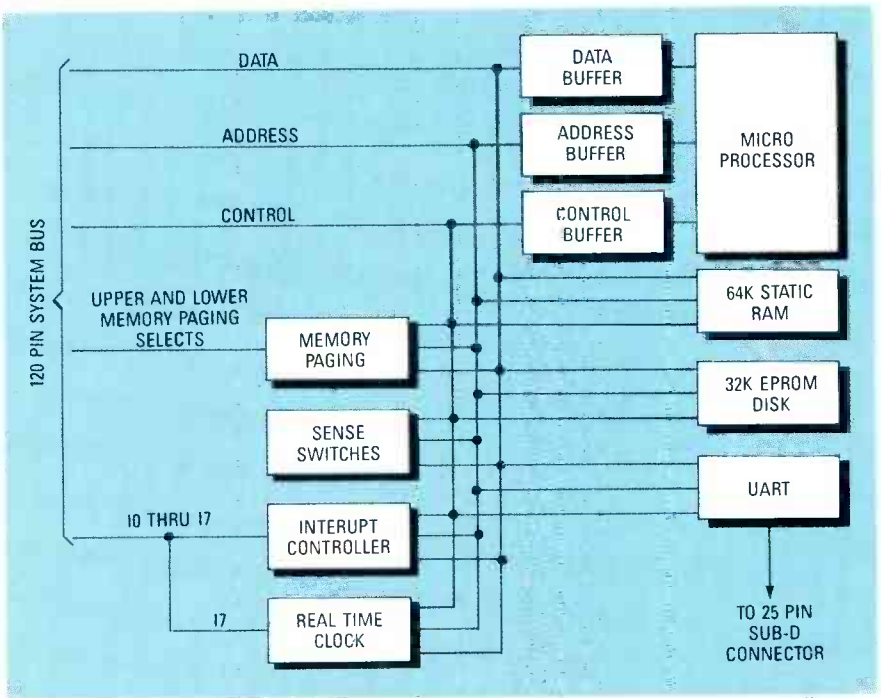


FIG. 1—THE ORGANIZATION OF THE REACTS CPU board is shown here in block-diagram form.

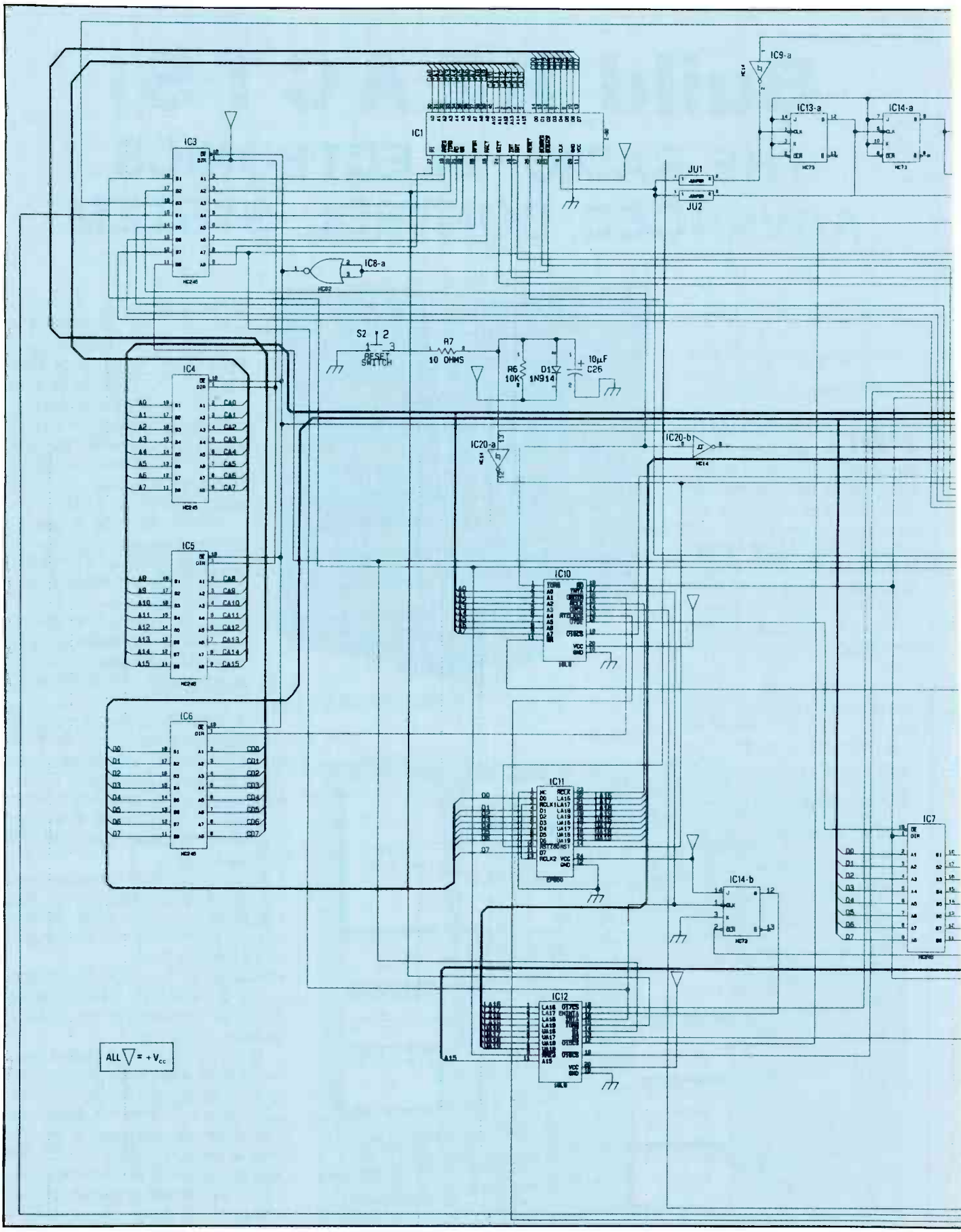


FIG. 2—THE REACTS CPU is built around the powerful Z80 microprocessor. Note that all of the bypass capacitors (C1–C25, C27–C29) have been eliminated from this schematic for clarity.

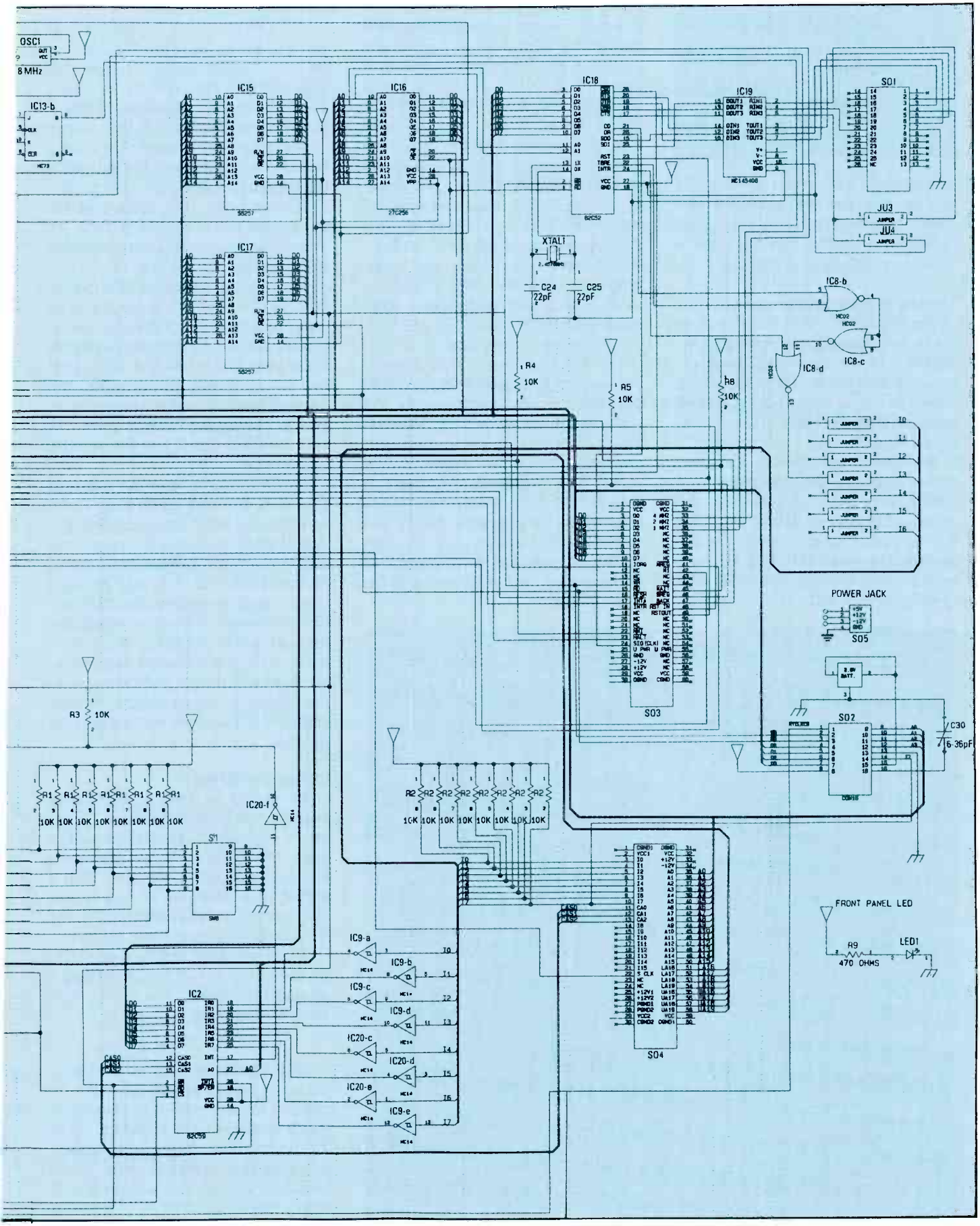


TABLE 1—I/O PORTS

Subsystem	I/O Port(s) Used
Sense Switches	187
Real Time Clock	192 thru 207
Memory Paging	210
Interrupt Controller	216 thru 217
UART	212 thru 215

tem to make the system function. If you are familiar with assembly-language programming and have your own cross assembler, you can create a custom system from scratch.

Theory of operation

The REACTS 7000 CPU is relatively conventional in organization. Figure 1 shows an overall block diagram of the system. The schematic is shown in Fig. 2. Note that because of its large size, the print had to be reduced in scale.

As already discussed, the processor used in the computer is a CMOS version of the Z80 (IC1). An on-board crystal oscillator provides the necessary clock signals for the system. Jumpers JU1 and JU2 are used to select between an 8-MHz (JU1 installed) or 4-MHz (JU2 installed) clock frequency. Other major subsystems on the central-processor module includes a set of eight sense switches, an interrupt controller, a *U*niversal *A*synchronous *R*eceiver/*T*ransmitter (UART), two 32K static RAM chips, a 32K boot PROM-disk, bus buffers, and the memory-paging capability that allows the addressing of up to one megabyte of system RAM. Also, an optional real-time clock is plugged in as a daughter board on the CPU module. All of those components must communicate with the Z80 processor; most of that communications takes place via the I/O ports. We will look at that in more detail later.

In our system each subsystem is hard-wired to a predetermined I/O port address; the addresses for the subsystems are shown in Table 1. Those addresses are known to the operating system, and communication occurs automatically in most cases. If required, an application program can also bypass the operating system and communicate directly with any subsystem. We will talk more about how to bypass the operating system in future articles.

TABLE 2—BUS DEFINITIONS

Left Bus				Right Bus			
Pin No.	Function	Pin No.	Function	Pin No.	Function	Pin No.	Function
1	CASE GND	31	DGND	1	DGND	31	CASE GND
2	VCC	32	VCC	2	VCC	32	VCC
3	INT 0	33	+12V	3	DO	33	4 MHZ
4	INT 1	34	−12V	4	D1	34	2 MHZ
5	INT 2	35	A0	5	D2	35	1 MHZ
6	INT 3	36	A1	6	D3	36	RESERVED
7	INT 4	37	A2	7	D4	37	RESERVED
8	INT 5	38	A3	8	D5	38	RESERVED
9	INT 6	39	A4	9	D6	39	RESERVED
10	INT 7	40	A5	10	D7	40	RESERVED
11	CA 0	41	A6	11	IO/M	41	RESERVED
12	CA 1	42	A7	12	RESERVED	42	RESERVED
13	CA 2	43	A8	13	RESERVED	43	RESERVED
14	INT 8	44	A9	14	$\overline{WR}$	44	RESERVED
15	INT 9	45	A10	15	$\overline{RD}$	45	$\overline{WAIT}$
16	INT 10	46	A11	16	$\overline{RFSH}$	46	$\overline{BREQ}$
17	INT 11	47	A12	17	$\overline{INTA}$	47	BACK
18	INT 12	48	A13	18	$\overline{INTR}$	48	$\overline{RESET}$ IN
19	INT 13	49	A14	19	RESERVED	49	RESET OUT
20	INT 14	50	A15	20	RESERVED	50	RESERVED
21	INT 15	51	LA16	21	RESERVED	51	RESERVED
22	RESERVED	52	LA17	22	$\overline{NMI}$	52	RESERVED
23	RESERVED	53	LA18	23	$\overline{HALT}$	53	RESERVED
24	RESERVED	54	LA19	24	SIO (CLK)	54	RESERVED
25	+12V (PWR)	55	UA16	25	UNREG PWR	55	RESERVED
26	+12V (PWR)	56	UA17	26	GND (±12)	56	GND (±12)
27	GND (PWR)	57	UA19	27	−12V	57	RESERVED
28	GND (PWR)	58	UA19	28	+12V	58	RESERVED
29	VCC	59	VCC	29	VCC	59	VCC
30	CASE GND	60	DGND	30	DGND	60	CASE GND

The microprocessor

The Z80 processor is inherently capable of addressing up to 64K bytes of memory. Additionally, the Z80 can address up to 256 eight-bit I/O ports. The following is a discussion of how I/O operations take place in the system.

Whenever the computer executes an I/O command, it notifies the rest of the system by raising the system bus' $\overline{MREQ}$ line high. (Pin definitions for the system bus are given in Table 2). When that occurs, the lower 8 address lines contain the address of the I/O device. The $\overline{RD}$ (read) and $\overline{WR}$ (write) lines tell the system whether that is an input or output; i.e. if the read line is low the system is requesting an input, if the write line is low, the data on the bus is an output. Incidentally, the memory-read or -write system operates in exactly the same manner, except the $\overline{MREQ}$ line is low for memory operations.

In summary, in order for a device that uses I/O-port addressing to be selected, the $\overline{MREQ}$ line must be high. Additionally, it must have an address that matches the address on the lower address lines (A0–A7), and the $\overline{IORQ}$ signal must be correct for that particular channel. If all those conditions are met when inputting, the correct data will be placed on the data bus by the inputting device and then sent to the processor. For an output, the processor will place the correct data on the bus.

Sense switches

As stated in Part 1, the sense switches can be thought of as a "poor-man's keyboard." They allow you to input data to the system without connecting any other device. That's useful in a minimal system where size, space, and/or cost prevent using a more sophisticated input device.

Those switches are hard-wired to input channel 187. If you are writing a program in BASIC you simply type the following line:

```
120 S = INPUT 187
```

That would be read by the interpreter to mean input the data on channel 187 and store it as variable S. Since there are eight switches, up to 256 unique instructions could be supplied to the computer with those switches. Indeed, if you really like to work, you could input all of the standard ASCII codes using only the sense switches.

In addition, the four rightmost switches are used by the REACTS' disk-operating system at power-up. The setting of those switches select the console device, the serial port's baud rate, and which disk drive the system should boot from. A common use of the sense switch would be to automatically load and execute a program at power up.

Interrupt controller

The Z80 processor has two interrupt inputs—a nonmaskable and a maskable interrupt. Indeed, one of the reasons that the Z80 has become so popular as a controller is the power of its interrupt system.

A CMOS version of the industry standard 8259 interrupt controller (IC2) was added to the REACTS CPU. That provides us with eight additional vectored (i.e. prioritized) interrupt inputs. Those interrupts are brought out to the system bus and can be used by any of the other modules. Complete control of the interrupt system can be made under software control. Communication with the interrupt subsystem is made through I/O ports 216 and 217. Future articles will show you how to exploit interrupts. For now, let's just say that the interrupt system adds real power to the REACTS computer. In addition, many programming requirements can be simplified by using interrupts.

The UART

A standard RS-232 serial port is included on the REACTS CPU board. The serial port's communication parameters, baud rate, number of stop bits, word length, parity, etc., are configured by the Z80 through an 8252 UART (IC18). The 8252 also converts the parallel data from the system into a serial data train for use with serial communications systems. The CTS (*C*lear *T*o *S*end) line is configured—always high (for send-only or full-duplex applications) or floating—via jumpers JU3 and JU4. The serial port can be used to interface the computer module to a terminal, modem, or any other device that requires serial data input/output. The operating system communicates with the 8252 UART through I/O ports 212, 213, 214, and 215. The CRT controller we will build later on does not use that port, which means that it is normally available for any other purpose. But if we use an external terminal or computer as the controlling device, that port is used as the communication port.

Sources

The following items are available from DataBlocks, Inc., 579 Snowhill Road, Glenwood, GA 30428. Or call (800) 652-1336; in Georgia call (912) 568-7101: DP-CPU—design package of schematics and instructions, $10.00; PC-CPU—PC board for CPU mocule (includes DP-CPU design package,$37.00; PC-CLK—PC Board for clock, $18.00; SYS-PROM—the REACTS operating system (enhanced SB-80) installed on a 32K UV-erasable PROM (includes operating system documentation), $44 00; REC-CPU—complete kit of parts, PC boards, IC's, connectors, for CPU module (does not include clock or system PROM), $147.00; REC-CLK—complete clock subsystem including all parts, PC boards, NiCd battery, and connectors, $43.00; and REC-SYS—All of the above, $218.00. An Elpac power supply is also available for $49.00. Please add $10.00 postage and handling per order. GA residents must add appropriate sales tax.

Memory paging

System memory paging is performed via I/O port 210. The four least-significant data bits select the lower 32K page while the four most-significant data bits select the upper 32K page. That allows us to literally change the contents of the system memory in about 10 microseconds. That is equivalent to a DMA (*D*irect *M*emory *A*cess) transfer rate of approximately 10 gigabytes-per-second, which is fast by any standard, or of being able to move the entire contents of a 40-megabyte hard disk in 4 milliseconds. The basic REACTS system will support more than 1 megabyte of additional memory.

The memory-paging system is implemented using three custom PAL (*P*rogrammable *A*ray *L*ogic) IC's (IC10–IC12). Those can be purchased from the supplier mentioned in the Sources box.

Static RAM

Two 32K static CMOS RAM IC's (IC15 and IC17) provide 64K of system memory for the computer, and that is just the basic memory on the CPU module. Static memory IC's are somewhat expensive, but their use makes battery powering easy. That's because static RAM doesn't have any of the traps associated with multiple processor systems—we don't have to make sure that the memory is in any special configuration to power down or to perform DMA's.

System disk

As we discussed earlier, even the most minimal REACTS system includes a disk operating system. That is because the CP/M P drive is a 32K UV-erasable PROM that is included on the CPU module (IC16). That PROM is set up to allow for the BIOS (*B*asic *I*nput/*O*utput *S*ystem software) as well as drive P to be installed. There is enough storage available on that prom disk to store the BASIC interpreter and a decent sized user program. That means that for some applications, no other system hardware, such as a disk, needs to be added to the basic CPU module; only your interface hardware is required.

In a future article we will provide the construction plans for a PROM programmer as well as for a large RAM/PROM disk system.

Real-time clock

In many applications a real-time clock will be desirable and perhaps even mandatory. The real-time clock used by REACTS can be programmed to operate in a twelve or twenty-four hour time-keeping format. It can provide single or repeated interrupts to the processor with a resolution of 0.1 second. It includes an automatic calendar function (that accounts for leap years), and it includes a NiCd battery for back up. I/O ports 192 through 207 are used to configure and set the clock. The interrupt output of the real-time clock is connected to system interrupt 7.

The clock interfaces with the main CPU board via a 16 pin connector. (Note that the rest of the clock circuit will be shown in a future installment of this series.) The use of an interface circuit makes the clock optional and keeps the sytem cost to a minimum in systems where the clock is not needed.

Next time

That's all we have room for this time. Next time we will get our hands dirty and show you how to build the CPU module. **R-E**

BUILD THIS

WIRELESS STEREO LINK

This great little stereo FM transmitter lets you listen to whatever you want, whenever you want, wherever you want.

WILLIAM SHEETS and RUDOLF F. GRAF

YOU'RE WATCHING THE BEST BOXING match you've seen in years on your cable-television sports channel. The fighters are really slugging it out. Now the dog decides he has to go out and he's not going to wait. What do you do? You connect the television's audio to our FM broadcaster, put on your *Walkman* stereo tuned to a frequency near 88 MHz, and take the dog out without missing a punch.

In this article we'll show you how to build a low-cost, low-power stereo FM transmitter that can broadcast about 100 feet in a typical residential environment. Its signal is received on an unused FM channel, just as if it were any other FM station.

The idea of a radio transmitter for use with a home-audio system is not new. Those who were into electronics in the 1950's will remember the "phono oscillators" that were used to broadcast phonograph records to a nearby AM radio. Today, however, modern-IC devices make it possible to build a high-fidelity stereo FM transmitter that doesn't need much "tweaking" to get it working. Also, all of the necessary parts are available from the source that is listed in the Parts List.

FM transmitter

Whereas the old phono oscillator could only broadcast a mono signal, stereo requires two audio channels—one for left audio and one for right audio. An FM stereo signal has the frequency spectrum shown in Fig. 1. The main channel of the audio baseband (50 Hz to 15 kHz) is the sum of the left- and right-channel (L + R) audio. A monophonic receiver is able to receive that, and everyone is happy. Also, a *stereo difference* channel (L − R) is generated. That channel is the difference between the left and right signals. The (L − R) signal modulates a 38-kHz subcarrier, whose sideband products are transmitted along with the main audio.

The 38-kHz carrier is suppressed in accordance with FCC technical standards for stereo-FM modulation (the reason for that is beyond the scope of this article). But the 38-kHz subcarrier is necessary for reception of the L − R signal, so it must be supplied in some way at the stereo FM receiver. It is reconstructed in the receiver by using a 19-kHz pilot carrier sent along by the transmitter. The 19-kHz pilot carrier represents 10% of the full-modulation amplitude.

A block diagram of our FM stereo transmitter is shown in Fig. 2: The left and right audio inputs are fed into a matrix consisting of two halves of an LM1458 dual operational amplifier. One half of the IC uses a summing configuration to algebraically add the two audio waveforms to create the main-channel audio. It has a gain of −1 for each input, so each input contributes equally to the output of the op-amp. The output is the algebraic sum (L + R) of the left and right chan-

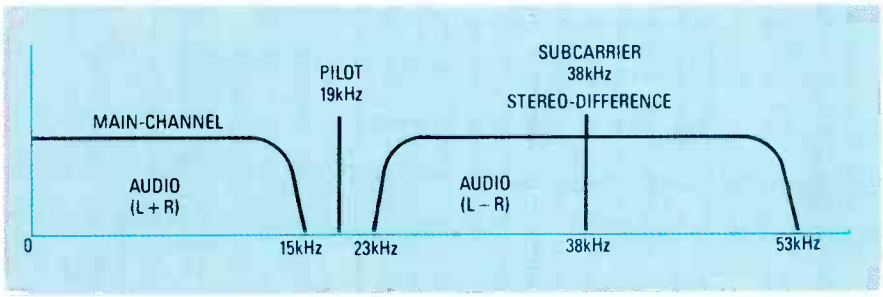


FIG. 1—THE FREQUENCY SPECTRUM of an FM-stereo signal, and the MPX transmitter must duplicate this signal in order for an FM receiver to pick it up.

nels. The other half of the LM1458 is set up to algebraically subtract the two inputs to create the stereo-difference channel. The right input is subtracted from the left input to form the L – R signal. Note that if the inputs are the same, the L – R output would be zero.

The difference (L – R) signal is fed to a balanced modulator, an MC1496 IC. That modulator produces sum and difference frequencies of the audio and subcarrier input. Both the audio input and the subcarrier input are suppressed by the IC—only the sum and difference frequencies appear at the output. A balance control is used to set the correct DC voltage on the IC to achieve maximum 38-kHz subcarrier suppression. (If a 1-kHz audio signal (L – R) and a 38-kHz subcarrier are mixed in that stage, a signal having only 37- and 39-kHz components appears at the (L – R) subcarrier output. If the audio signal is 10 kHz, we have 28- and 48-kHz components in the output.)

The 38-kHz signal is derived from a 76-kHz oscillator and a CD4027 dual flip-flop. One flip-flop divides the frequency by 2, producing a 38-kHz square wave; the other flip-flop divides the 38-kHz square wave by 2 to obtain a 19-kHz square wave. Both the 38- and the 19-kHz square waves are converted to sine waves by passing the signal through a tuned circuit.

The L + R signal, the L – R subcarrier signal, and the 19-kHz pilot signal are fed to a summing amplifier whose output is a composite multiplex (MPX) signal that is fed to a *V*oltage-*C*ontrolled *O*scillator (VCO) operating at the low end of the FM broadcast band. Controls are provided to adjust each component of the MPX signal to its correct level.

To ensure stability, the VCO is powered by a Zener-regulated power source and its output is fed to a buffer-amplifier that isolates the VCO from the antenna-output connector. The antenna should be about 12 inches long, and any piece of wire will do.

Circuit details

The schematic is shown in Fig. 3. The left- and right-audio inputs are connected to J1 and J2. Capacitors C1 and C2 couple audio to R2 and R4 (input resistors for the L + R channel) and R11 and R12 (input resistors for the L – R channel). Resistor R3, connected between R2 and R4, is used to set the ratio of gains for the L and R signals to exactly 1:1. Ideally, if R2 is equal to R4, then R3 is set at the midpoint. Resistor R6 sets the stage gain to about one (unity gain).

The L – R difference amplifier is IC1-b. Resistors R8, R10, and R11 form an adjustable network similar in function to R2, R3, and R4. Signals from the right channel are coupled by R12 and R13. A network made up of resistors R14, R15, and capacitor C3 is used to bias both op-amp sections at half the supply voltage. Since the gain of IC1-b, as seen from the non-invert-

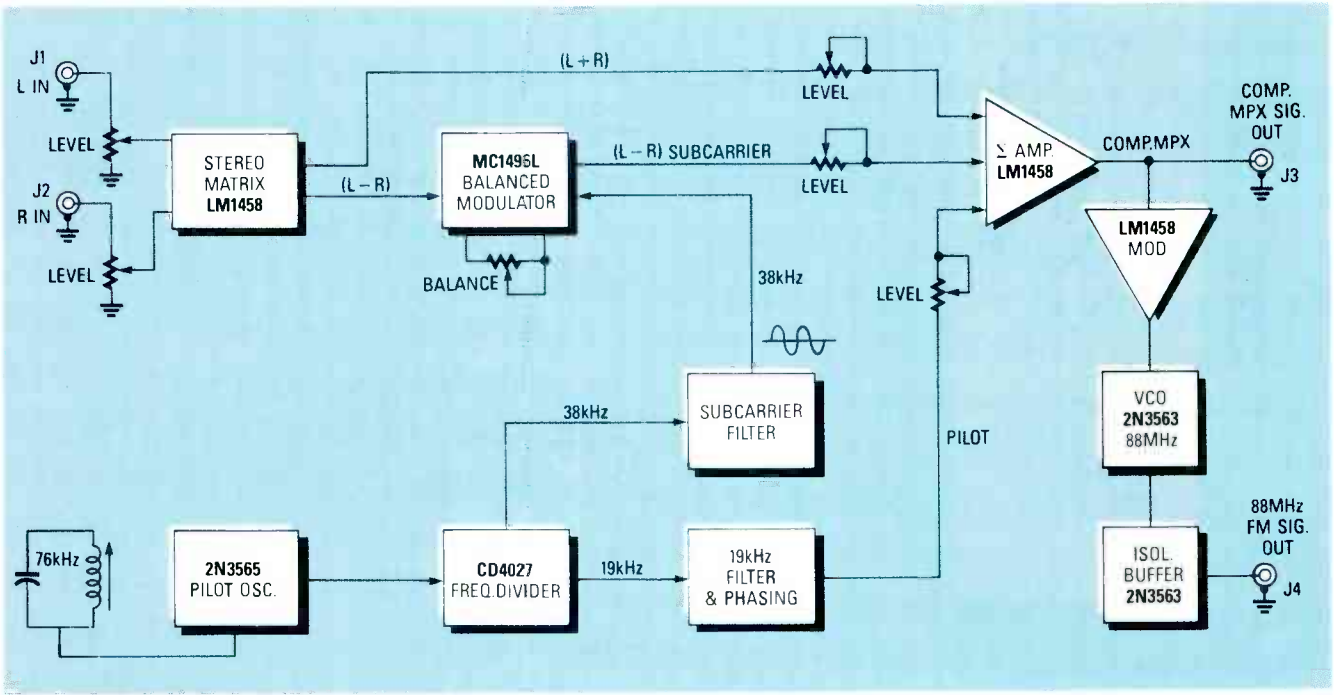


FIG. 2—THIS BLOCK DIAGRAM of the stereo FM transmitter will make it easier to understand how it actually works.

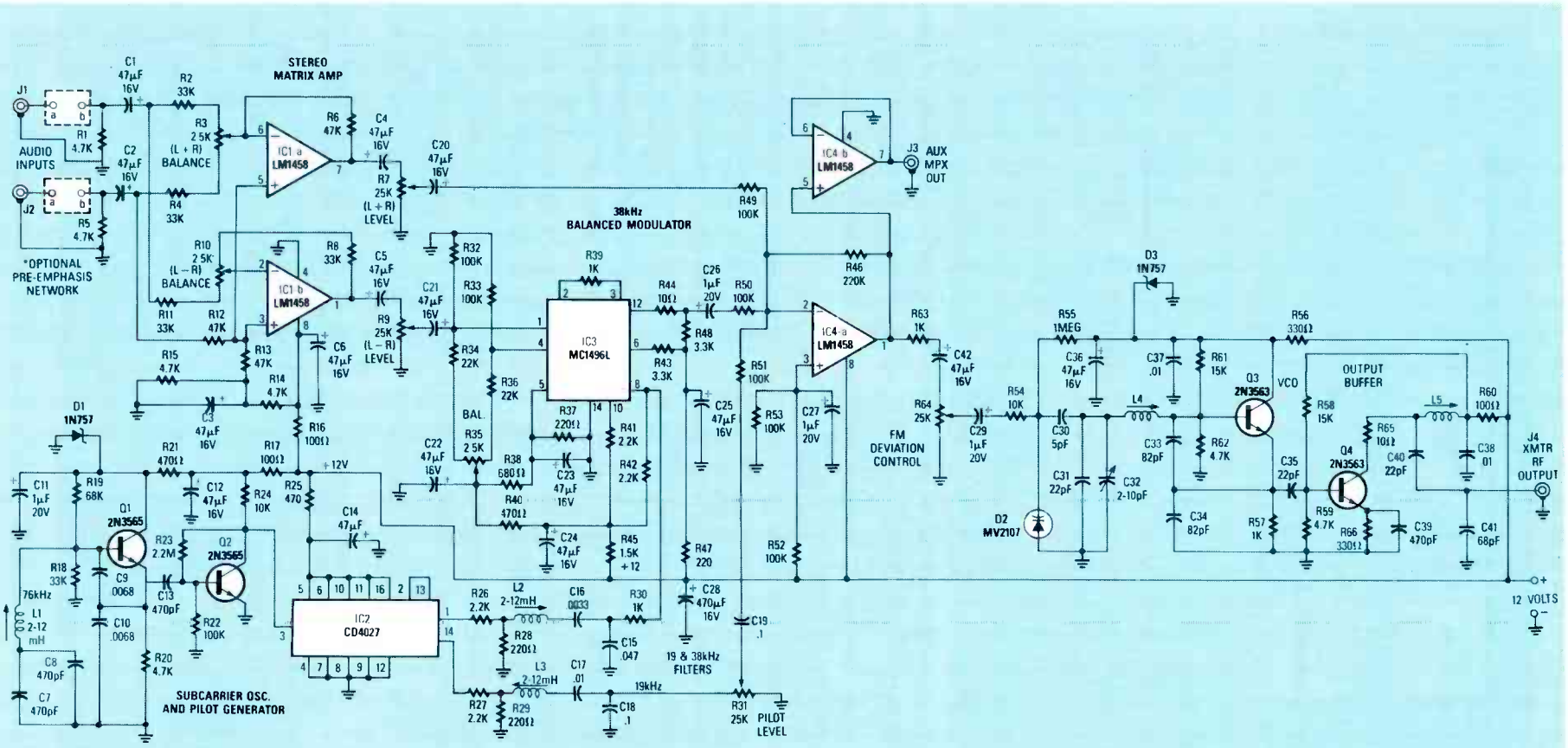


FIG. 3—THIS STEREO FM TRANSMITTER is capable of transmitting a stereo signal up to a hundred feet.

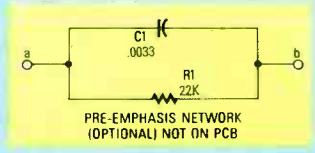


FIG. 4—THIS PRE-EMPHASIS NETWORK can be added to the audio inputs of the MPX transmitter, if necessary.

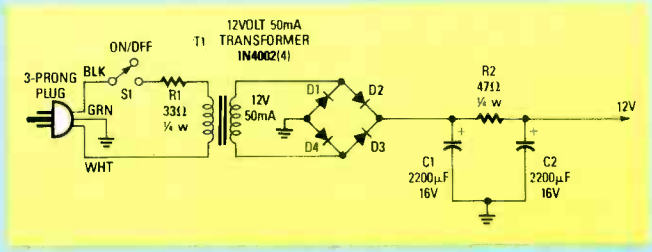


FIG. 5—THIS POWER SUPPLY can be used if you do not want to power the transmitter with batteries.

PARTS LIST— MPX TRANSMITTER

All resistors are ¼-watt, 10% unless otherwise noted
R1, R5, R14, R15, R20, R59—4,700 ohms
R2, R4, R8, R11, R18—33,000 ohms
R3, R7, R9, R10, R31, R35, R64—25,000 ohm potentiometer
R6, R12, R13—47,000 ohms
R16, R17, R60—100 ohms
R19—68,000 ohms
R21, R25, R40—470 ohms
R22, R32, R33, R49–R53—100,000 ohms
R23—2.2 Megohms
R24, R54—10,000 ohms
R26, R27, R41, R42—2,200 ohms
R28, R29, R37, R47—220 ohms
R30, R39, R57, R63—1,000 ohms
R34, R36—22,000 ohms
R38—680 ohms
R43, R48—3,300 ohms
R44, R65—10 ohms
R45—1,500 ohms
R46—220,000 ohms
R55—1 Megohm
R56, R66—330 ohms
R58, R62—15,000 ohms

Capacitors
C1–C6, C12, C14, C20–C25, C36, C42—47 µF, 16 volt radial-lead electrolytic (PC-mounting type)
C7, C8—470 pF (silver mica or NPO)
C9, C10—0.0068 µF, Mylar
C11, C26, C27, C29—1 µF, 20 volt radial-lead electrolytic
C13, C39—470 pF, ceramic 20%
C15—0.047 µF, Mylar 10%
C16—0.0033 µF, Mylar 10%
C17—0.01 µF, Mylar 10%
C18, C19—0.1 µF, Mylar 10%
C30—5 pF, silver mica or NPO
C28—470 µF, 16-volt radial lead electrolytic
C31, C35, C40—22 pF, silver mica or NPO
C32—2–10 pF trimmer capacitor
C33, C34—82 pF, silver mica or NPO
C37, C38—0.01-µF disc
C41—68 pF, silver mica or NPO

Semiconductors
IC1, IC4—LM1458N op-amp
IC2—CD4027 dual JK flip flop
IC3—LM1496N balanced modulator
D1, D3—1N757 9.1 volt Zener diode
D2—MV2107 varactor diode
Q1, Q2—2N3565 NPN transistor
Q3, Q4—2N3563 NPN transistor

Other components
L1–L3—2–12 mH variable inductor (No. Country Radio, P/N 212103)
L4, L5—5-½ turns #22 enameled wire on Cambion blue 8-32 × ¼ slug (see text)
J1–J4—RCA jack
Miscellaneous—1 on/off switch, 1 LED and a 1K resistor for an optional pilot light, 1 cabinet, hardware, shielded wire, power-supply components if needed, components for Fig. 8 if needed.

