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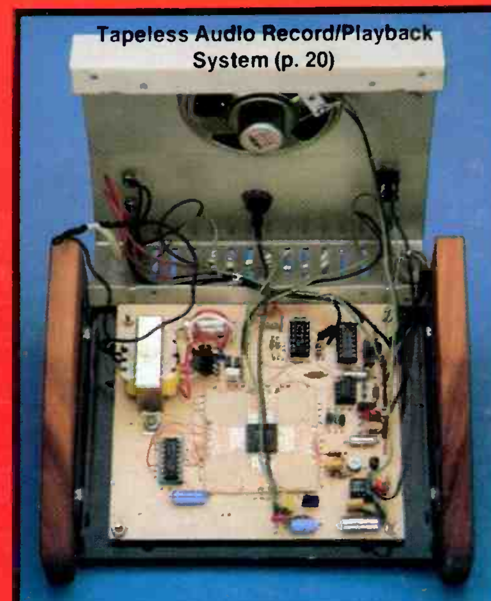
Tapeless Audio Record/Playback System (p. 20)

Newest Flat-Panel Displays

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- S … ctor In-Circuit Tester
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- Automatic Audio Panner
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Semiconductor Tester (p. 34)


Latest Developments in Flat-Panel Displays (p. 10)

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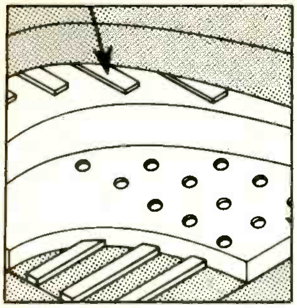
MODERN ELECTRONICS
THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

APRIL 1988

VOLUME 5, NUMBER 4



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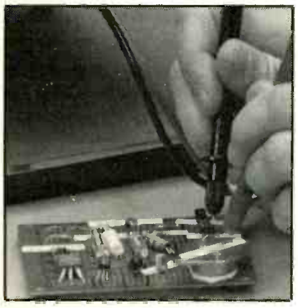

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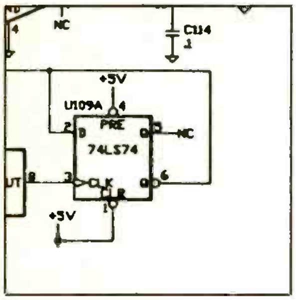

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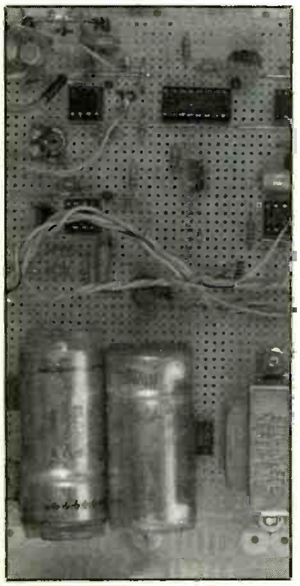

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COLUMNS

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EDITORIAL

The Electronic Chariot

When I got my driver's license, the only electronics in an automobile was in its AM radio. Today, automotive electronics is an integral part of any car model, even the least expensive ones. In a few years, however, it will virtually permeate an automobile that might rightly be called an electronic chariot.

In the car entertainment area today, AM/FM radios and cassette tape players can be considered standard equipment. A host of options expand the electronics card: CD players, power-boost amplifiers, active speaker crossover networks and graphics controllers, with digital audio tape players expected to emerge soon. Scanners, radar detectors and cellular telephones are electronic choices that are widely available, too, as are all manner of electronic anti-theft devices.

Many dashboards dazzle a driver's eyes with their digital electronic readouts, both numeric and graphic. There's even an interactive dashboard control center on one car, introduced in a 1986 Buick Riviera. It features a CRT touch-sensitive screen whose inputs are controlled by up to 10 microprocessors. With it, the driver can employ the touch of a fingertip to set the radio, climate, and trip monitor, among other actions. Readings from a variety of gauges can be activated, too.

More than anything, though, are the electronics/computers buried in a car that you never see. Chrysler introduced electronic cruise control that provides steady automatic speed with greater accuracy, system turnoff if there's rapid acceleration that might be caused by, say, wheels slipping on ice, etc. Ford and Chrysler provide lockup control of automatic transmissions in some models. Electronic antilock braking was introduced on some prestigious imported cars and is now available on some U.S. models. Electronic ignition systems are old hat now, as are engine computer control modules that automatically handle a bevy of functions. Synthesized voice alerts and active suspension control systems are also among the newly available electronic/computer options on some car models.

Coming up are refinements of the same, plus newly anticipated developments such as satellite communications links from an automobile that might be used for navigation, inter-car communications bolstered by automatic voice warnings if proximity detectors indicate impending problems (a car moving too close to another one, theft deterrence by being able to sense a car's location, etc.). Diagnosing of repairs will soon be improved as dealers' service departments get new on-line computerized test instruments, one of which has a plug-in data recorder for checking a car for an intermittent problem while it is being driven.

All these developments are very impressive, especially since virtually everyone can see or feel the changes themselves. We also share the frustrations faced by automobile service people, who have to invest in computer terminal test equipment and continual upgrading to check new computer modules in the latest automobiles.

We suffer with them by paying higher and higher labor charges to compensate for their added test equipment expense and training time. And we help out car manufacturers who squeeze a 1/2-million transistors into a single chip by paying a small fortune for a whole module instead of small change for a little part.

Clearly, there's a price to be paid for greater fuel economy, smoother rides and safer braking, all made possible by advances in electronics. But, then, when did we ever get something for nothing?

Art Salsberg

Eavesdropping

• On "Laser Eavesdropping" (November 1987 issue) and laws governing illegality concerning eavesdropping, I also agree with Forrest Mims' moral position. It's like that of [the late] John Frye in *Electronics World*, LXXX (December 1968), pages 54 and 55, and also Harry Houdini, *A Magician Among the Spirits*, chapter 13, and *Discover* (November 1987), pages 50 through 56.

Hans L. Lembke
Milwaukee, WI

Hot Buyers

• Your article "Floppy Disk Drive Testing," *Modern Electronics,* October 1987, is of great advantage. Something was missing, however. For instance, a list of manufacturers' floppy drives that will not work or be put in proper operation by use of "Memory Minder" and to what address I respond to purchase the software.

Christopher Haenel
Pittsburgh, PA

We didn't find any diskette drives that couldn't be checked out. J&M Systems' city and state were given in the review. The full address is J&M Systems, Ltd., 15100-A Central SE, Albuquerque, NM 87123 (Tel.: 505-292-4182).—Ed.

• I thoroughly enjoyed the October 1987 issue of *Modern Electronics*, particularly the "Proportional Temperature Controller," which is an ideal project for my darkroom. However, I am having difficulty locating the Signetics TDA1023 time proportional triac trigger.

William R. Warren
Lacota, MI

This component is available from Digi-Key Corp., P.O. Box 677, Thief River Falls, MN 56701, among others.—Ed.

Project Updates

• There is no continuity in the text between page 35 and page 36 of "A General-Purpose Speech Synthesizer" (October 1987). Is there something important missing here?

Jim O'Keefe
New York, NY

Nothing is missing! During page layout two blocks of copy were accidentally transposed. The first seven lines in the first column on page 36 should follow the remaining lines in that column.—Ed.

• Most gremlins were chased out of the "General-Purpose Speech Synthesizer (October 1987) with the fix given in the January 1988 Letters column. But there are a couple more. In Fig. 2, the rightmost data line to IC11 and IC12 should be moved up one line, as indicated in Figs. 4 and 5. The Q7 pin in Fig. 4 is actually number 19—not 9. Finally, C4 thru C7 and others on that line are 0.01-μF and C8, C9, C11 and C12 are 22-pF capacitors.

Incidentally, anyone who is having difficulty finding a 3.12-MHz crystal for this project can use a common 3.58-MHz "colorburst" crystal instead. I've used these successfully in the past with the SPO256A-AL2.

Terrence Vaughn
W. Covina, CA

ME

SONY HEDGES VCR BET. Sony Corp. announced it will be making the marketing VHS videocassette recorders after carrying the Beta-format VCR banner all these years. It isn't giving up on Beta types, however, though its share of the market is small and getting smaller. Although the company may be whistling in the dark concerning its continuance with Beta, as the sole maker of this format it still accounts for a lot of machines world-wide.

HOME EQUIPMENT CONTROL BUS. It's not a new idea, but NEC's Home Electronics Group has introduced a home control system that uses the ac power line. It's called the Spectrum AC and, unlike other systems, uses spread-spectrum technology instead of single frequencies and operates at 9600 baud. According to NEC, this design avoids the effects of line noise that could mar effective control. It's supposed to be available for use in commerical buildings at the end of '88.

CHALLENGING IBM. The Big One will have to fend off ever-increasing competition, it seems. Now Apple Computer, in its efforts to gain a greater foothold in corporations, has embarked on a joint development effort with Digital Equipment Corp. The intention is to integrate Macintosh personal computers and Appletalk networks with DEC's VAX systems and DECnet/OSI networks.... The cloners are marching against IBM, too, with claims that IBM's PS/2 hardware/software systems have been cracked. Everyone's wondering if there'll be a lawsuit for patent infringement, licensing deals, or what? On the other hand, many people wonder if there's a solid enough market for PS/2 clones at this moment since the AT-bus machines and supporting software and peripherals are still doing so well in the marketplace.

IN-STORE MUSIC SAMPLING. In the golden days of 78-rpm records, a prospective buyer could take a record into a little booth and listen to it via headphones before buying (or not buying) it. As 33-rpm long-play records took over, this music-sampling opportunity disappeared. This action was strange in a way since the LP's were less prone to damage by customers handling them and selling prices rose very substantially. Heat-shrink wrapping by manufacturers did the trick. Now, Interac Corp. (Los Angeles, CA), collaborating with major music-label companies, developed a music sampler supported by a video-related slide show called, of all things, "The Music Sampler." It consists of Interac's digitized image technology combined with the company's digital audio system, and has reportedly been installed in selected Tower Records stores in the greater Los Angeles area. With audio from new releases, supplemented by video slides provided by major record labels, shoppers can choose among new releases to hear (excepts, that is) and view. Hopefully, such browsing possibilities will grow.

EE ENROLLMENT DROPS. Electrical engineering undergraduate enrollment dipped slightly for the first time in a decade, while other engineering enrollments dropped steeply. This leveling off is reported to be due to the low birth rate in the 1960's. However, the number of part-time EE undergraduates, and master's and Ph.D. candidates increased.

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GE RCA

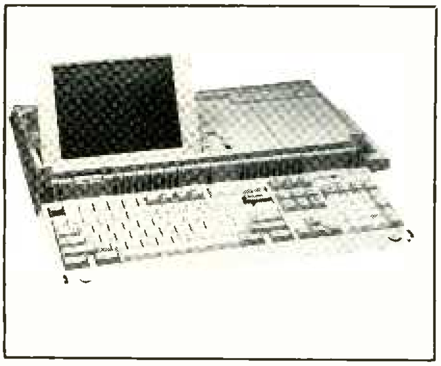
CIRCLE 29 ON FREE INFORMATION CARD

NEW PRODUCTS

For more information on products described, please circle the appropriate number on the Free Information Card bound into this issue or write to the manufacturer.

Portable Computer With Bundled Software

Amstrad, Inc. (Irving, TX) has introduced the Model PPC 512, a portable IBM PC-compatible computer that comes with MS-DOS 3.3 and the user's choice of bundled software. The computer is built around an 8086 microprocessor running at 8 MHz. The 11-pound computer features an 80 × 25-character (640 × 200-pixel) supertwist LCD display screen, single or dual 3.5-inch disk drives, a full-size 101-key AT-style keyboard, and 512K of user RAM.