Note: The following items are available from North Country Radio, P.O. Box 53, Wykagyl Station, New Rochelle, NY 10804: PC board and all components that mount on it including all resistors, capacitors, semiconductors, L1–L3, cores and wire for L4 and L5 (LED and 1K resistor, power-supply components, cabinet, on/off switch, and phono jacks NOT included) $57.50 + $2.50 S/H. PC board only $14.00 + $2.50 S/H. NY residents must include sales tax.

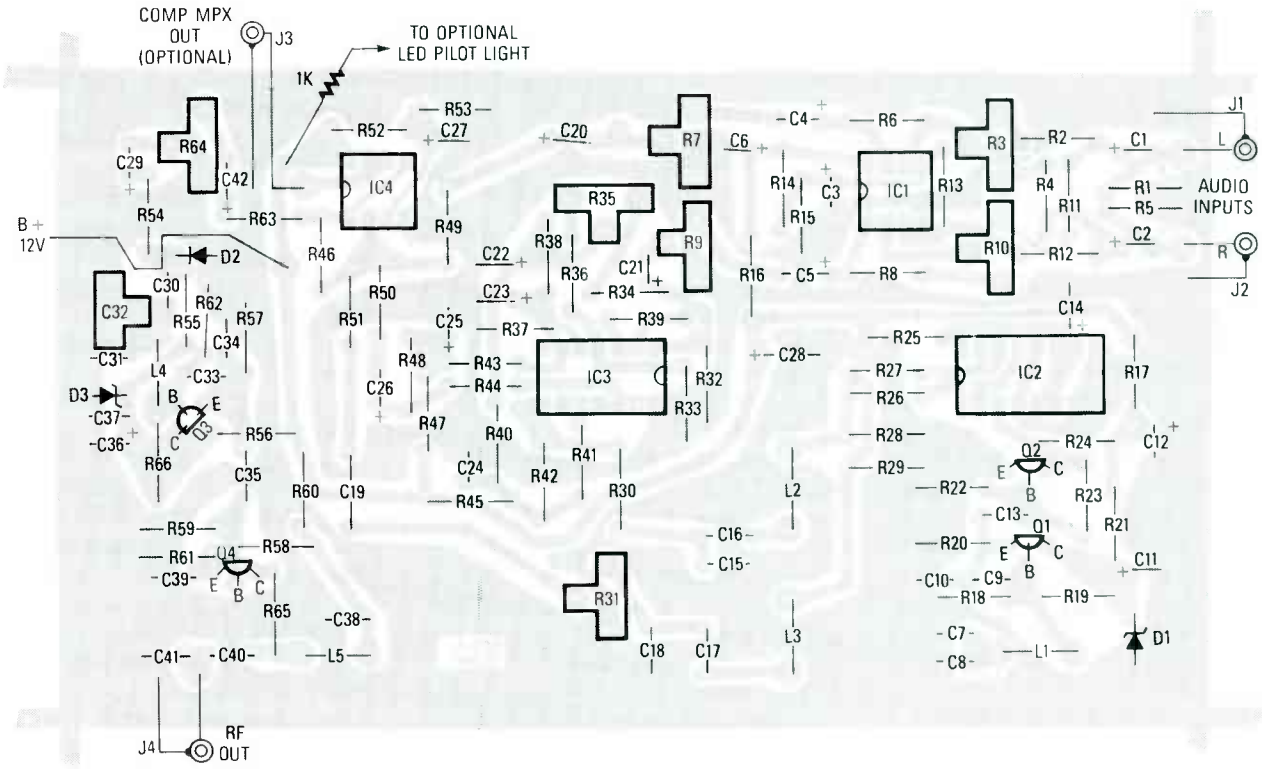


FIG. 6—FOLLOW THIS PARTS-PLACEMENT diagram when you are constructing the MPX transmitter.

ing input (pin 3), would be 2 if R11 is equal to R8 and R10 is at midpoint, R12 and R13 divide the input signal by 2. Resistor R10 is set so that when the left and right inputs are exactly equal (shorted together with a clip lead), the output from IC1-b (measured across R9) is exactly zero. That fulfills the necessary condition that

the L − R signal be equal to 0 when both inputs are identical.

As we discussed earlier, the transmitter must generate a pilot signal at 19 kHz and a 38-kHz subcarrier signal. Oscillator Q1's output is 76 kHz. The frequency-determining network is formed by capacitors C7–C10, and inductor L1, which is adjustable and used to set the oscillator frequency to exactly 76 kHz. The oscillator signal is coupled by C13 to buffer-amplifier Q2. Resistors R22–R24 bias Q2, while C12 and R17 provide filtering to remove 76-kHz components from the B+ line. The collector of Q2 provides a negative going pulse train to IC2, a dual JK flip-flop. That flip-flop divides the 76-kHz signal by 2 to get 38 kHz, and again by 2 to get 19 kHz. The 38-kHz and 19-kHz signals are square waves. Since we need sine waves, two filters (L2, C15, C16) and (L3, C17, C18) provide harmonic filtering to pass only the fundamental frequencies. Resistor R30 couples the 38-kHz sine wave (about 1 volt p-p) to modulator IC3. The pilot-level control, potentiometer R31, couples a variable-level 19-kHz signal via capacitor C19 to the output-summing circuit. Phase adjustment of the subcarrier and the pilot is achieved by adjusting L2 and L3, respectively.

The subcarrier (L − R) component of the MPX signal is produced by IC3, a balanced modulator. IC3 produces an output that is the sum and difference of the two input frequencies at pin 1 (L − R audio) and pin 8 (38 kHz), without feedthrough of either input to the output. Level-control R9 feeds (L − R) audio through C21 to pin 1 of IC3. Resistors R32–R36 are an adjustable DC-bias network, and C22 grounds the wiper of R35 for AC signals. Resistor R44 is an auxiliary level-set resistor that is nominally 10 ohms, however, it may be increased up to 2.2K if an excess level is present at IC3 pin 12. Note that R43 should be within 10% of the value of the sum of R44 and R48. (The level-setting adjustment was not needed in our prototype but it is handy to have available.)

Output circuit IC4 is a summing amplifier having a gain of 2. Components R52, C27, and R53 bias the op-amp at half the supply voltage. The L + R audio from the wiper of level-control R7 is coupled via C20 to R49. The L − R subcarrier is coupled via C26 to R50. The 19-kHz pilot signal

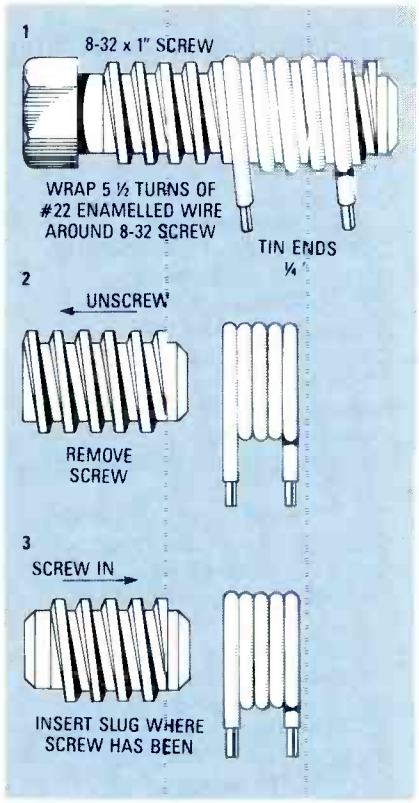


FIG. 7—COILS L4 AND L5 must be hand wound on an 8-32 screw.

from R31 is coupled to R51. Those three signals are summed and amplified, and appear at IC4-a pin 1. Voltage-follower IC4-b provides an AUX MPX OUT for test purposes and a composite MPX signal if needed for experimental purposes.

The MPX signal is coupled through C29 and R54 to varactor diode D2 (a voltage-variable capacitor). Transistor Q3 and its associated components make up an 88-MHz Colpitts-type oscillator. A composite MPX signal from R64 modulates the capacitance of D2, which in turn modulates the frequency of the oscillator. Level-control R64 sets D2 so that a ± 75-kHz peak deviation is obtained with about 0.5 volts p-p at the left and right inputs. Varactor D2 is coupled to the oscillator tank circuit through C30. As the capacitance of D2 varies, it modulates the frequency of oscillator Q3, which is set by C32 to an unused channel around 88 MHz.

Transistor Q4 is a low-gain buffer-amplifier whose primary purpose is to isolate the oscillator (Q3) from the effects of variable loading caused by the antenna. Resistor R65 suppresses a tendency toward unwanted UHF oscillation. A matching circuit for a 50-ohm output load or antenna is made up of L5, C40, and C41. The output level of that matching circuit is 100–120 millivolts rms into 50 ohms, or about ¼ milliwatt.

We did not need any audio pre-emphasis, because the received signal sounded good without it. For those who require pre-emphasis, the optional circuits in Fig. 4 can be added to the audio inputs.

About 50 milliamperes at 12 volts is required to power the transmitter. A schematic for a suitable power supply is shown in Fig. 5. It can be assembled using point-to-point wiring on a terminal strip, or by any other appropriate method. Otherwise, 8 AA penlight cells can be used as the power source.

Construction

A PC layout is provided in PC Service. A drilled and plated PC board is available from the source listed in the Parts List, and construction should begin with the mounting of all fixed resistors and diodes. See Fig. 6 for the component placement. Next, install all of the capacitors, being sure to observe the polarity of the electrolytics. Then install the potentiometers, transistors, and IC's. Finally, install coils L1, L2, and L3 (and be careful when handling the coils because they are wound with fine wire and are somewhat delicate).

You must hand-wind coils L4 and L5. As shown in Fig. 7, they consist of 5-½ turns of #22 enameled wire wound on an 8-32 screw thread. After you wind the wire, remove the screw and replace it with a Cambion *blue* slug. They are manufactured by Midland Ross, Cambion Division (One Alewife Pl., Cambridge MA 02140). Note that the wire and slugs for the two coils are included in the kit from the source mentioned in the Parts List. Otherwise, ferrite slugs salvaged from an old CB radio or TV set might work as cores. After being adjusted, the slug can then be held in place with a dab of Q-dope or hot-melt glue.

After all of the components are installed, carefully check your work for shorts, opens, and poor solder joints. Also, check for correct component orientations, since incorrect orientation may cause irreversible damage to the IC's and other circuitry.

That's all we have room for in this installment. Next time we will show you how to check out and align your wireless transmitter. **R-E**

USING BARGRAPH DISPLAYS

LED Bar-graph displays are now being used to replace moving-coil meters. This month we take a look at how they can be used.

RAY MARSTON

BAR-GRAPH DISPLAYS ARE INEXPENSIVE and often superior alternatives to analog moving-coil meters. They are immune to inertia and sticking problems, so they are fast-acting, and unaffected by vibration or position. Their scales can easily be given any desired shape, such as a vertical or horizontal line, an arc, or a circle. In a given display, individual LED colors can be mixed to emphasize particular sections of the display. Over-range detectors can be activated from the driver IC's to sound an alarm and/or flash the entire display.

Bar-graph displays have better linearity than conventional moving-coil meters, with typical linear accuracies of 0.5%. Scale definition depends on the number of LED's used, although a 10-LED display provides adequate resolution for just about any practical purpose.

LM3914 Dot/bar-driver IC's

The LM3914 family of dot/bar-graph driver IC's are manufactured by National Semiconductors. Each type is capable of directly driving up to 10 LED's, or several IC's can be cascaded to drive as many as 100 LED's in either the dot or bar mode. The family comprises three devices: the linear scaled LM3914, the log-scaled LM3915, and the semi-log LM3916.

All three device types use the same basic internal circuitry. Fig. 1 shows the internal circuit of the linear-scaled LM3914, together with its connections for operating as a 10-LED voltmeter, having a 0–1.2-volt scale. The IC contains ten voltage comparators, each with its non-inverting terminal connected to a specific tap on a precision voltage divider. All inverting terminals are wired in parallel and driven by a unity-gain buffer. The buffer's input (pin 5), is protected against overload voltages to ± 35 volts. The output of each comparator can sink up to 30 mA. The sink currents are internally limited; the limit can be externally pre-set by resistor (R1).

The IC also contains a floating 1.2-volt reference source connected between pins 7 and 8. In Fig. 1, the voltage reference is shown externally connected via pins 6,7,8, and 4 to the internal voltage divider. The IC also contains a dot/bar se-

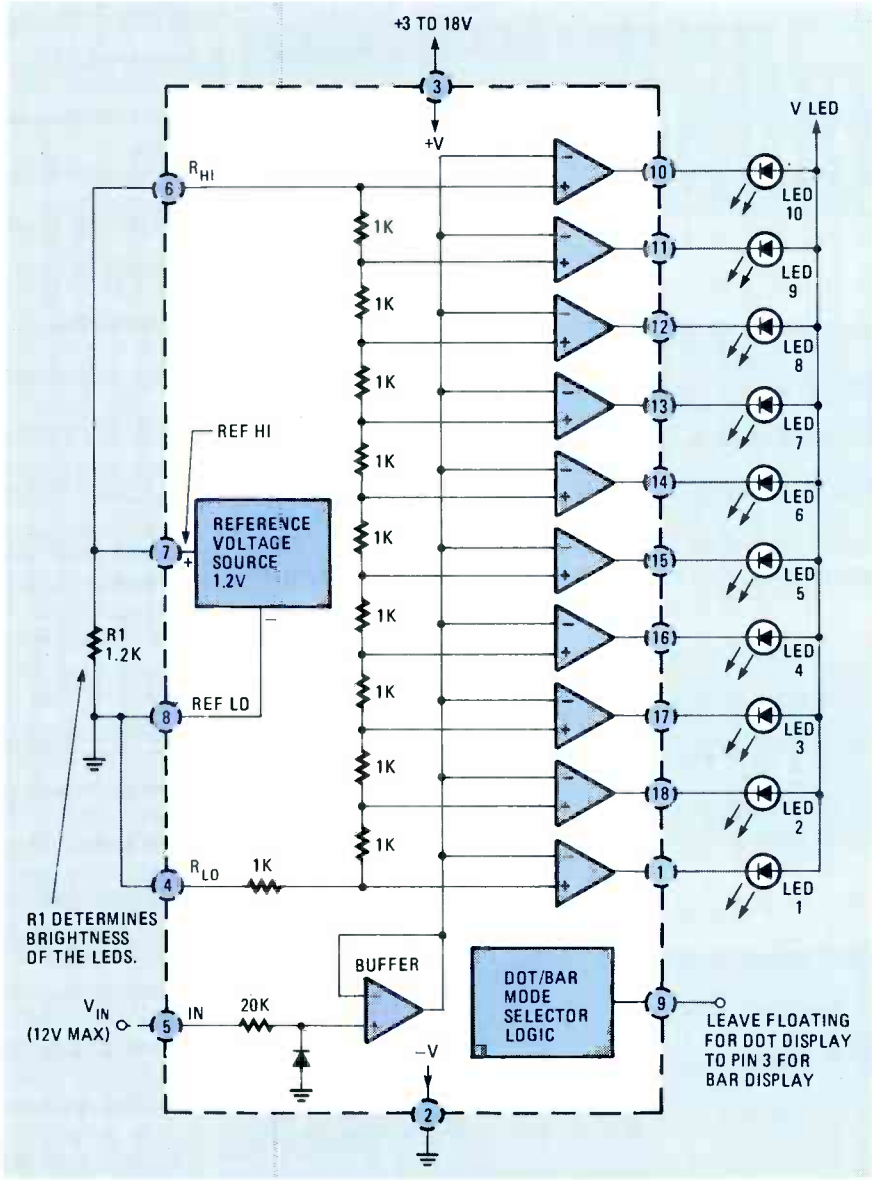


FIG. 1—INTERNAL CIRCUITRY OF THE LM3914, with connections for making a 10-LED 0–1.2-volt linear meter having a dot or bar display.

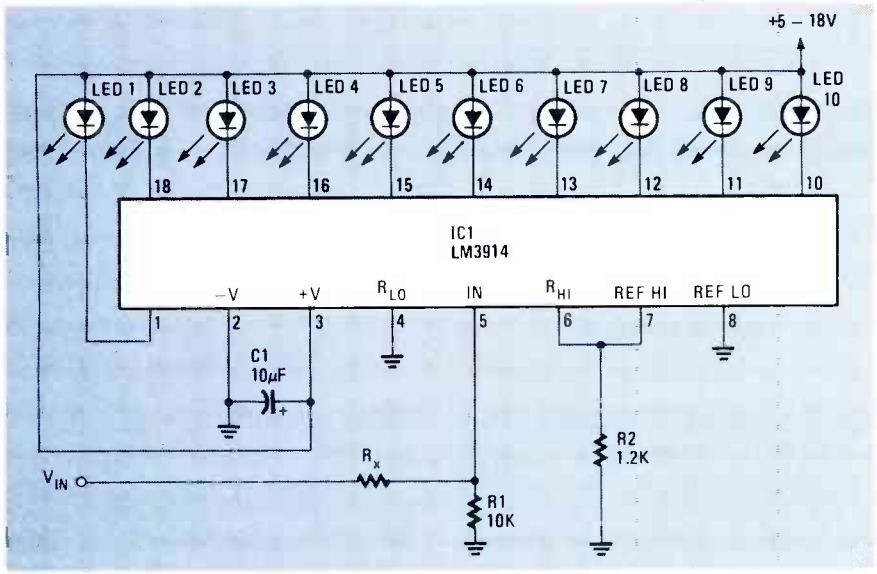


FIG. 2—THE FULL-SCALE DISPLAY CAN BE ADJUSTED from 1.2–to 1000 volt.

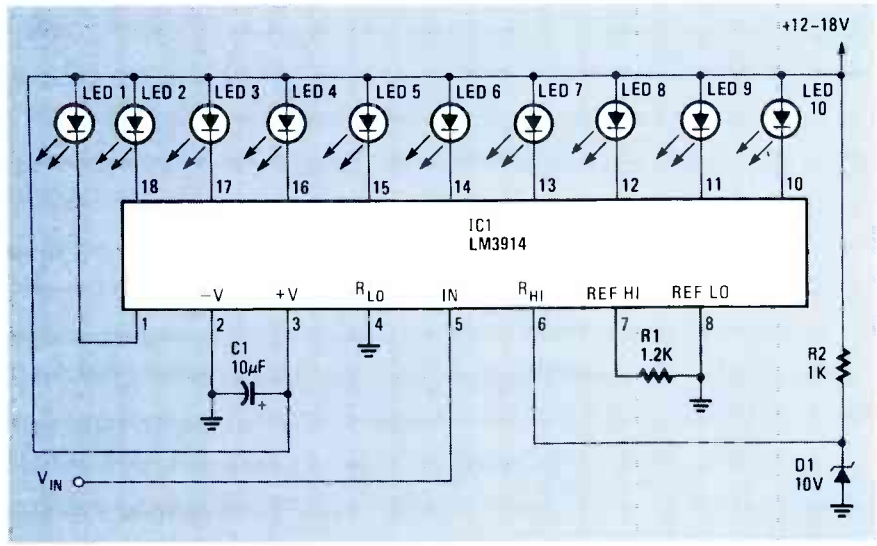


FIG. 3—AN EXTERNAL REFERENCE VOLTAGE CAN BE USED to make a 10 volt full-scale-display meter.

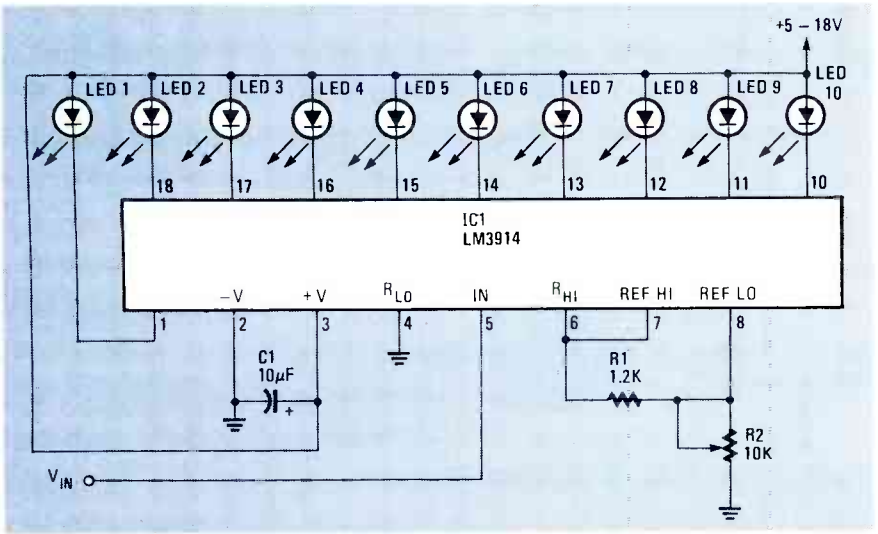


FIG. 4—A VARIABLE-RANGE DOT-MODE VOLTMETER can be made by using a 10K potentiometer to set the full-scale display.

lector (pin 9) network so that the dot or bar mode can be set externally.

How it works

Assume that the device is set for bar-mode operation and that, as already shown, the 1.2-volt reference is applied across the internal resistive voltage divider. Thus, 0.12 volt is applied to the inverting or reference input of the first comparator, 0.24 volt to the next, 0.36 volt to the next, and so on. If a slowly rising input voltage is applied to pin 5, the following sequence of actions then take place:

- When the input voltage is zero, the outputs of all ten comparators are disabled and all LED's are off.
- When the input voltage reaches the 0.12-volt reference value of the first comparator, its output conducts and turns on LED 1.
- When the input reaches the 0.24-volt reference value of the second comparator, its output also conducts and turns on LED 2; LED's 1 and 2 are both on.
- As the input voltage is further increased, progressively more and more LED's are turned on, until eventually the last comparator conducts and all ten LED's (the full-scale display) are illuminated.

A similar kind of operation takes place when the LM3914 logic is set for dot-mode operation, except that only one LED turns on at any given time. At zero volts, no LED's are on, and above 1.2 volts only LED 10 is on.

Some finer details

In Fig. 1, R1, which is connected between pins 7 and 8 (the output of the 1.2-volt reference), determines the amount of current that will flow through the LED's. The current through each LED is roughly ten times the output current of the 1.2-volt source, which can supply up to 3 mA; that allows LED currents of up to 30 mA to be set by R1. If, for example, a total resistance of 1.2K, (equal to the parallel value of R1 and the 10K of the IC's internal voltage divider) is placed across pins 7 and 8, the 1.2-volt source will therefore conduct 1 mA and each LED will conduct 10 mA, when illuminated.

The IC's internal 10-stage voltage divider is floating, meaning that both ends are available externally for maximum versatility. It can be powered from either the internal reference voltage, or from an external source. If, for

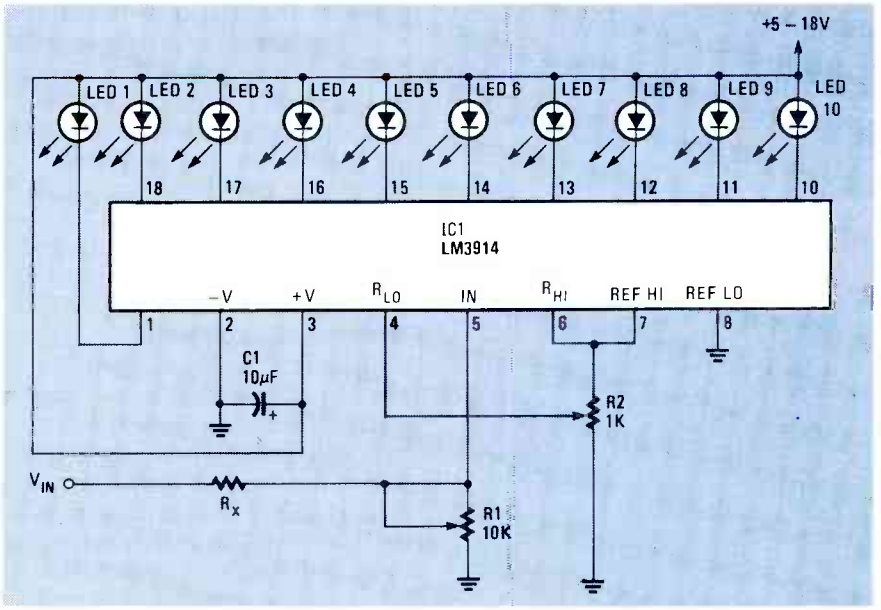


FIG. 5—THIS EXPANDED-SCALE DOT-MODE voltmeter will only display inputs between 10–15 volts.

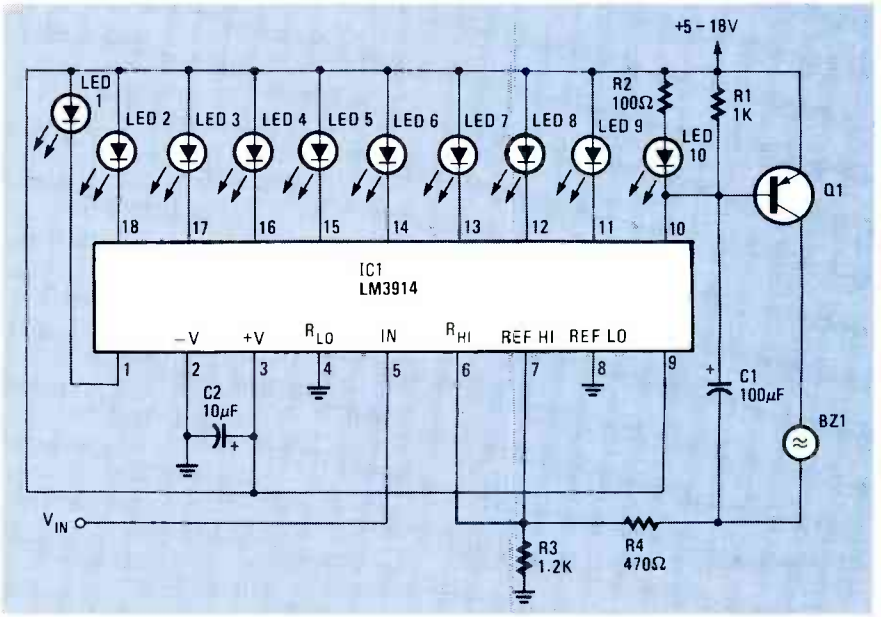


FIG. 6—AN OVER-RANGE ALARM CAN BE ADDED to sound a buzzer and flash the entire display when the full scale display is illuminated.

example, the top of the network is connected to a 10-volt source and the low end is connected to ground, the IC will function as a voltmeter, having a 0–10-volt scale. However, if the low end of the network is connected to a 5-volt source, the IC will function as a restricted-range voltmeter, having a 5–10-volt scale. The only constraint on using the internal divider is that its supply voltage must not exceed a voltage that is 2 volts less than the IC's supply voltage (which is limited to 25-volts maximum).

The IC's internal reference voltage produces a nominal output of 1.28 volts (its limits are 1.2 to 1.34 volts), but as we'll show later, it can be externally programmed to produce effective reference values up to 12 volts. Also, by wiring pin 9 to pin 3, the IC will operate in the bar mode. (If pin 9 is left floating, it will operate in the dot mode.)

The major difference between the three members of the LM3914 family of IC's is in the resistance values used for the internal 10-stage voltage divider. In the LM3914, all resistors in the divider have equal values, so the device has a linear display of ten equal steps, which makes the LM3914 well-suited for most applications. In the LM3915, the resistors are logarithmically weighted, which results in a log display that spans 30 dB in ten steps of 3 dB, making it suitable for signals having a wide dynamic range. In the LM3916, the resistors are weighted in a semi-log fashion which produces a display that is specifically suited to VU-meter applications.

Practical applications

Let's move on now and take a look at some practical applications, paying particular attention to the linear LM3914.

Figures 2 through 5 show various ways of using the LM3914 IC to make 10-LED dot-mode voltmeters. Note that pin 9 in all of the circuits is left floating to provide dot-mode operation, and a 10μF capacitor is wired directly between pins 2 and 3 to ensure circuit stability.

Figure 2 shows the connections for making a variable-range (1.2- to 1000-volt full-scale) voltmeter. The low ends of the internal reference (pin 8) and the divider (pin 4) are grounded, and their top ends (pins 7 and 6) are joined together, so the meter has a basic full-scale sensitivity of 1.2 volts. However, variable ranging is provided by the Rx-R1 voltage divider at the input (V_{in}). For example, when Rx is zero, the full-scale display is 1.2 volts, but when Rx is 90K the full-scale display is 12 volts. Resistor R2 is wired across the internal reference voltage, and sets the *on* current of all LED's to about 10 mA.

Figure 3 shows how to make a fixed-range 0- to 10-volt meter. An external 10-volt Zener, D1, connected to the top of the internal divider provides the reference voltage. The supply voltage to that circuit must be at least two volts greater than the Zener diode's reference voltage.

Figure 4 shows how the internal reference of the IC can be made to effectively provide a variable voltage, thereby allowing the meter's full-scale-display value to be set anywhere in the range of 1.2–10 volts. The 1-mA current (determined by R1) of the floating 1.2-volt internal reference flows to ground via R2, and the resulting R2 voltage raises the reference voltage (pins 7 and 8) above zero. If, for example, R2 is set to 2.4K, pin 8 will be at 2.4 volts, while pin 7 is 3.6 volts. R2 thus enables the voltage at pin 7, which is connected to the top of

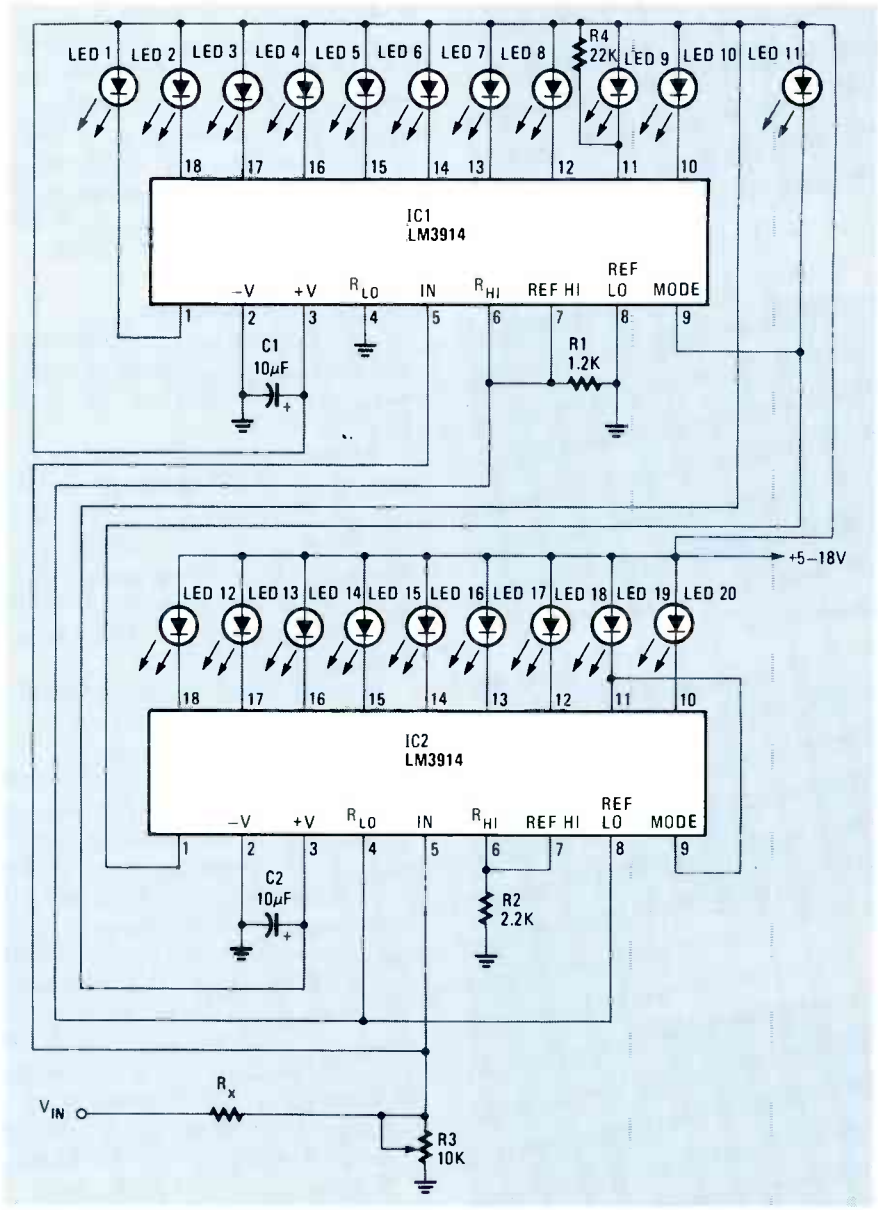


FIG. 7—A DOT-MODE 20-LED VOLTMETER has special connections so that LED 10 shuts off when LED 11 turns on.

the internal divider, to be varied from 1.2 volts to approximately 10 volts, so the full-scale-display value of the meter is determined by those values.

The circuit of Fig. 5 shows the connections for making an expanded-scale meter that, for example, reads voltages in the range 10–15 volts. Potentiometer R2 sets the LED current at about 12 mA, and also enables a reference value in the range from 0 to 1 volt to be set on the low end of the internal divider. Thus, if R2 is set to apply 0.8 volt to pin 4, the basic meter will read voltages only in the range of 0.8–1.2 volts. By adding the voltage divider Rx-R1 to the input of the circuit, that range can be amplified to between 10 and 15 volts, or whatever range is desired. Note that the dot-mode circuits of Figs. 2 to 5 can be programmed to operate in the bar mode by simply connecting pin 9 to pin 3. If the IC should become warm from power dissipation when operating in bar mode, try adding a 7.5-ohm resistor in series with the LED supply voltage.

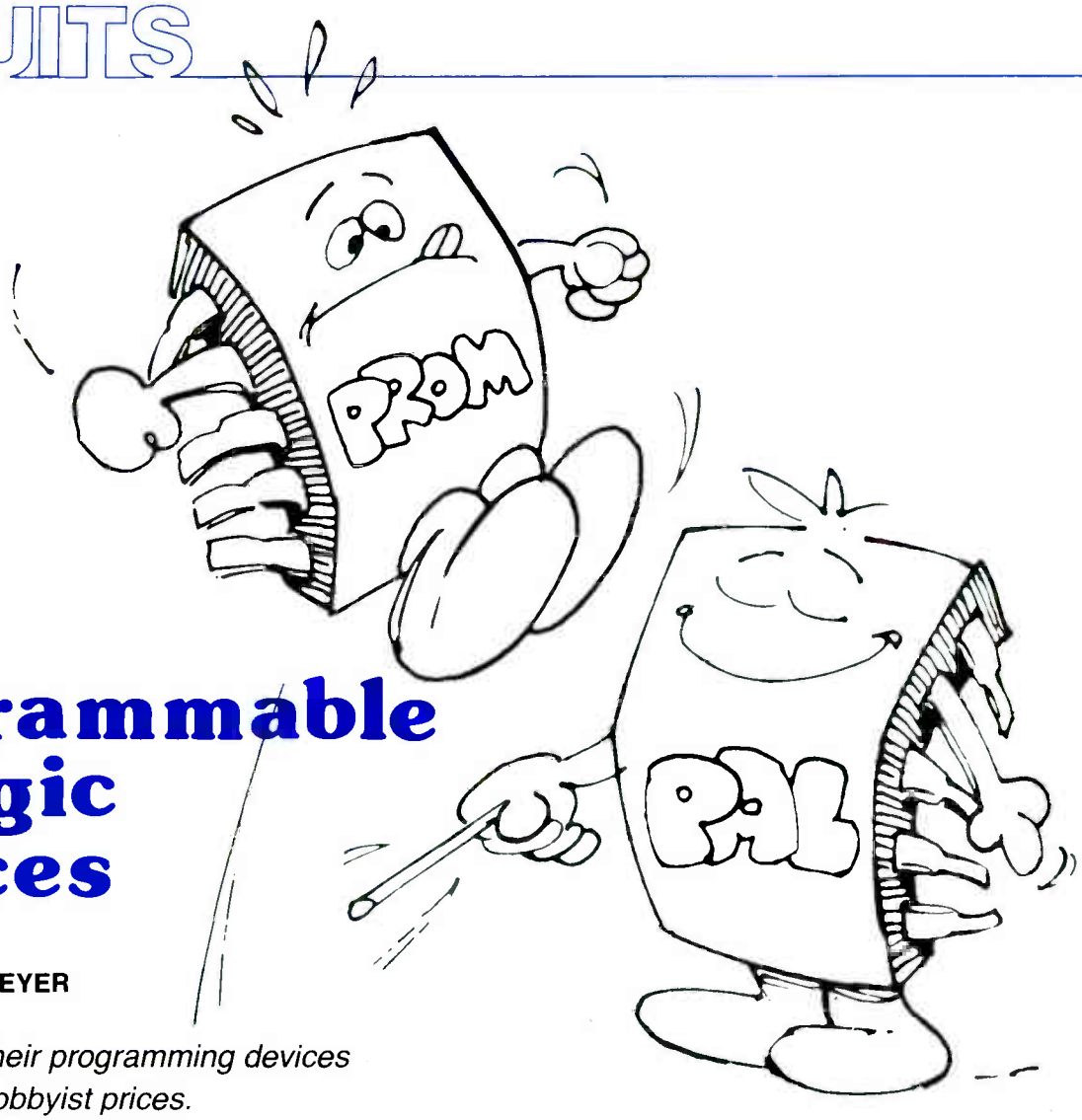
Figure 6 shows how the basic LM3914 circuit can be fitted with an over-range alarm that powers a buzzer and flashes the entire display when the full-scale display is illuminated. If the comparator's output for LED 10 goes low, Q1 is turned on, which sounds the buzzer BZ1. At the same time, C1 starts to discharge and momentarily brings pin 7 low. That sets the comparator's outputs to approximately V+. Therefore, the voltage across the LED's is not enough to keep them on, so the display briefly shuts off. C1 then begins to charge up again, due to the high at pin 10, so Q1 and the buzzer shut off. The voltage at pin 7, and subsequently the LED's, are then restored, and if the full-scale display is still present, the cycle repeats.