A unique feature of this new portable computer is that it is designed to operate on ac line power, a vehicle 12-volt dc electrical system, an Amstrad PC 1640 power supply and regular C cells. It also plugs into any standard 9-pin DIN socket for use with any PC-compatible video display monitor.

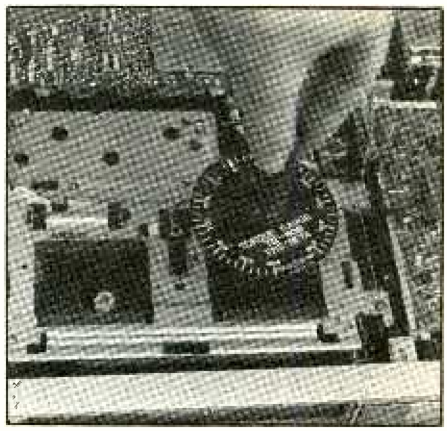
"Discover Kit" is one bundled software option, designed for the first-time or casual computer user. It consists of easy-to-use word-processor, database and spreadsheet software. Called DiscoverWrite, DiscoverFile and DiscoverPlan, the software enables the user to immediately write letters, make and file notes, use the computer as a calculator and play games without having to use manuals or DOS.

Option No. 2 is Migent's "Ability" integrated software that offers more experienced users sophisticated word processor, spreadsheet, business graphics, database management, communications and audio/visual presentation capabilities. $949 with single drive; $1,049 with dual drive.

CIRCLE 37 ON FREE INFORMATION CARD

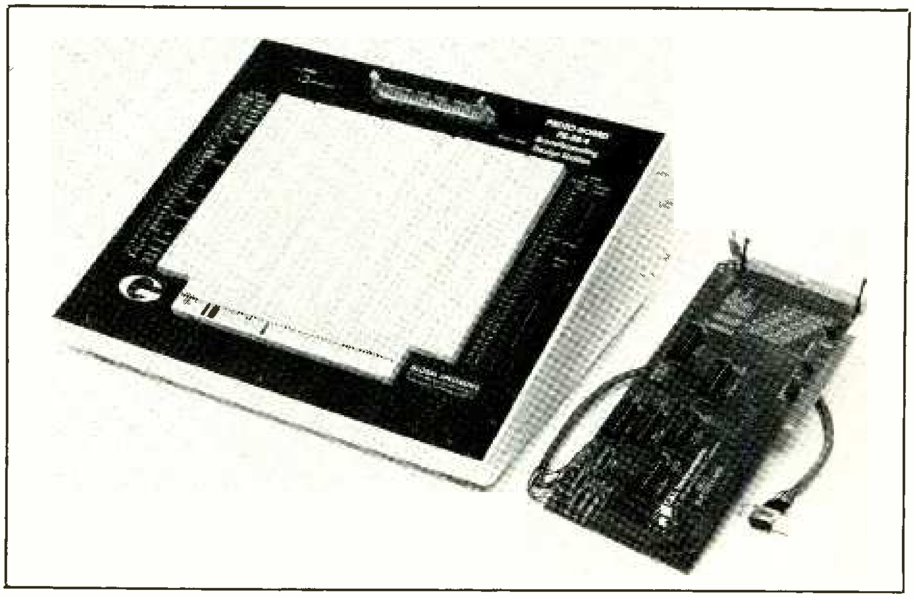
VCR Torque Gauge

A universal dial-type torque gauge from Tentel (Campbell, CA) indicates both clockwise (+) and counterclockwise (−) torque on VHS and Beta videocassette recorders to a full 600 gram/centimeters. The Model TQ-600 has an extra-long reach that provides easy access to spindles in any VCR transport. The gauge is machined from aircraft-quality aluminum, making it rugged enough to be used in the field as well as on a workbench.



Accompanying the gauge is an accessory VHS T.E.A.C.H. (Tentel Easy Access Cassette Housing) cassette. This cassette eliminates the need for blocking optical sensors and shorting of switches, permitting fast torque readings. Also included is an instruction manual with a reference chart that outlines 11 critical torques for common VHS transports. $139.

CIRCLE 38 ON FREE INFORMATION CARD



PC Prototyping Breadboard

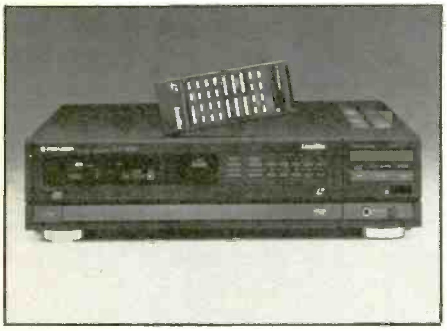
Global Specialties' new Model PB-88/4 breadboarding system for IBM PCs and compatibles offers a convenient way to prototype or experiment with interfaces. A buffered plug-in card and 60-conductor cable that connects directly to any PC or compatible allows the PB-88/4 to bring all computer bus signals to labeled solderless sockets. More than 3,300 contact points are provided on the breadboarding area.

Power for the breadboarding system is provided by the host computer with which it is used and is switchable from the PB-88/4's front-panel "on" LED. The solderless breadboard measures 13″W × 11.5″D × 6″H.

CIRCLE 39 ON FREE INFORMATION CARD

LD/CD/CDV Player

The new Model CLD-1030 LD/CD/CDV player from Pioneer Electronics (USA) Inc. uses a single tray to play 5″ CD and CDV, 8″ and 12″ LaserVision and the new 3″ CD disks. The machine automatically senses type of disk. Picture quality is enhanced by a 420-line horizontal reslution and 46-dB luminance S/N. Audio enhancement is the result of digital filters and includes 96-dB S/N and 95-dB dynamic range on CDs and LaserDiscs with digital sound tracks.



Front-panel improvements include a large fluorescent display with calendar and six new control keys. The display enables the user to read working mode, chapter/track number and time/frame number directly from the front panel, providing an alternative to on-screen display of this information.

Ten keys allow the user to control the most frequently used functions directly at the player's panel as well as through the supplied wireless remote-control transmitter. Keys are included for program editing, open/close, play/pause, forward/reverse scan, chapter skip/track search and random play.

This new player has on-board memory capable of playing back a sequence of up to 20 tracks or chapters (twice as many as in the earlier Model CLD-1010). An improved disc loading mechanism includes a tray that extends fully when opened, making it easier to insert discs. Dimensions are 17¼″D × 16$\frac{9}{16}$″W × 4$\frac{5}{16}$″H. $900.

CIRCLE 40 ON FREE INFORMATION CARD

50-MHz Analog/Digital Storage Oscilloscope

The Philips Model PM 3350 from John Fluke Mfg. Co., is a 2-channel digital storage oscilloscope that offers real-time capability and ease-of-use. It has a maximum sampling frequency of 100 Msamples/second, maintained on both channels simultaneously for high-resolution signal display and storage.

In digital mode with triggering up to 100 MHz, cursor facilities take a wide range of measurements from the on-screen traces. Backup or reference memories are available for comparison purposes, and the cursors also operate in this mode.

One-button "autoset" is available in both analog and digital modes for automatic channel selection and set-

(Continued on page 86)

What's New in Flat-Panel Displays

Laptop computers with easy-to-read flat-panel screens are possible with electroluminescent displays. *(Courtesy Lohja Electronics)*

The latest crop is slimmer, lighter and easier to use, enhancing your viewing task to the point of comfort

By Bill Siuru, Ph.D., PE

If your last experience with flat-panel displays was with the difficult-to-view liquid-crystal (LCD) types of a few years ago, you are in for a pleasant surprise with the displays now being used. Flat-panel display technology has taken great leaps forward. Advances have not been confined to just basic displays, either; they have also been made in touch-screen input technology. The result of this development activity is display devices that each year become easier to read and use and the paving of the way of a new generation of visual equipment.

With the enormous (and lucrative) potential of flat-panel displays, many companies are now investing heavily in development to produce flat-panel displays that rival or surpass the visible performance of CRT displays, at prices that are competitive with CRT displays. For example, a thin, lightweight display is imperative for laptop and transportable computers. There are obvious military applications for flat-panel displays, too, ranging from display panels in advanced fighter aircraft to wall-size "war-room" situation displays for keeping track of troop, materiel and weapons deployment, as well as for tracking space satellites.

On The Cover:
Flat-panel displays like this thin-film electroluminescent (TFEL) model take up less space than a CRT in the cockpit of an aircraft. *(Courtesy Planar Systems, Inc.)*

Supertwisted LCDs represent a major breakthrough in the viewability of flat-panel liquid-crystal displays. *(Courtesy Tektronix, Inc.)*

The aircraft industry's special interest is in development of flat-panel displays that reduce instrument depth and, thus, reduce the size of the cockpit. Potentially the most lucrative applications area for flat-panel displays is in motor vehicles, where millions of these devices annually will eventually replace analog meters and other indicators.

Meeting the Challenges

Many challenges must be overcome in developing usable flat-panel displays, foremost of which is viewability, which includes viewing angle, contrast ratio and resolution. Poor viewing angles plagued earlier LCD panels, which might have looked okay when viewed head-on but virtually washed out (became illegible) when viewed at only slight angles off-axis. Contrast ratio is the ratio of the brightness of displayed information to that of the screen's background. Resolution can be measured by the number of "lines" that can be distinguished per millimeter. The better the resolution, the clearer will be the picture on the screen and the more faithfully information will be reproduced, whether that information is graphics or text.

Since many flat-panel displays will be used in battery- powered computers and other portable devices, low-power requirements are a critical feature of this technology. Where flat-panel displays must compete with traditional CRT displays, full color is often desirable.

Because displays must be driven by other electronics, interfaces are also a very important consideration. Flat displays must be reliable and have life expectancies comparable to CRTs. Finally, they must be relatively easy to manufacture in quantity, easy to integrate into a system and, of course, be competively priced.

Display Types

The three basic types of flat-panel displays of greatest interest today include the familiar liquid-crystal display (LCD), electroluminescent (EL) panel and the plasma display. Touch-screen displays represent an alternative means of feeding data into a system as well.