Twenty-step voltmeter

The circuit in Fig. 7 shows how a pair of LM3914's can be cascaded to create a 20-step, 0–2.4-volt dot-mode voltmeter. Although the input terminals of the two IC's are connected in parallel, IC1 is configured to indicate 0–1.2 while IC2 is configured to indicate 1.2–2.4 volts. For that reason, the bottom of the voltage divider, and the low side of IC2's 1.2-volt reference are coupled to the top of the voltage divider and the high side of IC1's 1.2-volt reference. The low side of the 1.2 volt reference, and the bottom of IC1's voltage divider are grounded, and the top end of IC2's voltage divider is connected to the high side of it's 1.2-volt reference. Since the reference voltage of IC2 has been raised 1.2 volts above that of IC1, IC2's R3 must be raised to 2.2K. Because the circuit is set up for dot mode, we want IC1's LED 10 to shut off when IC2's LED 11 turns on. In order to do that, R4 is added in parallel with LED 9, and pin 9 of IC1 is connected to pin 1 of IC2. Also, IC2's pin 9 must be connected to pin 11. Those connections, in combination with the internal circuitry, will cause LED 10 to shut off when IC2 becomes active. If it is desired to cascade more than two IC's in the dot mode, all IC's must have R4 added in parallel with LED 9, and pin 9 connected to pin 1 of the next IC, with the exception of the last IC, whose pin 9 must be connected to pin 11.

The circuit in Fig. 7 can be wired for bar-mode operation. The connections would be similar except that pin 9 must be connected to pin 3 of each IC, and the resistor (R4) that had been connected across IC1's LED 9 must be eliminated.

Although the practical circuits have been devoted to the LM3914 IC, the log-type LM3915 and semi-log LM3916 can be directly substituted in most of the circuits. Depending on the transducer you use, a bar-graph display can represent any quantity, such as light, heat, or vibration. **R-E**



Programmable Logic Devices

ERNEST MEYER

Both PLD's and their programming devices are available at hobbyist prices.

Part 2 LAST TIME OUT WE looked at the early history of programmable logic because it gave us an understanding of how easily programmable IC's can be used. And to make practice conform to theory, we even designed and blew an actual PLD (*P*rogrammable *L*ogic *D*evice) just to demonstrate how it might be done by a hobbyist.

As we continue our journey through programmable-logic history, we will go a little way beyond the technology actually available to most hobbyists. However, because the field is developing so rapidly it won't be long before even the most sophisticated devices find their way into common digital projects.

Of course, while being able to program a PLD will naturally make it easier for you to use more sophisticated devices as they appear in the marketplace. Even now the PLD's available to hobbyists can replace more than a half-dozen conventional parts. Indeed, PLD's are already so complex they warrant the use of software for device design and verification, which is a fancy way of saying "creating a fusemap."

As with everything else, there is both a hard and easy way to do things. In this article we'll program PLD's the easy way by using inexpensive software that will run on any standard IBM-PC or compatible.

Software to design hardware

A considerable number of programs are presently available that will help you design a programmable IC. We looked at the earliest program, Monolithic Memories' PALASM, in the previous part of this series.

The idea of PALASM was to make programmable-logic design more accessible to digital designers working in small design houses. Previously, the large programmable-logic distributors (such as Harris and Signetics) had sought to sell only to "captive" markets—large companies like IBM and AT&T. In that way, one service-support engineer could be assigned to each large customer, thereby providing efficient service at a low cost to the distributor. (Harris and Signetics reasoned that providing adequate support for many smaller companies would be too expensive.)

With PALASM, however, even the smallest design house could easily use programmable logic, so reckoning that it would boost the company's sales of programmable IC's, Monolithic Memories made the software available free of charge to qualified businesses.

The strategy worked, and Monolithic Memories rapidly became the largest programmable-logic distributor in the world at that time. The other players in the market were quick to follow suit. For example, Sig-

netics, the company that had pioneered the commercialization of PLD's, realized it was losing market share to the newcomer, and released its own design software toolkit, called AMAZE. Signetics also provided its software free of charge to digital-design houses.

However, as we discussed in Part 1, the FPLD architecture from Signetics has both a programmable AND plane and a programmable OR plane, whereas Monolithic Memories' PAL architecture has only a programmable AND plane. As a consequence, PALASM cannot program FPLD's, and AMAZE cannot program PAL's. (Which is why MMI and Signetics gave away rather than sold their software—anyone using the software had to use the corresponding IC's.)

It is therefore hardly surprising that some independent software companies seized on the opportunity to provide a software tool for both device types. Assisted Technologies developed the first universal PLD design tool, CUPL, which is now sold by PCAD (1290 Parkmore Ave., San Jose, CA). Indeed, many of the design examples you get with CUPL still have the name Assisted Technologies on them.

The software ABEL, developed by Data I/O (10525 Willows Rd. NE, Redmond, WA 98073), does much the same thing as CUPL, but is much easier to use, although it is a great deal more expensive (around $1,000) than hobbyist-versions of CUPL.

Getting started

A starter kit version of CUPL is available for $50 from JDR Microdevices (110 Knowles Drive, Los Gatos, CA 95030). In addition to the software, the kit contains one each of four ready-to-program PAL's: the 16L8, 16R8, 16R6, and the 16R4; their characteristics are shown in Table 1. Keep in mind that the starter-kit CUPL can only program those four devices. The supplied PAL's are actually manufactured by Texas Instruments, but they are functionally identical to the same parts from Monolithic Memories.

How the software works

All the software tools for programmable logic design have a similar structure, whose basic design flow is shown in Fig. 1. As you can see, there are a number of different ways where-

TABLE 1

FUNCTION	16L8	16R4	16R6	16R8
DEDICATED INPUTS	10	8	8	8
DEDICATED REGISTERED OUTPUTS (TRI-STABLE)	—	4	6	8
BI-DIRECTIONAL COMBINATIONAL OUTPUTS (TRI-STATABLE)	8	4	2	—

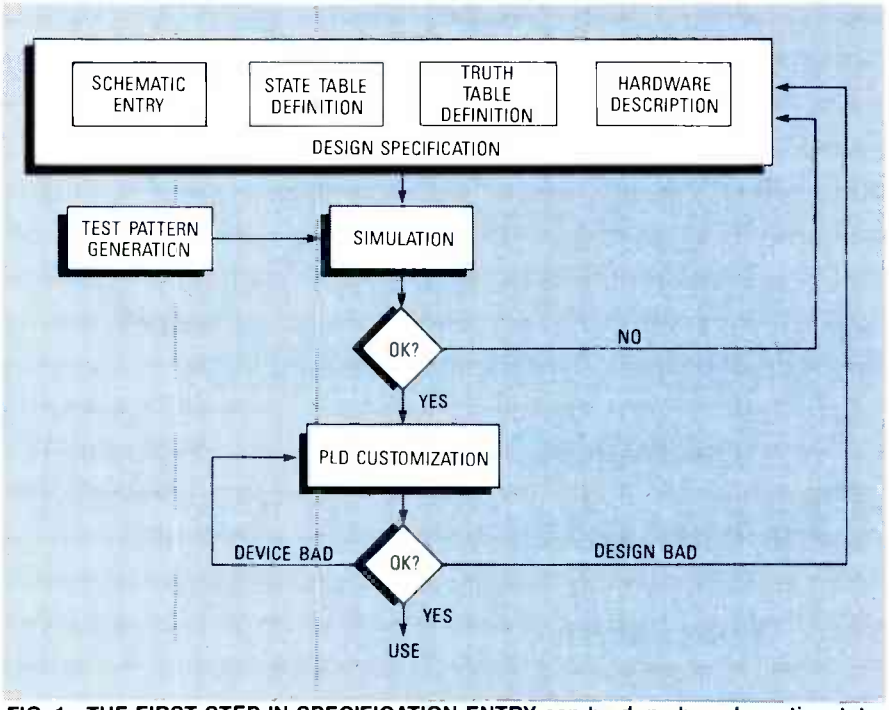


FIG. 1—THE FIRST STEP IN SPECIFICATION ENTRY can be done by schematic, state-table definition, truth-table definition, or a description of the hardware itself.

by the first step—the design specification entry—can be done: by schematic, state-table definition, truth-table definition, or a description of the hardware itself. In the commercial world, engineers like to use a schematic-entry system, whereby the logic-circuit schematic is entered in the computer and the software is then able to derive the fuse map from the schematic.

The most commonly used drafting software used to generate fuse maps is the DASH drafting software from Data I/O's subsidiary, FutureNet. Both ABEL and AMAZE accept data from DASH, while CUPL accepts schematics designed on PCAD's design system, PCAD-CAE1. Since DASH and CAE1 cost $25,000 and $7,500 respectively, they are beyond the budget of most hobbyists.

Although PALASM, AMAZE, CUPL, and ABEL do not accept schematics by themselves, hobbyists can use the design-entry systems actually built into the software and enter a high-level description of the logic in a text-form input file.

CUPL

CUPL is the highest language, hence, it's the easiest for the hobbyist to use. Using an ordinary word processor, such as WordStar or XyWrite, you can create a logic-description file. CUPL then performs both automatic logic minimization of the file and compiles a documentation file having the extension .PLD. For example, if we described a logic description of a two-bit counter in CUPL format and told CUPL to give it the name DIVIDER, CUPL would create a disk file DIVIDER.PLD.

There are separate fields in the input file: *header information* (included at the top of all the files created by CUPL, so you can make sense of your old printouts), *notes*, *pin labels*, and *logic description*. In CUPL, you don't include the part number in the

```
CUPL            2.11c  Serial# 2-99999-001
Device          p16r8  Library DLIB-f-23-10
Created         Tue Jan 01 00:37:57 1980
Name            Divider
Partno          EM0001
Revision        02
Date            8/30/87
Designer        E. Meyer
Company         VLSI
Assembly        Breadboard
Location        U2
*QP20
*QF2048
*QV13
*G0
*F0
*L0512 01111111111111111111111111111111
*L0544 11111111101111111111111111111111
*L0768 01111111111111111111111111111111
*L0800 11111111101110111111111111111111
*L0832 11111111111011101111111111111111
*C131A
*P 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
*V0001 C1XXXXXXXN0XXXXLLXXN
*V0002 C1XXXXXXXN0XXXXLLXXN
*V0003 C1XXXXXXXN0XXXXLLXXN
*V0004 C1XXXXXXXN0XXXXLLXXN
*V0005 PXXXXXXXXN0XXXX11XXN
*V0006 C0XXXXXXXN0XXXXLLXXN
*V0007 C0XXXXXXXN0XXXXLHXXN
*V0008 C0XXXXXXXN0XXXXHLXXN
*V0009 C0XXXXXXXN0XXXXHHXXN
*V0010 C0XXXXXXXN0XXXXLLXXN
*V0011 C0XXXXXXXN0XXXXLHXXN
*V0012 C0XXXXXXXN0XXXXHLXXN
*V0013 C0XXXXXXXN0XXXXHHXXN
*E797
```

FIG. 2—THIS IS THE FUSE MAP compiled by a CUPL for a 16R8 PLD.

logic-description file, although it helps to write your intended part number in a notes field so that you can remember the target device for which the pin assignments were specified. Note that the pins must be labeled before the logic equations; otherwise, CUPL cannot tell what pins the logic should be attached to.

CUPL then uses DIVIDER.PLD to create additional files: DIVIDER.DOC (a documentation file), DIVIDER.LST (a file showing all the line numbers given to the lines in A:DIVIDER.PLD—so if there's an error message reported for a particular line, you can find it), DIVIDER.ABS (a binary code file), and DIVIDER.JED (the fusemap file).

One of CUPL's advantages is that it creates an error file. If you make an error in the file used to blow the fuses, CUPL reports the error and its location. If there's an error in your .PLD file (which is likely on your first attempt), CUPL reports the error and its line number in an .LST file, whose information is used to correct the original .PLD file.

Although CUPL programming might appear to be time-consuming, it won't take very long after you've done it a couple of times. Figure 2 shows the fusemap for a 16R8 that was compiled by a CUPL .PLD file with the filename DIVIDER.

We can, if we choose, edit the fusemap directly. In fact, we can create the fusemap directly with the fusemap editor, and not bother with the logic description at all. However, if we do that we cannot then simulate the design.

A logic simulator is a program that processes two input files to create one output file. The first input file contains a logic-description. The second input is a *test pattern* file; a set of logical ones and zeros that you want to put into the circuit. The simulator puts the ones and zeros into the software model and outputs the pattern of ones and zeros that the logic simulator thinks the device will make.

PLD programmers

Simple PLD programmers are available from a number of sources, among them JDR, whose PLD programmer sells for about $300. Most modern PLD programmers are run by a control board that uses one adapter slot in an IBM-compatible computer. An umbilical cord connects the control board to an external box containing a ZIF (Zero *I*nsertion *F*orce) socket into which PLD's are inserted.

Every PLD type has its own unique internal fuse arrangement. Most PLD's use different pins for programming. The JEDEC fusemap produced by CUPL (the .JED file), includes a section that tells the programmer which pins are where. To program a PLD, one pin is raised to a high-voltage (typically 12 to 25 volts), which puts the IC in the programming mode. The high voltage enables the MODE pin to double as a normal signal pin when the device is not being programmed. The high voltage level also ensures that power-supply glitches will not set the PLD into the programming mode during normal operation, which would be disastrous.

Each fuse to be blown can then be addressed by another set of pins that act as fuse-address lines for the device in the programming mode. The addressed fuse is blown when a final pin is toggled high.

Since two pins are needed for power and ground, one further pin is needed for setting the programming mode, and yet another pin is needed to trigger the fuse-blowing operation; only 16 pins are left for addressing fuses on a 20-pin PLD, meaning there are 2^{16} fuses. Devices with a larger number of fuses can use a multiplexed address bus to define all the possible fuse locations. However, the only parts that most hobbyists will use that are multiplex-addressed are PROM's.

However, a designer doesn't need to worry about exactly how a PLD programmer works. A software *shell* supplied with the programmer on floppy disk disguises the operation of the actual hardware from the user. The designer specifies the type, manufacturer, and JEDEC file to use during programming: the programmer blows the PLD and checks that the blow is performed as expected by the user.

Unusual architectures

Although most PLD's have 20 or 24 pins, some larger PLD's have as many as 64 pins. Currently, the largest PLD device with a standard architecture contains about 2,000 equivalent

gates, making the IC big enough to contain an entire 32-bit floating-point accelerator. (Available from Intel, 1900 Prarie City Rd., Fulsom, CA, and Altera Corp. 3515 Monroe, Santa Clara, CA), Unfortunately, the sheer size of that IC really places it beyond the capabilities of standard ABEL and CUPL software. Stand-alone design systems priced at around $5000, which both include schematic entry, have been developed by Intel and Altera Corp. for that massive chip.

Even more

An even larger IC, the X3090, from Xilinx (2069 Hamilton Ave., San Jose, CA 95125), which uses multiplexers instead of fuses, contains about 9,000 equivalent gates, and the device can be configured "on the fly" with standard logic levels. Just to confuse things, people still refer to the internal connections—the multiplexers—as fuses. Design systems for the *X3090* are presently priced in excess of $20,000, although prices are destined to drop.

The Xilinx *X3090* is just one part with the new architectures that are just emerging in PLD technology. Another IC with unusual architecture is the 39V18 from Lattice Semiconductor (5555 Northeast Moore Ct., Hillsboro, OR 97124). The 39V18 is unique in that it was specially designed to emulate all the standard PLD architectures. Fuses in all the macros enable them to be configured like any of the macros in a range of PLD's; thus, one Lattice part can be a direct-pin replacement for a large number of PLD's in existing designs.

Beating the equivalent gate

We have previously alluded to *equivalent gates*. In essence, the density of customizable components is measured by the number of 2-input NAND gates that would be required to perform the same function for the largest circuit that can be configured in a programmable IC. However, that measurement can be very misleading. The logic in the macros, and their interconnection, really determines the power of a PLD.

For example, a 16R8, which contains eight flip-flops, is perfect for a complex function requiring eight counting stages. A 16L8, which contains about 50 less gates, also contains eight macros, but it does not contain any flip-flops in the macros: Two macros are needed to make a flip-flop. Therefore, at most, the 16L8 can contain a 4-bit counter—half the size of the 16R8.

But, then you must wonder, why is the equivalent gate count of the 16L8 so high? Well, the large *fan-in* into each of the macros—there are eight separate summing inputs into each macro—enables the building of very large sums-of-product terms. Functions that need gates with a large number of inputs therefore fit particularly well into a PLD. Bus decoding and state machines both fall into that category.

A 16L8 can provide eight bus-decoding functions at the same time. If a circuit has an 8-bit bus that turns on eight peripherals at eight separate and distinct addresses, then all eight addresses can be decoded by one IC. That accounts for the high equivalent-gate count. An equivalent SSI implementation could require as many as 14 quad 2-input NAND-gate devices.

In view of the particular suitability of PLD architectures to bus decoding, some manufacturers have enhanced the power of the programmable-plane structure by combining standard logic functions into the programmable IC's. Harris Corp. (Semiconductor Section, PO Box 883, Melbourne, FL 32901), the company that pioneered programmable logic, was the first to take that architectural path. Harris' *82C339* combines a multiplexed bus interface with a summing plane that acts as a programmable comparator. As a consequence, the device can produce four decoded outputs from a 16-bit bus multiplexed onto eight signal lines, as implemented by the 8088 (the microprocessor in the IBM-PC). Intel has made a special PLD called the BIC (*B*us *I*nterface *C*ontroller), which contains eight bidirectional latches, with the control-logic lines for the latches fed by a conventional programmable AND plane.

Registered PLD's are good for state machines. The output of state-machine devices depend on the previous input as well as the current input. Since a 16R8 contains eight flip-flops, the device can record eight states, with one flip-flop putting out a high logic level for each *on* state. Each flip-flop's output can be fed back into the array and logically combined with the other flip-flop states and the current inputs to switch the device into the next state.

Monolithic Memories, Altera, and Signetics have all made *programmable sequencers* containing a large number of extra "buried" flip-flops to contain "buried states" (states that do not cause any change at the outputs). .MDNM/

Altera and Monolithic Memories have taken the alternative approach of combining a programmable AND plane and a PROM into one device, in which PROM outputs can be fed back into the PLD portion. The PLD can combine that data and the inputs to produce a new address in the PROM to go to. Up to 256 states are supported by those IC's. Unfortunately, CUPL is not capable of programming those state machines as yet, although ABEL can program some of them. With time, of course, all of those devices will come within the reach of the hobbyist.

Process technology

We have already tracked the development of new PLD architectures, from the very first programmable device to the most recent innovations. To make things easier to follow, in the course of our discussion we sidestepped the advances in process technology (how the devices are manufactured), although they have also been very important in PLD development.

Originally, PLD's were all made using TTL (*T*ransistor-*T*ransistor-*L*ogic). Modern variations of TTL are very fast, but all types of TTL devices use a great deal of power. MOS technology, which uses electric fields rather than current to switch the gates, uses much less power and packs higher densities of transistors into ever smaller areas of silicon. Most modern devices are CMOS. As a matter of fact, except for the programmable sequencer from Signetics, all the advanced architectures we have discussed in this article use CMOS technology.

In the first part of this article we discussed the difference between single- and dual-level metal. Typically, densities higher than 2,000 gates, and I/O delays of less than 45 nanoseconds (speeds higher than 15 MHz) are not possible with single-level metal. In some situations, I/O delay is very important.

Different fuses

We also discussed different fuse technologies. As you might re-

member, nichrome and polysilicon fuses were the first types to be used. Nichrome fuses are still in use. Currently, tungsten, and sometimes titanium, are added to the fuse material because they burn out more cleanly. Also, the electric field across the vacated space left by a vaporized fuse can cause *metal migration*. In other words, over time the metal ions are magnetically dragged back into the fuse cavity; that is, the fuses can actually grow back. Thankfully, *grow back* is relatively rare with modern technology and standard operating conditions.

With some modern PLD's, the reverse of metal growback—called *avalanche-induced migration*—is actually used to remove the fuse. Also, lower temperatures can be used with avalanche-induced migration, which increases device reliability. Further, the fuses in some modern PLD's are fashioned in a *bow-tie* shape rather than the traditional *hourglass*. The sudden narrow taper at the point of fuse burnout in bow-tie fuses reduces the rate of metal migration.

Besides traditional fuse technologies, several newer processes are now used for manufacturing PLD's, which allow the device to be reprogrammed.

Those erasable PLD's (usually called EPLD's) use the same technology as EPROM's in that they don't use fuses at all, but rather contain *floating gates*. Those are small semiconducting regions between the two

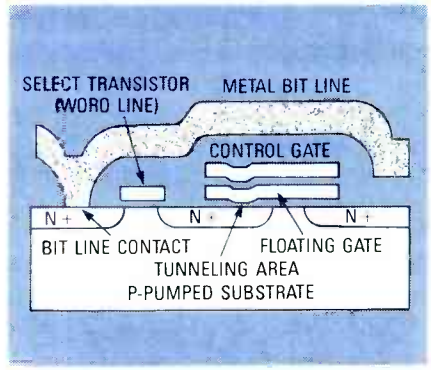


FIG. 3—THE STRUCTURE OF a floating gate. A charge on the floating gate creates a small electrical field that acts as a conducting link between the two metal levels.

metal levels. The electrical characteristics of the floating gate are very carefully selected so that its polarity is not affected by normal +5-volt conditions. But the floating gate can be charged up in the high-voltage programming mode. The charge creates a small electrical field that acts as a conducting link between the two metal levels. On the other hand, uncharged gates do not act as a connection. Figure 3 shows the structure of a floating gate.

EPLD's are usually programmed at a higher voltage level than standard PLD's (which reduces the rate the charge can leak off a charged gate), placing them beyond the reach of most inexpensive PLD programmers.

EPLD's, like EPROM's, contain small *windows* that allow them to be wiped clean by exposure to ultraviolet light. Thus EPLD's can be reprogrammed by the circuit designer.

In the most recent PLD technology developments, EPLD's have largely been replaced by EEPLD's, which are like EEPROM's. Since "E-squared" devices, as they are called, use electricity rather than ultraviolet light for the cleaning procedure, they don't need windows, thus making the package less expensive, even though the silicon is more difficult to make. Lattice Semiconductor uses E-squared for the *39V18*.

EPLD and EEPLD technologies allow the factory to check that the devices are fully functional before shipping by programming and checking a pattern. If there's an error, the PLD can be wiped clean and reprogrammed. Also, designers can reuse the same device for different circuits when prototyping. Similarly, hobbyists can use the same device over and over, in different projects.

Conclusion

PLD's are becoming commonplace in a diverse variety of applications. In computers, PLD's are particularly suitable for use in the state machines that control such system-level operations as start-up sequences, interrupt handling, control transfer, I/O arbitration, and peripheral-processor control. In the consumer world, programmable logic has found its way into video/audio control systems, washing machines, toys, automobile dashboards, and even traffic lights and elevators. Programmable logic is also common in military and aerospace applications, as well as in hospital equipment, nautical navigation systems, and telecommunications.

Quite possibly, in the near future a single PLD might provide all the circuits for any kind of device because PLD implementation avoids the process of "gluing" circuits using custom IC fabrication. By using a PLD instead of a custom IC, virtually any logic circuit can be almost instantly refabricated by simply creating a new fuse map and using it to blow a new device.

Figure 4 shows some of the materials that can be used by the average hobbyist and technician to design and create custom PLD circuits. **Radio-Electronics** will soon feature an article on how you can use that equipment to design and blow useful experimenter PLD circuits. **R-E**

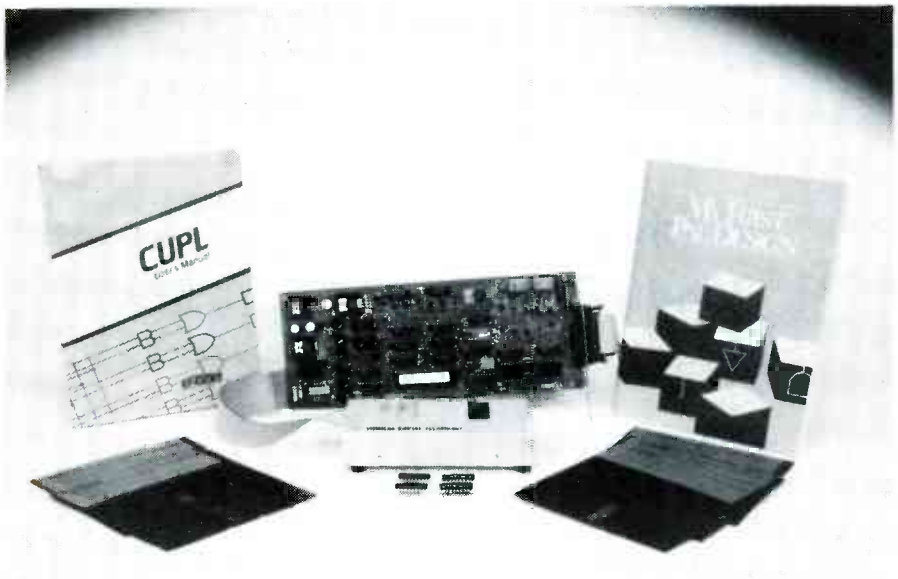


FIG. 4—A PLD PROGRAMMER CARD and an inexpensive PAL introduction kit containing four different PLD's and a simplified version of CUPL are all you need to get started in PLD design. Both are available at JDR Microdevices.

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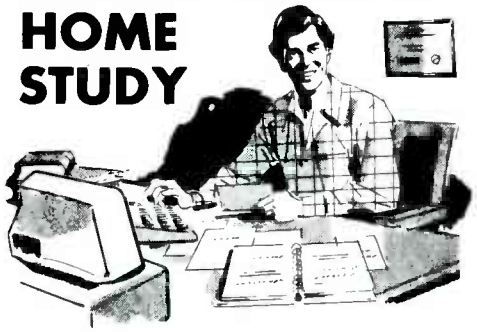

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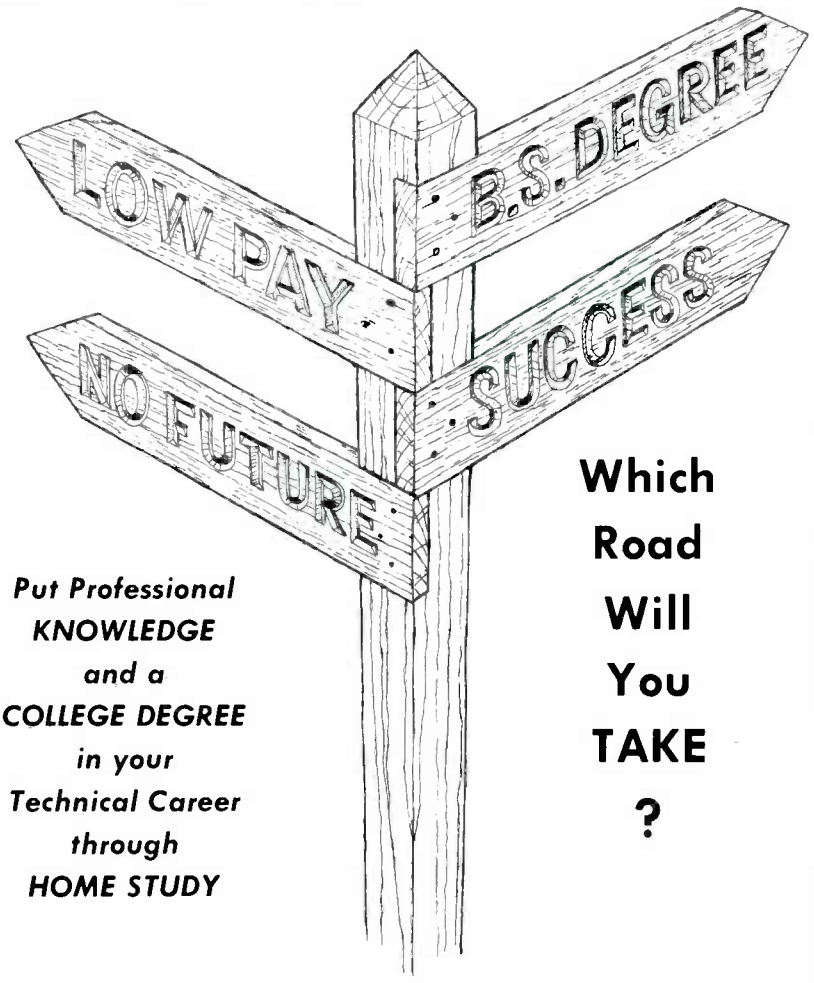

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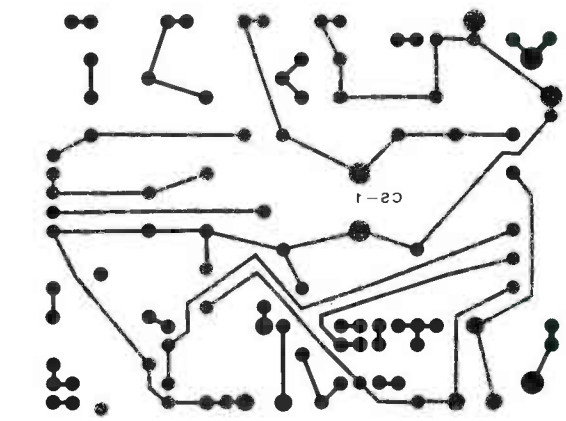
One of the most difficult tasks in building any construction project featured in **Radio-Electronics** is making the PC board using just the foil pattern provided with the article. Well, we're doing something about it.

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!

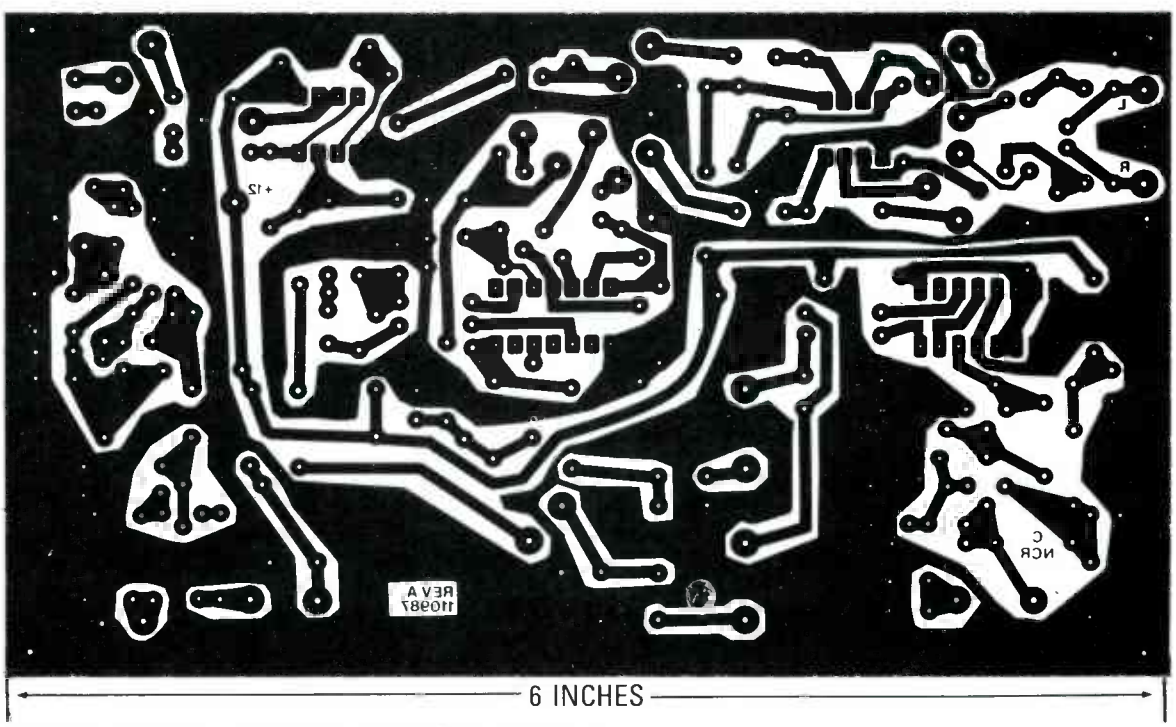
Note: The patterns provided can be used directly only for *direct positive photoresist methods.*

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 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



PLASMA DISPLAY power-supply PC board.



BUILD THE FM WIRELESS LINK using this PC board.

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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 used to.

We can't tell you exactly how long an exposure time you will need as it depends on many factors 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.

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:

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MORE PC BOARDS ON PAGE 83

HARDWARE HACKER

Using Posistors
More on superconductors
Monitors for the Apple IIgs
New video integrated circuits
IBM to Apple communications

DON LANCASTER

Tips, products, and publications

LET'S START OFF WITH SOME UPDATES on things we've covered previously, and an opportunity for creative hackers. I have found two more places to get information on those new superconductor developments we looked at last month. Check into the Materials Research Society. Those folks have videotapes and superconductor-conference proceedings available, some priced as low as $15.

While this next item is certainly not hacker priced at $750 per year, see if you can't con someone else into subscribing to the brand new Superconductors Update Package from Chemical Abstracts. That is probably the ultimate source for current superconductor info.

You'll find a story on page 177 of the October issue of *EDN* that gives you more uses and ideas for the digital EEPOT's we looked at two columns ago.

If you have any electronic high-tech design that can in any way involve home furnishings, textiles, or clothing, there are prototype grants worth up to $10,000 now available through the Innovative Design Fund. Contact them directly for rules and whatever.

We'll repeat our usual reminder that this is your column and you can get technical help from me at Synergetics; see the Need Help box elsewhere in this article. The big goodie this month involves reasonably priced hacker video IC's. But first...

What is a Posistor?

A Posistor is one trade name for a non-linear resistor whose resistance changes with temperature in a very unusual way. As Fig. 1 shows us, the resistance at first decreases gradually with increasing temperature, up to a certain point known as the critical temperature. Above that point, the resistance will instead dramatically increase with temperature.

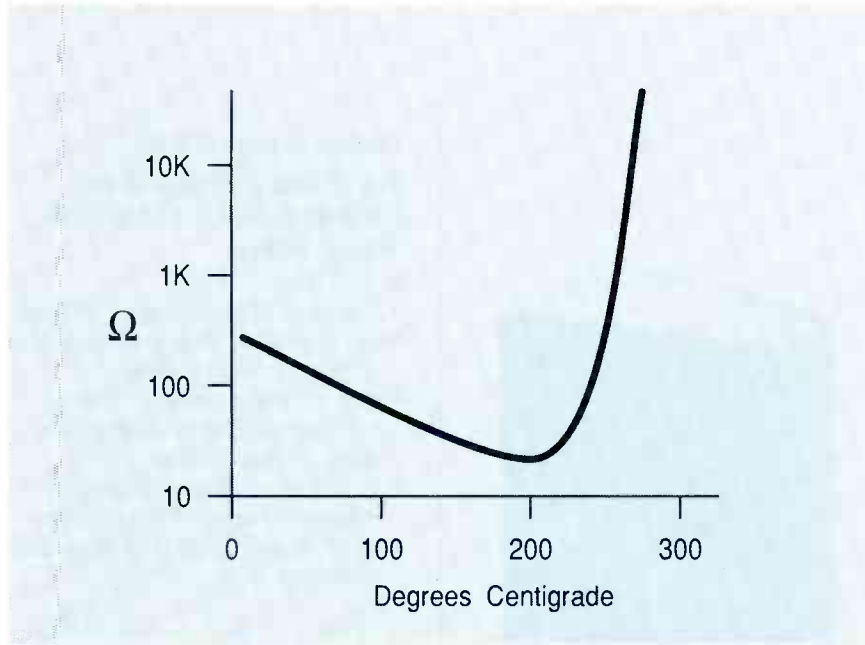

FIG. 1—RESISTANCE VERSUS TEMPERATURE curve for a typical Posistor. Above the critical temperature, the resistance sharply increases and the current dramatically drops.

Those devices are available in a wide variety of sizes with various critical temperatures. Posistors are usually made from barium titinate that has been doped with strontium to adjust the critical temperature. Like most resistors, they are bipolar devices that conduct equally well in either direction.

Another name for a Posistor is a PTC Switching Thermistor. Two of the primary sources of those products include Murata-Erie and Midwest Components. To get started with them, check out Murata-Erie's new short form catalog 61-05 or else Midwest's Thermistors, Thermal Switches, and Varistors catalog.

Despite their very low cost, their simple circuitry, and their mind-blowing uses, Posistors do not seem to have aroused much hacker interest to date. Yet, they are ideal components that are quite easy to experiment with.

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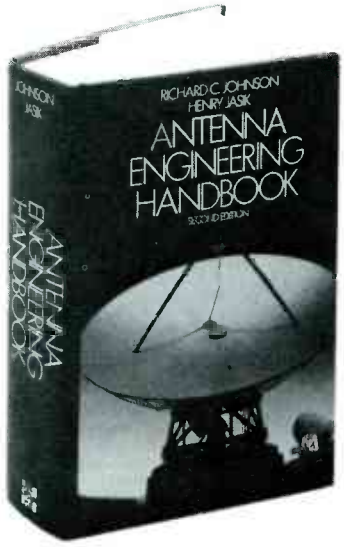

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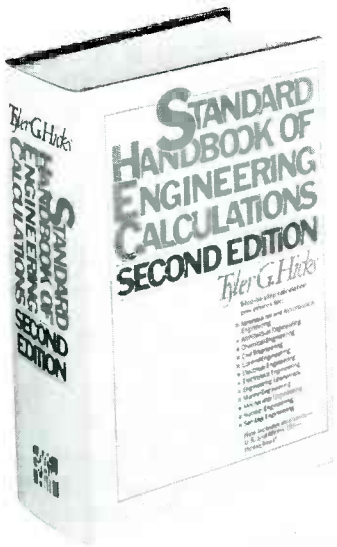

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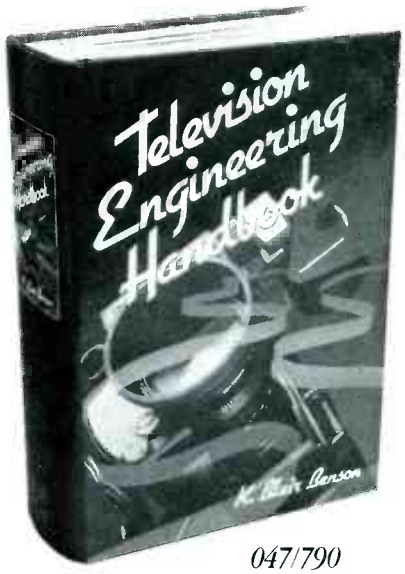

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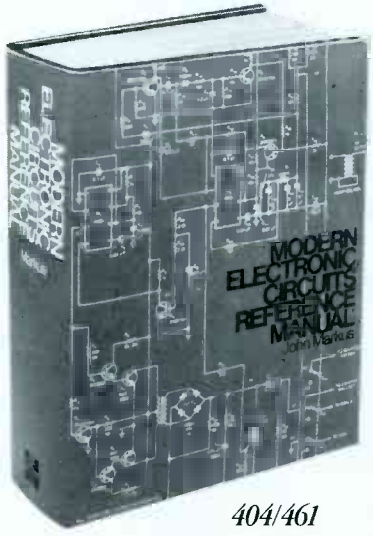

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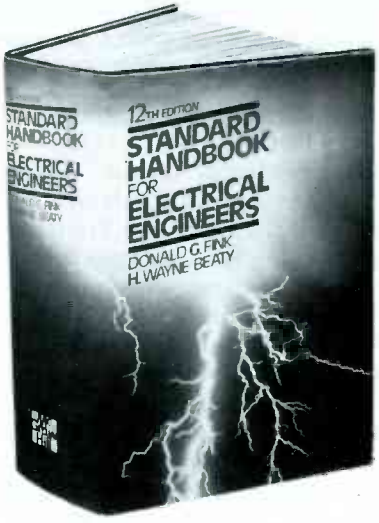

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So what good are Posistors?

There are several basic ways of using a Posistor. If you apply a fixed voltage, your Posistor will rapidly heat up to its transition temperature and will stay at that temperature. Thus, you have an all solid-state single-piece temperature regulator.

Unlike a thermostat, there is no mechanical hysteresis or any dead band present, and the switching can be exactly repeated.

And, unlike the thermistors and thermocouples, the very non-linear resistance change forms a sudden and well defined switching point. On the other hand, that critical temperature is a fixed property of the Posistor, so you cannot adjust it like you could a more traditional controller.

If you instead apply an input current, you end up with a time delay circuit, for the Posistor will slowly heat up towards its critical temperature and then effectively switch itself off. The time delay depends on both the current and the amount of heatsinking.

If you place a load in series with the Posistor, you can create an overload-protector circuit. When the load attempts to draw too much current or if the Posistor overheats, the Posistor goes into a high-resistance state, thus protecting the load from damage.

If the Posistor is not powerful enough, you can amplify its output suitably with a relay or a Triac. Companion heaters can also be used to control larger loads.

Let's quickly look at some real world uses: A flat-panel heater may be combined with a Posistor so as to automatically heat liquid-crystal displays whenever your ambient temperature gets down too low. A Posistor can be used as an air-flow detector by arranging things so moving air cools the Posistor well below its critical temperature, while a lack of enough air flow will cause the device to exceed the critical temperature.

A Posistor in series with the starting winding of a motor will power the starting winding for only several seconds until the Posistor overheats and limits the current to a low value. Therefore, the device can replace the bulky and unreliable centrifugal switches used in many induction motors.

Alternately, a different Posistor in series with the main motor winding will protect that winding from mechanical or input overload. If the current gets too high, the Posistor overheats, and then limits the current. Resetting is automatic and takes place a few seconds after the overload stops.

Various other safety circuits are possible. Those include using a Posistor to sense the temperature of a battery being charged, to protect hi-fi speaker systems, to prevent thermal runaway in an electronic circuit, to sense the liquid level in a tank, or as a freeze alarm in solar panels.

Some TV sets use degaussing coils, needed to prevent any stray magnetic fields from trashing the color convergence. A Posistor in series with a degaussing coil will let the coil run for only a few seconds only when the power is first applied.

I am now looking into using a Posistor as a heater for a cheap

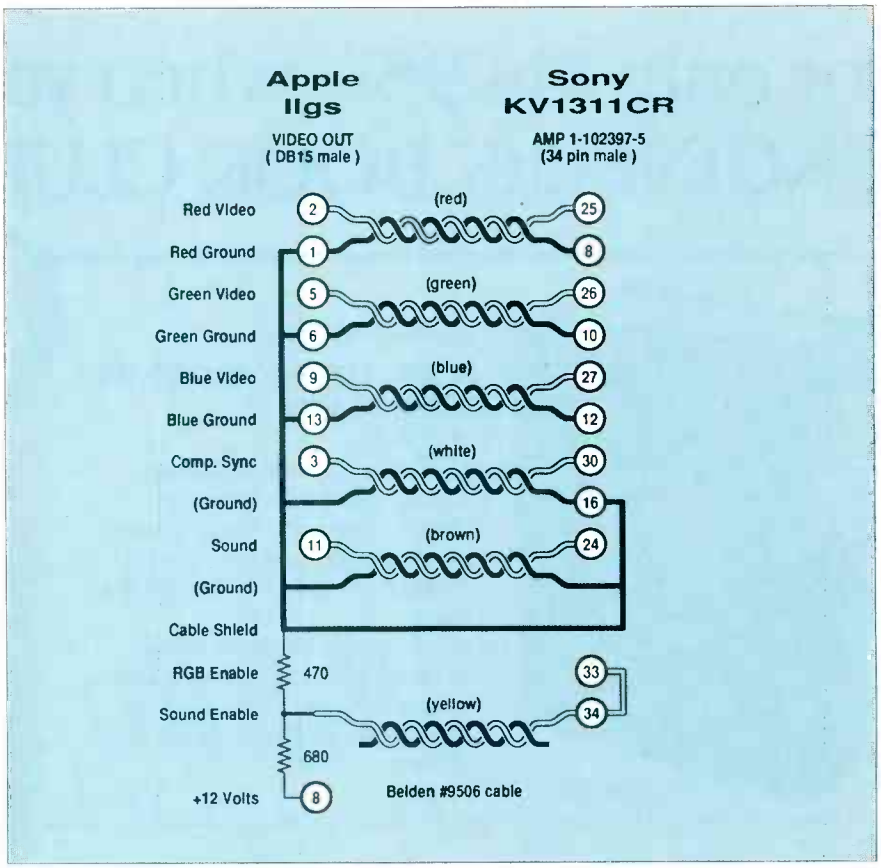

FIG. 2—AN INTERFACE CABLE to go between the Apple *IIgs* computer and the Sony *KV1311-CR* linear RGB monitor/receiver.

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street-price do-everything machine. It is a television receiver with 196 channels of off-the-air and cable capability, including a handy remote control. On the side is a fancy panel that has inputs for composite video, digital RGB, linear RGB, audio, and even for teletext! Outputs include video, audio, VCR editing, and hi-fi multiplexed sound.

A special cable is required to interface the DB-15 connector on the *IIgs* to the 34-pin DIP header connector on the monitor receiver. Figure 2 shows you the details for that cable. You can also get a cable for $20 from the folks at Redmond Cable.

If you use the ready-to-go cable, be very careful to plug it in correctly. To keep the cost down, the connector is neither keyed nor idiot-proofed.

So how good is it?

The picture quality and color is every bit as good as the stock Apple monitor. But, since there are only 192 or 200 scan lines on the *IIgs* video, the 13-inch display tends to break up characters into individual dot lines. Thus, I feel the original monitor has a higher perceived character readability, that is particularly noticeable when word processing.

On the other hand, 13 inches is often too small to be pleasant for such activities as group VCR watching. So, I guess one problem with the *KV1311-CR* monitor is that the screen is both too big and too small.

By the way, this is strictly an NTSC set, with the usual 15735-Hz horizontal scanning. It is not suited for EGA or other uses that require a higher scanning rate.

Rumor has it that the low street price is caused by it being a discontinued model, and that something better is now in the works. But "something better" is always in the works. And probably much more expensive.

One big warning: One person

bought the monitor for his *IIc* and tried using the composite NTSC video input. He was appalled when he found all his 80-column text was hopelessly smeared. There simply is no color monitor available anywhere that can attractively display 80 column text from an NTSC-coded composite-color-video input. The reason, of course, is that there is not enough bandwidth available in the NTSC encoding to allow display of more than 45 or so characters, maximum, across the screen. That is why you go RGB in the first place.

So, yes you can use this monitor receiver with a *IIc* or a *IIe*. But your 80 column text will only be legible and pleasant when you have added an a third-party RGB card.

The smallish speaker in the *KV1311-CR* does sound bunches better than the tiny Apple speaker, but it is not in the least suitable for serious music-synthesis use. You can take an audio output off the earphone jack for further amplification and/or better speakers.

It is nice to have a "real" volume control handy, compared to the front panel firmware setting. A pair of snap-on feet allow you to angle the display for monitor use or to flatten it for TV watching.

There's also no handle, a major defect that the monitor receiver shares with the original Apple unit. The center of gravity of both of the monitors is in a very unexpected place, making either of them very easy to drop.

Anything new in video?

I've just gotten word on two new Maxim IC's that will have all sorts of hacker video uses. Those are so new that I do not even have the pinouts yet, but here goes...

Figure 3 shows the new MAX455, a single-chip, $10, multiplexing video amplifier. What that jewel does is let you select one of eight video inputs and route them to a driver amplifier that can directly drive a 75-ohm cable. The channel selection is done by inputting a binary one-of-eight code. The channel-select lines can be any length at all without causing serious problems.

Channel isolation can be as high as 70 dB's That borders on broadcast quality. Circuits of two and four input channels are also offered.

One obvious use would be as a home-video control center. Inputs could come from your TV set, cable, VCR, and such. The outputs could be routed any way you like.

Maxim has also made the output video driver separately available as the MAX452, shown in Fig. 4. Its cost is around $3, and it can easily drive long lengths of 75-ohm coax. The bandwidth can be as high as 50 megahertz.

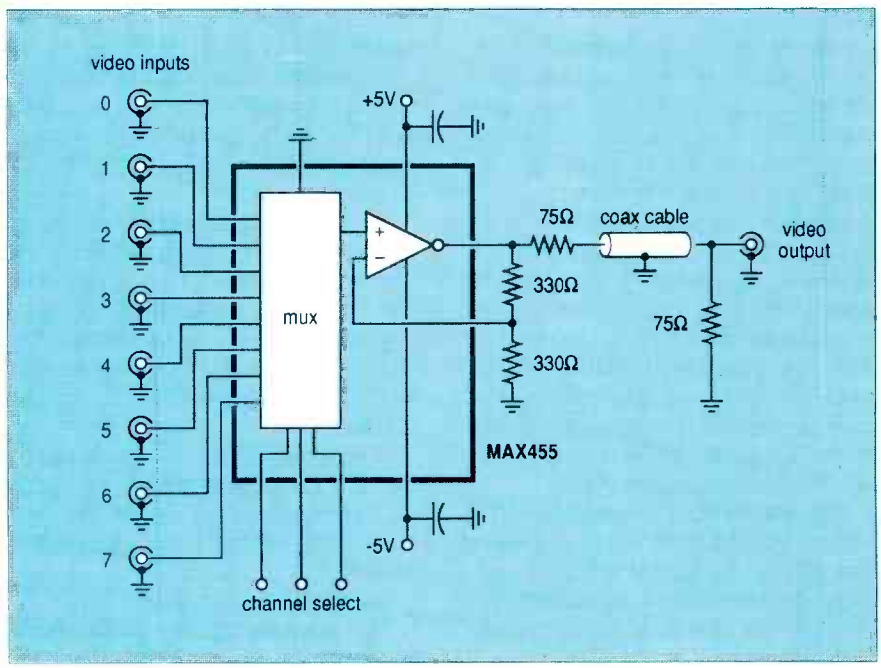

FIG. 3—AN EIGHT POSITION, single-IC video selector and driver.

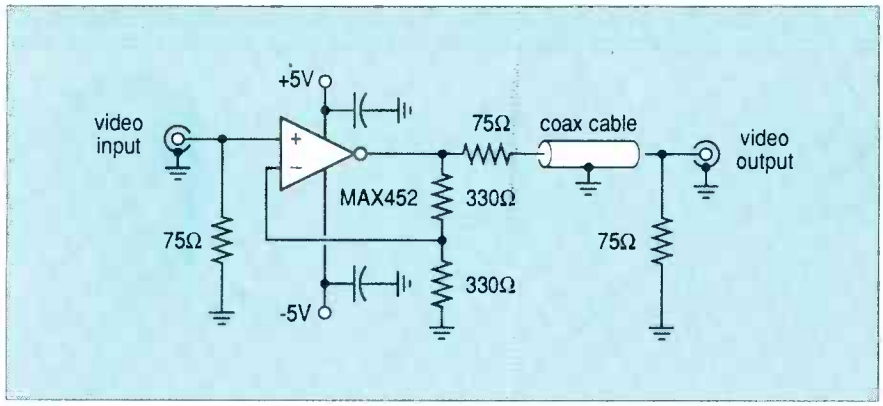

FIG. 4—THE VIDEO DRIVER is available separately as the MAX452.

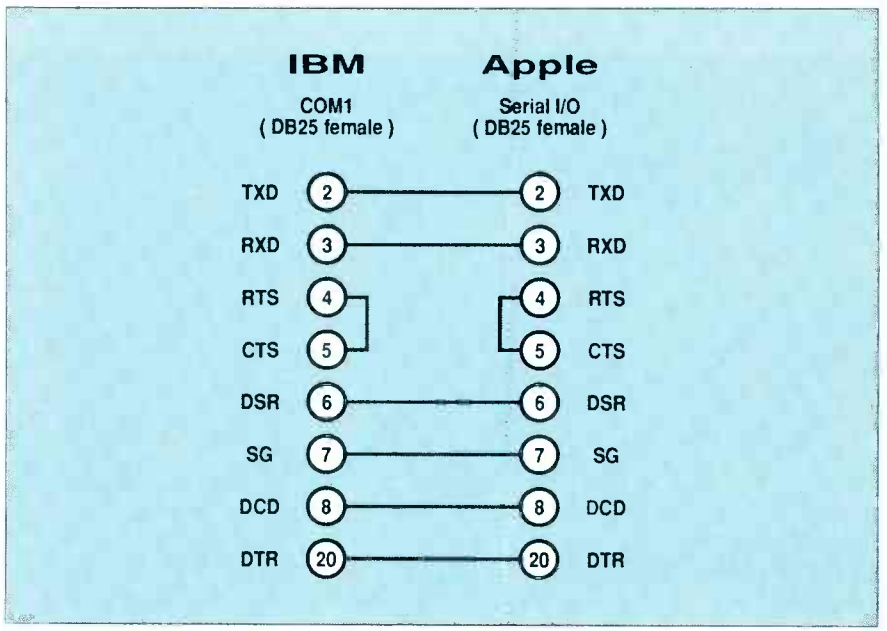

FIG. 5—AN INTERFACE for Apple to IBM text-file exchanges.

One warning: Despite their apparent power and simplicity, those are advanced hacker components. You absolutely *must* use double-sided printed-circuit layouts with large ground-plane areas. Shielding and guarding of inputs and outputs is mandatory. A good oscilloscope is a must. High-quality decoupling capacitors *must* be used directly at the supply pins.

In short, wide-bandwidth video circuits will only work if you treat them with respect.

Can An Apple *IIc* and an IBM PC exchange text files?

You can exchange text files from most any computer to most any other by using serial communication ports and then sending the characters from one machine to another.

Figure 5 shows a simple adaptor that I built to let you get between an IBM PC and an Apple *IIc*, *IIe*, or *IIgs*. You build that adaptor for about $5 worth of parts. It plugs directly into the COM-1 port of the IBM or clone machine.

Be sure to use two female DB-25 connectors. A pair of soldered No. 12 wire loops can be used to hold the connectors together.

At the IBM end, you need a card that gives you the COM-1 serial interface. You also usually will need some sort of a telecommunications software package. I use *PC-Talk*.

On a *IIc*, I prefer the ProDOS *Applewriter*, v2.0 or v2.1. That package lets you send, receive, or edit text all within one single program. To receive, you use the [Q]-1 command. To transmit, you use [P]-NP. An ordinary printer cable, such as might be used between the *IIc* and an *Imagewriter I*, is

(Continued on page 103)

ANTIQUE RADIOS

Servicing antique radios

RICHARD D. FITCH,
CONTRIBUTING EDITOR

IN JANUARY, WE BEGAN TO LOOK AT VOICE-coil problems and their cures. Let's finish up that discussion now before moving on.

An off-center voice coil is usually caused by some kind of damage to the cone itself. Often, recentering or repairing the cone will also recenter the voice coil. An off-center cone is usually caused when the cone's outer edge works loose from its frame. That can be caused by the speaker being dropped—or, more likely, the outer edge just came loose from a combination of vibration and the glue drying out.

So how do you repair an off-center coil? Often, simply re-gluing the speaker's surround to its frame will cure the problem. While some early technicians suggested forcing a warped cone into position with wrinkled-up newspaper loosely inserted between the frame and the back of the cone, it usually eliminated the scratchy-sound but resulted in a thin, tinny sound—one lacking in bass.

Hard to get

One of the first things learned when you get into antique radios is that few, if any, of the parts we mention are available at your modern electronics supply store. That is especially true for resistors and capacitors, and you can create serious problems in an antique radio if you don't make the proper parts substitution. For example, because of the high voltages used in tube radios, for use in those radios, a resistor's wattage rating is every bit as important as its resistance value.

Although the term *resistor* might bring to mind a small round piece of carbon having colored bands that indicate its value, tolerance, and perhaps its voltage rating, in antique radios the term resistor can mean the usual fixed-value carbon and wirewound types, rheostats, potentiometers, ballasts, and line-cord resistors. In fact, early carbon resistors didn't use color bands to indicate the resistance value.

Generally, the color of the body was the first digit, a color dot on one end was the second digit, and a dot in the center of the resistor was the zero-multiplier. A brown body, green end, and an orange dot was a 15,000 ohm resistor. As a general rule, a carbon resistor's tolerance was 20%, and you estimated the power rating. Small resistors were ½-watt, anything larger was 1-watt or 2-watt—you simply hoped you guessed the rating correctly. If tolerance was important, the usually unmarked end was painted silver for 10% and gold for 5%.

Ballast resistors and ballast tubes (a resistor mounted inside a glass tube) are resistive devices specifically designed to control the filament voltage applied to one or more tubes. They were necessary because many antique radios used tubes that required different operating voltages and/or currents. The ballast resistors equalized the filament voltages so that, for example, applying 10 volts to one tube didn't result in the destruction of other tubes that might require only 5-volts filament power.

Figure 1 shows some of the ways

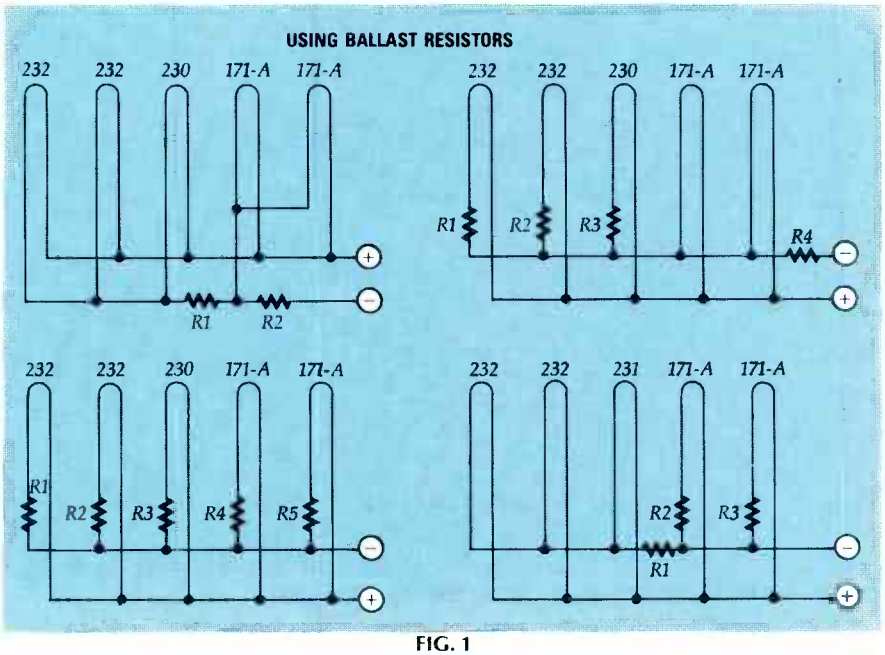

FIG. 1

that ballast resistors were connected. Depending on the particular design, antique radios might use from one to maybe five resistors to control filament voltages; so be sure to check the ballast resistors when substituting tubes in very early radios. The substitute tube's filament voltage and current has to be the same as the tube that is being replaced. If not, you'll have to calculate the value of a new ballast resistor. (Popular early tubes like the 71 have a 5-volt, .025-ampere filament, as do similar tubes like the 01A, 00A, 40, and 12A. Those tubes can be interchanged without changing the value of the ballast resistor.)

Rheostats are two-terminal, wirewound variable resistors that were commonly used in the filament circuit; they permitted the owner to easily correct for the natural decrease over time in the output voltage of the battery that powered the filaments. When the control finally reached its end—or zero resistance—the battery voltage could no longer be compensated and the owner knew that it was time to go out and replace the battery.

An interesting note about rheostats is that their wattage rating is reduced as the resistance is reduced. That is why those devices appear to burn out at the end of least resistance.

Next time

In the next installment of this column we'll cover the tubes used in antique radios, the old-fashioned "condenser" (what we now call a capacitor), and then we'll show you how we go about restoring an antique radio—which is the ultimate goal of the antique-radio hobbyist.

By now, most of you are familiar with the people and businesses who have indicated they have antique radio parts or information available, because every few months I include a list of them in the column. If you need assistance even faster than that, simply send me a SASE. I'll do my best to try to help you out, but please keep in mind that I don't sell parts or information on radios. I can only try and help you locate a source for what you need. R-E

continued from page 48

used if the display does not completely ignite or is weak.

- Connect the high-voltage output (the black HV lead) to the beginning of the display. *CAUTION: Always route that lead away from any conductive object. The lead must be short and direct.*
- Set R13 fully clockwise (longest trace time). Set R12 fully counterclockwise (minimum display). Set S1 to its INTERNAL position.
- Connect the device to a polarized power outlet and adjust R12 for a full-length neon display. (It will take several trace periods to obtain the correct setting.)
- Adjust R13 for the desired speed of the trace time. Note that a point on the control will cause the system to shut down. Maximum speed occurs right after that point.
- Allow the unit to cycle for about an hour. Remove power and check the temperature of power transistor Q1. It should only be warm to the touch. If it is running hot, it may be necessary to decrease the setting of R12.

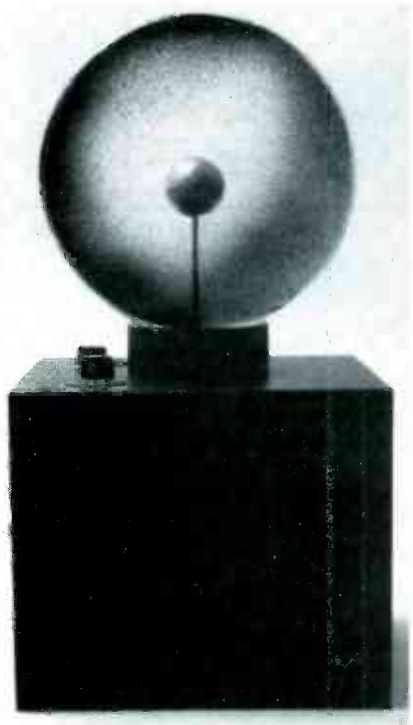

FIG. 7—THE COMPLETED DISPLAY should resemble this author's prototype. Be sure that the globe base you select can support the size of plasma globe that you intend to use.

The length of the display that can be operated will vary considerably. The kind of gas, the diameter of the glass tubing, and stray capacitance can greatly effect operation. It might be necessary to experiment when energizing larger displays.

Modulation effect

Set S1 to its AUDIO position and feed in a signal from the 8 ohm output of a radio or a stereo. Adjust the radio's volume for a display that seems to track the intensity of the sound.

Special note

The output energy of this device is 25 kHz at approximately 10,000 volts. For safe operation, adequate insulation of the output lead is mandatory for safe operation. Silicon or teflon insulation having a rating of at least 25 kV is recommended. Route the output lead so it isn't near any conductive objects, and splices should be sealed in high voltage putty or silicon rubber. R-E

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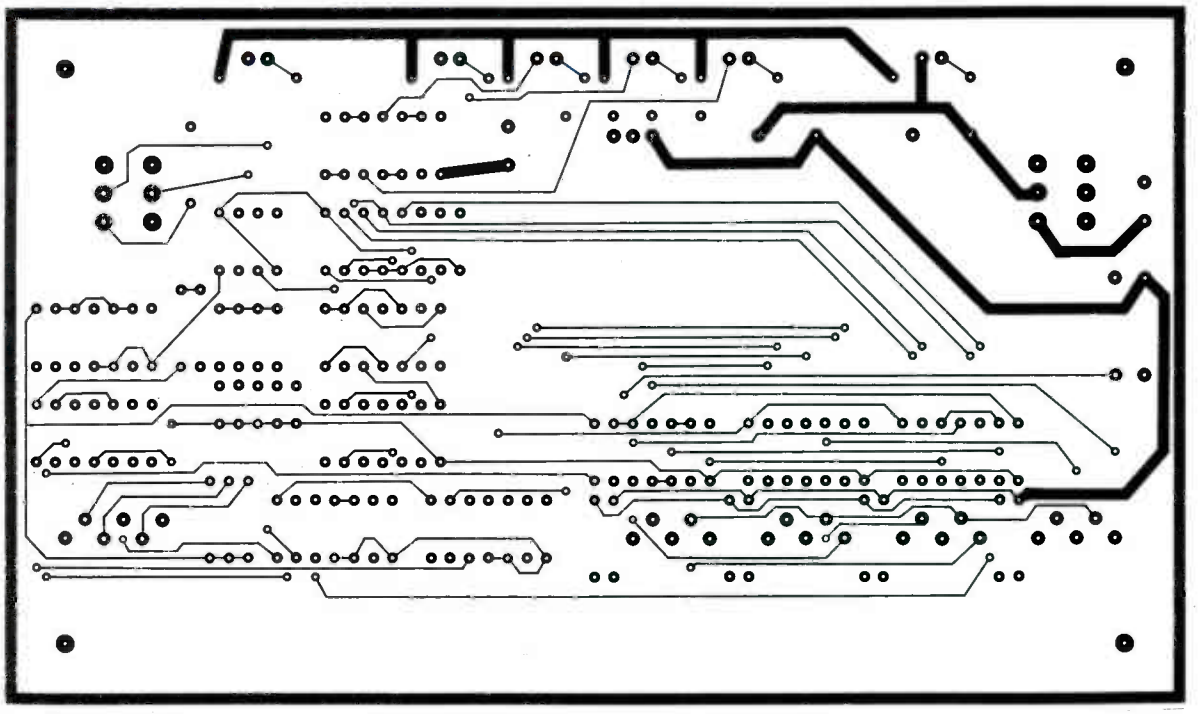
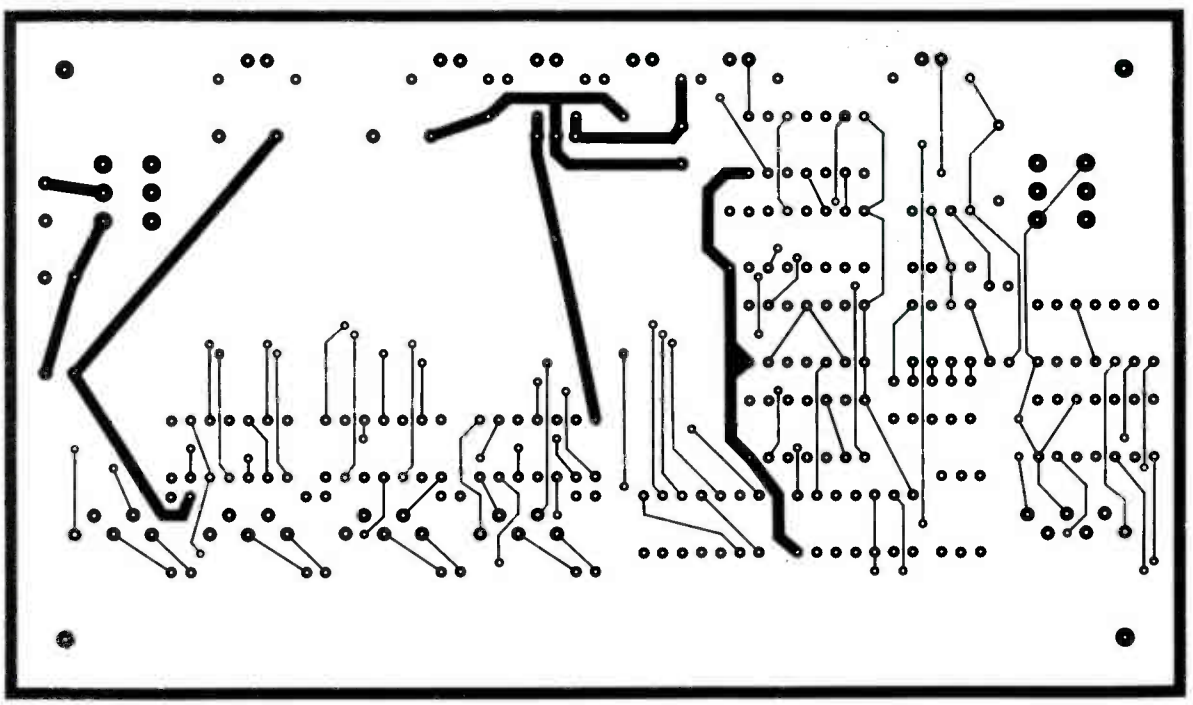


6-1/8 INCHES

SOLDER SIDE of the printer multiplexer board.



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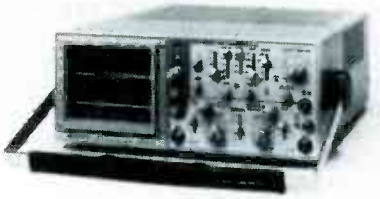

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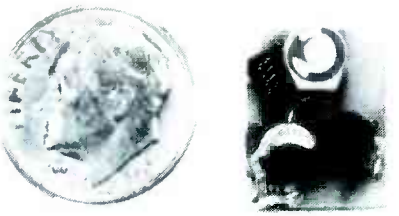

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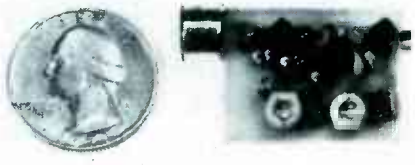

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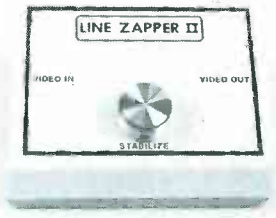

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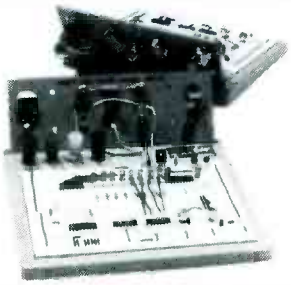

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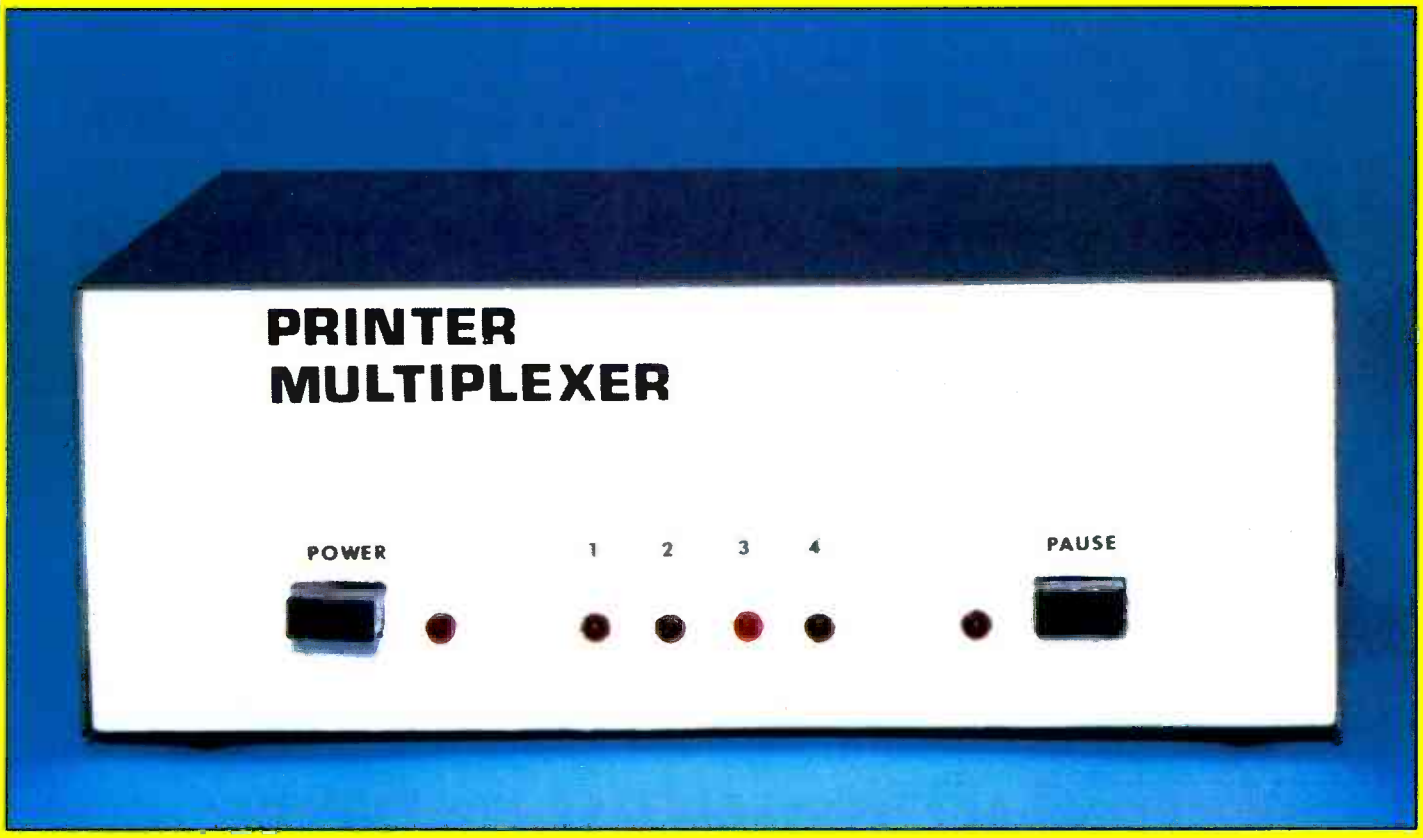

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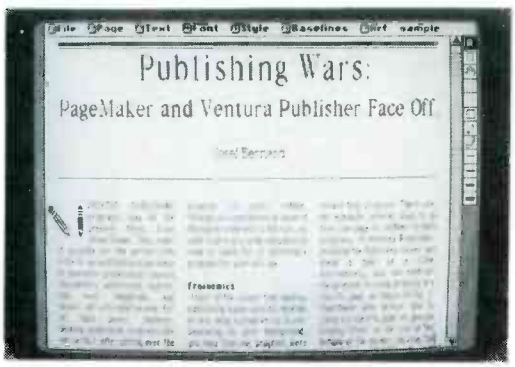

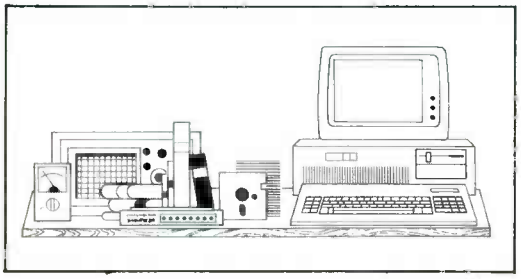

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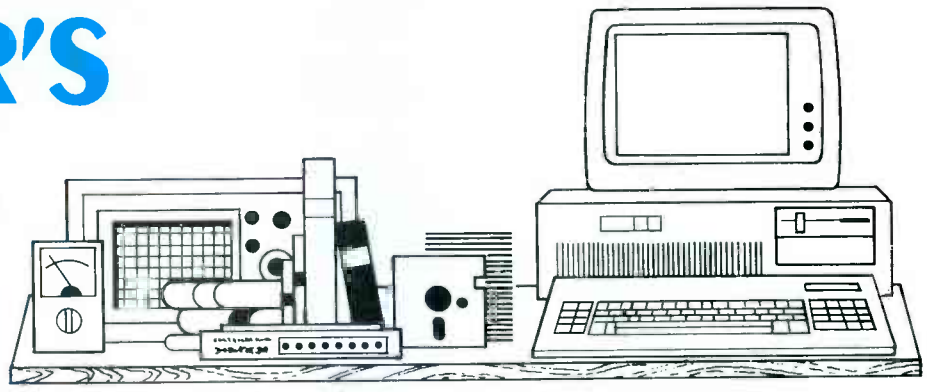

Baby AT Motherboard, Flip-Top Case from JDR Microdevices

Accelerator cards was our theme in the November 1987 issue. We examined a number of products, ranging from an inexpensive clock-speed enhancer to a 80386-based replacement motherboard that cost $1500.