Most LCDs use liquid-crystal molecules sandwiched between two sets of polarizers and transparent electrodes. The LCD depends on the po-

A Cyclops ES Touch Screen with the electronics package that makes it work in the background. *(Courtesy Wells-Gardner Electronics Corp.)*

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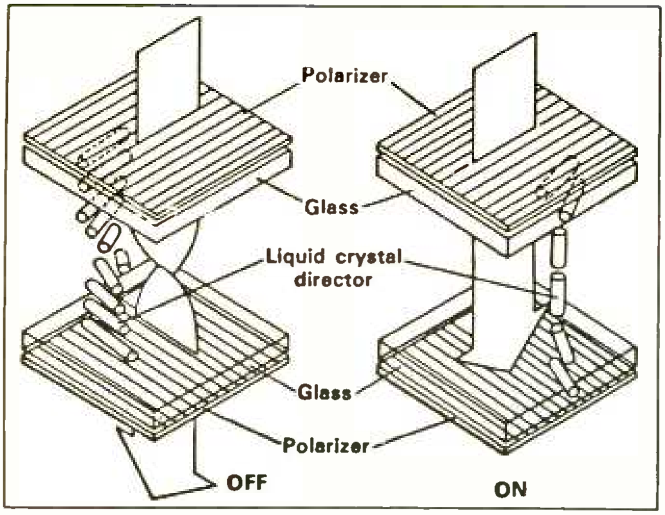
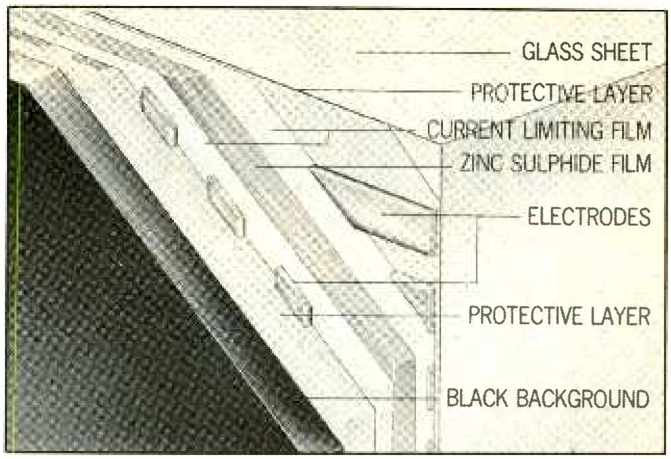


Schematic of a liquid-crystal display panel arrangement that uses the "twisted-molecule" principle. In the "off" state, the polarizing light ray is twisted by a liquid-crystal detector so that it passes through the lower polarizer and is reflected back to provide a light screen background. In the "on" state, the light is untwisted and does not pass through the polarizer, thus presenting an on-screen dot. *(Courtesy Tektronix, Inc.)*



Schematic of an electroluminescent display. The display is composed of a thin-film structure that is grown directly on a sheet of glass so thin that together they measure only 0.001 mm in thickness. Display information is fed to the substrate through electrodes that have been integrated into the thin-film structure. *(Courtesy Lohja Electronics)*

larizing characteristics of light to provide a displayed image. On the top surface of the sandwich is a transparent glass surface, and a reflector is on the lowest-most surface. When the crystal is in the "off" state, the liquid crystals are twisted so that the light is turned to pass through the polarizer and is returned by the bottom reflector. This particular LCD cell then provides the background of the screen.

When an electric field is applied to the LCD through the electrodes, the crystal molecules line up so that light is absorbed by the lower polarizer and is not reflected. This cell then is dark and provides the individual dot image that is formed into the lines of the dot matrix (a matrix is a regular arrangement of columns and rows) on the screen.

In some applications, such as in automotive instrument panels, the lower polarizer is rotated 90 degrees so that the "on" condition occurs when light is reflected and the dark LCD occurs in the "off" condition. This arrangement gives a bright line on a dark background.

LCDs are relatively inexpensive to produce and, thus, are already found in a multitude of consumer products. The technology behind them is well-developed and has been exploited much further than the EL and plasma display technologies.

Chief drawbacks of LCDs come in the area of viewability and are the reason why flat-screen displays of the past have been difficult to view. Viewing angles are typically quite narrow, and contrast ratios are less than half those of better EL and plasma devices. Also, unless some type of backlighting is used, the LCD can be used only under relatively strong ambient light.

Electroluminescent screens operate on the principle that certain materials will glow when excited by a high voltage. However, unlike fluorescent lighting that also works on the electroluminescent principle using a glowing gas such as neon, EL displays use exotic materials like europium, manganese or terbium contained in a "host" material like calcium, sulfide or zinc.

Very thin films of the EL materials are sandwiched between twin insulators, giving these display devices the name "TFEL," which stands for Thin-Film ElectroLuminescent. ELs do not glow until either the driving ac or dc voltage exceeds the required breakdown potential.

Typical EL displays have contrast ratios of 20:1 and, unlike LCDs, glow so that they can be read even under very-low light conditions. EL brightness depends on such factors as temperature and the amplitude or frequency of the driving voltage. EL displays can be viewed over angles as wide as 140 degrees, and resolutions are within the range of three lines per millimeter.

Plasma displays usually have neon or argon gas between two electrodes in much the same setup as in neon panel lamps. The gas is the medium used to produce an image on (actually, in) the screen. When the voltage applied across the electrodes exceeds a threshold level, the gas starts to glow. Once the gas begins to glow, the voltage applied to the electrodes can be decreased to a lower sustaining level and the gas will continue to glow. This is important because it greatly reduces the display's memory requirements; that is, the sustained glowing eliminates the need to continually refresh the memory.

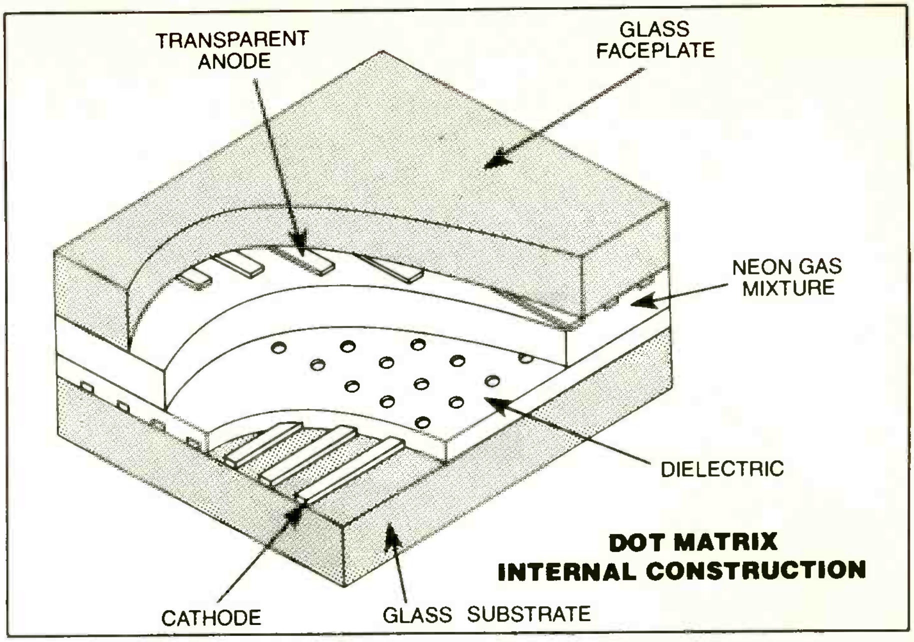
Plasma displays have already gained fairly wide acceptance because of proven reliability and high-level viewability. Current plasma displays have lifetimes on the order of 20,000 hours. Typical plasma displays have a viewing angle of about 120 degrees and contrast ratios of 20:1 or better. Resolution and brightness are excellent.

One of the main disadvantages is that plasma displays are relatively inefficient and require rather high operating voltages. While laptop computers that use plasma displays are noted for their easy-to-read screens, they can operate on batteries (if at all) for only a very short period of time. Also, plasma displays are monochrome devices; a technique for making color plasma displays still eludes the researchers.

Tackling the Problems

The key problems being tackled in LCD development today are concerned with improving readability. That is, the push is on to providing better contrast and viewing angles and making LCDs that can be used under poor lighting conditions.

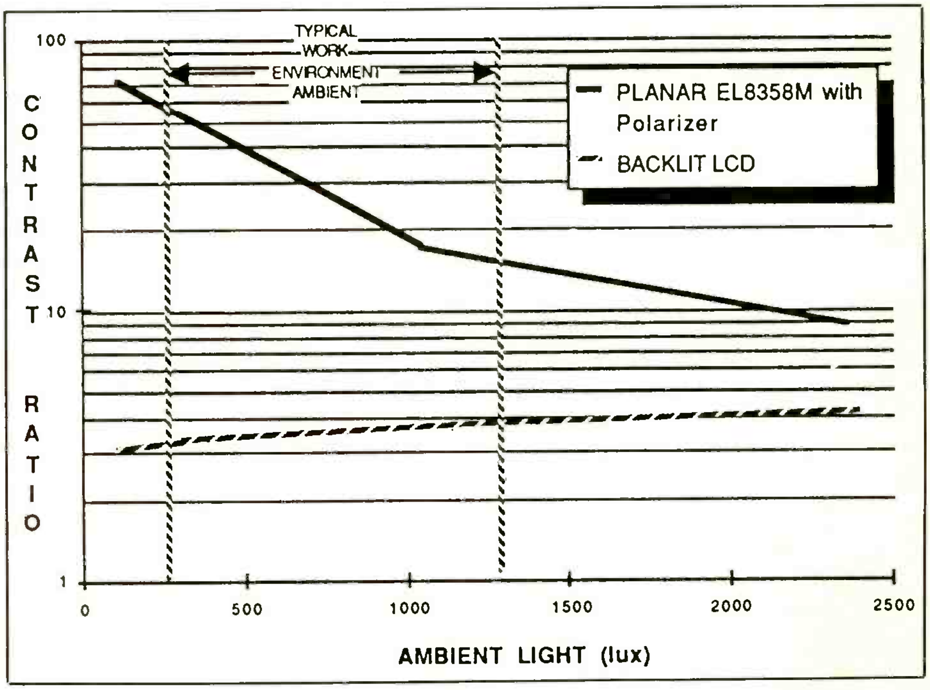
One of the most promising means to increase viewability, mainly the contrast ratio, is by "supertwisting" the liquid-crystal molecule's angles up to 270 degrees, compared to the normal 90 degrees when driving voltage is applied. Supertwisting is accomplished by doping the liquid crystal material with another optically active molecule that has special properties that twists the entire molecular structure of the liquid crystal.



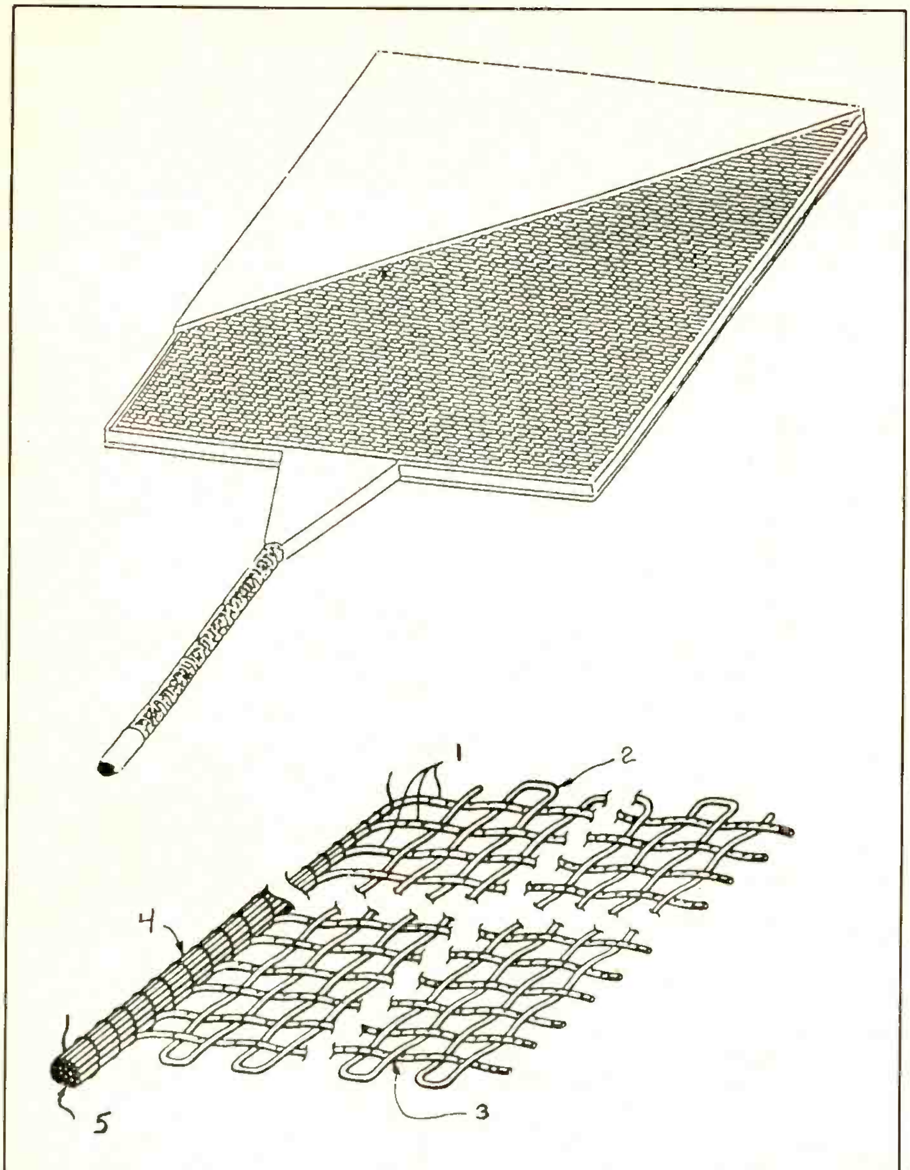
Schematic of a plasma display. *(Courtesy Dale Electronics, Inc.)*

Supertwisting goes by the rather technical title "super-twisted birefringence effect," or SBE. Tektronix, Inc.'s recently announced Hypertwist LCD has a twist of 270 degrees, giving a much greater viewability angle, plus a contrast ratio of greater than 12:1.