One product category we inadvertently neglected was the Baby AT motherboard, which packs the computing power of an AT onto a board that is the size and shape of a standard XT motherboard. By swapping your PC's motherboard with a Baby AT motherboard, you can thereby increase the performance of your machine without using an expansion slot.

There are several other advantages to a replacement motherboard. First of all, a well-designed board is, generally speaking, more reliable than an accelerator card, because all components (both hardware and software) have been selected to run at the correct speed.

The second advantage is more subtle: It provides you with a means of gradually upgrading your entire system, not just your CPU, as is the case with accelerator cards. The reason is that you can plug in your eight-bit memory card and disk controllers when you make the swap. Then, later, as your budget permits, you can add sixteen-bit components to further increase performance.

JDR Microdevices markets a high-quality dual-speed (8 and 10 MHz) Baby AT motherboard that sells for under $400. It has an on-board clock/calendar (with back-up battery), built-in set-up routines, terminals for connecting an external reset switch, speaker, keylock, and LED speed indicator, and a math coprocessor socket. The support IC's are the Chips & Technologies set; the BIOS was written by Award Software.

The board comes without RAM, but with sockets for as much as one megabyte of RAM. You can install four banks of 64K DRAM's, two or four banks of 256K DRAM's, or two rows of both kinds of IC's. With four banks of 256K IC's, you can divide the RAM between DOS and extended memory equally (512K/512K), or as 640K (DOS) and 384K (extended). The extended memory can be used as a RAM disk, a disk cache, or directly by applications software (AutoCAD, for example) that knows how to use it. You can use standard 150-ns IC's at the 8-MHz speed; operation at 10 MHz requires 120-ns IC's. The faster DRAM's presently cost about 30% more than the slow ones.

The board comes with a slender manual that details connector pins, DIP switch settings, RAM-size selection, memory map etc. It does not provide detailed installation instructions, but that should be no problem for readers of **Computer Digest**.

The BIOS supports several types of floppy disks, including both 360K and 1.2M 5-¼ inch diskettes, and 720K and 1.4M 3-½ inch diskettes. You can boot from any disk in a supported format. Numerous hard-disk formats are also supported by it.

The built-in set-up program allows you to set the clock/calendar, select hard- and floppy-disk type, primary video adapter, memory configuration, and default speed. If the set-up program detects an error, it so informs you, and allows you either to re-configure or to continue.

According to the manual, you should be able to switch speed via a hot key, but actually speed switching is accomplished through the set-up program or by an auxiliary program. A RAM-resident version of the speed-select program is also provided.

To install the board, remove all expansion cards from your PC, then remove its motherboard. Install RAM on the Baby AT motherboard, and then install the board itself. Last, re-install your expansion cards. The motherboard has eight slots: two are eight-bit XT slots, and six are sixteen-bit AT slots. Many eight-bit cards will fit in a sixteen-bit slot, but some won't because the board extends all the way down to a line that is parallel to the edge connector that plugs in the motherboard. Another problem will occur when you decide to upgrade your disk controller or expansion memory cards. AT cards are higher than PC/XT cards, so you'll need a new case.

After installing your hardware, everything works as before, only faster. The 8-MHz clock provides performance similar to a standard 8-MHz IBM PC AT, and the 10-MHz is about 25% faster than that. That's about four and five times, respectively, the speed of a standard PC.

Flip-top case

If you need a case for a standard-size motherboard (to mount the Baby AT motherboard, for example) we highly recommend JDR's Junior AT-style flip-top case. It sells for about $150, includes a 150-watt power supply, and space for three half-height drives. The case also includes all necessary mounting hardware, and a decorous front panel with keylock, three LED indicators (labeled Power, Turbo, and Hard Disk), a momentary-action switch (labeled Reset), and a non-momentary switch (labeled Turbo).

We especially like the case because it is three inches narrower than a standard XT case, yet it provides easy access to the motherboard and disk-drive bays. Because the bays are stacked vertically, disk drives do not block access to the motherboard. The lowest bay is not accessible

through the front panel; normally you'd mount a hard disk there and two floppies (or one floppy and a tape backup unit) above.

The flip-top is highly convenient, especially if you do much testing, or otherwise need to get at your PC's innards very often. Another great convenience is the fact that you can completely remove the front panel, further increasing access to the guts of the machine.

The case is predrilled for a standard XT-style motherboard; plastic mounting hardware is included. The front-panel mounted components (speaker, LED's, etc.) all have long leads attached, and the leads are terminated in push-on Berg-type connectors. The only problem we've found is that the speaker connector is only two pins wide, instead of the standard four.

In addition to the two motherboard connectors, the power supply provides five connectors for disk drives, eliminating the unreliable Y connector often used to expand older PC's.

We've used the Baby AT motherboard and the flip-top case for several weeks beside our stock XT, and have experienced only one problem: We've been spoiled by speed. Working on the XT has become intolerable.

Turbo Pascal 4.0 and Turbo Professional 4.0

Debugging tools for Turbo Pascal were reviewed in the December 1987 issue. As our review was being written, Borland announced a new version of Turbo Pascal. We finally managed to get a copy, and we are, to say the least, impressed. The compiler itself is faster, it produces faster code, and much leaner code. For example, the following program compiles under 3.0 to an 11K COM file, and under 4.0 to a 2K EXE file:

```
program hello;
begin
writeln('Hello')
end.
```

Turbo 4.0 comes on three floppy disks; a 600-page manual describes the program. The disks contain several demonstration programs, a program useful for converting programs written in the previous version of the compiler, two versions of the compiler (the familiar integrated environment and a traditional command-line activated one), and quite a bit more.

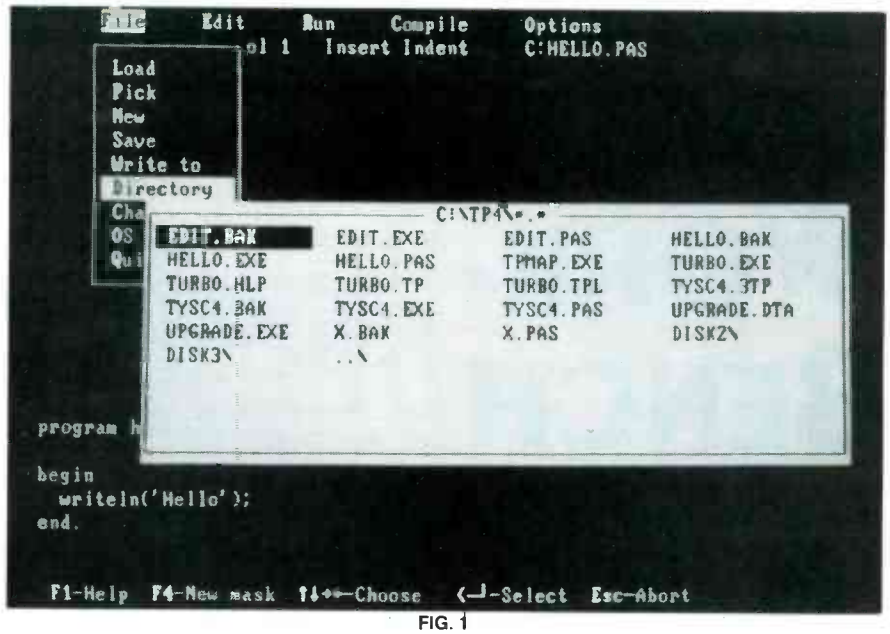

FIG. 1

Changes in the compiler include the ability to link "units" at compile time. A unit is a collection of routines that (usually) perform related tasks. For example, separate units are provided that provide screen handling, printer I/O, floating-point math, etc. Unused units need not be included in the run-time file, so, for example, you don't have to carry the floating-point library around in every program you write. You can create your own units for any specialized applications programs.

Pascal purists may object, but the new Turbo includes many non-standard extensions to the language. For example, there are now five integer data types (shortint, integer, longint, byte, word), there are many hardware-dependent functions and procedures, including greatly expanded support for graphics.

The work environment still includes a configurable WordStar-like editor, but, as shown in Fig. 1, drop-down menus are now used to accomplish various tasks, and extensive on-line help is available at any time.

Turbos 4.0's only shortcoming, and one that we expect will be remedied in 1988, is lack of a debugger. (The debuggers discussed in the December issue will not work with 4.0 files.) However, compiled programs can be debugged using Periscope (also reviewed in the December issue of **Computer Digest**) or other third-party debuggers.

Turbo Professional 4.0

The first company to market an add-on product for Turbo 4.0 is Turbo Power Software (who also markets a debugger

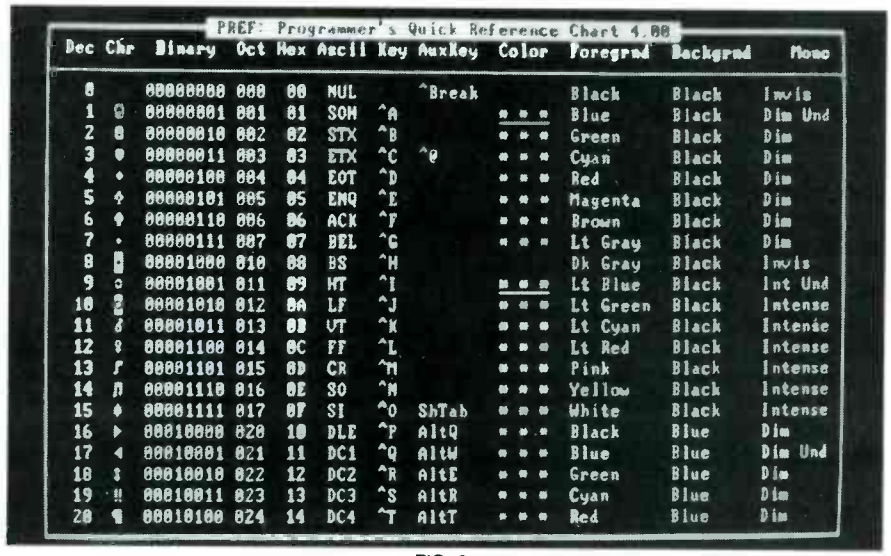

FIG. 2

for version 3). Turbo Professional 4.0 is a rewritten version of a similar set of routines developed for version 3; the new version includes many enhancements, excellent documentation, and several useful demo programs (for example, the RAM-resident programmer's reference shown in Fig. 2). Source code for all demos is included in the Turbo Professional 4.0 package.

Turbo Professional 4.0 includes several pre-compiled units that enhance or complement the units provided by Borland. (Again, all source code is included.) Those units provide many of the routines programmers end up writing for themselves or simply doing without. The new units provide extended string and screen handling, DOS and BIOS support, support for building your own interrupt service routines and RAM-resident programs, and much more. One example program shows you how to create a RAM-resident program using only thirty lines of code!

Separate utilities include a screen-generator that lets you create menus by "painting" them on the screen; the program then generates the appropriate Turbo Pascal source code for you. Other utility programs include a file sorter, a difference finder, several snazzy demos that show off Turbo Professional Windowing capabilities, as well as several useful RAM-resident "desktop accessories". Thos "accessories" include such things as a programmer's calculator, the afore-mentioned reference chart, a keyboard macro program, and more.

All in all, Turbo Professional is a great piece of software; it should be useful to beginners and professionals alike. In fact, we like it enough to recommend it highly.

Products Evaluated

- Baby AT Motherboard, MCT-BATMB ($379.95), and Junior AT-style flip-top case, ($149.95), JDR Microdevices, 110 Knowles Drive, Los Gatos, CA, 95030, (800) 538-5000, (408) 866-6200.
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- Turbo Pascal 4.0 ($99.95 or upgrade for $39.95), Borland International, 4585 Scotts Valley Drive, Scotts Valley, CA 95066, (800) 543-7543.
CIRCLE 43 ON FREE INFORMATION CARD

- Turbo Professional 4.0 ($99.95), Turbo Power Software, 3109 Scotts Valley Drive, Suite 122, Scotts Valley, CA 95066, (408) 438-8608.
CIRCLE 44 ON FREE INFORMATION CARD

- Interchange ($39.95), Systems Manufacturing Technology, 1145 Linda Vista Dr., San Marcos, CA 92064, 619-744-3590.
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Interchange File Exchange System

If you are considering the purchase of an IBM *PS/2* but have put it off because your present library of 5¼-inch diskettes won't work with the new 3½-inch drive, take heart. Systems Manufacturing Technology (1145 Linda Vista Dr., San Marcos, CA 92064) has an elegant solution called *Interchange*. That product will allow you to exchange files between any two PC-compatible computers, in either direction, regardless of disk size or format.

Instead of using a diskette to transfer files from one machine to another, *Interchange* communicates files and data between the two computers via the parallel-printer ports. File exchange is not limited to disk-drive type, and data may be transferred from floppy or hard disk on one computer to floppy or hard disk on the other with no restrictions as to destination or disk type. Data exchanges from a RAM disk to any other type of storage device can also be made using *Interchange*.

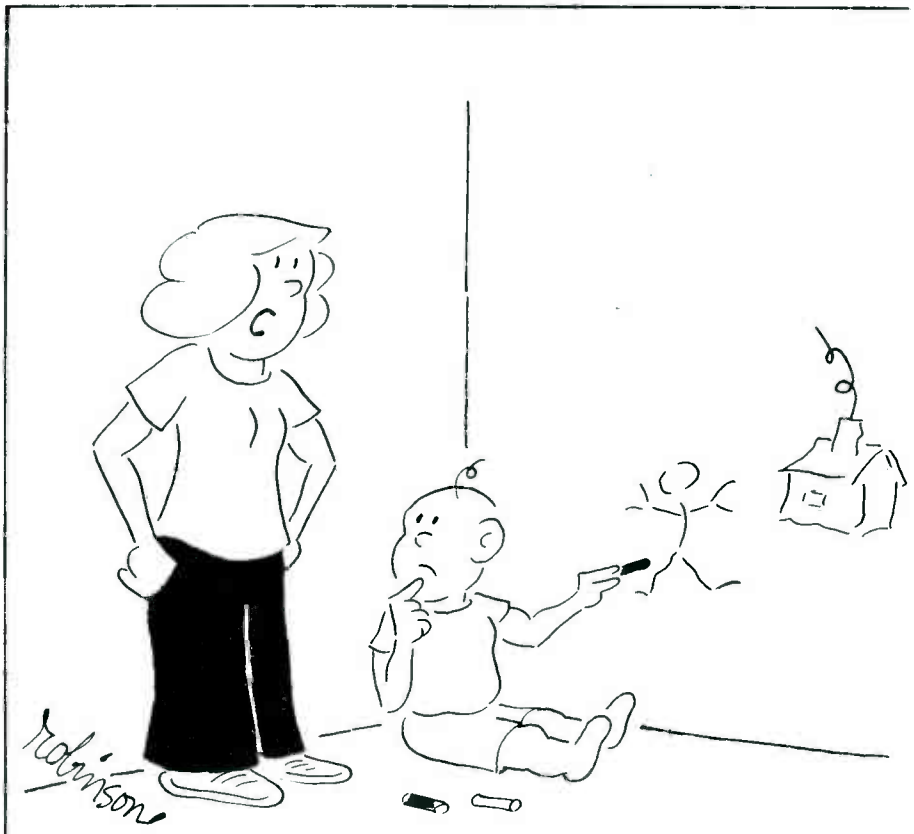
Interchange is a communications system that operates almost exactly like a modem. The *Interchange* package consists of nothing more than a parallel interface cable and a software program called COPYX. When the cable is installed between the parallel-printer ports of the two computers and the software is run, file transfers between the two machines can be made very easily.

To initiate a file transfer, the COPYX program is first loaded into the computer that is to receive the file, causing an *Interchange* status screen to appear on the monitor and also sets up the system as the destination computer. Next, the COPYX software is loaded into the computer that contains the file to be sent, thereby establishing the communications link. The *Interchange* software comes on both a 5¼- and a 3½-inch diskette so that it can be used in systems having either type of drive.

Once the communications link is established, to transfer a file all you need to do is enter the file name and its destination; wild cards are permitted for source file names. If no destination is assigned, an identical file path is created by the software on the receiving disk for the file transfer.

Because *Interchange* sends data in parallel format, as opposed to the serial format used during a modem exchange, file transfers proceed at an extremely high speed; as a result an entire one-megabyte directory can be transferred in just under a minute.

Priced at $39.95, *Interchange* is an excellent package that is economical and easy to use.–*TJ BYERS.*



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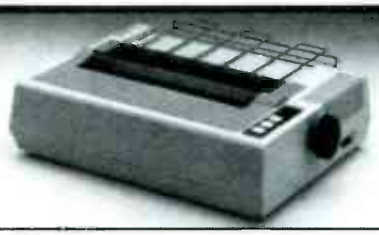

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Many a small business has more computers than printers. The reason why purchasing a separate printer for each user is unjustified is because few users actually print all day long. Besides, buying separate printers can be expensive.

The biggest problem of printer sharing is how to hook things up. Many people simply switch cables, but that's inconvenient, and wastes time. Others use some sort of mechanical switch, but that's also inconvenient, because the user must get up and physically push a button or turn a knob.

Another approach is to use a device called a printer multiplexer. The device connects the computer to the printer automatically, eliminating the need to switch cables or press buttons.

The multiplexer presented here allows you to connect as many as four computers to the same serial (RS-232) printer. The multiplexer works by scanning each computer's output port sequentially. As soon as one computer begins a print job, the multiplexer locks onto that computer and allows data to flow from computer to printer. Meanwhile, the busy lines to the other computers' output ports are asserted. When the print job is done, the multiplexer releases the busy lines, and resumes scanning.

One special feature of our printer multiplexer is the PAUSE button, which can be used to halt data flow from the computer to the printer. As long as that button on the unit is pressed, no computer will be able to send data to the printer.

How it works

To accomplish multiplexing the printer multiplexer uses hardware handshaking. Handshaking is the term used to describe what prevents the computer from sending data to the printer when the printer is not ready for it. Generally speaking, there are two types of handshaking: software and hardware. There are several varieties of each type of handshaking, but XON/XOFF and busy line, respectively, are the most common.

In the XON/XOFF method, the printer sends control characters to the computer to indicate when it is able to accept data, and when it is not. To use that type of handshaking, the printer multiplexer would have to be microprocessor controlled. We wanted a simple and inexpensive method of printer sharing, so software handshaking is not used.

In the busy-line method, the printer controls the state of its Data Terminal Ready line (which is usually pin 20 of a 25-pin D connector). In general, if DTR is high (+12 volts), then the printer can accept data. If DTR is low (−12 volts), then the printer cannot accept data. Unfortunately, some printers interchange the meanings of high and low. Our design does not allow for busy-line polarity selection, however, modifying the multiplexer to do so is a relatively simple task.

In the multiplexer, if the printer holds its own DTR line low (indicating that it's busy), then all DTR lines going to the computers are also held low. When the printer is ready to accept data, the DTR line of the currently selected

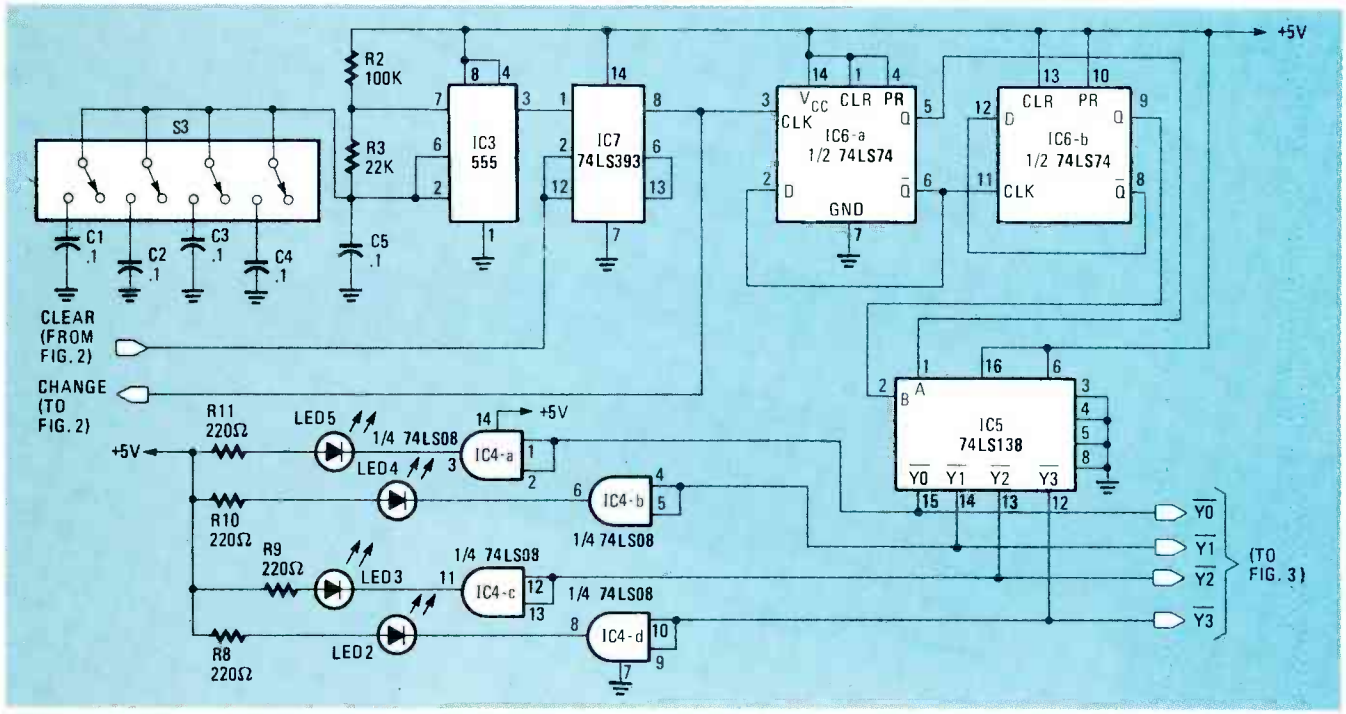

FIG. 1—SEQUENTIAL SCANNING CIRCUIT: As long as no signal is present at the CLEAR input, the outputs of IC5 are asserted one after the other.

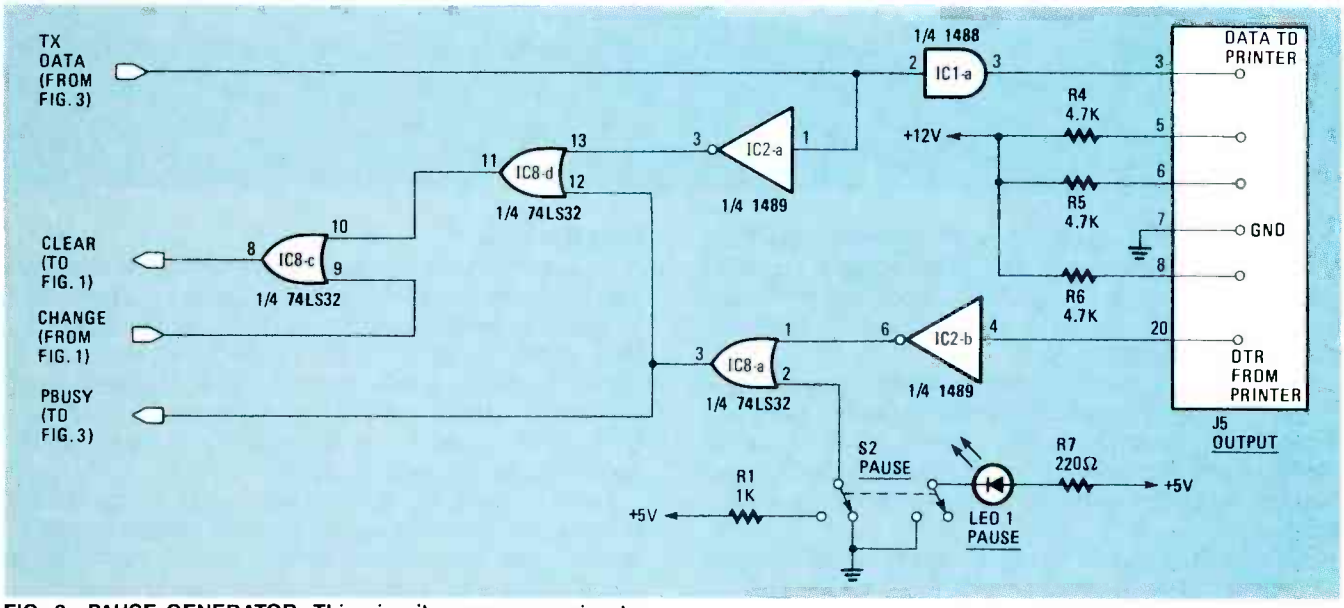

FIG. 2—PAUSE GENERATOR: This circuit causes scanning to stop whenever data is received at TX DATA, when the printer is busy (i.e., pin 20 of J5 is low), when the PAUSE switch is pressed, or when IC8 (shown in Fig. 1) changes state.

computer is released, and the DTR lines of the unselected ports remain low.

Computer-port selection is done with a 555 timer and three other IC's, as shown in Fig. 1. The 555 (IC3) runs in the astable mode; its rate determines how often the multiplexer switches ports. The values shown for R2, R3, and C5 cause a pulse to be generated about once every second. One second should be enough time for most applications, but the DIP switch (S3) allows additional capacitance to be added to the timing circuit; doing so increases the delay to two, three, four, and five seconds, as each section of the switch is closed. Variable time delay was provided to ensure that a computer was not cut off in the middle of a print job. If five seconds does not allow enough time, resistor values could be increased to further increase the time delay.

Whatever the delay, the timer clocks IC7, a 74LS393 8-bit counter. After 128 counts, pin 8 of IC7 goes high, and that clocks IC6-a, half of a 74LS74, and it in turn drives IC6-b, the other half. The Q outputs of both flip flops are decoded by IC5, a 74LS138 3-to-8 line decoder. The active output of that IC selects the current computer. The

outputs labeled $\overline{Y0}$ through $\overline{Y3}$ are used to generate the DTR signals and thereby to determine the active port.

The selected computer port is indicated on the front panel via LED2–LED5. The 74LS138 outputs are simply buffered by IC4, a 74LS08. As scanning continues, each LED lights up in turn.

The preceding description shows how the multiplexer cycles through the four ports. But how does it select one and stop the counting?

An input port is selected by way of the clear inputs (pins 2 and 12) of the 74LS393, which are used to inject a time delay in the switching sequence. If those inputs are brought high, then the counter resets and starts counting from zero again. So if it's continually cleared, it will never count 128 pulses, the flip-flops in IC6 will not change state, and neither will IC5.

Actually there are three reasons why IC7 might be prevented from counting: when data is being sent from a computer, when the printer is busy, or when the pause function is engaged. As shown in Fig. 2, that is accomplished by using several OR gates (and some inverters).

As the computer sends data, the first bit of that data, which appears after buffering (by circuits discussed below) at the TX Data input of Fig. 2, will cause the clear lines to go high, resetting the counter. That signal is ORed with the DTR signal and with the output of the PAUSE button. Thus, the counter will also be reset whenever the printer's DTR line goes low (indicating printer is busy); or the pause line goes high (indicating pause button is pressed).

In Fig. 3, IC9-a, IC9-c, and IC9-d combine the data inputs from each port into the single signal that drives TX Data (shown in Fig. 3). The buffers in IC11 convert the incoming RS-232 signals to TTL levels; the buffers in IC10 convert the outgoing TTL signals to RS-232 levels.

The power supply, shown in Fig. 4, supplies ±12 volts to power the 1488 line drivers. The power supply also provides +5 volts for the remaining circuits.

Construction details

It's easiest to build the multiplexer on a small double-sided PC board, patterns for which are shown in PC Service. You can also purchase your own from the source mentioned in the Parts List.

If you choose to make your own, here's a helpful technique that was suggested by a friend who works in a PC board factory. This technique allows you to etch the two sides of the board so that they are aligned correctly. If they're not, drilling the board can result in holes that are centered on one side of the board, but do not go through the center of the pad on the other side. In fact, with severe misalignment, traces can be cut!

Rather than etching a single 0.062-inch board with the

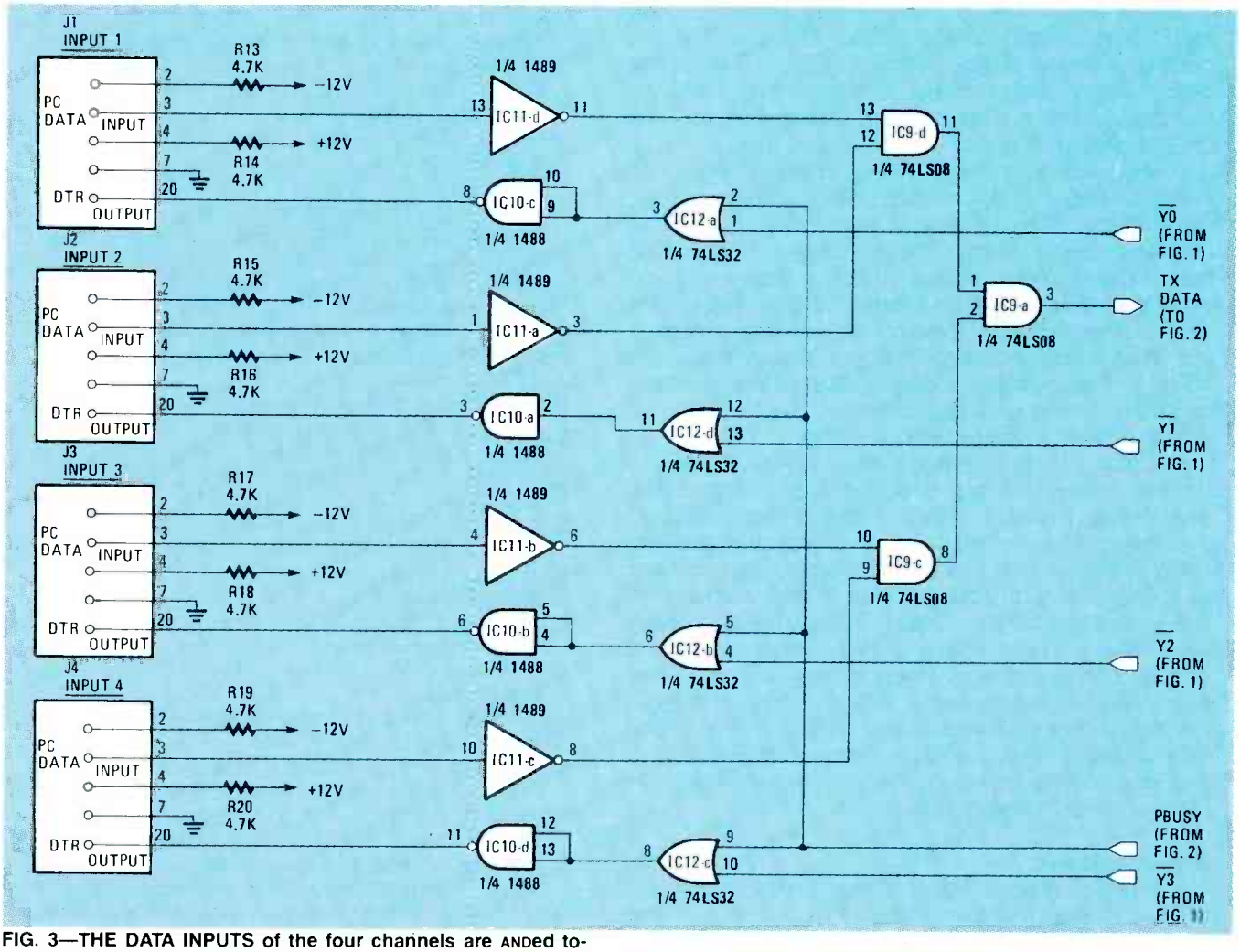

FIG. 3—THE DATA INPUTS of the four channels are ANDed together by IC9-a, IC9-c, and IC9-d to drive the pause generator that is shown in Fig. 2.

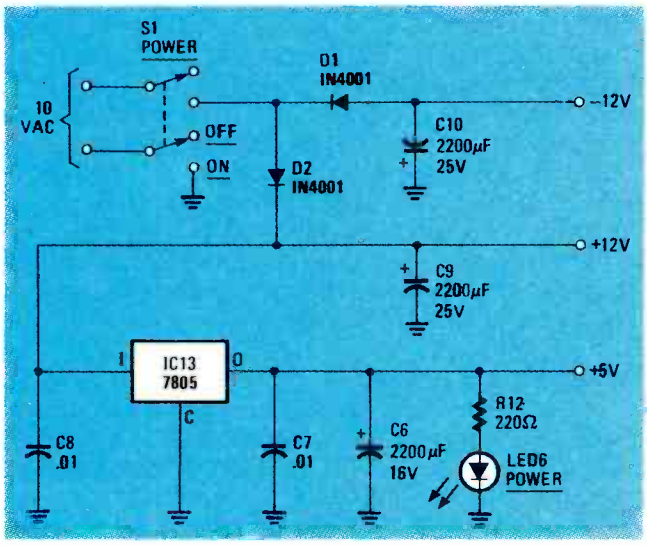

FIG. 4—THE MULTIPLEXER'S POWER SUPPLY: Mount IC13 on a small heatsink.

appropriate patterns on both sides, etch two 0.031-inch boards, one with the component-side patterns, and one with the foil-side patterns. When the two boards are placed back to back, you have a double-sided board with the standard 0.062-inch thickness.