One factor that reduces the viewing angle of an LCD is the multiplex-



Comparison of contrast ratios between backlit liquid-crystal display (LCD) and electroluminescent (EL) display. Contrast ratio is the "on" brightness of the display divided by the "off" brightness. The larger the value, the easier it is to read the displayed image. *(Courtesy Planar Systems, Inc.)*



The Lumitex™ Panel-Lite uses woven optical fibers to provide backlighting for LCD screens so that they can be read under low ambient light conditions. Fiber-optic strands (1) are woven with conventional threads (2) to create a wave pattern in the fiber-optic material (3). Loose ends are gathered into a cable (4). The ends are then cut and polished into a converter (5). *(Courtesy Lumitex, Inc.)*

ing required to address the individual information pixels that "write" the image on the screen. As the number of lines that must be addressed increases, the activation voltage available to twist individual crystals drastically decreases. This results in greatly reduced viewing angles.

One of the simplest ways to handle this problem is to divide the total display area into two or more smaller displays (areas). For example, a 640 × 400-pixel screen could be divided into four 320 × 200-pixel displays. But as the displays are divided, the electronics to drive and address cells grows in complexity and cost.

Another approach is to increase the slope of the brightness curve by increasing the tilt of the crystal when the driving voltage is applied.

The solutions to the lighting problem is to supply some kind of backlighting, but this dramatically drives up the cost of LCD devices that are usually aimed at applications where competitive pricing becomes a very important factor.

Some LCDs use an electroluminescent panel for backlighting, but Lumitex Inc. has developed a unique technique that uses fiber optics to provide backlighting. Optical fibers do not normally emit light, except at their ends, unless damaged. However, light will leave the fiber if it is bent to a fairly precise angle. By weaving the optical fibers with weft fiber, a lattice-like light-emitting panel can be formed. The result is a very uniform intensity, low manufacturing cost, and a very thin light source that can be used for backlighting an LCD panel.

Future Developments

Color displays are one of the goals on the horizon for EL displays. While full-color displays are not yet on the market, they are in the works. So commercial color panels should be available in the next few years.

Color for EL displays is accomplished by doping the EL layers so that they emit red, blue or green colors. By stacking three layers (one of each color), multiple colors can be obtained.

Thick-film EL panels have been developed by Cherry Electrical Products Corp. The advantage of thick films over TFELs is that they are easier to manufacture and are more reliable. Unlike TFELs, which are driven by an ac source, thick-film EL panels are dc driven.

Cherry claims it has overcome the problems of moisture, contamination and excessive heat that resulted in excessive voltages being required so that they exceed current capacities. Vacuum baking of the cells and current-limited drives have overcome this problem.

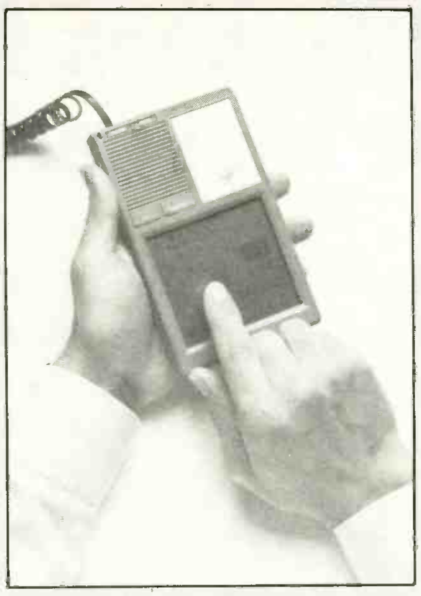
To obtain color from plasma screens, gases other than neon,

Portable Touch-Screen Terminal

Kiel Corporation (Amherst, NH) recently introduced a novel handheld computer terminal that makes use of a custom super-twist liquid-crystal display with an overlay touch-sensitive keyboard/screen to form a powerful field tool for easy use by people without computer operating experience. Using touch-screen technology that detects 8 × 6 positions of data input, the Videopad-2 data entry and retrieval model uses standard telephone lines and features a large 12-line × 25-character screen (a matrix of 120 × 96 pixels). It's powered by a 9-V alkaline battery.

Measuring about 6"H × 3¾"W × less than 1"D, Videopad-2 has an optional built-in modem and RS-232 port, and accommodates up to 32K of static RAM and 64K of CMOS EPROM. Its operating system uses up 10K of EPROM and 2K of RAM memory.

Operations are menu-driven, so the user doesn't have to learn a set of commands or codes. Input on the LCD "keyboard" uses one's own phrase and touch icons. The user-friendly key-



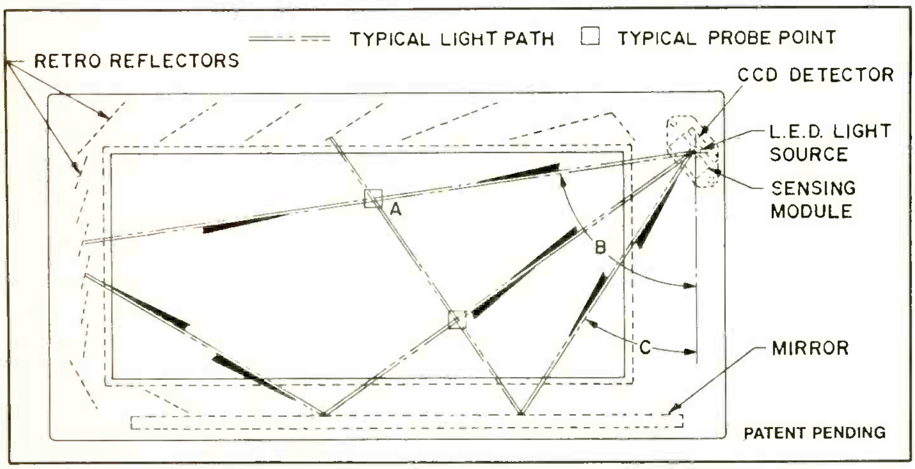
board is also programmable and allows one to manipulate keyboard space and display space. A software package called "Micropascal" is also available for versatile programming needs.

An Intel 80C31 8-bit CMOS microcontroller that runs at 11 MHz is at the heart of the computer terminal. It detects the position of the user's finger when he or she depresses the upper screen glass and thereby shorts two touch elements.

Battery life is estimated to be about 30 hours and RAM contents are maintained until voltage level drops below 2.5 volts. LOW BATT and VERY LOW BAT indications are issued when voltage drops below 6.5 V and 5.5 V, respectively. RAM contents are maintained even without a battery for 10 minutes by the unit's discharging capacitors, providing enough safe time to install a fresh 9-V battery.

The pad has two controls: an ON switch and a CONTRAST control. The unit shuts itself off automatically after five minutes of inactivity.

Recommended peripherals that can be connected through the RS-232 port are the Diconix Model 150 ink jet printer, Star Micronix DP8340 dot-matrix 40-column printer, and Hewlett-Packard's HBCR-8300 bar-code reader.



In the Cyclops® ES Touch Screen, light rays from a LED are emitted across the screen area and are reflected back on themselves by highly directional retroreflectors on one side and top of the screen's frame. The reflected rays are focused on a linear CCD detector. A mirror at the bottom of the screen allows the CCD to "see" two views of the light ray. Photodiodes measure the light level of the reflected rays and compares them with an average value. A reduced light level indicates that a light ray has been interrupted by a touch on the screen. A microprocessor determines the exact location of the touch point using triangulation. *(Courtesy Wells-Gardner Electronics Corp.)*

which gives off the current reddish-orange glow, would have to be used. Neon is currently being used because of its relatively low striking/holding voltage requirements. Other gases, such as xenon, require higher voltages and have shorter lifetimes than neon. This is the technological problem researchers are now working on; so color plasma displays are likely to be seen in the future.

Plasma displays are especially attractive for very-large "video" displays. Unlike projection CRTs, which are noted for their loss of definition and contrast near the edges of the screen. Even with screens 4 feet square, plasma displays can have constant contrast and resolution across the entire screen, and the screen could be a mere 6 inches deep.

Due to their "user-friendliness,"

(Continued on page 88)

Now You Can Record/Playback Messages Without Magnetic Tape!

New compact solid-state design provides up to 16 seconds of an automatic voice message without using magnetic tape or moving parts

By Anthony J. Caristi

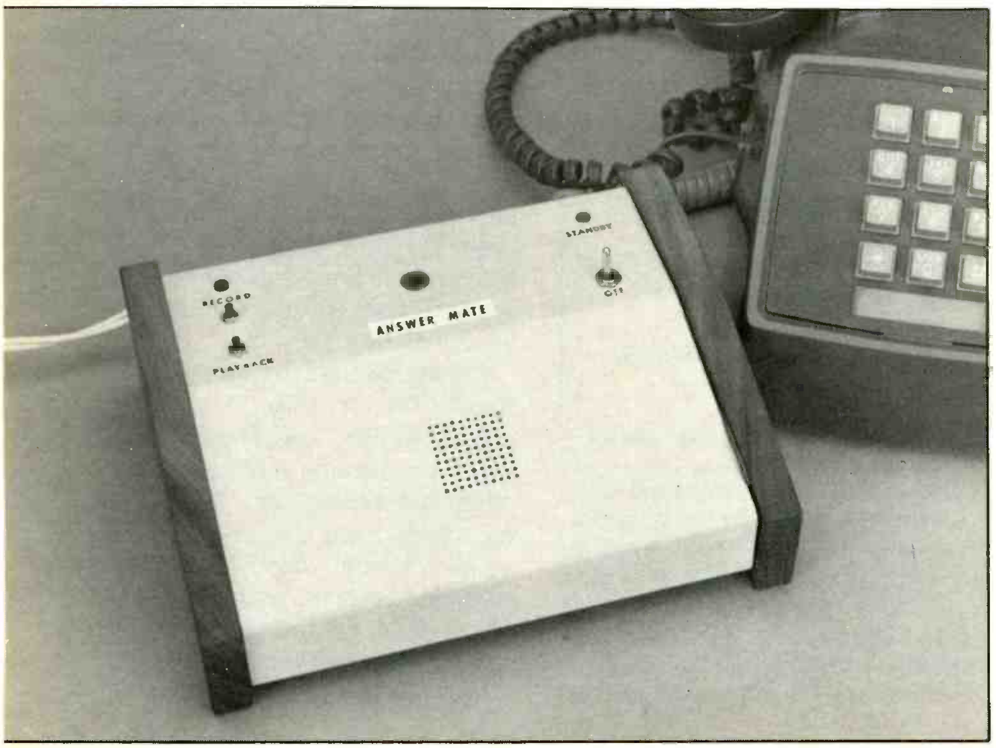
All of you are familiar with recording and playing back voice announcements on a telephone answering machine. Now you can do the same with an exciting new solid-state design built around a special LSI (large-scale-integration) chip. No audio tape cassette; no moving parts whatsoever. Moreover, your digitized voice will be faithfully reproduced. All for about $100 or less.

The advantages of an all-solid-state system such as this are clear. Firstly, there are no moving parts to wear out. Then, eliminating a tape machine makes it possible to package the system in a much more compact form. Finally, you can change messages in only a few seconds, as compared to the more lengthy and confusing procedure required when doing the same with a tape machine.

The "AnswerMate" project presented here can be used productively in a variety of ways. For example, it can serve to give a message to someone who activates it by pressing your front door bell. This might be a friend you were supposed to meet, but you had to dash out for five minutes and couldn't greet him or her personally. The AnswerMate voice message from you, made easily in seconds, might say, "I had to run out for a few minutes, Dick. Please wait for me. I'll be there shortly."

You might want to use AnswerMate as a fun gimmick, perhaps causing it to activate some vocal comments when someone sits on a chair. Or maybe you'd want it to issue an automatic spiel when a box is opened. The opportunities for using AnswerMate seem to be limited only by your imagination.

Finally, the project presented here is designed to be a "poor man's" telephone answering machine. It will automatically issue your message (up to either 8 or 16 seconds in duration) to a phone caller if you don't answer the call. This is especially handy when you want to provide callers with a quick message that you can be reached at another number or will re-



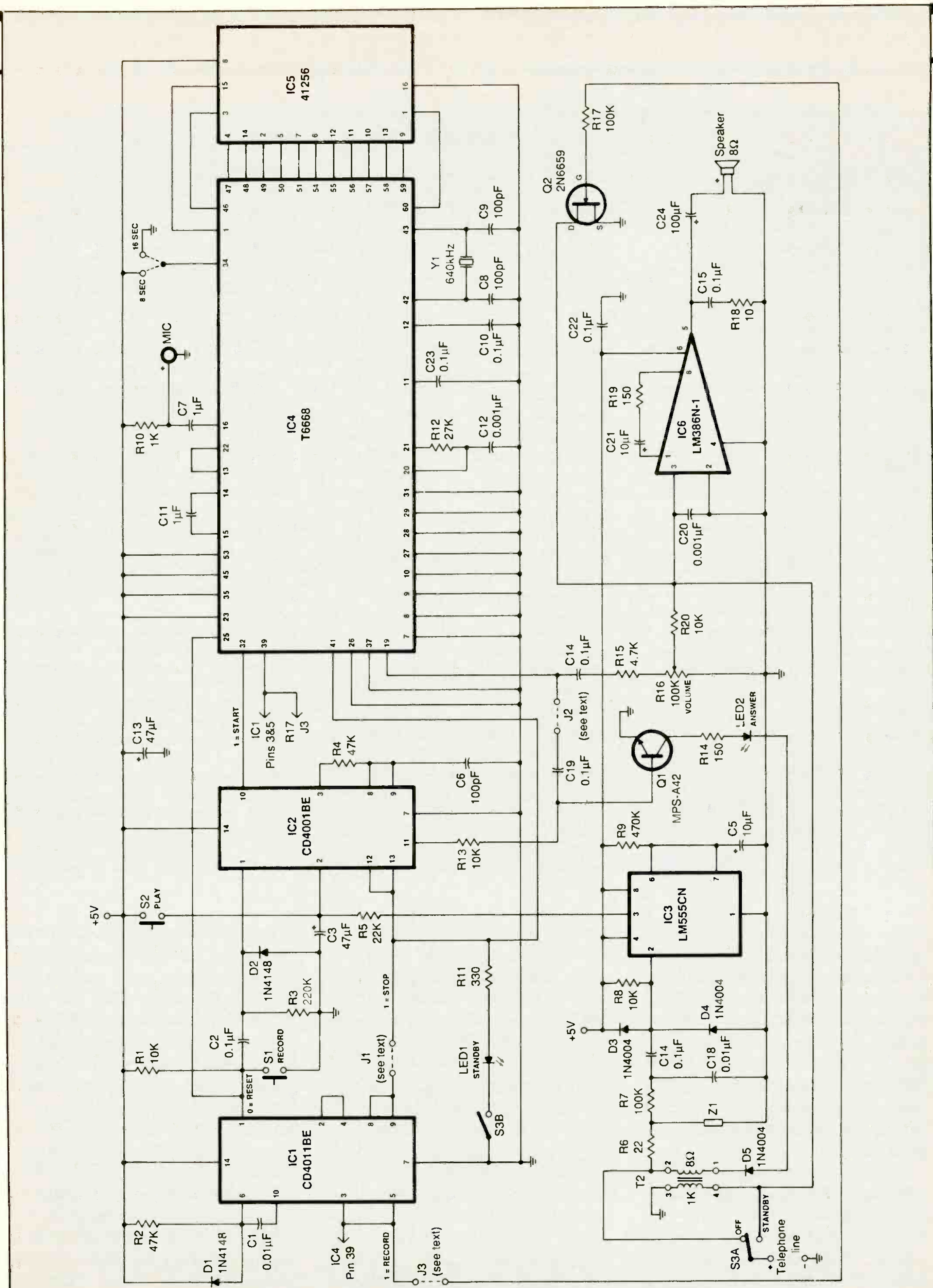


Fig. 1. Schematic diagram of project minus its power supply.

PARTS LIST

Semiconductors
D1,D2—1N4148 or equivalent silicon switching diode
D3 thru D7—1N4004 or equivalent silicon rectifier diode
D8—1N4735A or equivalent 6.2-volt zener diode
LED1—Green light-emitting diode
LED2—Red light-emitting diode
IC1—CD4011BE quad 2-input NAND gate
IC2—CD4001BE quad 2-input NOR gate
IC3—LM555CN timer
IC4—T6668 integrated circuit (Toshiba)
IC5—TMM 41256 256K × 1 dynamic RAM (Toshiba)
IC6—LM386N-1 audio power amplifier (National Semiconductor)
IC7—LM340T-5 voltage regulator (National Semiconductor)
Q1—MPS A42 or similar 300-volt npn silicon transistor (Motorola)
Q2—2N6659 or similar n-channel enhancement-mode field-effect transistor

Capacitors (50 or more WV)
C1,C18—0.01-μF ceramic
C2,C4,C10,C14,C15,C17,C19,C22, C23—0.1-μF ceramic
C3,C13—47-μF, 10-volt electrolytic
C5,C21—10-μF, 10-volt electrolytic
C6,C8,C9—100-pF ceramic
C7,C11—1-μF ceramic
C12,C20—0.001-μF ceramic
C16—1,000-μF, 16-volt electrolytic
C24—100-μF, 10-volt electrolytic

Resistors (¼-watt, 10% tolerance)
R1,R8,R13,R20—10,000 ohms
R2,R4—47,000 ohms
R3—220,000 ohms
R5—22,000 ohms
R6—22 ohms
R7,R17—100,000 ohms
R9—470,000 ohms
R10—1,000 ohms
R11—330 ohms
R12—27,000 ohms
R14—150 ohms
R15—4,700 ohms
R18—10 ohms
R19—150 ohms
R16—100,000-ohm audio-taper pc-type trimmer or panel-mount potentiometer (see text)

Miscellaneous
F1—0.5-ampere slow-blow fuse
MIC—Electret microphone element (Radio Shack Cat. No. 270-090 or similar)
S1,S2—Normally-open, momentary-action spst pushbutton switch
S3—Dpst toggle slide or toggle switch
SPKR—Miniature 4- or 8-ohm loudspeaker
T1—12.6-volt, center-tapped power transformer (Radio Shack Cat. No. 273-1365 or similar)
T2—1k-to-8-ohm audio coupling transformer (Radio Shack Cat. No. 273-1380 or equivalent)
Y1—640-kHz ceramic resonator
Z1—Metal-oxide varistor (Radio Shack Cat. No. 276-570 or equivalent)
Printed-circuit boards (see text); sockets for ICs; suitable enclosure (see text); bayonet or block-type holder for F1; ac line cord with plug; telephone cord with modular connector at one end; control knob for R16 (see text); dpst slide or toggle switch for message-length selection (optional—see text); No. 30 magnet wire; rubber grommets (2); Krazy glue or fast-set clear epoxy cement; silicone adhesive; lettering kit; clear spray acrylic; small-diameter heat-shrinkable or insulating plastic tubing; machine hardware; hookup wire; etc.

Note: The following items are available from A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463: Large pc board, $15.95; small pc board, $4.00; CD4011BE and CD4001BE, $1.75 each; LM555CN, $1.50; T6668, $14.00; TMM 41256, $11.95; LM386N-1, $2.95; LM340T-5, $2.50; 640-kHz ceramic resonator, $4.95; MPS A42 and 2N6695, $2.95 each; 1k-to-8-ohm audio coupling transformer, $4.95. Add $1.50 P&H per order. New Jersey residents, please add state sales tax.

turn at a certain time to accept their call (thereby throwing the ball back to the caller's corner and saving you the expense of a telephone call). Minor circuit modifications allow you to include incoming call monitoring. (In its present form, AnswerMate does not record incoming messages from callers, which would complicate the design and add considerably to its cost.)

A single 256K-bit dynamic RAM chip and the LSI IC digitize and store your voice for playback. During record and playback, separate LEDs provide visual indication that the project is operational and ready to perform its assigned task. When you are available to answer calls, you simply flip a switch to defeat the automatic transmit function so that callers will not be greeted by the recorded message. Here are complete plans for the phone-answering system. For non-phone use, one IC section (a ring-detector chip) could be eliminated to save a few bucks.

About the Circuit

As shown in Fig. 1, all recording and playback functions are controlled by *IC4*, a large-scale integration (LSI) chip dedicated to these two tasks. This Toshiba IC can be used in several different configurations, depending on the amount of memory and the desired speed or bit rate. In this project, the single 256K dynamic RAM chip identified as *IC5* was chosen to keep component cost as low as possible but to allow a usable message time. The bit rate, which you select with a jumper (or an optional switch) to either the V+ or ground bus, can be 16K or 32K, respectively. A timing circuit built into *IC4* is clocked at a 640-kHz rate, as determined by ceramic resonator *Y1*.