To drill the boards, first drill feedthrough holes near each corner of each board. (Pick feedthroughs from the parts-placement diagram shown in Fig. 5.) Align the boards, insert short pieces of stiff wire through the holes, and then solder the wires to both sides of the board. Then drill the remaining holes.

If you made your own board, before mounting any components install and solder jumpers in all feedthroughs. Then, for ease of assembly, mount all discrete components, except the power-supply capacitors, the voltage regulator, and the switches. Solder each on both sides of the board. Then install the IC's, either soldering them directly to the board or with wirewrap sockets. If you use sockets, mount them about ¼ inch above the board, to provide clearance for soldering. Now install the remaining components, and then make sure that all polarized components are installed correctly.

The next step is to prepare the case. You'll need to provide holes on the front panel for S1, S2, and the LED's, and holes on the back for the five RS-232 connectors and the power jack. Label the case with dry-transfer lettering.

Connect (but don't mount) the power jack and the RS-232 connectors. Input jacks J1–J4 are wired identically; output jack J5 is wired differently, so be careful! Solder all wires to both sides of the board. Then, after the jacks are connected, mount them to the case, making sure the output jack is mounted in the correct location. Now wire and mount the switches and LED's. With all components installed, the PC board can be mounted. Secure it to the bottom of the case using ⅜-inch standoffs. The complete assembly appears as in Fig. 6.

Testing and use

The first test is done before connecting the multiplexer to a printer. Make sure the PAUSE button is disengaged, and then apply power. The POWER LED should light up, as should one of the four port-indicator LED's. If that does not happen immediately, remove power and make sure all parts were installed in the correct locations, with the correct orientation, and that all solder joints are good. When the board is debugged, resume testing.

With no printer connected, the first port-indicator LED should remain lit, indicating that the scanning circuitry is in the pause state, because the multiplexer's ready input (pin 20 of J5) is simply floating.

Now connect a printer and one or more computers to the multiplexer. Be sure that the printer is on, has paper loaded, and is on line. The computer should be configured for the printer's baud rate, number of start and stop bits, and DTR handshaking.

The port-indicator LED's should light up sequentially now, indicating that the multiplexer is checking the input ports for data to print. Engage the PAUSE button. The LED that is currently lit should remain so. Now release the PAUSE button; scanning should resume.

Now try printing something from a computer. As the sequencer reaches the port that the computer is connected to, it should lock onto that port, and the printer should begin to print. Printing can be suspended at any time by simply pressing the pause button. Of course, if your printer has any memory of its own, printing may

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.
R1—1000 ohms
R2—100,000 ohms
R3—22,000 ohms
R4–R6, R13–R20—4700 ohms
R7–R12—220 ohms
Capacitors
C1–C5—0.1 µF, disk ceramic
C6—220 µF, 16 volts, electrolytic
C7, C8—0.01 µF, disk ceramic
C9, C10—2200 µF, 16 volts, electrolytic
Semiconductors
IC1, IC10—1488, quad RS-232 line driver
IC2, IC11—1489, quad RS-232 line receiver
IC3—555, timer
IC4, IC9—74LS08, quad AND gate
IC5—74LS138, 3-to-8 line decoder
IC6—74LS74, dual RS flip-flop
IC7—74LS393, 8-bit binary counter
IC8, IC12—74LS32, quad OR gate
IC13—7805, 5-volt regulator
D1, D2—1N4001 rectifier
LED1–LED6, standard
Other components
S1, S2—DPDT switch (Thorsen 35-491 or equivalent).
S3—four pole DIP switch
J1–J5—25-pin D connector
Miscellaneous
10-volt AC wall-mount power transformer, matching jack, case, hardware, etc.
Note: The following are available from Renton Products, P.O. Box 16271, Seattle, WA 98116: etched and drilled PC board, $19; complete kit of parts (including PC board, punched and painted case, power supply, all components, and hardware), $89; completely assembled and tested unit, $129. Washington residents add appropriate sales tax. All orders add $3 shipping and handling.

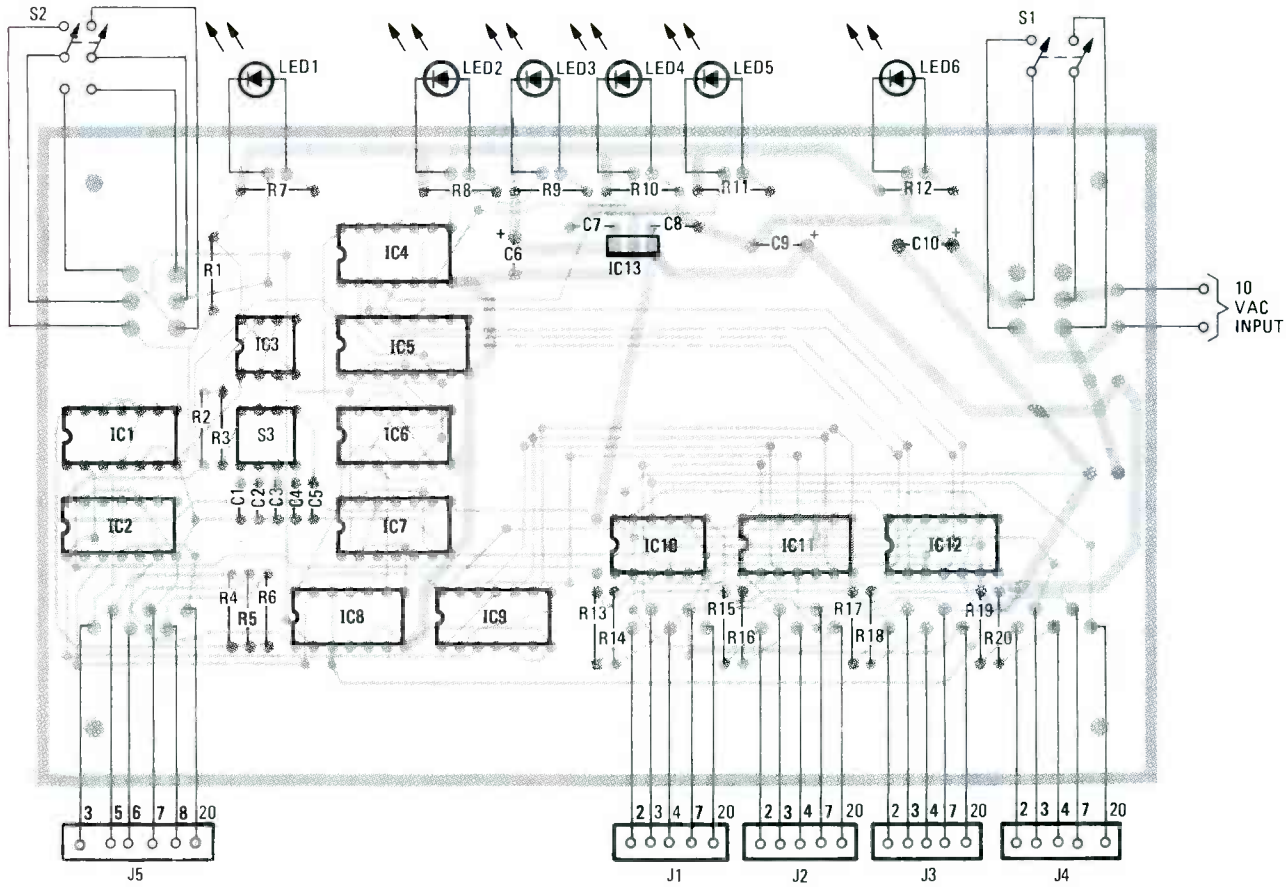

FIG. 5—MOUNT ALL COMPONENTS as shown here.

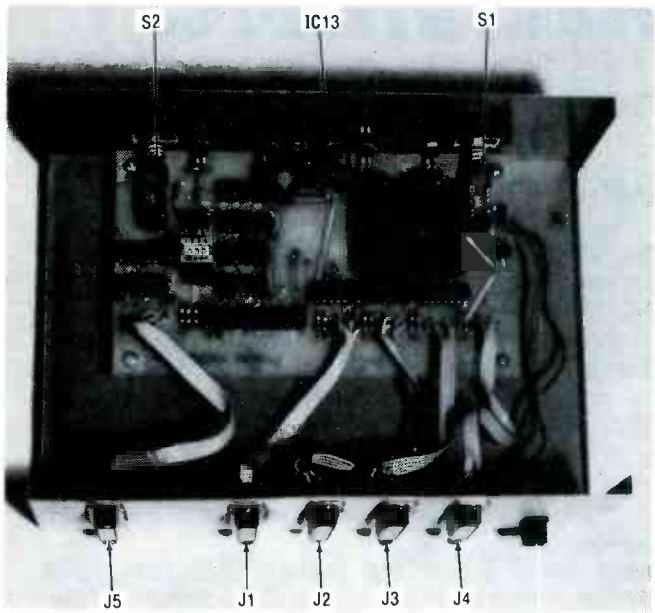

FIG. 6—THE FINAL ASSEMBLY looks like this.

continue for some time until the contents of that memory are exhausted. When the PAUSE button is released printing should resume.

Start a print job from the second computer before the first is finished. When the first computer is done the multiplexer will resume scanning. As it reaches the second computer's port, it should lock onto it and the printer should begin printing.

Cable notes

The multiplexer should be located with respect to the printer and the computers so that overall cable length is minimized. If a print buffer is being used, for all computers to benefit from it, it should be connected between the multiplexer and the printer.

Each of the multiplexer's input ports is configured so that it appears as a printer port. Data is received on pin 3, and pin 2 (which would be used to transmit data back from the printer to the computer) is simply held at a low RS-232 level. Pin 4 is the Data Set Ready signal; it is pulled high to 12–15 volts through a 4.7K resistor. Many computers require that pin to be high before they will transmit data.

The serial port of the IBM PC (and compatibles) is configured so that a cable with pin-for-pin connections (pin two to pin two, pin three to pin three, etc.) would be used with a modem. To connect a printer to a PC, a "null modem" cable must be built. The wiring is shown in Fig. 7. Or you could rewire the multiplexer's input ports so that a "straight" cable could be used.

The port from the multiplexer to the printer should be wired up with a straight cable. However, check your printer's documentation just to be sure.

Problems and solutions

You may have problems using the multiplexer with some software packages. For example, a CAD program might output some data, do some calculations, and then output some more data. During the calculations, the mul-

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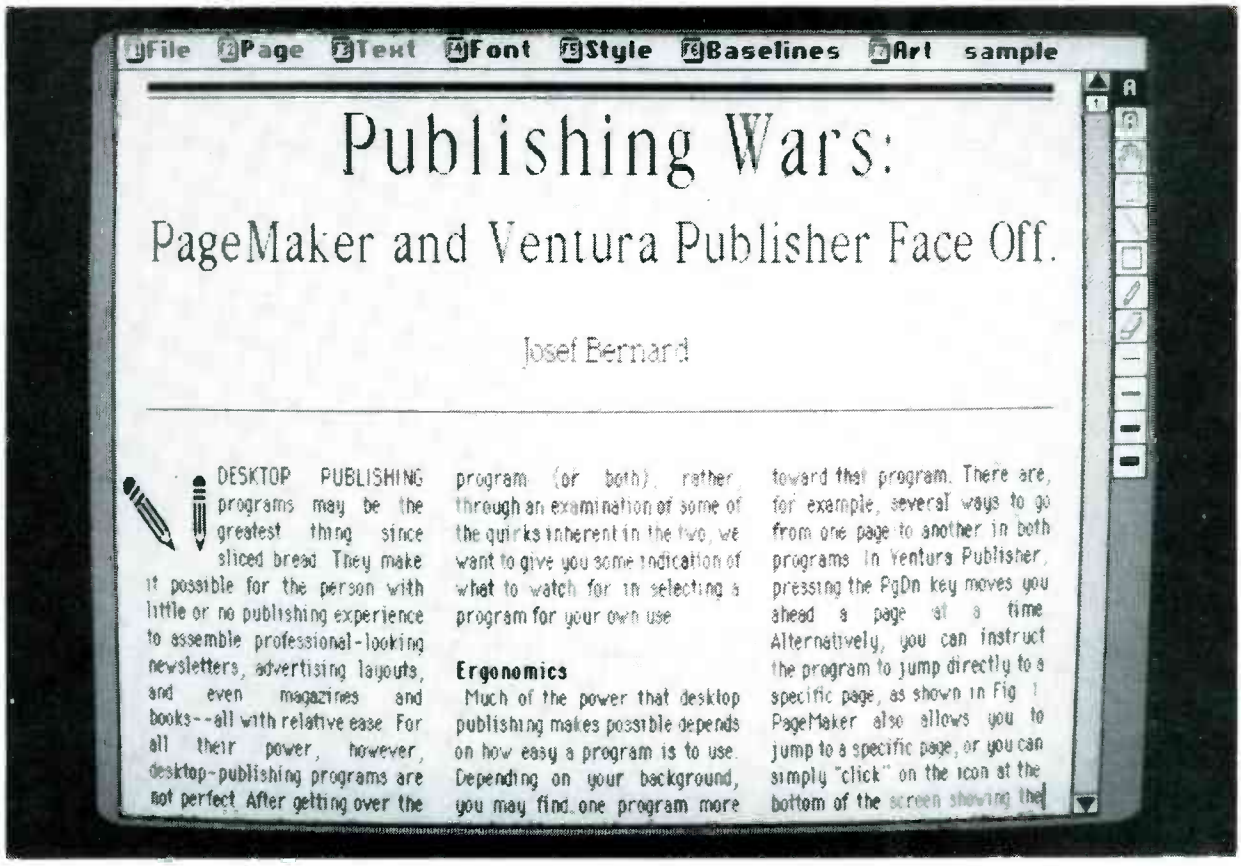

DESKTOP PUBLISHING

PageMaker and Ventura Publisher face off.

JOSEF BERNARD

In February we introduced you to desktop publishing packages. Now it's time to take an in-depth look at how two heavyweights—PageMaker and Ventura Publisher—fare in head-to-head competition.

Desktop publishing programs may be the greatest thing since sliced bread. They make it possible for the person with little or no publishing experience to assemble professional-looking newsletters, advertising layouts, and even magazines and books—all with relative ease. For all their power, however, desktop-publishing programs are not perfect. After getting over the initial wonder of seeing the pages of his publication appear like magic on the screen of his monitor, the desktop publisher soon begins to discover a number of "little things" that prevent him from doing exactly what he wants to.

In spite of those small things, each is a top-of-the-line program whose sheer number of features can make it overwhelming and difficult to work with. But that power is what makes those programs the first choice for many: Just about anything you need is there—if you can find it. Of course there are significant differences between them, and those differences can greatly affect your attitude toward, and use of, either package.

So here is one user's view, based on several months of living with both programs. Two versions—1.0 and 1.1—of Ventura Publisher were used; the later one corrects many deficiencies of the earlier.

This is not intended to be a comprehensive review of either program (or both); rather, through an examination of some of the quirks inherent in the two, we want to give you some indication of what to watch for in selecting a program for your own use.

Ergonomics

Much of the power that desktop publishing makes possible depends on how easy a program is to use. Depending on your background, you may find one program more comfortable or easier to use than the other.

PageMaker, for example, runs under Microsoft Windows, and it has features that seem natural for users already used to working in that environment. And because it got its start on Apple's Macintosh, PageMaker, even on a PC-based system, will feel comfortable to a Macintosh user.

Ventura Publisher, on the other hand, runs under Digital Research's GEM (Graphics Environment Manager) en-

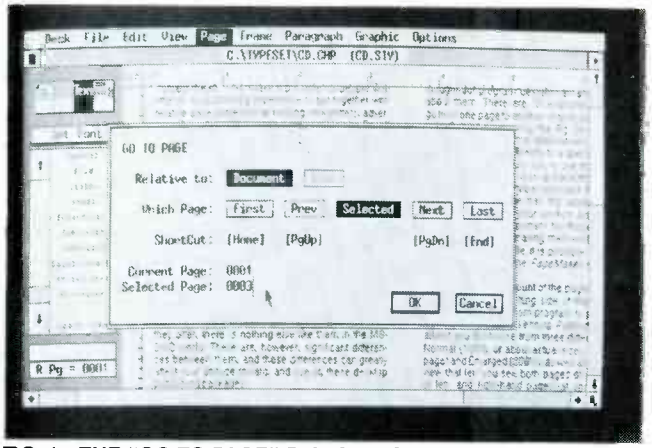

FIG. 1—THE "GO TO PAGE" DIALOG BOX in Ventura allows you to jump to any page in a document.

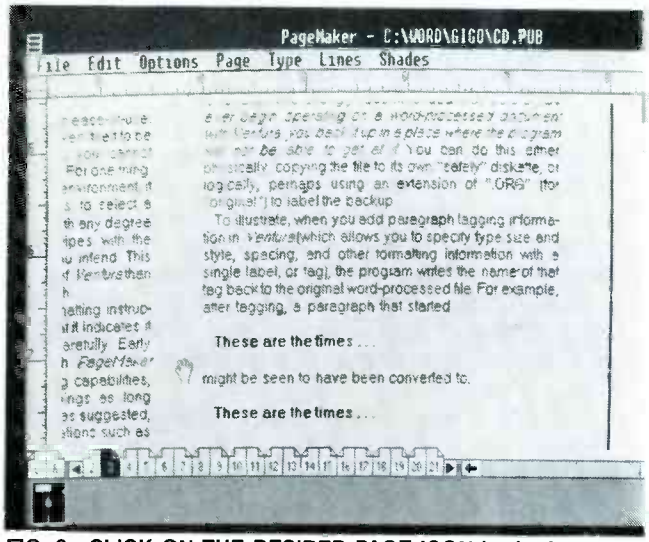

FIG. 2—CLICK ON THE DESIRED PAGE ICON in the lower left corner of the screen to go to that page in PageMaker. The current version of your publication is automatically saved for you. The "grabber hand" between the two columns of text provides an easy way of changing the view.

vironment. GEM and Windows provide similar working environments, but they differ enough from one another so that once you establish a preference for one, switching to the other requires some effort.

Getting around in a program provides a good example of how established preferences (and well-thought-out program design) can affect your feelings toward that program. There are, for example, several ways to go from one page to another in both programs. In Ventura Publisher, pressing the PgDn key moves you ahead a page at a time. Alternatively, you can instruct the program to jump directly to a specific page, as shown in Fig. 1. PageMaker also allows you to jump to a specific page, or you can simply "click" on the icon at the bottom of the screen showing the page number you want (Fig. 2). (See the glossary elsewhere in this section for definitions of click and other mouse-related terms.) The click method in PageMaker has the added advantage of automatically saving the current page to disk before jumping to the new page—and that's especially important for those who aren't as conscientious about periodically saving their work as they should be. It's possible to work with either method, but the PageMaker system is more convenient.

On-screen views

In both quantity and quality, page views—the amount of a page you can see on-screen—also differ from program to program, as do the resulting sizes of the characters and graphic images. Ventura Publisher, for example, allows you to choose from three different page views: Normal (100%, or about actual size), Reduced (entire page), and Enlarged (200%), as well as a Facing Pages view that lets you see both pages of a spread—a pair of left- and right-hand pages—at once. Views can be selected by picking an item from a menu, or by using a Control-key combination from the keyboard. The latter can be annoying for left-handed mouse users, because you must let go of the mouse, move your hand to the keyboard, press the appropriate keys, and then find the mouse again.

With a high-resolution, full-page vertical-screen monitor—a $1000+ investment, as shown in Fig. 3—those three views might be enough. On an ordinary PC-type screen, however, you can usually see only a portion of a page at one time. At 100% and 200% magnifications, the only ones at which ordinary type sizes can be read, you must scroll blindly around the page to find what you want to see. Scrolling becomes laborious if you don't know where a particular piece of text is located, because Ventura Publisher requires you to use separate vertical and horizontal scroll bars to move the page around in the screen's field of view.

Pagemaker provides you with more view-size choices, and with a more convenient system for working with them. In addition to allowing you to view pages at the three magnifications used by Ventura, PageMaker permits you to examine a page at 50% and 75% magnifications, which are frequently useful for getting an overall picture of a page while still being able to make out many of the details on it.

Moving around PageMaker's screen is simpler than moving around Ventura's. It can be accomplished in several ways. There are, for those who are comfortable with them, scroll bars that, in effect, move the electronic page

FIG. 3—A HIGH-RESOLUTION FULL-SCREEN MONITOR will permit you to view more of your work more legibly than a mono or EGA monitor. Such monitors generally cost $1000 and more, but are a necessity for serious desktop publishing work.

beneath the screen window. There is also what Aldus calls a "grabber hand," which was shown back in Fig. 2. The hand seems to grab onto the page and slide it in the direction you move your mouse. The grabber hand permits movement in any direction, so it is considerably more convenient than combining separate horizontal and vertical movements via scroll bars.

A third type of screen movement relates another way in which PageMaker allows you to change page-size view. Besides the ability to select page views from menus and with Control-key combinations, PageMaker also has a simple "point-and-click" method of going from one size to another. Just by clicking on a page you are automatically switched to the next larger or smaller view, depending on the current view.

Further, the point where you click will become the center of the new view. To see a close-up, then, of a particular portion of a full-page view, all you have to do is to click where you want to more detail—and that certainly speeds things up. Version 1.1 of Ventura offers a similar feature: When you change views using a Control-key combination, the part of the screen on which the mouse pointer rests becomes the center of the new view.

Another comment on Ventura Publisher's ease-of-use: Ventura (especially in Version 1.0) has proven itself to be somewhat less than trustworthy. That is, you cannot always depend on it to do what you tell it to. For one thing, possibly as a result of its GEM operating environment, it is difficult, especially at low magnifications, to select a portion of text, or to operate on a graphic, with any degree of accuracy. It usually takes several swipes with the mouse to select precisely the material you want. The problem was worse in the original version of Ventura than in the updated one, but it exists in both.

Further, Ventura frequently seems to ignore formatting instructions, or to apply formatting contrary to what it indicates it is using, so you have to check your copy carefully. Early reviews praised Ventura Publisher for its global formatting capabilities, indicating that it was perfect for long articles and books. On the other hand, it was suggested that PageMaker was better suited to relatively short publications such as newsletters. However, in view of the fact that Ventura must be checked every step of the way for proper adherence to your instructions, whatever value this feature may pretend to offer is lost. *(Although global reformatting is not foolproof, Ventura offers better management of long documents: the ability to link "chapter" files together to create a multi-part document, and the ability to create tables of contents and indexes.*—Editor)

File Handling

The files created by both Ventura Publisher and PageMaker can be large, especially if much fancy formatting and graphics are involved. Each program handles files in a different way. Ventura breaks a publication up into a number of small files (Fig. 4), each containing information pertinent to a different aspect of that publication—captions, graphics, body text, etc. The total size of those files is not much greater than that of the simple text and graphics files by themselves.

Fortunately, Ventura keeps track of what's stored where and finds things automatically as needed. The package

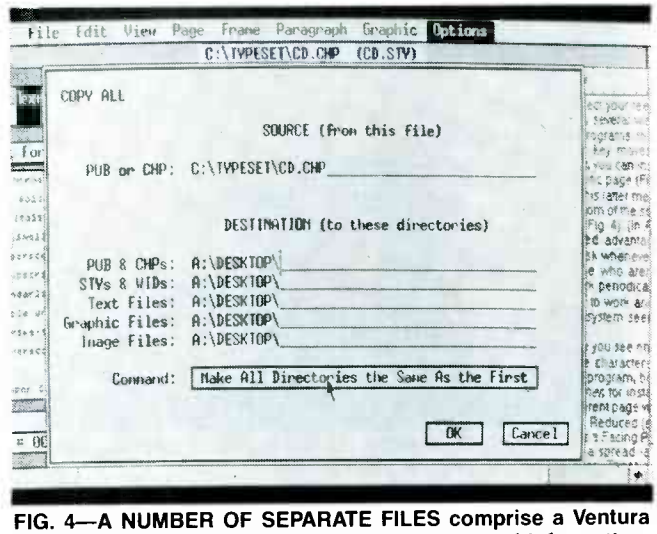

FIG. 4—A NUMBER OF SEPARATE FILES comprise a Ventura publication. Each file contains a different type of information, including text, graphics, format, etc.

includes a utility that will automatically find all the files related to a particular publication so they can be copied for backup or for transfer to another system.

By contrast, PageMaker puts everything required for a publication into a single file. Depending on the amount of formatting involved, even a single-page publication appears to require a minimum of almost 150K, and file sizes can rapidly approach—and exceed—the capacity of a 360K diskette. Special methods are required to transfer or backup such files.

One of the files that Ventura incorporates into a publication is the original text file. Unlike PageMaker, which imports a *copy* of a document file and leaves the original untouched, Ventura uses the original file, and modifies it as you edit and format it. The problem is that if you don't have a separate backup copy of your file, it's easy to modify it in ways you don't intend, possibly losing information. For example, while in Ventura, if you delete several paragraphs of text with the intention of bringing them into your publication somewhere else, you won't be able to unless you have a separate backup copy. For that reason, we strongly recommend that before you ever begin working on a document with Ventura, you back it up in a place where the program will not be able to get at it. You can do so by copying the file to a "safety" diskette, or perhaps by creating an additional copy on your hard disk with an .ORG extension (for original).

To illustrate: When you add paragraph-tagging information (which allows you to specify type size and style, spacing, and other formatting information) to a Ventura publication, the program writes the name of that tag back to the original text file, which can be in a number of different formats, including WordStar, XYwrite, DCA, etc. For example, a paragraph that begins:

These are the times . . .

might be converted to:

BODY TEXT = These are the times . . .

Ventura's ability to recognize and pick up tagging information from those embedded labels can be convenient if you intend to specify formatting as you write or edit with your word processor. It is, however, a nuisance if you want to print out the word-processed (not the Ventura) version of your document. In addition, Ventura doesn't

always recognize that embedded tagging information. In fact, it frequently seems to ignore it, or to carry over the embedded labels into the document as if they were text and not formatting information. That makes putting such formatting information into a text file—and trusting that it will make it through into your publication—a risky business, at best.

Graphics

Both Ventura Publisher and PageMaker are able to create simple graphics (lines, circles, boxes, etc.), and both can import graphics from AutoCAD, PC Paintbrush, and other CAD and draw/paint programs. Ventura and PageMaker offer comparable drawing facilities, and each has its own special touches. Pagemaker's graphics toolbox is shown in Fig. 5.

For example, besides serving to separate columns or to set off artwork in a publication, lines can be used for special effects. For example, if you use a radical (square root) sign, you may want to extend a line over the entire part of the mathematical expression included under that sign. Hyphens or dashes probably won't do the job, but a custom-drawn rule will.

Here, another facet of Ventura's imprecision shows itself. It turns out that Ventura works in much larger increments than PageMaker. That is, in PageMaker you can draw a line of any length, or extend or shorten a line to any length, and position it anywhere on the screen. The only restricting factor seems to be the resolution of the display being used.

Ventura, though, has definite ideas about such things. You can draw a line of this length or that, but not of any length in between (Fig. 6). Similarly, you can move the line to here or there, but not to an intermediate position. The quantum of movement seems to be only about the width of a character, but that's enough to frustrate many dreams of perfect composition.

Imported artwork is another story. In general, you can place a graphic image or digitized photograph anywhere you like, and, because it is a whole, any imprecision in placement will not affect its content. Within limits, either program even allows you to change the size and aspect (height-to-width) ratio of an image.

Both Ventura and Pagemaker have definite restrictions on the graphics programs (and devices, in the case of scanned images) from which they can import images. If you plan to incorporate graphics into a publication, check—before you get too deeply involved and it's too late—to make sure that the graphics material is compatible with the desktop publishing program you want to use.

Image format can also be a problem. AutoCAD, for example, can save drawings in several different formats. Ventura can use several of them; PageMaker allows you to select from several others. Of course, formats that PageMaker and Ventura can use are different.

Further, some of the acceptable formats do not translate completely when they are converted from the original AutoCAD format, and some special effects may get lost. That's not always important, but it may be critical in *your* application.

Also, one of the formats accepted by Ventura is not available in early versions of AutoCAD, only in the most recent ones. So be aware of what you're going to have to work with before you reach the point of no return.

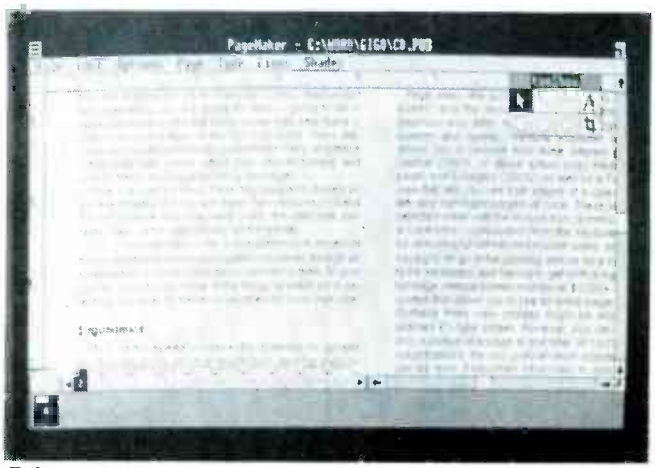

FIG. 5—PAGEMAKER PROVIDES A GRAPHICS TOOLBOX (shown in the upper right corner) that allows you to create lines, circles, and boxes, and to crop and scale graphics images.

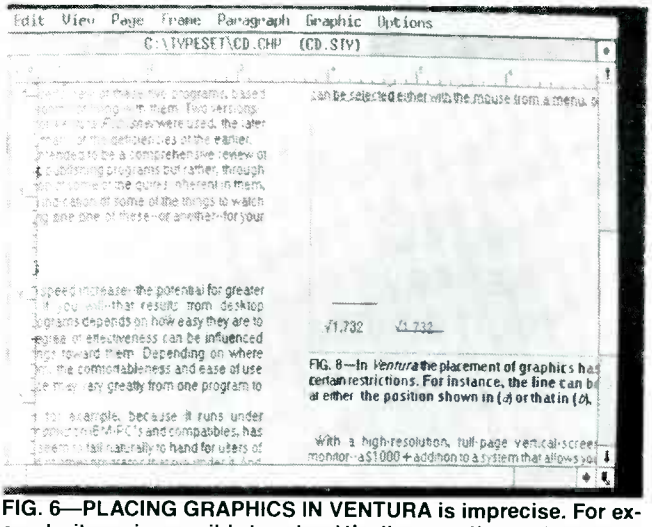

FIG. 6—PLACING GRAPHICS IN VENTURA is imprecise. For example, it was impossible to extend the line over the mathematical expression in the box properly. Either it is too high (left) or too low (right).

It's up to you

Just as there are those who feel that PageMaker is unquestionably superior to Ventura, there are no doubt a number of Ventura users who deride PageMaker as being too "Macintosh-y," too inconvenient, and too time-consuming. They may, for instance, be accustomed to using scroll bars to maneuver about the screen, and they may feel that any other system is awkward and perhaps even "unprofessional." And Ventura does have a number of specialized features that simply don't exist in PageMaker.

So to decide which program is best for you, you have to consider the type of publication you will produce, and the programs (word processor and graphics) you will use to create it. We mentioned some difficulties with AutoCAD earlier; another example is Microsoft Word: present versions of both PageMaker and Ventura can not accept formatting information contained in Word's style sheets. As for the missing features—can you work without them or around them?

You may come to the conclusion that neither program is suitable for your purposes, and that another will serve you better. But whatever you decide, we hope that the information presented here will give you some idea of what's available and the kinds of problems to expect.

PRINTER MULTIPLEXER

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tiplexer's timer may time out, in which case the multiplexer would resume scanning. It might then lock onto another port and mix up print jobs.

Another problem might be using a word-processor in a single-sheet mode, wherein the software pauses after printing each page and then allows you to insert a new sheet of paper. Again, during the pause, the multiplexer could resume scanning.

The solution in both cases would be to increase the timeout period. First try closing the sections of the DIP switch; if that doesn't help, you can increase resistor values, capacitor values, or both, in the 555 circuit.

Another less-desirable approach is to press the multiplexer's PAUSE button when you need to change sheets of paper. You could also take the printer off line.

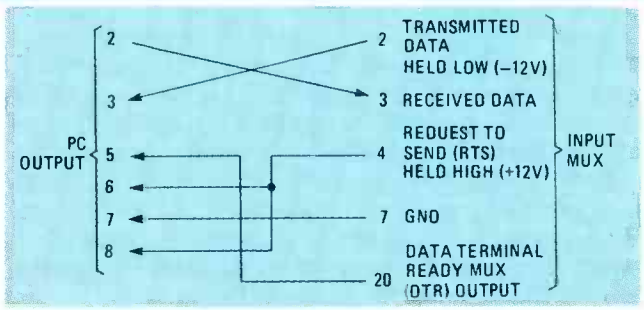

FIG. 7—HOW TO CONNECT THE MULTIPLEXER to an IBM PC or compatible.

Some programs may tell you that the printer is not ready if the DTR line is low. That could happen if a second print job were started before a first ended. In that case you may find that it is necessary to instruct your program to print several times until the multiplexer gets around to checking your port.

HARDWARE HACKER

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used between the *IIc* and the adaptor.

It is very important that both ends are speaking the same data rate and format. A good starting point is 1200 baud, no parity, and two stop bits. You can speed things up later after you get the basic process working.

Note particularly the treatment of pins 4 and 5. The COM-1 port uses the CTS and RTS auxiliary handshake signals, while their use and support on the Apple side is very rare.

Should you elect to use a communications program on the *IIc* end, you should also cross pins 2 to 3, 3 to 2, 6 to 20, and 20 to 6.

What's new this month?

There's an interesting RF/IF Signal Processing Handbook available free from the Mini-Circuits people. Among other products, they have some very low-cost (99 cents!) and ultra-wideband linear amplifiers available.

One possible source for oddball or discontinued IC's is Rochester Electronics. Stock here is catch as catch can.

You might want to see if you can qualify for a free subscription to the *NASA Tech Briefs*. This monthly magazine has all sorts of interesting ideas, some electronic, others just high tech. More often than not, their ideas "just barely miss", but with a little thinking and rework, there can be a gold mine here.

News and Views of Imagineering is a very interesting newsletter with lots of future oriented ideas in the electronics, computing, and related engineering fields.

There's also a publication called the *Payphone Exchange* if you are at all interested in the commercial payphone business. These days, most anyone can install their own private pay telephone just about anywhere they want to.

Turning to my own products, I've now got a complete set of autographed and bound *Ask the Guru* reprints from my sister column over in *Computer Shopper* magazine. Those mostly involve Apple-II computing and desktop publishing, plus several hacker goodies not found elsewhere.

And, if you might be thinking of converting your hardware hacking into a source of nickels, be sure to check out my *Incredible Secret Money Machine* book. Write or call, and I'll be happy to send you more info on these and others. **R-E**

"Using a metal detector in this weather isn't as dumb as you think! We're looking for the snow plow!"