To provide control of the recording and playback functions, two additional chips are needed. These are

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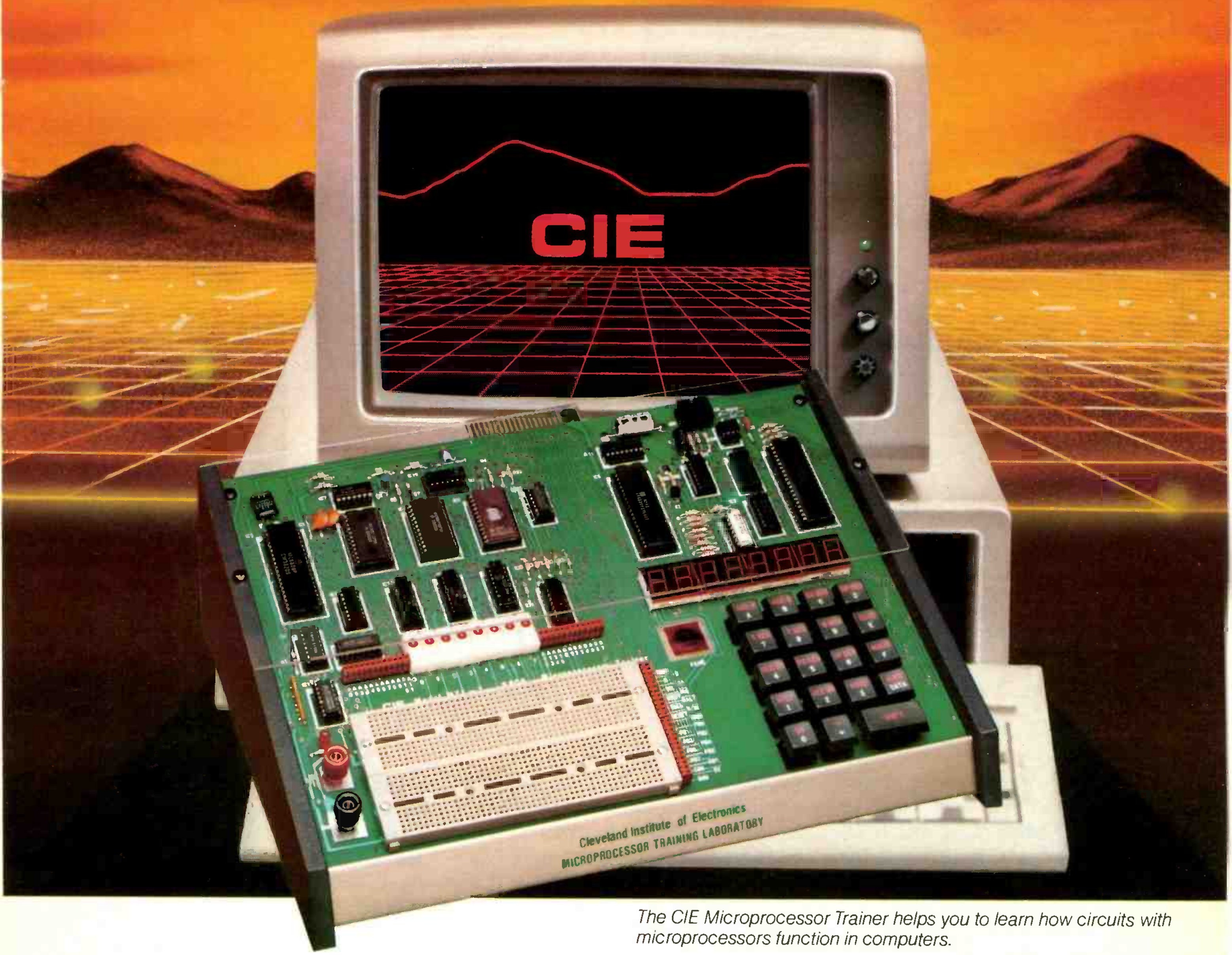

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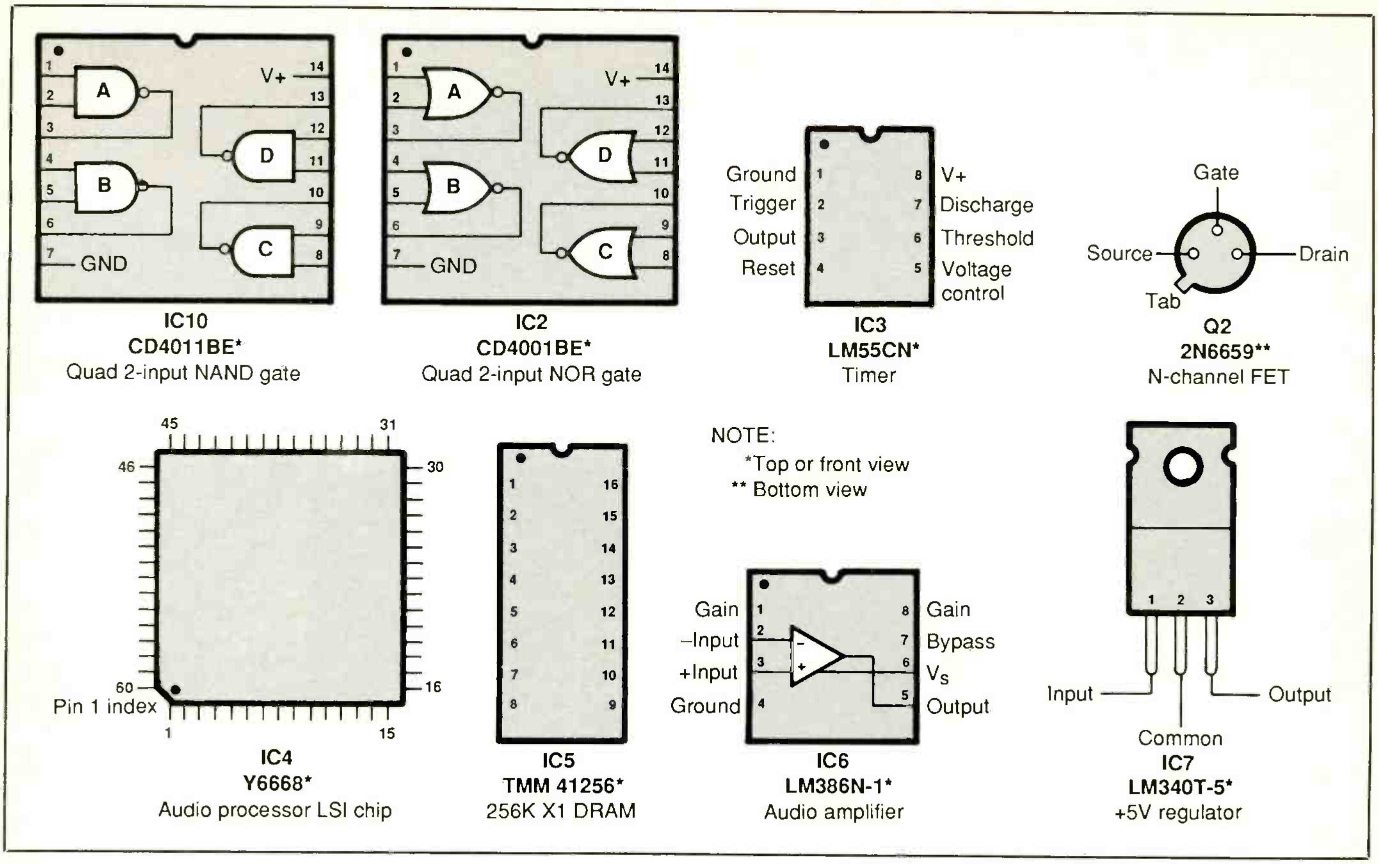


Fig. 2. Pinouts and some internal details of selected solid-state devices used in this project.

IC1 and *IC2*, which set the proper logic levels to the control inputs of *IC4*. NAND gates *IC1A* and *IC1B* (see Fig. 2 for gate identification for *IC1* and *IC2*) are connected as a flip-flop to control record/playback mode selection at pin 39 of *IC4*.

When RECORD pushbutton switch *S1* is pressed, a 0 logic level is applied to pin 1 of *IC1*. This causes the output of NAND gate *IC1A* at pin 3 to go to a logic 1 condition and remain there until a stop pulse is received at input pins 8 and 9 of *IC1C*.

The logic-0 level from *S1* is also applied to pin 25 of *IC4*. This directs *IC4* to reset in preparation for a new recording sequence. When *S1* is released, a positive-going pulse is fed to pin 1 of *IC2* and ultimately appears at pin 32 of *IC2* to allow you to start recording.

When recording begins, pin 41 of *IC4* goes to a logic-0 level. This extinguishes STANDBY light-emitting diode *LED1* and clocks memory chip *IC5* through 256K bits. This takes 8 or 16 seconds, depending on the bus to which the jumper at pin 34 of *IC4* is connected. The sequence then stops and *LED1* turns on again.

During recording, sounds that reach the microphone are amplified by *IC4* and broken down into digital form. RAM chip *IC5* stores this digital information as a representation of the audio signal reaching the microphone in the pin 16 circuit of *IC4*.

At the end of the recording, the circuit automatically stops and sets pin 41 of *IC4* back to logic 1. The rising waveform at pin 41 returns the *IC1A/IC1B* bistable latch to its playback state. During the recording process, the positive output of *IC1A* at pin 3 also mutes audio amplifier *IC6* so that no feedback occurs between speaker and microphone.

The digital recording data is stored inside *IC5*, and remains there as long as power is applied to the circuit or a new recording is initiated by pressing RECORD switch *S1*. At any time, it is possible to hear the stored recording by pressing PLAY pushbutton switch *S2*. This generates a positive pulse at start input pin 32 of *IC4*. The circuit then clocks through all addresses in *IC6* at a 16K- or 32K-bit rate (according to the setting of the jumper at pin 34) to extract the stored digital information. The digital data is then filtered and amplified by *IC4* to reconstruct the original recorded audio. The output at pin 19 of *IC4* is fed to audio power amplifier *IC6* through VOLUME control *R16* to drive loudspeaker *SPKR*.

Bear in mind that the reconstructed audio consists of 256K bits of digital information, clocked at a rate of 16 or 32 kHz to accommodate a 16-

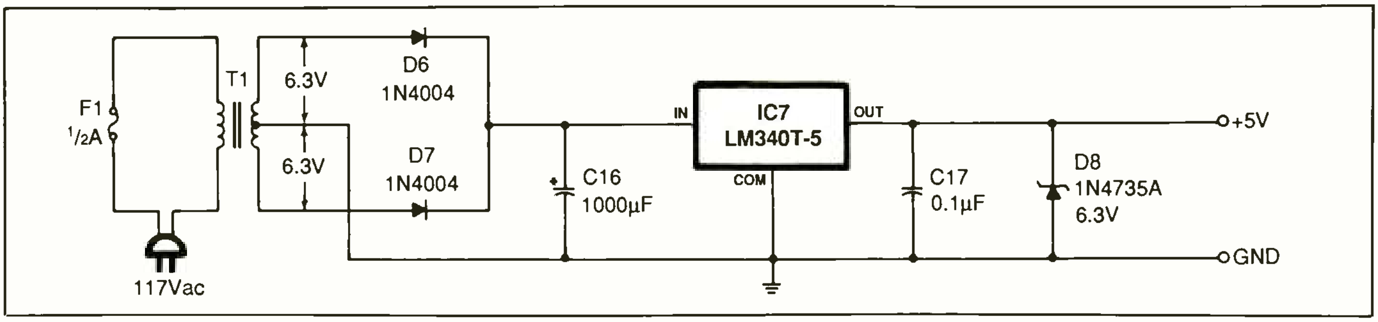


Fig. 3. Schematic diagram of project's 117-volt ac-operated dc power supply.

or 8-second message. Though either rate will give good to excellent audio fidelity, the faster 32-kHz rate for an 8-second message is superior.

When the circuit is in standby (rest), STANDBY *LED1* will be on and *IC4* will be in its playback mode. Timer chip *IC3*, wired as a monostable multivibrator, serves as a ring-signal detector for the telephone line. When the 90-volt, 20-Hz ring signal appears across the telephone line, pin 2 of *IC3* goes to a logic-1 level and remains there for about 5 seconds, determined by the time constant of the RC network composed of *R9* and *C5*.

The logic 1 at pin 2 of *IC3* is fed to input pin 2 of NOR gate *IC2A*. This generates a start pulse that is fed through *IC2C* whose pin 10 output is fed to the pin 32 input of *IC4* in a manner similar to that obtained by pressing *S2*. When this occurs, *IC4* clocks out the digital encoded audio data stored in *IC5* and feeds it to the *IC6* audio power amplifier. As the outgoing message is delivered to the telephone line, it can also be heard through the project's built-in speaker.