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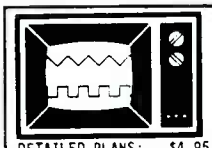

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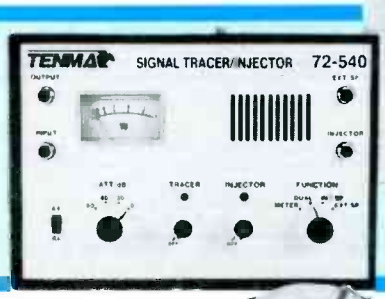

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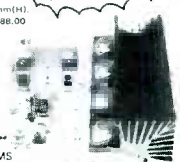
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LM309K	1.25	LM747	.69
LM311	.59	MC1330	1.69
LM311H	.89	MC1350	1.19
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LM317T	.69	LM1488	.49
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LM319	1.25	LM1496	.85
LM320 see7900		ULN2003	.79
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LM393	.45	RC4558	.69
LM394H	5.95	LM13600	1.49
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TL497	3.25	75110	1.95
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NE556	.49	75154	1.95
NE558	.79	75188	1.25
NE564	1.95	75189	1.25
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LM566	1.49	75452	.39
NE590	2.50	75477	1.29

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6551	2.95

2.0 MHz

6502A	2.69
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6545A	3.95
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6502B	4.25

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6809	2.95
6809E	2.95
6810	1.95
6820	2.95
6821	1.25
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68B09	5.99
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Z80-CPU	1.25

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Z80A-CTC	1.69
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2797	29.95
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4.0	1.95
5.0	1.95
5.0688	1.95
6.0	1.95
6.144	1.95
8.0	1.95
10.0	1.95
10.738635	1.95
12.0	1.95
14.31818	1.95
16.0	1.95
18.0	1.95
18.432	1.95
20.0	1.95
22.1184	1.95
24.0	1.95
32.0	1.95

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1.8432	5.95
2.0	5.95
2.4576	5.95
2.5	5.95
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
16.0	4.95
18.432	4.95
20.0	4.95
24.0	4.95

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74F04	.35
74F08	.35
74F10	.35
74F32	.35
74F64	.55
74F74	.39
74F86	.55
74F138	.79
74F139	.79
74F253	.89
74F157	.89
74F240	1.29
74S00	.29
74S02	.29
74S04	.29
74S08	.35
74S10	.29
74S32	.35
74S74	.49
74S86	.35
74S112	.50
74S124	2.75
74S138	.79
74S153	.79
74S157	.79
74S158	.95
74S163	1.29
74S175	.79
74S195	1.49
74S240	1.49
74S241	1.49
74S244	1.49
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74S373	1.69
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74S471	4.95
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4011	.19	4069	.19	74HC157	.55
4012	.25	4070	.29	74HC244	.85
4013	.35	4081	.22	74HC245	.85
4015	.29	4093	.49	74HC273	.69
4016	.29	14411	9.95	74HC373	.69
4017	.49	14433	14.95	74HC374	.69
4018	.69	14497	6.95	74HCT00	.25
4020	.59	4503	.49	74HCT02	.25
4021	.69	4511	.69	74HCT04	.27
4023	.25	4518	.85	74HCT08	.25
4024	.49	4528	.79	74HCT32	.27
4025	.25	4538	.95	74HCT74	.45
4027	.39	4702	9.95	74HCT138	.55
4028	.65	74HC00	.21	74HCT139	.55
4040	.69	74HC02	.21	74HCT161	.79
4042	.59	74HC04	.25	74HCT240	.89
4044	.69	74HC08	.25	74HCT244	.89
4046	.69	74HC10	.25	74HCT245	.99
4047	.69	74HC14	.35	74HCT273	.99
4049	.29	74HC32	.35	74HCT373	.99
4050	.29	74HC74	.35	74HCT374	.99
4051	.69	74HC86	.45	74HCT393	.99
4052	.69	74HC138	.45	74HCT4017	1.19
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6.8	15V	.42	2.2	35V	.19
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22	15V	.99	10	35V	.69

DISC

10µf	50V	.05	.001µf	50V	.05
22	50V	.05	.005	50V	.05
33	50V	.05	.01	50V	.07
47	50V	.05	.05	50V	.07
100	50V	.05	.1	12V	.10
220	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
4.7	50V	.11	10	50V	.16
10	50V	.11	22	16V	.14
47	35V	.13	47	50V	.19
100	16V	.15	100	35V	.19
220	35V	.20	470	50V	.29
470	25V	.30	1000	16V	.29
2200	16V	.70	2200	16V	.70
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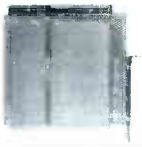

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WBU-208	3220	TIE POINTS	39.95

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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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7808T	.49	7905K	1.69
7812T	.49	7912K	1.49
7815T	.49	78L05	.49
7905T	.59	78L12	.49
7908T	.59	79L05	.69
7912T	.59	79L12	1.49
7915T	.59	LM323K	4.79
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1N4148	25/$1.00	4N33	.89
1N4004	10/$1.00	4N37	1.19
1N5402	.25	MCT-2	.59
KBP02	.55	MCT-6	1.29
2N2222	.25	TIL-111	.99
PN2222	.10	2N3906	.10
2N2907	.25	2N4401	.25
2N3055	.79	2N4402	.25
2N3904	.10	2N4403	.25
4N26	.69	2N6045	1.75
4N27	.69	TIP31	.49

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16	IDWRAP 16	10	1.95
18	IDWRAP 18	5	1.95
20	IDWRAP 20	5	1.95
22	IDWRAP 22	5	1.95
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IDC CONNECTORS/RIBBON CABLE

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
WIREWRAP HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WIREWRAP HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.63	.89	.95	1.29	1.49	1.69
RIBBON HEADER	IDMxx	---	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	.85	1.25	1.35	1.75	2.05	2.45
10' GREY RIBBON CABLE	RCxx	1.60	3.20	4.10	5.40	6.40	7.50

FOR ORDERING INSTRUCTIONS, SEE D-SUBMINIATURE CONNECTORS, BELOW

SPECTRONICS CORPORATION EPROM ERASERS

Model	Timer	Chip Capacity	Intensity (uW/Cm²)	Unit Cost
PE-140	NO	9	8,000	$89
PE-140T	YES	9	8,000	$139
PE-240T	YES	12	9,600	$189

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SPDT	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.50
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SPST	MINI-PUSHBUTTON N.O.	.39

DIP SWITCHES

4 position	.85	7 position	.95
5 position	.90	8 position	.95
6 position	.90	10 position	1.29

D-SUBMINIATURE CONNECTORS

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.45	.59	.69	.69	1.35	1.85
	FEMALE	DBxxS	.49	.69	.75	.75	1.39	2.29
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	.49	.69	---	.79	2.27	---
	FEMALE	DBxxSR	.55	.75	---	.85	2.49	---
WIREWRAP	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	1.39	1.99	---	2.25	4.25	---
	FEMALE	IDBxxS	1.45	2.05	---	2.35	4.49	---
HOODS	METAL	MHOODxx	1.05	1.15	1.25	1.25	---	---
	GREY	HOODxx	.39	.39	---	.39	.69	.75

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 59¢

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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
TIL-313	COM CATHODE	.3"	.45
TIL-311	4x7 HEX W/LOGIC	.270"	10.95

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		1-99	100-UP
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JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

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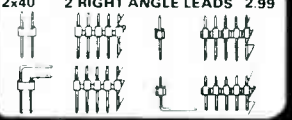

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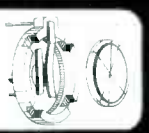
HOLDER $1.49



25 PIN D-SUB GENDER CHANGERS $7.95

IC SOCKETS/DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
SOLDERTAIL SOCKETS	xxST	.11	.11	.12	.15	.18	.15	.20	.22	.30
WIREWRAP SOCKETS	xxWW	.59	.69	.69	.99	1.09	1.39	1.49	1.69	1.99
ZIF SOCKETS	ZIFxx	---	4.95	4.95	---	5.95	---	5.95	6.95	9.95
TOOLED SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
TOOLED WW SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIERS	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
DIP PLUGS (IDC)	IDPxx	.95	.49	.59	1.29	1.49	---	.85	1.49	1.59

FOR ORDERING INSTRUCTIONS, SEE D-SUBMINIATURE CONNECTORS, ABOVE

The JDR system was well engineered. Parts did fit together well, and everything worked perfectly the very first time I flipped on the power...A real genius could probably find everything he'd need at JDR to build a revolutionary new computer.

Steve Kosek – Chicago Tribune

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COILED KEYBOARD EXTENDER	$7.95

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- SET X-Y AXIS FOR AUTO CENTER OR FREE MOVEMENT
- FIRE BUTTON FOR USE WITH GAME SOFTWARE
- INCLUDES ADAPTOR CABLE FOR IBM

SWITCHING POWER SUPPLIES

PS-135 $59.95

- FOR IBM XT COMPATIBLE
- UL APP., 135 WATTS
- +5V/15A, +12V/4.2A -5V/.5A, -12V/.5A
- ONE YEAR WARRANTY

PS-150 *150W MODEL* $69.95

PS-135/150

PS-200 $89.95

- FOR IBM AT COMPATIBLE
- 200 WATTS
- +5V/22A, +12V/8A -5V/.5A, -12V/.5A
- ONE YEAR WARRANTY

PS-200

PS-A $49.95

- FOR APPLE TYPE SYSTEM
- +5V/6A, +12V/3A -5V/1A, -12V/1A
- APPLE CONNECTOR

PS-1558 $34.95

- 75 WATTS, UL APPROVED
- BY POWER SYSTEMS
- +5V 7A, +12V/3A -12V/250mA, -5/300mA

PS-1558

MONITORS

SAMSUNG MONOCHROME

- IBM COMPATIBLE TTL INPUT
- 12" NON-GLARE, LOW DISTORTION, AMBER SCREEN
- RES: 720 x 350
- SWIVEL BASE
- 1 YEAR WARRANTY

$129.95

MULTISYNC *BY NEC* $549.95

- ORIGINAL CGA/EGA/PGA COMPATIBLE MONITOR
- AUTO FREQUENCY ADJUSTMENT
- RESOLUTION AS HIGH AS 800 x 560

EGA *BY CASPER* $399.95

- 15.75/21.85 KHz SCANNING FREQUENCIES
- RES: 640 x 200/350
- .31mm DOT PITCH
- 14" BLACK MATRIX SCREEN
- 16 COLORS FROM 64

RGB *BY CASPER* $279.95

- COLOR/GREEN/AMBER SWITCH
- RES: 640 x 240
- RGB/IBM COMPATIBLE
- 14" NON-GLARE SCREEN
- .39mm DOT PITCH
- CABLE FOR IBM PC INCLUDED

MONOCHROME *BY SAKATA* $69.95

- IBM COMPATIBLE TTL INPUT
- 12" NON-GLARE GREEN SCREEN
- CABLE FOR IBM PC INCLUDED

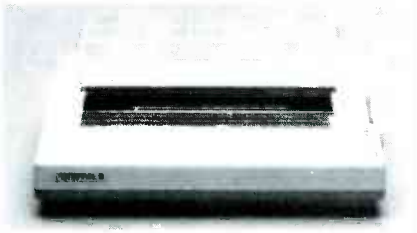
TOLL FREE 800-538-5000 U.S. AND CANADA

20MB HARD DISK ON A CARD

- SAVES SPACE AND REDUCES POWER CONSUMPTION
- IDEAL FOR PCs WITH FULL HEIGHT FLOPPIES
- LEAVES ROOM FOR A HALF LENGTH CARD IN ADJACENT SLOT

$349

RITEMAN II PRINTER



- 160 CPS DRAFT, 32 CPS NLQ MODE
- SUPPORTS EPSON/IBM GRAPHICS
- 9 x 9 DOT MATRIX
- FRICTION AND PIN FEEDS
- VARIABLE LINE SPACING & PITCH

$219.95

IBM COMPATIBLE PRINTER CABLE $9.95

REPLACEMENT RIBBON CARTRIDGE $7.95

DISK DRIVES

5¼" SEAGATE HARD DISK DRIVES

ST-225	HALF HEIGHT 20MB 65ms	$259
ST-238	HALF HEIGHT 30MB 65ms (RLL)	$299
ST-251	HALF HEIGHT 40MB 40ms	$469
ST-277	HALF HEIGHT 60MB 40ms (RLL)	$649
ST-4038	FULL HEIGHT 30MB 40ms	$559
ST-4096	FULL HEIGHT 80MB 28ms	$895

½ HEIGHT FLOPPY DISK DRIVES

5¼" TEAC FD-55B DS/DD 360K	$99.95
5¼" TEAC FD-55F DS/QUAD 720K	$119.95
5¼" TEAC FD-55G DS/HD 1.2M	$129.95
5¼" FUJITSU M2551A DS DD 360K	$89.95
5¼" FUJITSU M2553K DS HD 1.2M	$119.95
5¼" DS/DD 360K	$69.95
5¼" DS/HD 1.2M	$109.95
3½" MITSUBISHI DS/DD (AT OR XT)	$129.95

DISK DRIVE ACCESSORIES

½ HT MOUNTING HARDWARE FOR IBM	$2.95
MOUNTING RAILS FOR IBM AT	$4.95
"Y" POWER CABLE FOR 5¼" FDDs	$2.95
5¼" FDD POWER CONNECTORS	$1.19

DRIVE ENCLOSURES WITH POWER SUPPLIES

CAB-2SV5	DUAL SLIMLINE FOR 5¼"	$49.95
CAB-1FH5	FULL HEIGHT FOR 5¼"	$69.95
CAB-2SV8	DUAL SLIMLINE FOR 8"	$209.95
CAB-2FH8	DUAL FULL HEIGHT FOR 8"	$219.95

EASYDATA MODEMS

All models feature auto-dial/answer/redial on busy, power up self test, touchtone or pulse dialing, built-in speaker. Hayes and Bell Systems 103 & 212A compatible, full or half duplex, PC Talk III Communications software with internal models and more.

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12H	1200 BAUD ½ CARD	$69.95
24B	2400 BAUD FULL CARD	$179.95

EXTERNAL

(NO SOFTWARE INCLUDED)

12D	1200 BAUD	$119.95
24D	2400 BAUD	$219.95

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Attractive, sturdy steel cases fit the popular sized motherboards and include speakers, faceplates, expansion slots and all necessary hardware.

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ALL MCT PRODUCTS CARRY A 1 YEAR WARRANTY

INTERFACE CARDS

FROM MODULAR CIRCUIT TECHNOLOGY

LOW COST

MCT-CG

DISPLAY CARDS

MCT-MGP MONOCHROME GRAPHICS **$59.95**

TRUE HERCULES COMPATIBILITY, SUPPORTS LOTUS 123

- SOFTWARE DRIVER ALLOWS COLOR GRAPHICS PROGRAMS TO RUN ON A MONOCHROME MONITOR
- PARALLEL PRINTER PORT

MCT-EGA ENHANCED GRAPHICS ADAPTOR **$149.95**

100% IBM COMPATIBLE, PASSES IBM EGA DIAGNOSTICS

- 256K OF VIDEO RAM ALLOWS 640 x 350 IN 16 OF 64 COLORS
- COMPATIBLE WITH COLOR AND MONOCHROME ADAPTORS

MCT-CG COLOR GRAPHICS ADAPTOR **$49.95**

COMPATIBLE WITH IBM COLOR GRAPHICS STANDARDS

- SHORT SLOT SUPPORTS RGB, COLOR & COMPOSITE MONOCHROME
- 640/320 x 200 RESOLUTION, LIGHT PEN INTERFACE

MULTIFUNCTION CARDS

MCT-MF MULTIFUNCTION **$79.95**

ALL THE FEATURES OF 6 PACK - AT HALF THE PRICE

- 0-384K DYNAMIC RAM USING 4164s
- SERIAL, PARALLEL, GAME PORTS, CLOCK/CALENDAR

MCT-MGMIO MONOGRAPHICS I/O **$119.95**

TOTAL SYSTEM CONTROL FROM A SINGLE SLOT

- 2 FLOPPY CONT, SERIAL, PARALLEL, GAME FORT, CLOCK/CAL
- RUN COLOR GRAPHICS SOFTWARE ON A MONOCHROME MONITOR

MCT-MIO MULTI I/O FLOPPY **$79.95**

A PERFECT COMPANION FOR OUR MOTHERBOARDS

- SERIAL, PARALLEL, GAME PORT, CLOCK/CALENDAR
- SUPPORTS UP TO 2 360K FLOPPIES, 720K WITH DOS 3.2

MIO-SERIAL 2nd SERIAL PORT $15.95

MCT-IO MULTI I/O CARD **$59.95**

USE WITH MCT-FH FOR A MINIMUM OF SLOTS USED

- SERIAL PORT, CLOCK/CALENDAR WITH A BATTERY BACK-UP
- PARALLEL PRINTER PORT ADDRESSABLE AS LPT1 OR LPT2

IO-SERIAL 2nd SERIAL PORT $15.95

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ADDS UP TO 3 MEGABYTES OF RAM TO THE AT

- USER EXPANDABLE TO 1.5 MB OF MEMORY (ZERO K INSTALLED)
- INCLUDES SERIAL PORT AND PARALLEL PORT

ATMF-SERIAL 2nd SERIAL PORT $24.95
MCT-ATMF-MC PIGGYBACK BOARD (NO MEMORY) $29.95

MCT-ATIO AT MULTI I/O **$59.95**

USE WITH MCT-ATFH FOR A MINIMUM OF SLOTS USED

- SERIAL, PARALLEL AND GAME PORTS
- USES 16450 SERIAL SUPPORT CHIPS FOR HIGH SPEED OPERATION

ATIO-SERIAL 2nd SERIAL PORT $24.95

MEMORY CARDS

MCT-RAM 576K RAM CARD **$59.95**

A CONTIGUOUS MEMORY SOLUTION IN A SHORT SLOT

- USER SELECTABLE CONFIGURATION AMOUNTS UP TO 576K USING 64K & 256K RAM CHIPS (ZERO K INSTALLED)

MCT-EMS EXPANDED MEMORY CARD **$129.95**

2 MB OF LOTUS INTEL MICROSOFT COMPATIBLE MEMORY FOR XT

- CONFORMS TO LOTUS/INTEL EMS
- USER EXPANDABLE TO 2 MB
- EXPANDED/CONVENTIONAL MEMORY, RAMDISK AND SPOOLER

MCT-ATEMS AT VERSION $139.95

DRIVE CONTROLLERS

MCT-FDC FLOPPY DISK CONTROLLER **$29.95**

QUALITY DESIGN OFFERS 4 FLOPPY CONTROL IN A SINGLE SLOT

- INTERFACES UP TO 4 FDDs TO AN IBM PC OR COMPATIBLE
- SUPPORTS BOTH DS/DD AND DS/QD WITH DOS 3.2

MCT-HDC HARD DISK CONTROLLER **$79.95**

HD CONTROL FOR WHAT OTHERS CHARGE FOR FLOPPY CONTROL

- SUPPORTS 16 DRIVE SIZES INCLUDING 5, 10, 20, 30 & 40 MB
- DIVIDE 1 LARGE DRIVE INTO 2 SMALLER, LOGICAL DRIVES

MCT-FDC-1.2 1.2MB FLOPPY CONTROLLER **$69.95**

ADD VERSATILITY & CAPACITY TO YOUR XT

- SUPPORTS 2 DRIVES, BOTH MAY BE 360K OR 1.2 MEG
- ALLOWS DATA TO FLOW FREELY FROM XTs TO ATs

MCT-FH FLOPPY/HARD CONTROLLER **$139.95**

SYSTEM STARVED FOR SLOTS? SATISFY IT WITH THIS TIMELY DESIGN

- INTERFACES UP TO 2 FDDs & 2 HDDs, CABLING FOR 2 FDDs & 1 HDD
- SUPPORTS BOTH DS DD & DS/QD WITH DOS 3.2

MCT-ATFH AT FLOPPY/HARD CONTROLLER **$149.95**

FLOPPY HARD DISK CONTROL IN A TRUE AT DESIGN

- SUPPORTS UP TO 2 360K 720K 1.2MB FDDs AS WELL AS 2 HDDs USING STANDARD CONTROL TABLES

Seagate

½ HEIGHT HARD DISK DRIVES

40 MB $469

60 MB $649

Drives are Seagate models ST-251 (40 MB) & ST-277 (60 MB RLL) 5¼" half heights FAST 40ms access time!

½ HT HARD DISK SYSTEMS

20 MB $289

30 MB $329

Systems include Seagate ½ height hard drive, drive controller, cables & instructions. All drives are pre-tested & warranted for 1 year.

IBM COMPATIBLE MOTHERBOARDS

FROM MODULAR CIRCUIT TECHNOLOGY

MCT-TURBO TURBO 4.77/8 MHz **$99.95**

- 4.77 OR 8 MHz OPERATION WITH 8088-2 & OPTIONAL 8087-2 CO-PROCESSOR
- FRONT PANEL LED SPEED INDICATOR AND RESET SWITCH SET SUPPORTED
- CHOICE OF NORMAL/TURBO MODE OR SOFTWARE SELECT PROCESSOR SPEED

MCT-XTMB STANDARD MOTHERBOARD $87.95

MCT-ATMB 80286 6/8 MHz **$379.95**

- 8 SLOT (2 EIGHT BIT, 6 SIXTEEN BIT) AT MOTHERBOARD
- HARDWARE SELECTION OF 6 OR 8 MHz
- 1 WAIT STATE
- KEYLOCK SUPPORTED, RESET SWITCH, FRONT PANEL LED INDICATOR
- SOCKETS FOR 1 MB OF RAM AND 80287
- BATTERY BACKED CLOCK

MCT-BATMB MINI 80286 **$389.95**

- REPLACEMENT BOARD FOR XT STYLE CHASSIS
- OPERATE AT 6/10 MHz WITH UP TO 1MB ON-BOARD MEMORY (ZERO K INSTALLED)
- SOCKET FOR 80287 MATH CO-PORCESSOR
- BATTERY BACKED CLOCK
- 8 SLOTS: 2 EIGHT BIT, 6 SIXTEEN BIT
- USES CHIPS & TECHNOLOGY CHIP SET FOR RELIABILITY AND SMALL SIZE

IBM COMPATIBLE KEYBOARDS

FULL ONE YEAR WARRANTY

MCT-5339 **$79.95**

- IBM ENHANCED STYLE LAYOUT
- SOFTWARE AUTOSENSE FOR XT OR AT COMPATIBLES
- LED INDICATORS
- AUTO REPEAT FEATURE
- SEPARATE CURSOR PAD

MCT-5060 **$59.95**

- IBM AT STYLE LAYOUT
- SOFTWARE AUTOSENSE FOR XT OR AT COMPATIBLES
- LED INDICATORS
- AUTO REPEAT FEATURE

MCT-5150 XT STYLE LAYOUT **$49.95**

MCT-5151 KB5151™ EQUIV. **$69.95**

WHY BUY A SYSTEM FROM JDR?

- BUILD IT YOURSELF AND SAVE!
- MONEY BACK GUARANTEE (ASK FOR DETAILS)
- LEARN ABOUT THE INNER WORKINGS OF A COMPUTER
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- MOST ORDERS SHIPPED IN 24 HOURS
- QUALITY COMPONENTS AND COMPETITIVE PRICES
- TOLL FREE TECH SUPPORT IN THE U.S. AND CANADA

BUILD YOUR OWN 256K XT COMPATIBLE

- MOTHERBOARD
- 256K OF MEMORY
- 135 WATT POWER SUPPLY
- FLIP-TOP CASE
- XT STYLE KEYBOARD
- 360K FLOPPY DRIVE
- DRIVE CONTROLLER
- MONOCHROME MONITOR
- GRAPHICS ADAPTOR

FOR ONLY $494.01

ANYONE CAN BUILD A SYSTEM IN ABOUT 2 HOURS USING A SCREWDRIVER AND OUR EASY-TO-FOLLOW INSTRUCTIONS!

DEVELOPMENT TOOLS

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PROGRAMS 27xx & 27xxx EPROMS UP TO 27512

- SUPPORTS VARIOUS PROGRAMMING FORMATS AND VOLTAGES
- SPLIT OR COMBINE CONTENTS OF SEVERAL EPROMS OF DIFFERENT SIZES
- READ, WRITE, COPY, ERASE CHECK AND VERIFY
- SOFTWARE FOR HEX AND INTEL HEX FORMATS

MCT-EPROM-4 4 GANG PROGRAMMER **$189.95**
MCT-EPROM-10 10 GANG PROGRAMMER **$299.95**

MCT-PAL PAL PROGRAMMER **$269.95**

MCT-MP PROCESSOR PROG. **$199.95**

PARTIAL LISTING ONLY-CALL FOR A FREE CATALOG!

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What's New at AMERICAN DESIGN COMPONENTS?

"The Source" of the electro-mechanical components for the hobbyist.

We warehouse 60,000 items at American Design Components – expensive, often hard-to-find components for sale at a fraction of their original cost!

You'll find every part you need – either brand new, or removed from equipment (RFE) in excellent condition. But quantities are limited. Order from this ad, or visit our retail showroom and find exactly what you need from the thousands of items on display.

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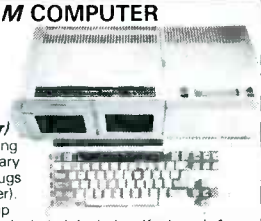
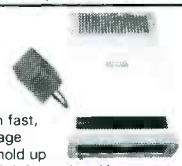
THERE'S NO RISK.
With our full 90-day warranty, any purchase can be returned for any reason for full credit or refund.

ADAM COMPUTER



(Less printer)
No wiring necessary (just plugs together). Hook-up diagram included. Includes: Keyboard, 1 cassette digital data drive, 2 game controllers, power supply, & one cassette. Capable of running CP/M, has built-in word processor.
Item #7410 Complete – **$99.00**

ADAM 5¼" DISK DRIVE



Gives your Adam fast, reliable data storage & retrieval. Can hold up to 160K bytes of information. Uses industry-standard SS/DD disks. Connects directly to your Adam memory console. Comes w/disk drive power supply, Disk Manager disk and owner's manual.
Mfr – Coleco, model 7817
Item #12830 *Like New* – **$199.00**

Adam/ColecoVision Accessories . . .

Data Drive –
Item #6641 **$19.95**

Printer Power Supply –
Item #6642 **$14.95**

ASCII Keyboard –
Item #6643 **$19.95**

Controllers (Set of 4) –
Item #7013 **$9.95** RFE

***Adam* Cassettes** –
(Consisting of Smart Basic, Buck Rogers & blank cassette.) Item #7786
BAKER'S DOZEN – **$19.95**

***Adam* Link Modem (Software incl.)** –
Item #12358 **$29.95**

Auto-Dialer Address Book –
Item #12365 **$19.95**

Disk Drive Power Supply –
Item #14603 **$14.95**

***Adam* Daisy Print Wheel** –
Item #13305 **$3.95**

***Adam* Ribbon Cartridge** –
Item #13306 **$3.95**

***ColecoVision* to *Adam* Expansion Kit** –
Item #9918 **$59.95**

Expansion Module #2 –
Play arcade-quality driving & racing games on your *ColecoVision*. Incl. ***Turbo*** cartridge.
Item #13146 **$39.95** New

Roller Controller –
Gives full 360° game control. Hi-speed action of an arcade. Can be used w/ the *Adam*. Incl. ***Slither*** cartridge.
Item #13147 **$39.95** New

Super Action Controller Set –
Gives you individual control of 4+ on-screen players. Incl. ***Baseball*** cartridge.
Item #13148 **$39.95** New

3½", 20 Mb, HALF HT. HARD DISK DRIVE

Fits standard 5¼" spacing. High speed, low power.
Mfr – Lapine #LT200/2000
Item #15853 **$199.00** New

15 Mb 5¼" FULL HT. HARD DISK DRIVE

(IBM® PC/XT Compatible)
Removed from working equipment. Tested & formatted.
Mfr – CMI model CM5619
Item #14511 **$199.00**

10 Mb, 5¼", HALF HT. HARD DISK DRIVE

(IBM® Compatible)
Shock mounted, high speed, low power. Mfr – Tandon TM252
Item #13250 **$159.00**
Controller Card for above
Item #10150 **$89.00**

12", HIGH RES. TTL MONITOR

12 VDC/110 VAC (w/built-in power supply). Green phosphor. Schematic supplied.
Mfr – Capetronic #DS-1030;
Item #6811 **$19.95** New

Fans . . .

115 CFM MUFFIN® FANS

115 VAC, 60 Hz.; 21W.; 28A.; 3100 RPM; 5-blade model, aluminum housing. Can be mtd. for blowing or exhaust. Dim.: 4⅛" sq. x 1½" deep
NEW – Mfr: IMC
Item #1864 **$12.95**
USED – Mfr: Centaur/Howard
Item #5345 **$5.95**

27 CFM MINI FANS

115VAC; 50/60Hz.; 12W.
Low noise level fans, can be mounted for blowing or exhaust.

1" Thin –
Contains 9 plastic blades. Dim.: 3⅛" sq. x 1" deep
Mfr – Tobishi #U9201B
Item #10960 **$7.95** New

1½" Standard –
Contains 7 metal blades.
Mfr – Rotron #SU2A1
Item #5970 **$7.95** New

COMPUTER & GAME – EQUIPMENT –

5¼" FLOPPY DISKETTES

Single side/single density; 16 hard sectors. Mfr – Xerox #11R61630
Item #14537
Pack of 10 **$9.95** New

MAGNIFYING LAMP

Multi position, 30", completely adjustable swing arm w/3-way metal C-clamp. Has 4" diopter magnifying lens, w/ruler. Porcelain lamp socket, & on/off switch; uses up to a 60W bulb. Color: Beige. UL listed.
Item #13136 **$24.95** New

Protect your Printer/ Typewriter with our DIABLO CLEANING KIT

For printers & typewriters w/print wheel, spindle, & metal ball type print elements. Good for 5 cleanings. Incl.: platen cleaner, type/print element cleaner, sound shield cleaner, plus buffers & cloths.
Mfr – Diablo Supplies #9R87106
Item #15419
3 sets/**$14.95** New

STEPPING MOTORS for ROBOTICS . . .

Precision steppers with increments from 1 to 7.5 degrees. Speeds up to 5,000 steps.

Fig. 1

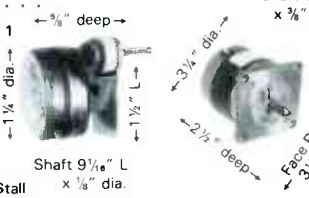


Fig. 2

Item No.	Step Angle	Volts DC	Stall Torque oz/in	Type	Mfr. & Part No.	Fig	Price
5431	1	5	17	PM	N.A. Phillips	1	$9.95 ea.
					A82310-M2		2/$14.95
5275	1.8	1.8	72	PM	Superior Electric	2	$19.95 ea.
				2 Ø	MO61-FF-6201B		2/$37.50
7630	1.8	3.0	200	PM	Superior Electric	2	$34.50 ea.
					M092-FT-402		2/$59.50

GIANT ZOOM LENS

Variable focal length (9.5 to 10.5")
High-quality precision lens system. Consists of: symmetrical lens with iris, 2 additional front elements (one movable & the other fixed). Focal length adjusts: 9.5 to 10.5". F 5.6 lens max. aperture variable F 5.6 to F 11.
Dim.: 4¹⁵⁄₁₆" L x 4¾" dia.
Mfr – Schneider Optics
Item #9349 **$29.95** New

– BATTERIES – FANS – BLOWERS

INTEGRATED CIRCUITS . . .

Static Rams . . .

2114-45	1024 x 4 (450ns)	$ .99	HM6116LP-3	2048 x 8 (150ns)	$1.89
2148-55		3.49	HM6116LP-4	2048 x 8 (200ns)	1.85
2149	1024 x 4 (45ns)	2.49	6147P		2.95
2167S-45		3.95	6167P-6		4.50

Dynamic Rams . . .

4116-200	16,384 x 1 (200ns)	$ .69	TMS4416	16,384 x 4 (150ns)	$3.75
4116-250	16,384 x 1 (250ns)	.49	4464-150	65,536 x 4 (150ns)	4.95
4164-150	65,536 x 1 (150ns)	1.25	8118	16,384 x 1 (120ns)	.49
TMS4164	65,536 x 1 (150ns)	1.95	41256-150	262,144 x 1 (150ns)	2.95

Eproms . . .

2708	1024 x 8 (450ns)	$4.95	2764-250	8192 x 8 (250ns)	$3.55
2716	2048 x 8 (450ns)	3.49	MCM68766	8192 x 8 (350ns)	15.95
TMS2532	4096 x 8 (450ns)	5.95	27128A-25	16,384 x 8 (250ns)	5.00
2732	4096 x 8 (450ns)	3.95	27128-250	16,384 x 8 (250ns)	4.25
2732A-25	4096 x 8 (250ns)	3.95	27C256	32,768 x 8 (250ns)	7.95
27C64	8192 x 8 (250ns)	4.95	27256	32,768 x 8 (250ns)	5.95
2764	8192 x 8 (450ns)	2.95	27512	65,536 x 8 (250ns)	11.55
2764A-25	8192 x 8 (250ns)	3.55			

Linear Devices . . .

LH0002CN	$5.35	LM319N	$1.07	LM380N	$ .80
LM10CLH	2.65	LM324N	.35	LM380N-8	.98
LH0070-0H	3.55	LM334Z	1.07	LM381N	1.16
TL071CP	.53	LM336Z	.98	LM383T	1.34
TL072CP	.71	LM337MP	1.03	LM385Z	1.70
LM301N	.32	LM337T	1.34	LM386N-4	.80
LM307N	.41	LM338K	3.55	LM389N	.90
LM310N	1.16	LM339N	.44	LM393N	.41
LM311N	.41	LF347N	.90	LF398N	2.15
LM317K	2.65	LM348N	.62	LF411CN	.71
LM317LZ	.62	LM350K	3.55	TL494CN	1.75
LM317MP	.80	LF353N	.53	TL496CP	1.34
LM317T	.90	LF356N	.80	TL497ACN	1.97
LM318N	1.07	LM358N	.44	NE555V	.26

Linear Devices (continued) . . .

XR-L555	$ .62	7824K	$11.21
LM556N	.53	7805T	.44
NE558N	1.07	7812T	.44
NE564N	1.75	7815T	.44
LM565N	.90	7818T	.44
LM566CN	1.25	7824T	.44
LM567V	.80	78S40	1.75
NE570N	2.24	7905K	1.21
NE571N	1.75	7906K	1.21
NE592N	.80	7912K	1.21
LM748CN	.53	7915K	1.21
DS8T28N	1.57	7918K	1.21
LM1456V	1.75	7924K	1.21
LM1458N	.44	7905T	.53
LM1488N	.62	7912T	.53
LM1496N	.90	7915T	.53
LM1899N	1.43	7918T	.53
ULN2003A	.90	7924T	.53
DS26LS31CN	1.34	79L12AC	.53
DS26LS32CN	1.34	79L15AC	.53
LM2901N	.53	LF13201N	2.33
LM2903N	.53	LM13600N	1.07
LM2907N	1.75	LM1889	1.85
LM2917N	1.39	75107N	.90
LM2917-14N	1.34	75108N	.90
LM2931CT	1.07	75110A	1.34
MC3346P	.90	75115	1.07
MC3486	1.34	75123N	1.34
MC3487	1.34	75124N	1.34
SG3524	1.75	75138N	2.65
LM3900N	.53	75154N	1.25
LM3914N	1.75	75450N	.53
RC4136N	.80	75451CN	.44
RC4151NB	.90	75452CN	.44
RC4193NB(DE)	2.65	75453CN	.44
7805K	1.21	75463N	.53
7812K	1.21	75472	.80
7815K	1.21	75492N	.71
7818K	1.21	76477	3.55

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Consists of 8 asstd. cartridges, incl.: ***Number Nabber, Star Post, Radar Rat, Jupiter Land, Viduzzles, Golf, Dragon's Den,*** & ***ABC Voice.***
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Set of 8 — **$39.95** New

C16 & +4
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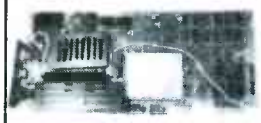
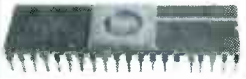
Set of 8 — **$29.95** New

COMMODORE VIC 20 CPU BOARD



Insides of the Commodore VIC 20. For parts only — guaranteed not to work!
Item #12144 **$14.95**

MICROCOMPUTER with EPROM MC68705



MC68705 — HMOS, 8-bit, medium performance microcomputer. On-chip resources: 3776 bytes Eprom, 112 bytes RAM, 8 inputs & 24 programmable bidirectional out-puts. Self-programming boot strap.
Item #13608 **$9.95**

ANALOG to DIGITAL CONVERTER

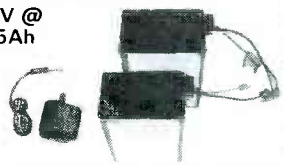
Binary output: 12 bit; Conversion time: 8 microseconds; Linearity: 8 ms. ±1/2 lbs. Parallel and series outputs; internal reference.
Mfr — Datel ADC-HZ-12BGC
Item #7052 (RFE—tested good!)
Originally ~~$130.00~~
Special — **$39.95**

SWITCHING POWER SUPPLY

DC Output: −5V @ .5A
+24V @ 1.0A
+5V @ 8.6A
Input: 115/230 VAC, 50/60 Hz.
Dim.: 7⅜"W x 1¾"H x 6⅛"D
Mfr — Xerox #105S80441
Item #15756 **$19.95** New

12V BATTERY PACK & MATING CHARGER

12V @ 9.5Ah



Consists of: 2 solid gell cell batteries, 6V @ 9.5Ah ea. Connected in series by a fusable harness. Mating battery charger: 12VDC @ 800Ma. Perfect for battery operated toys, robotics, solar storage, burglar & fire alarms, etc. OA Dim.: 4¼"W x 5½"H x 5½"D
Item #14619 **$29.95** New

A GANG OF BATTERIES

(4V increments @ 5Ah)

Rechargeable lead acid batteries, each is 4V @ 5Ah. Can be ganged (use 3 to make 12V), or connected in series or parallel to give any voltage or current in 4V increments.
Mfr — Gates 0809-0021
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(Please note: If you buy 3 to make 12V, price is $3.95 × 3.)