When *IC4* is in its active state, pin 41 goes to logic 0, extinguishing *LED1*. At the same time, *Q1* is forward biased through the inverting action of *IC2D*, causing the transistor to draw current from the telephone line and answering the call. ANSWER light-emitting diode *LED2* is turned on by the loop current from the telephone line, and the audio signal that appears at pin 19 of *IC4* is impressed on the base of *Q1* to transmit the recorded message to the calling party.

When the full 256K bits of digital information have been processed by *IC4*, the circuit returns to its standby state. At this time, *Q1* cuts off to "hang up" the phone. The project is then ready for the next incoming call.

STANDBY/OFF switch *S3* allows you to break the connection to the telephone line so that you can easily disable the answering function when it isn't needed. A second pole on *S3* also cuts off STANDBY *LED1* to give you visual indication that the project has been disabled.

Transformer *T2* provides the means by which a call-screening function is incorporated into the project. Call screening allows you to hear the calling party's voice without having to pick up your telephone's handset. It gives you the option of answering the call or not.

Power for the project is provided from the 117-volt ac line with the dc power supply shown schematically in Fig. 3. Transformer *T1* steps down the incoming 117 volts ac to 12 volts ac. This center-tapped voltage is fed to *D6* and *D7* for full-wave rectification. The pulsating dc from *D6* and *D7* is then filtered to pure dc by *C16*, after which it is regulated to + 5 volts dc by regulator *IC7*.

Total power required by the project is very low. Hence, no heat sinking is required for *IC7*. With very-low power drain, the project can be left continuously plugged into the ac line and add very little to the cost of your electricity usage.

Construction

Owing to the relative complexity of this project, printed-circuit construction is a virtual necessity. Though you can mount and wire almost all of the circuitry on perforated board that has holes on 0.1-inch centers, using suitable soldering or Wire Wrap hardware, you *must* use a pc "carrier" board for LSI chip *IC4*. This chip is packaged in a flat pack that must be surface mounted and requires its own separate pc board. It doesn't come in a plug-in package configuration.

You need two single-sided pc boards. You can fabricate your own boards using the actual-size artwork shown in Figs. 4 (main board) and 5 (*IC4* board), or you can purchase ready-to-wire boards from the source given in the Note at the end of the Parts List. Whichever way you go, be sure to use sockets for all ICs except *IC4* and *IC7*.

Figure 6 shows the locations and orientations of the components that mount on the main board and connection points for all off-the-board components and hookups. Wire this board exactly as shown, beginning with installation of the IC sockets (do *not* install the ICs in the sockets at this time) and follow with the resistors (note that *R20* mounts upright—not flat on the board) and nonpolarized capacitors. Then in-

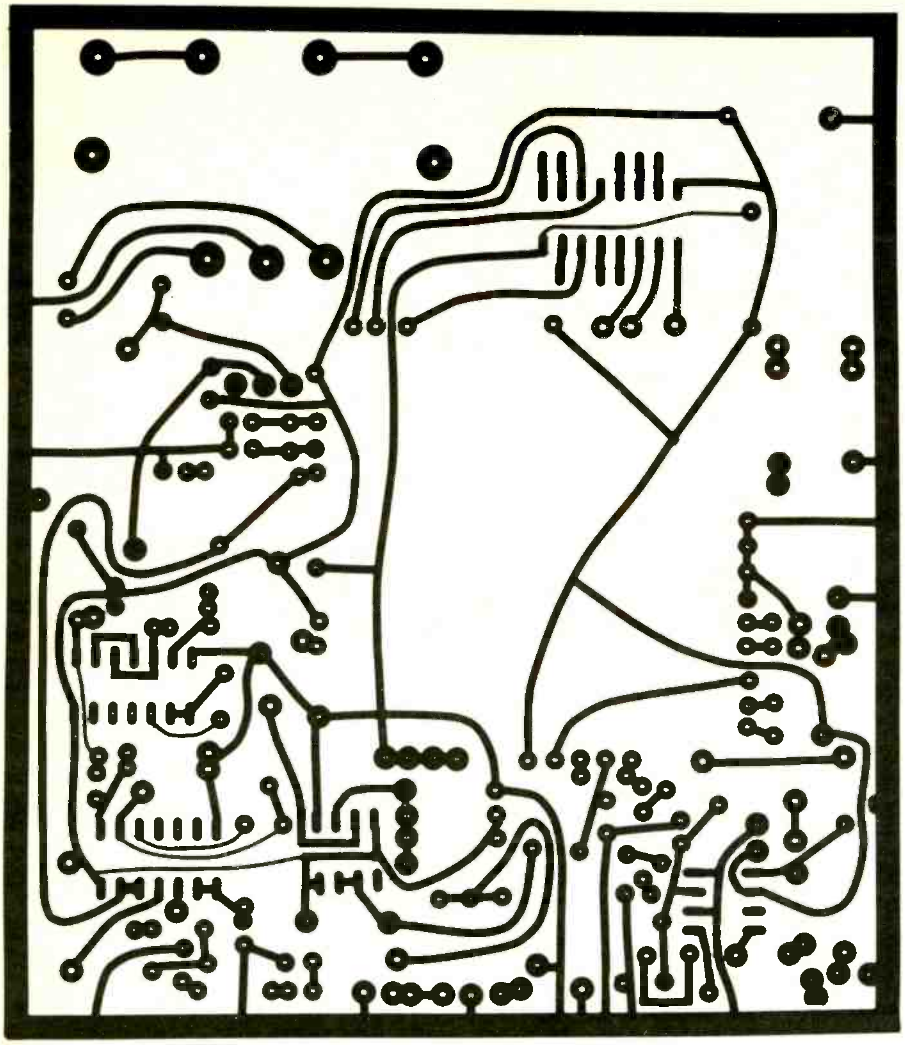


Fig. 4. Actual-size etching-and-drilling guide for main printed-circuit board.

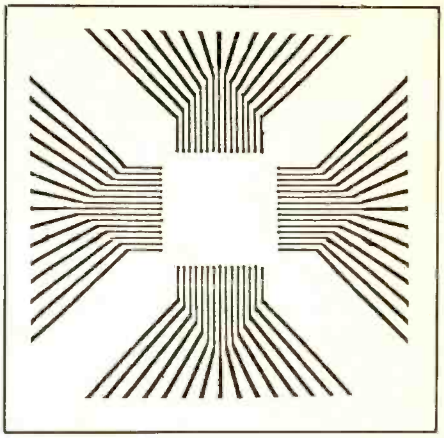


Fig. 5. Actual-size etching guide for "carrier" pc board for IC4 LSI chip. This board requires no holes to be drilled for making connections to IC or main circuit board.

stall and solder into place ceramic resonator *Y1*.

You can use either a miniature pc-type trimmer potentiometer for VOLUME control *R16*, installing it as shown, or a panel-mount control that can be conveniently readjusted without having to disassemble the project. If you decide on the panel-mount pot, use insulated hookup wires between it and the appropriate holes in the pc board.

Next, install the electrolytic capacitors, diodes, transistors and voltage regulator *IC7*. Make absolutely certain that these components are properly polarized or based before soldering their leads or pins to the pads on the bottom of the board. Just one of these components installed incorrectly will render the circuit inoperative and may cause very expensive damage.

Identify the primary and secondary leads of power transformer *T1*. Mount the transformer in the upper-left of the board as shown. Plug its leads into their respective holes in the board and solder them to the pads on the bottom of the board.

Decide now what message length you want. If you want an 8-second message, connect a jumper wire from the pad above the one labeled 34 to the pad labeled V+. If you want a 16-second message, install the jumper between the pad above the one labeled 34 and the pad labeled GND just above it. Alternatively, if you wish to have a choice between the two message lengths at different times, you can wire the jumper between the pad above the one labeled 34 and the center lug of a dpst slide or toggle switch and wire the lugs of the switch's alternate positions to the V+ and GND pads. Then, whenever you want to increase or decrease the message length, you simply set the switch to the position that gives you what you want. Regardless of which message length you choose, the telephone company gives you a grace period of about 10 seconds to pick up the call after the project has "hung up."

Now decide whether or not you want to include in your project a call-screening function, which allows you to hear the calling party's voice without having to pick up your telephone's handset. To add call screening, simply add transformer *T2* to the circuit as shown at the bottom of the board layout drawing. Make sure you wire the low-impedance (8-ohm) side of *T2* in series with the telephone line. Note in Fig. 1 that when this option isn't used, the positive (+) side of the telephone line through *S3A* goes directly to *R6* instead of to *T2*.

Four insulated jumper wires must be installed. These are identified in Fig. 1 as J1 through J4. The same numbering scheme is used in Fig. 6. J1 is shown continuous here. To make the J2, J3 and J4 jumper connections, simply install a jumper wire between like J numbers. If you omit call answering, you can also omit the J4 jumper. You can install these jumper wires either on top or the bottom of the board, whichever is more convenient. Use light-gauge (No. 24) insulated wire jumpers.

Strip ¼ inch of insulation from both ends of 14 6-inch lengths of insulated hookup wire (make the wire count 20 if you've decided to use a panel-mount potentiometer for *R16* and a switch for selecting recording-time length). Plug one end of these wires into the holes labeled S1, S2, S3A OFF, S3A STBY, LED1 ANODE, LED2 ANODE, MIC+, MIC−, SPKR+ and SPKR−. The other ends of these wires will be connected later.

When the main board is completely wired, turn it over and carefully inspect all soldered points for poor soldering and particularly for solder bridging between closely spaced pads and conductors. Reflow the solder on any questionable connection, and carefully remove any solder bridges. Flip over the board and double check all components for values and orientations. When you're satisfied that all is okay, set the circuit-board assembly aside.