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140 VA

Provides voltage regulation & ultra-isolation for microprocessor-based equipment. Contains less than 3% harmonic distortion, better than 60 dB traverse noise rejection. Contains dual outlet for CPU & monitor, & 6 ft. line cord.
Input: 95 — 130V, 60Hz.
Output: 120V @ 1.17A
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Mtd on metal base w/rubber ft.
Mfr — Sola #63-13-114
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NEON TRANSFORMER

(Hi-Voltage)

7300VAC @ 5 Ma.
May be used for for powering neon lights, replacing oil burner ignition transformer, building Jacob's ladder (spark gap). High-volt. output: ¼ quick connect terminal & case ground input fully enclosed metal case. Wt.: 12 lbs. Base mount: 4½"H x 5⅛"W x 6⅞"
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Output: +5 VDC, .9A
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+12 VDC, .3A
Input: 120 VAC/60 Hz., .25A
Mfr — Coleco #55416
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9VDC ADAPTER

Input: 115 VAC, 50/60 Hz.
Output: 9.5V @ 1A.
Dim.: 2⅜"W x 3⅛"H x 2" deep
Commodore #251539-01/02
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(Microprocessor) HC-18U

Mhz.	Item #
1.8432	7915
3.2768	13911
3.579545	12361
4.0	7045
4.032	13041
5.0	13043
5.0688	6786
6.0	12362
6.144	13226
10.736835	1953
12.0	7920
13.7931	7362
14.31818	7359
16.0	13425
18.432	13227
20.0	12360
48.0	7389
122.666	7037

$1.75 ea.

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Dim.: 5½"H x 4⅛"W x 2⅜"D
Mfr — Elpower
Item #7039 **$14.95**

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Dim.: 4"H x 2⅝"W x 1¾"D
Major Mfrs.
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7½" Reel, 2400 ft.

Bulk erased. Major mfrs.: Arnpex, Scotch, etc.
Item #6711 — ¼ Mil.
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Dim.: 3½" sq. x1½" H.
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With 60W power supply (fan cooled).
Can accommodate:
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Input: 115/230V, 50/60 Hz.
Originally for Burroughs computer.
Dim.: 11"W x 8"H x 12" deep
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(Advanced version of the Timex 1000)

42-key mech. keybd. 2K RAM. Rev. video, Z80A, 6.5MHz processor, ROM 8K BASIC. Graphics cap./sound–music, TV or monitor. Joystick input. 115 VAC. AC adapt., TV cable, & cass. cables. Runs tapes for Sinclair/Timex 1000-ZX85 Mfr - Power 3000. (In orig. boxes.)
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7400

Part No.	1-9	10+	Part No.	1-9	10+
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7402	.29	.19	7486	.45	.35
7404	.29	.19	7489	2.05	1.95
7405	.35	.25	7490	.49	.39
7406	.39	.29	7493	.45	.35
7407	.39	.29	74121	.45	.35
7408	.35	.25	74123	.55	.45
7410	.29	.19	74125	.55	.45
7414	.49	.39	74126	.69	.59
7416	.39	.29	74143	3.95	3.85
7417	.39	.29	74150	1.35	1.25
7420	.35	.25	74154	1.35	1.25
7430	.35	.25	74158	1.59	1.49
7432	.39	.29	74173	.85	.75
7438	.39	.29	74174	.59	.49
7442	.55	.45	74175	.59	.49
7445	.79	.69	74176	.99	.89
7446	.89	.79	74181	1.95	1.85
7447	.89	.79	74189	1.95	1.85
7448	2.05	1.95	74193	.79	.69
7472	.89	.79	74198	1.85	1.75
7473	.39	.29	74221	.99	.89
7474	.39	.29	74273	1.95	1.85
7475	.49	.39	74365	.65	.55
7476	.45	.35	74367	.65	.55

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Part No.	1-9	10+	Part No.	1-9	10+
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74LS02	.29	.19	74LS166	.99	.89
74LS04	.35	.25	74LS173	.59	.49
74LS05	.35	.25	74LS174	.49	.39
74LS06	1.09	.99	74LS175	.49	.39
74LS07	1.09	.99	74LS189	4.59	4.49
74LS08	.29	.19	74LS191	.59	.49
74LS10	.29	.19	74LS193	.79	.69
74LS14	.49	.39	74LS221	.69	.59
74LS27	.35	.25	74LS240	.69	.59
74LS30	.29	.19	74LS243	.69	.59
74LS32	.35	.25	74LS244	.69	.59
74LS42	.49	.39	74LS245	.89	.79
74LS47	.99	.89	74LS259	.99	.89
74LS73	.39	.29	74LS273	.89	.79
74LS74	.35	.25	74LS279	.49	.39
74LS75	.39	.29	74LS322	4.05	3.95
74LS76	.55	.45	74LS365	.49	.39
74LS85	.59	.49	74LS366	.49	.39
74LS86	.35	.25	74LS367	.49	.39
74LS90	.49	.39	74LS368	.49	.39
74LS93	.49	.39	74LS373	.79	.69
74LS123	.59	.49	74LS374	.79	.69
74LS125	.49	.39	74LS393	.89	.79
74LS138	.49	.39	74LS590	6.05	5.95
74LS139	.49	.39	74LS624	2.05	1.95
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74LS157	.45	.35	74LS640	1.09	.99
74LS158	.45	.35	74LS645	1.09	.99
74LS163	.59	.49	74LS670	1.09	.99
74LS164	.59	.49	74LS688	2.39	2.29

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74S08	.35	74S196	2.49
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74S32	.35	74S244	1.49
74S74	.45	74S253	.79
74S85	1.79	74S287*	1.49
74S86	.49	74S288*	1.49
74S124	2.75	74S373	1.49
74S174	.79	74S374	1.49
74S175	.79	74S472*	2.95

74F

74F00	.29	74F139	.69
74F04	.29	74F157	.69
74F08	.29	74F193	2.95
74F10	.29	74F240	.99
74F32	.29	74F244	.99
74F74	.39	74F253	.69
74F86	.39	74F373	.99
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CD4008	.69	CD4081	.25
CD4011	.19	CD4082	.25
CD4013	.29	CD4093	.35
CD4016	.29	CD4094	.89
CD4017	.49	CD40103	2.49
CD4018	.59	CD40107	.49
CD4020	.59	CD40109	.79
CD4024	.49	CD4510	.69
CD4027	.35	CD4511	.69
CD4030	.29	CD4520	.75
CD4040	.65	CD4522	.79
CD4049	.29	CD4538	.79
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CD4053	.59	CD4555	.79
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50464-15	65,536 x 4	(150ns) (4464)	4.95
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2114N-2L	1024 x 4	(200ns) Low Power	1.49
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6264LP-12	8192 x 8	(120ns) LP CMOS	4.25
6264P-15	8192 x 8	(150ns) CMOS	3.49
6264LP-15	8192 x 8	(150ns) LP CMOS	3.75
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EPROMS

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TMS2532A	4096 x 8	(450ns) 21V	5.95
TMS2564	8192 x 8	(450ns) 25V	9.95
TMS2716	2048 x 8	(450ns) 3 Voltage	9.95
1702A	256 x 8	(1μs)	6.95
2708	1024 x 8	(450ns)	4.95
2716	2048 x 8	(450ns) 25V	3.75
2716-1	2048 x 8	(350ns) 25V	4.25
27C16	2048 x 8	(450ns) 25V (CMOS)	5.49
2732	4096 x 8	(450ns) 25V	3.95
2732A-20	4096 x 8	(200ns) 21V	4.25
2732A-25	4096 x 8	(250ns) 21V	3.95
27C32	4096 x 8	(450ns) 25V (CMOS)	5.95
2764-20	8192 x 8	(200ns) 21V	4.25
2764-25	8192 x 8	(250ns) 21V	3.75
2764A-25	8192 x 8	(250ns) 12.5V	3.95
2764-45	8192 x 8	(450ns) 21V	2.95
27C64-15	8192 x 8	(150ns) 21V (CMOS)	6.49
27128-20	16,384 x 8	(200ns) 21V	6.95
27128-25	16,384 x 8	(250ns) 21V	5.95
27128A-25	16,384 x 8	(250ns) 12.5V	5.25
27C128-25	16,384 x 8	(250ns) 21V (CMOS)	6.95
27256-20	32,768 x 8	(200ns) 12.5V	6.95
27256-25	32,768 x 8	(250ns) 12.5V	5.95
27C256-25	32,768 x 8	(250ns) 12.5V (CMOS)	7.95
27512-20	65,536 x 8	(200ns) 12.5V	13.49
27512-25	65,536 x 8	(250ns) 12.5V	11.95
68764	8192 x 8	(450ns) 25V	13.95

EEPROMS

2816A	2048 x 8	(350ns) 5V Read/Write	5.95
2817A	2048 x 8	(350ns) 5V Read/Write	7.95
2865A	8192 x 8	(250ns) 5V Read/Write	9.95
52B13 (21V)	2048 x 8	(350ns) 5V Read Only	1.49

COMMODORE CHIPS

Part No.	Price
LAG570	10.95
WD1770	11.95
SI3052P	2.49
6502	2.65
6504A	1.95
6507	4.39
6510	9.95
6520	1.95
6522	3.95
6525	4.95
6526	14.95
6529	2.95
6532	6.49
6545-1	4.95
6551	4.49
6560	10.95
6567	14.95
6569	24.95
6572	8.95
6581 (12V)	14.95
6582 (9V)	14.95
8360	14.95
8501	10.95
8502	7.95
8563	15.95
8564	9.95
8566	24.95
8701	9.95
8721	14.95
8722	9.95
*251104-04	10.95
310654-05	9.95
318018-03	10.95
318019-03	10.95
318020-04	10.95
325302-01	10.95
325572-01	14.95
*82S100PLA**	15.95
901225-01	11.95
901226-01	11.95
901227-03	11.95
901229-05	11.95

*No specs available
**Note: 82S100PLA = U17 (C-64)

SATELLITE TV DESCRAMBLER CHIP

The MM5321 is a TV camera sync generator designed to supply the basic sync functions for either color or monochrome 525 line/60Hz interfaced and camera video recorder applications. COLOR BURST GATE & SYNC ALLOW STABLE COLOR OPERATION

MM5321N. $11.95

INTERSIL Also Available!

74HC HI-SPEED CMOS

Part No.	Price	Part No.	Price
74HC00	.25	74HC175	.69
74HC02	.25	74HC221	1.19
74HC04	.29	74HC240	.99
74HC08	.29	74HC244	.99
74HC10	.29	74HC245	.99
74HC14	.49	74HC253	.59
74HC30	.29	74HC259	.89
74HC32	.29	74HC273	.99
74HC74	.39	74HC373	.99
74HC75	.39	74HC374	.99
74HC76	.45	74HC595	1.29
74HC85	.79	74HC688	.99
74HC86	.39	74HC943	8.95
74HC123	.89	74HC4040	.99
74HC125	.49	74HC4049	.59
74HC132	.69	74HC4050	.59
74HC138	.19	74HC4060	.99
74HC139	.49	74HC4511	1.29
74HC154	1.49	74HC4514	1.79
74HC163	.65	74HC4538	.89
74HC174	.69	74HC4543	1.19

74HCT — CMOS TTL

74HCT00	.29	74HCT139	.59
74HCT02	.29	74HCT157	.69
74HCT04	.29	74HCT174	.69
74HCT08	.29	74HCT175	.69
74HCT10	.29	74HCT240	.99
74HCT32	.29	74HCT244	.99
74HCT74	.49	74HCT245	1.19
74HCT86	.49	74HCT373	1.19
74HCT138	.59	74HCT374	1.19

74C—CMOS

74C00	.29	74C174	.79
74C02	.29	74C175	.79
74C04	.29	74C221	1.79
74C08	.35	74C240	1.79
74C10	.35	74C244	1.79
74C14	.59	74C373	1.95
74C32	.35	74C374	1.95
74C74	.59	74C912	8.95
74C85	1.49	74C915	1.39
74C86	.35	74C920	6.95
74C89	5.49	74C921	6.95
74C90	.99	74C922	3.95
74C154	2.95	74C923	3.95
74C173	1.05	74C925	5.95

LINEAR

DS0026CN	1.95	LM1458N	.39
TL074CN	1.19	LM1488N	.49
TL084CN	.99	DS14C88N (CMOS)	1.19
AF100-1CN	8.95	LM1489N	.49
LM307N	.45	DS14C89N (CMOS)	1.19
LM309K	1.25	LM1496N	.89
LM311N	.45	MC1648P	3.49
LM317T	.79	LM1871N	1.95
LM318N	.99	LM1872N	1.95
LM319N	1.29	LM1896N-1	1.49
LM323K	3.95	ULN2003A	.99
LM324N	.39	XR2206	3.95
LM338K	4.95	XR2211	2.95
LM339N	.39	XR2243	1.95
LF347N	1.79	26LS29	3.95
LM348N	.69	26LS31	1.19
LM350T	2.95	26LS32	1.19
LF351N	.39	26LS33	1.49
LF353N	.49	LM2901N	.39
LF355N	.79	LM2907N	1.29
LF356N	.89	LM2917N (8 pin)	1.95
LF357N	1.09	MC3419CL	6.95
LM358N	.49	MC3446N	1.69
LM360N	2.19	MC3450P	1.95
LM361N	1.79	MC3470P	1.95
LM380N-8	.99	MC3471P	1.95
LM386N-3	.89	MC3479P	4.79
LM387N	.99	MC3486P	1.69
LM393N	.39	MC3487P	1.69
LM399H	2.95	LM3900N	.49
LF411CN	.79	LM3905N	1.19
TL497ACN	1.49	LM3909N	.99
NE540H (C540H)	2.95	LM3914N	1.95
NE555V	.29	LM3916N	1.95
XR1555	.59	NE5532	.69
LM556N	.49	NE5534	.69
NE558N	.89	7805K (LM340K-5)	1.29
LM565N	.99	7812K (LM340K-12)	1.29
LM567V	.79	7815K (LM340K-15)	1.29
NE592N	.89	7805T (LM340T-5)	.49
LM741CN	.29	7812T (LM340T-12)	.49
LM747CN	.59	7815T (LM340T-15)	.49
MC1350P	1.09	7905K (LM320K-5)	1.35
MC1372P	1.95	7905T (LM320T-5)	.59
MC1377P	2.29	75472	.59
MC1398P	8.95	75477	.89
LM1414N	1.29	MC145106P	3.25
		MC145406P	2.95

IC SOCKETS

Low Profile		Wire Wrap (Gold) Level #3	
8LP	.11	8WW	.59
14LP	.12	14WW	.65
16LP	.13	16WW	.69
24LP	.25	24WW	1.19
28LP	.27	28WW	1.39
40LP	.29	40WW	1.89

Soldertail Standard (Gold & Tin) & Header Plug Sockets Also Available

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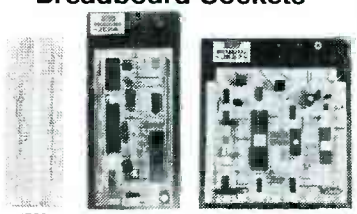
PROTOTYPING PRODUCTS

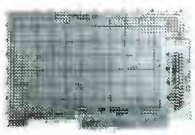
Jameco Solderless Breadboard Sockets



JE23 JE24 JE27

Part No	Dim. L x W	Contact Points	Binding Posts	Price
JE20	6½ x ¾	200	0	$ 2.29
JE21	3¼ x 2⅛	400	0	$ 4.49
JE22	6½ x 1⅜	630	0	$ 5.95
JE23	6½ x 2⅛	830	0	$ 7.49
JE24	6½ x 3⅛	1,360	2	$14.95
JE25	6½ x 4¼	1,660	3	$22.95
JE26	6⅞ x 5¾	2,390	4	$27.95
JE27	7¼ x 7½	3,220	4	$37.95

Jameco General Purpose Prototype PC Boards



JE417 (Pictured)

- Wire Wrap
- Component Testing
- Point-to-Point Wiring
- 31/62 Connection

JE415 (6½", No Pads, PC/XT). $14.95
JE417 (6½", Plated w/Pads, PC/XT). . . . $19.95

Extender Board

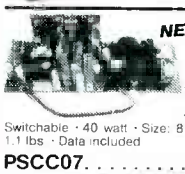
JE421 (4¾" Extender, 31/62 Connector) . . $19.95

DATA BOOKS

30003	National Linear Data Book (82).	$19.95
30005	Logic Data Book - Vol. II (84).	$19.95
30009	Intersil Data Book (87).	$14.95
21398	CMOS Cookbook (86).	$14.95
210830	Intel Memory Handbook (87).	$17.95
230843	Intel Microsystem Hndbk. Set (87). . . .	$24.95

MUFFIN/SPRITE-STYLE FANS

TA450S. $11.95
Torin Industries (4.68" sq., 50 cfm)
SU2A1. . . . . $11.95
EG&G Rotron (3.125" square, 34 cfm)



NEW! Switching Power Supply
+5V@5A, +12V@1A x 2

· Regulated, 110VAC/220VAC Switchable · 40 watt · Size: 8½"L x 3"W x 2⅝"H · Weight: 1.1 lbs · Data included

PSCC07. . . . . $14.95

Jameco Computer Power Protection

JE1190

JE1190 Power Base. $29.95
JE1191 6-Outlet Power Strip $11.95
JE1192 300 Watt Back-Up. . . . $299.95
JE1193 500 Watt Back-Up. . . . $399.95

IBM AND APPLE COMPATIBLE DISPLAY MONITORS

Franklin 12" Green Monochrome

Apple II, II+, *IIe*, *IIc* Compatible
· Composite video output · 18MHz
· Resolution: 800 lines at center

SMON. $59.95

SMON

12" Amber Monochrome —
TTL Input, High Resolution (PC/XT/AT)
AMBER. $109.95

14" RGB Color — CGA Compatible Amber/Green/Color Switchable, 640 x 200 Resolution (PC/XT/AT)
TTX1410. . . . . $279.95

14" EGA Color - EGA/CGA Compat., 720 x 350 (max.) resolution (PC/XT/AT)
TE5154. . . . . $399.95

14" Ultrascan Color — CGA/EGA/PGC/VGA Compatible, 800 x 560 (max.) Resolution (PC/XT/AT)
4375M. $579.95

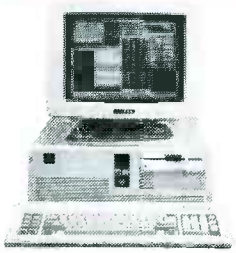
JE1055

IBM PC/XT/AT Compatible Cards

JE1050 Mono Graphics Card. . . . . $ 59.95
JE1052 Color Graphics Card. . . . . $ 49.95
JE1055 EGA Card. $149.95

JAMECO COMPUTER KITS

FREE! PC Write Word Processing Software Included!



Jameco's IBM™ AT Compatible Mini-286 6/8/10/12MHz Kit!

Part No.	Description	Price
JE1043	1.2M/360K Floppy Control . .	$ 49.95
JE1015	XT/AT Style Keyboard.	$ 59.95
41256-120	512K RAM (18 Chips) . . .	$ 89.10
JE1012	Baby AT Flip-Top Case. . . .	$ 69.95
JE1032	200W Power Supply.	$ 89.95
JE1022	5¼" High Density Disk Drive .	$109.95
JE1003	Baby AT Motherboard (Zero-K RAM-incl. Award BIOS ROM) . .	$399.95

EGA Monitor TE5154 $399.95
EGA Card JE1055 $149.95 (not included)

Reg. List $868.80
SAVE $68.85!

JE1008 IBM™ AT Compatible Kit. $799.95

Jameco's 4.77/8MHz Turbo IBM PC/XT Compatible Kit

4164-150	128K RAM (18 Chips). .	$ 35.10
41256-150	512K RAM (18 Chips). .	$ 77.10
JE1010	Flip-Top Case.	$ 34.95
JE1015	XT/AT Style Keyboard. .	$ 59.95
JE1030	150 Watt Power Supply	$ 69.95
JE1020	5¼" DSDD Disk Drive . .	$ 89.95
AMBER	12" Amber Monitor . . .	$109.95
JE1001	4.77/8MHz Turbo Motherboard (Zero-K RAM – Includes Award BIOS ROM).	$104.95
JE1071	Multi I/O with Controller and Graphics.	$119.95

Regular List $695.85
SAVE $95.90!

JE1005 (IBM™ PC/XT Turbo Compatible Kit) . . $599.95

Jameco's IBM PC/XT/AT Compatible Motherboards

· Award BIOS ROM included

JE1000 4.77MHz (PC/XT). . . . . $ 89.95
JE1001 4.77/8MHz (PC/XT). . . . $104.95
JE1003 6/8/10/12MHz (AT). . . . $399.95

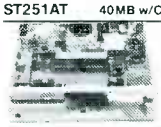
Additional Add-Ons Available!

COMPUTER PERIPHERALS

Seagate 20, 30 & 40MB Half Height Hard Disk Drives

ST225K (Pictured)

ST225	20MB Drive only (PC/XT/AT) . . .	$269.95
ST225K	20MB w/Controller (PC/XT) . . .	$319.95
ST238	30MB Drive only (PC/XT/AT) . . .	$299.95
ST238K	30MB w/Cont. (PC/XT/AT)	$339.95
ST251	40MB Drive only (PC/XT/AT) . . .	$469.95
ST251XT	40MB w/Cont. Card (PC/XT) . . .	$549.95
ST251AT	40MB w/Cont. Card (AT).	$589.95



Jameco PC/XT & AT Compatible Disk Drives

JE1022 (Pictured)

JE1020 360K Black Bzl. (PC/XT/AT) . . . $ 89.95
JE1021 360K Beige Bzl. (PC/XT/AT). . . $ 89.95
JE1022 1.2MB Beige Bzl. (AT). $109.95

DATATRONICS 2400/1200/300 Modems

· Hayes command compatible · Bell 103/212A compatible · Auto-dial/auto-answer · FCC approved · 1-year warranty · The 1200H & 2400S include MaxiMite Communication Software · The 1200C & 2400E do not include software

1200H	1200/300 Baud Internal Modem. . . .	$ 79.95
2400S	2400/1200/300 Internal Modem. . . .	$174.95
1200C	1200/300 Baud External Modem. . . .	$119.95
2400E	2400/1200/300 External Modem	$219.95

Jameco Extended 80-Column Card for Apple *IIe*

· 80 Col./64K RAM · Doubles amount of data your Apple *IIe* can display as well as its memory capacity · Ideal for word processing · Complete with instructions

JE864 $49.95

ADD12 (Disk Drive II, II+, *IIe*) **$99.95**

Additional Apple Compatible Products Available

ZUCKERBOARD

TANDY 1000 Expansion Memory Half Card

Expand the memory of your Tandy 1000 (128K Version) to as much as 640K. Also includes DMA controller chip.

TE512 Includes 512K RAM. $119.95
TANC Plug-in Clock option chip (only) $39.95

20Meg Hard Disk for Tandy 1000/SX

T20MB 20MB Hard Disk Drive Board for Tandy 1000. . . . . $494.95
SX20MB 20MB Hard Disk Drive Board for Tandy 1000SX. $499.95

Accessories for Commodore VIC-20, C-64 & C-128

JE232CM (Pictured)

JE232CM (RS232 Inter. VIC-20, C-64 and C-128 in 64 mode) $39.95
CPS10 (C-64 Power Supply). $39.95
CPS128 (C-128 Power Supply). . . . $59.95

U.S. Funds Only
Shipping: Add 5% plus $1.50 Insurance
(May vary according to weight)

$20 Minimum Order

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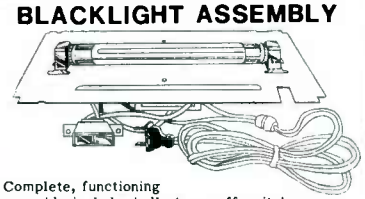
BLACKLIGHT ASSEMBLY

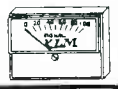


Complete, functioning assembly includes ballast, on-off switch, power cord, sockets and F4T5-BL blacklight. Mounted on a 7 1/8" X 3 1/8" metal plate. Use for special effects lighting or erasing EPROMS.

CAT# BLTA $10.00 EACH

1mA METER

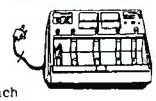
Modutec 0-1 mA signal strength meter with KLM logo. 1/4" X 1 3/4" X 7/8" deep.



CAT# MET-2 $2.00 each

NI-CAD CHARGER/TESTER

DELUXE universal charger and tester for almost every size Ni-cad battery available.



CAT# UNCC-N $15.00 each

RECHARGEABLE NI-CAD BATTERIES

AAA SIZE 1.25V 180mAH	$2.25
AA SIZE 1.25V 500mAH	$2.00
AA with solder tabs	$2.20
C SIZE 1.2V 1200mAH	$4.25
SUB-C SIZE solder tab	$4.25
D SIZE 1.2V 1200mAH	$4.25

COMPUTER GRADE CAPACITORS

1,400 MFD 200 VDC
2" dia. X 3" high
CAT# CG-1420 $2.00

7,500 MFD 200 VDC
3" dia. X 4 3/4" h.
CAT# CG-75 $4.00

22,000 MFD 25 VDC
2" dia. X 4 3/4" h.
CAT# CG-22 $2.50

72,000 MFD 15 VDC
2" dia. X 4 3/8" h.
CAT# CG-130 $3.50

TRANSISTORS

2N2222A
3 for $1.00

PN2222A
4 for $1.00

2N2904
3 for $1.00

2N2905
3 for $1.00

2N3055
$1.00 each

PN3569
10 for $1.00

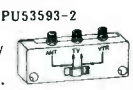
WALL TRANSFORMER

11.5 Vdc
1.95 AMP.
Input:
120 Vac

SIZE: 3 3/4" X 2 7/8" X 2 5/8"
CAT# DCTX-11519
$6.50 each

A/B SWITCH

JVC# PU53593-2
High quality A/B switch.



Measures: 3 3/4" X 1 7/16" X 1". 75 OHMS IN/OUT
CAT# ABS-2 $3.50 each

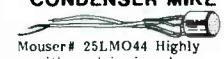
13.8 VDC REGULATED POWER SUPPLY

Solid state, fully regulated 13.8 Vdc power supplies. Both feature 100% solid state construction, fuse protection and LED power indicator. UL listed.

2 AMP CONSTANT, 4 AMP SURGE
CAT# DVP-412 $22.50 each

3 AMP CONSTANT, 5 AMP SURGE
CAT# DVP-512 $30.00 each

ELECTRET CONDENSER MIKE



Mouser# 25LMO44 Highly sensitive mini microphone. 6" wire leads. 0.39" dai. X 0.27" high. Omni directional. Operates on 2-10 Vdc @ less than 1 mA. 1K impedance. 50 to 8 K Hz range.
CAT# MKE-1 $1.00 EACH

SLIM LINE FAN

TOYO# TF92115A New 115 Vac cooling fan. 3 5/8" square X 1" deep. Metal housing. 5 blade impeller.

CAT# SCFE-115 $8.50 each
10 for $75.00

2K 10 TURN

Multi-turn pot
Spectrol# MOD 534-7161
CAT# MTP-10-2
$5.00 each

VENTED PROJECT CASE

Bopla #BO 718L Vented top and bottom. Black plastic with removable end panels. 9" X 8 1/2" X 4"

CAT# MB-718 $12.50 each

6-12 VDC MOTOR

Mabuchi # RS-550S Permanent magnet motor. 1 7/16" dia X 2 1/4" long
2,600 RPM @ 6 Vdc-200 mA
5,300 RPM @ 12 Vdc
CAT# DCM-7 $3.00 each

LED'S

Standard Jumbo Diffused T 1-3/4 Size

RED	10 for $1.50	
CAT# LED-1	100 for $13.00	1000 for $110.00
GREEN	10 for $2.00	
CAT# LED-2	100 for $17.00	1000 for $150.00
YELLOW	10 for $2.00	
CAT# LED-3	100 for $17.00	1000 for $150.00

FLASHING LED
w/ built in flashing circuit operates on 5 Volts...

RED	$1.00 each
CAT# LED-4	10 for $9.50
GREEN	$1.00 each
CAT# LED-4G	10 for $9.50

BI-POLAR LED
Lights RED one direction, GREEN the other. two leads.
CAT# LED-6 2 for $1.70

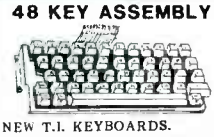
LED HOLDERS
Two piece holder.
CAT# HLED 10 for 65c

CLIPLITE LED HOLDER
Makes L.E.D. look like a fancy indicator

CLEAR	CAT# HLDCL-C
RED	CAT# HLDCL-R
GREEN	CAT# HLDCL-G
YELLOW	CAT# HLDCL-Y

4 of one color $1.00

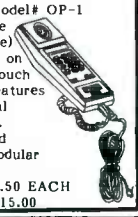
48 KEY ASSEMBLY



NEW T.I. KEYBOARDS. Originally used on computers, these keyboards contain 48 S.P.S.T. mechanical switches. Terminates to 15 pin connector. Frame 4" X 9"
CAT# KP-48 $3.50 each

PUSHBUTTON PHONE

Spectra-phone Model# OP-1 1 piece telephone with rotary (pulse) output. Operates on most rotary or touch tone systems. Features last minute redial and mute button. Includes coil cord with standard modular plug. IVORY.



CAT# PHN-1 $8.50 EACH
2 FOR $15.00

RELAYS

12 VDC-4PDT
P.C. mount
5 amp contacts
150 ohm coil
Size: 1 1/4" X 1 3/4" X 7/8"

CAT# 4PRLY-12PC $3.50
10 for $30.00

10AMP SOLID STATE
Control: 3-32 Vdc
Load: 10 AMPS, 120 Vac
Size: 2 1/2" X 3/4" X 7/8"

CAT# SSRLY-10A $9.50
10 for $85.00

25 AMP SOLID STATE
OPTO 22# 240D25
TTL compatable.
INPUT: 3-32 VDC
OUTPUT: 25 AMPS @ 240 VAC
SIZE: 2 1/2" X 3/4" X 7/8"

CAT# SSRLY-2524 $15.00 each

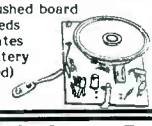
THIRD TAIL LIGHT

Sleek high-tech lamp assembly. Red lens is 2 3/4" X 5 1/2" mounted on a 4" high pedestal with up-down swivel adjustment. Has 12V replaceable bulb.

CAT# TLB $3.95 each

SOUND EFFECTS BOARD

P.C board with 2 1/4" speaker, 2 LEDs, IC, battery snap, other components 2 3/8" X 3". When switch is pushed board beeps and leds light. Operates on a 9V battery (not included)

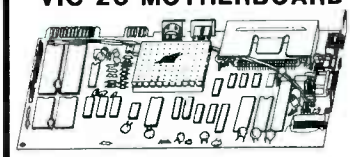


CAT# ST-3
$1.25 each

XENON FLASH TUBE

3/4" long X 1/8" dia.
CAT# FLT-1 2 for $1.00

VIC 20 MOTHERBOARD



26 IC's including 6502A and 6560. 2 ea. 6522, 2 ea. 8128, 2 ea. 901486, 3 ea. 2114. Not guaranteed but great for replacement parts or experimentation.
CAT # VIC-20 $15.00 each

SWITCHING POWER SUPPLY

Compact, well regulatec switching power supply designed to power Texas Instruments computer equipment.
INPUT: 14-25 vac @ 1 amp
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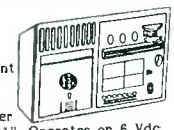
+5 vdc @ 1.2 amp
-5 vdc @ 200 ma.
SIZE: 4 3/4" square.
Includes 18 Vac @ 1 amp wall transformer designed to power this supply.

CAT# PS-TX $5.00 / set
10 for $45.00

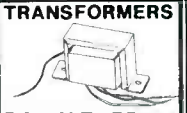
LIGHT ACTIVATED MOTION SENSOR

This device contains a photocell which senses sudden change in ambient light. Could be used as a door anunciator or modified to trigger other devices. 5 1/2" X 4" X 1". Operates on 6 Vdc. Requires 4 AA batteries (not included).



CAT# LSMD $5.75 per unit

TRANSFORMERS



5.6 VOLT- 750ma
CAT# TX-56 $3.00

12 V.c.t.-1amp
CAT# TX-121 $4.00

12 V.c.t.-2amp
CAT# TX-122 $4.85

12 V.c.t.-4amp
CAT# TX-124 $7.00

18 VOLT-650ma
CAT# TX-186 $2.00
10 for $18.00

24 V.c.t.-1amp
CAT# TX-241 $4.85

24 V.c.t.-2amp
CAT# TX-242 $6.75

24 V.c.t.-3amp
CAT# TX-243 $9.50

24 V.c.t.-4amp
CAT# TX-244 $11.00

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MINIATURE TOGGLE SWITCHES
rated 5 Amps

S.P.D.T. (ON-ON)
Non threaded brushing P.C. mount.

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S.P.D.T. (ON-ON)
Solder lug terminals.

CAT# MTS-4
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10 for $9.00

D.P.D.T. (ON-ON)
Solder lug terminals.

CAT# MTS-8
$2.00 each
10 for $19.00

MINI PUSH BUTTON
S.P.S.T. momentary. Push to make 1/4" brushing. Red button.

CAT# MPB-1 35c each
10 for $3.00

POLARITY SWITCH

Designed to control an external coaxial relay on a satellite t.v. system. Ideal for parts. Contains a 5 Vdc relay and many other parts on a P.C. board.

CAT# RPDS $1.75 each 10 for $15.00

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TI# UM1381-1. Designed for use with T.I. computers. Can be used with video cameras, games or other audio/video sources. Built in A/B switch enables user to switch from T.V. antenna without disconnection. Operates on channel 3 or 4. Requires 12 Vdc. Hook up diagram included.

CAT# AVMOD $5.00 each

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TTCP-8

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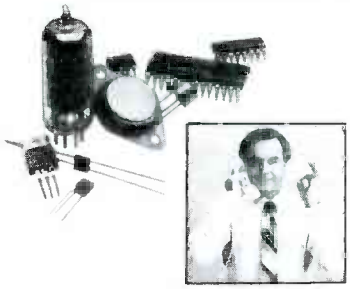

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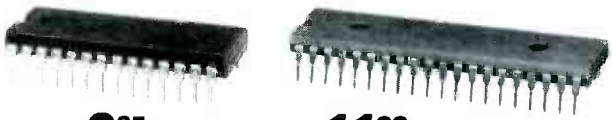

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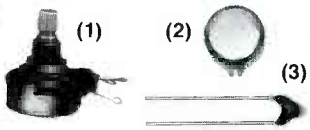
Irresistables



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(3) Thermistor. Resistance changes with temperature. #276-110 . . . **1.99**

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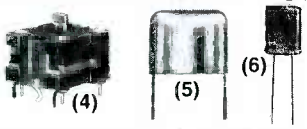

(4) 335 pF Variable Cap. Two-section, PC-mount. #272-1337, **4.95**

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(6) TV Colorburst Crystal. Precision 3.579545 MHz standard. #272-1310 . . . . . **1.69**

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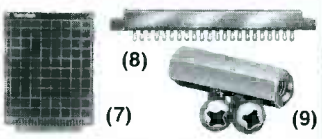
5	15 1/2"	270-1406	2.59
5	13"	270-1407	2.59
6	72"	270-1408	3.99
6*	17 3/4"	270-1409	2.49

*#270-1409 has L-mounting bracket.

Builders' Helpers



(7) Plug-In PC Board With Ground Plane. #276-188 . . . . . **4.99**

(8) 44-Position Card-Edge Socket. #276-1551 . . . . . **2.99**

(9) PC Board Standoffs With Screws. #276-195 . . . . **Pkg. 4/99¢**

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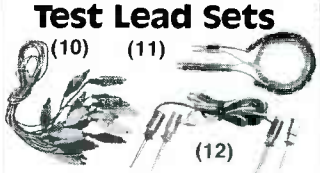
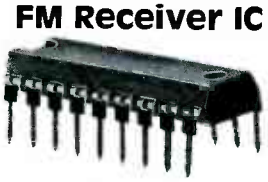


(10) Set of Ten Color-Coded Test Cables. Gator clips. #278-1156, **3.99**

(11) Coiled 6-Foot Leads. Probe at one end, banana plug at the other. #278-750 . . . . . **Pair/4.39**

(12) Mini-Clip Jumper. 20" long. #278-016 . . . . . **Pair/3.49**

FM Receiver IC



Combines RF, mixer, IF and demodulator in a single IC. Makes receiver projects a cinch to build; and with 70KHz IF, no coils are required. Built-in mute circuit reduces spurious reception. With application notes. #276-1304 . . . . . **5.95**

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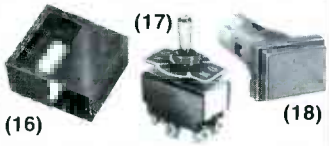

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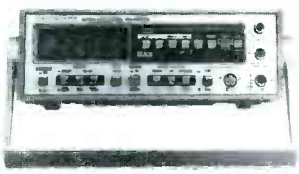

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