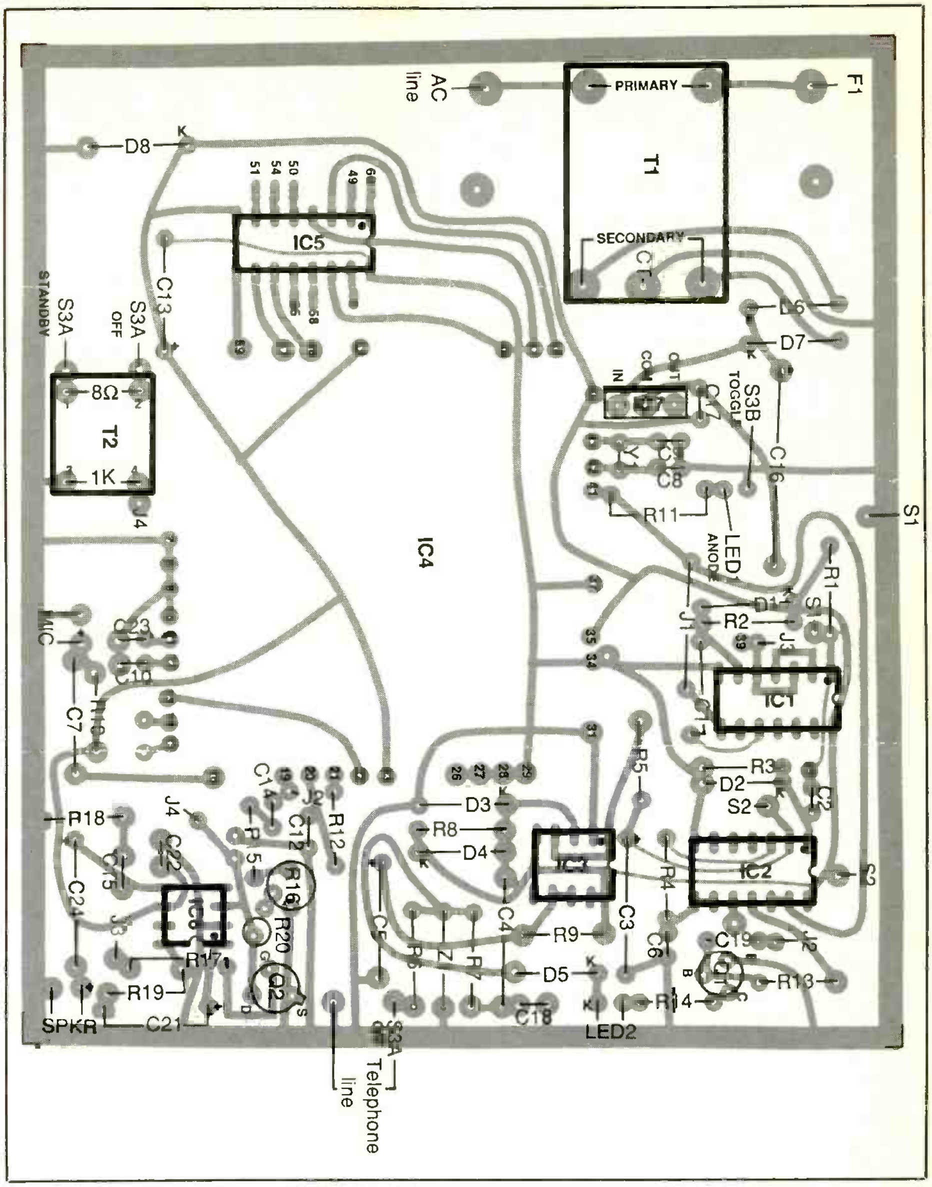


Fig. 6. Wiring diagram for main board.

Place the smaller pc board in front of you copper-pattern side up. You needn't concern yourself with orientation because all four sides of this board are identical to each other. Now examine the *IC4* LSI chip. You'll note that one corner of the package is sheared off diagonally. This corner is the "index" that lets you readily identify pin 1.

To mount the LSI chip on its separate pc board, you need a low-power soldering iron with a fine pointed tip. After allowing the tip to come up to soldering heat, carefully clean it. Place the LSI chip in the center of the pc board so that its leads directly line up with the traces on the latter.

Solder just one pin at each corner of the IC to the copper traces. Carefully examine the assembly to make certain that all other chip pins perfectly line up with their respective copper traces and that none straddles two traces. If you note misalignment that cannot easily be corrected by straightening possibly bent pins, you can easily desolder the chip from the board to reposition it as needed.

Once you're satisfied that all pins are properly aligned with the copper-trace pattern on the board, solder the remaining pins to the traces. The best way to do this is to apply soldering heat at the point where the end of each pin touches the board trace and the trace itself and flow just enough solder to assure a good electrical connection. To avoid heat damage to the chip, solder one pin on the side nearest you to the copper trace on one side of the board, rotate the board 90 degrees and solder one pin to the copper trace on the side now nearest you. Continue rotating the board and soldering just one pin until all pins have been soldered into place.

It's extremely important that you avoid creating solder bridges between the very closely spaced pin/trace connections. Clean your soldering tip frequently to remove excess solder build-up and oxidation, and use only enough solder to make good electrical connections. If you should accidentally create a solder bridge, use solder wick or a solder sucker to rectify the situation.

When you're finished soldering the pins to the copper traces, carefully examine all connections, preferably under a magnifying glass and good lighting, to make sure all connections are properly soldered.

Identify and mark the traces for pins 1, 7 through 16, 19 through 23, 25 through 29, 31, 32, 34, 35, 37, 41, 42, 43, 45 through 51, and 54 through 60. Carefully "wet" the ends of each of these traces with a thin film of solder (make sure you don't create any solder bridges).

Retrieve the main circuit-board assembly and place it in front of you oriented as shown in Fig. 6. Place the *IC4* circuit-board in the center of the main board, orienting it so that the pin 1 index is toward the lower-left. This is the orientation the smaller board must have when mounted on the larger board.

Use a very small amount of fast-setting epoxy or other adhesive to mount the *IC4* carrier board on the main circuit-board assembly in the proper orientation. Make sure that the smaller board doesn't cover any of the larger board's holes that will be used to electrically interconnect the two.

House your project in any type of enclosure that easily accommodates the circuit-board assembly and the off-the board components. An enclosure that has a sloping panel, like that shown in the lead photo, will give the project a professional appearance.

Machine the the front or top panel of the enclosure for mounting the two LEDs, the three switches and the microphone element. Then drill separate holes to provide entry for the ac line cord and telephone line through the rear panel. The fuse holder for *F1* can be either an inexpensive block type that mounts via a single machine screw, lockwasher and nut or a more expensive bayonet type. Drill the size hole for whichever type of holder you choose through the rear panel. If the enclosure you choose has no holes punched in it to allow the sound from the speaker to escape, drill 25 or more small holes in the area over which the speaker will be mounted for this purpose.

If you've decided to use a panel-mount potentiometer for *R16* and/or a switch for selecting 8 or 16 seconds of recording, you need holes for either or both of these options, preferably through the rear wall of the enclosure so that these items won't be out in plain sight.

After drilling all holes, deburr them to remove sharp and rough edges. Then place a rubber grommet in the ac line cord and telephone line holes. Tightly twist together the fine wires at the end of the ac line cord and lightly tin with solder. If your telephone cable has modular connectors on both ends, cut off and discard the connector at one end. (Note: FCC Regulations *require* a quick-disconnect modular connector at the line end of the telephone cord.) Trim about 4 inches of the outer plastic jacket from the cut end and ¼ inch of insulation from the black- and red-insulated conductors.

Pass the free ends of the ac line cord and telephone cable through their respective grommets and tie a knot in each about 6 inches from the free ends inside the enclosure to serve as strain reliefs. Run a thin bead of silicone adhesive around the perimeter of the loudspeaker and press it into place so that the hole pattern is centered in it.

Use a dry-transfer lettering kit to label the switch, LED and microphone holes with appropriate legends (see lead photo). If you're using them, also label the panel-mount VOLUME control and 8/16 second switch. When all labeling is done, apply two or three *light* coats of clear spray acrylic over them to protect them from abrasion.

When the acrylic spray has completely dried, mount the fuse holder, LEDs, switches, microphone element and VOLUME control in their respective locations. Use a drop or two of cyano-acrylate (Krazy) glue or fast-set clear epoxy cement to hold the LEDs and microphone element in place.

It's mandatory that the polarity of the connections for the telephone line to the project be correct, as indicated in Figs. 1 and 6. In most telephone installations, the green-insulated wire is positive (+) and the red-insulated wire is negative (−); The black- and yellow-insulated wires aren't used in modern installations. However, to be on the safe side, check the polarity of your telephone line. To do this, connect the "hot" and common probes of a dc voltmeter to the green- and red-insulated wires, respectively.

Plug the modular connector at the other end of the telephone cord into the telephone line and note the polarity indicated on the meter. If the indication is positive, label the green wire "+" and the red wire "−." On the other hand, if you get a negative indication, reverse the labeling. Disconnect the cord from the telephone line.

Plug the wire labeled "+" into the hole in the circuit-board assembly labeled TELEPHONE LINE + and the wire labeled "−" into the board hole labeled TELEPHONE LINE − and solder both into place. Then, connect and solder one conductor of the

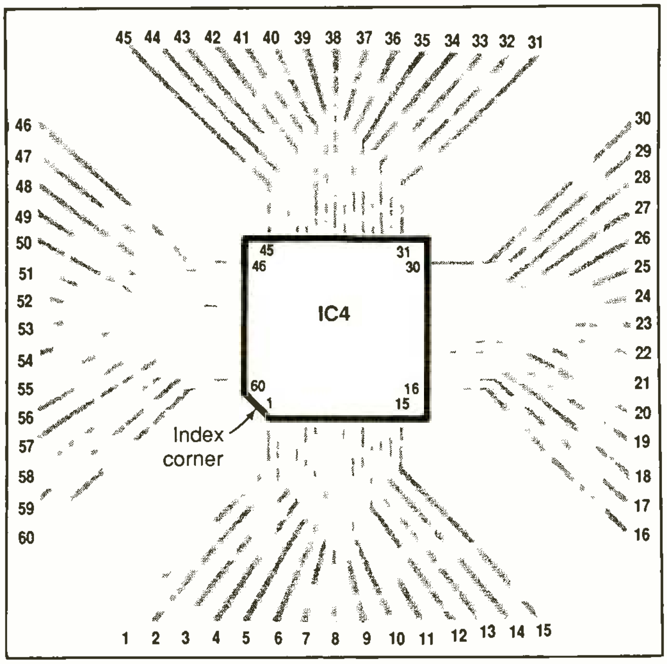
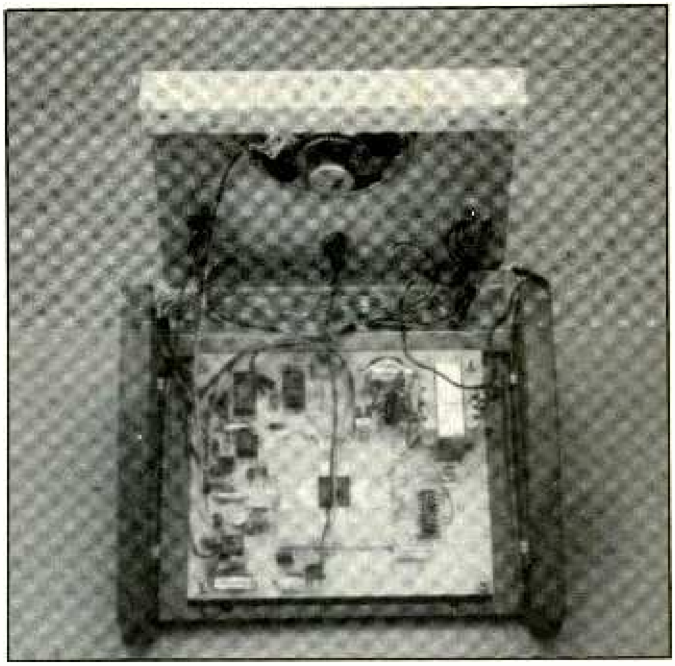


Fig. 7. Installation and pin/trace number details for LSI carrier board.



Interior view of finished project. Note how IC4 carrier board mounts on main board and is interconnected via small-gauge enameled magnet wire.

line cord to one lug of the fuse holder and plug the other line cord conductor into one of the holes labeled AC LINE CORD on the circuit-board assembly and solder into place. Trim ¼ inch of insulation from a long enough hookup wire to bridge between the other fuse block lug and the board hole labeled F1. Connect and solder this wire into place.

Locate the free ends of the switch wires and connect and solder them to the lugs of the appropriate switch lugs. If you're using a panel-mounted VOLUME control, do the same for its wires. Then, observing proper polarity, connect and solder the free ends of the MIC and SPKR wires to the microphone element and speaker lugs, respectively.

Slide a 1-inch length of small-diameter heat-shrinkable tubing or insulating plastic tubing over the free ends of the *LED1* and *LED2* anode wires. Cut the anode leads of both LEDs to ½ inch long and solder them to their respective board wires. Slide the tubing up the wires until it's flush against the bottoms of the molded LED cases and shrink into place. Trim the cathode lead of *LED2* to ½ inch and crimp and solder the appropriate wire from the board to it. Finally, connect and solder the cathode lead of *LED1* to the appropriate lug on *S3B*; if necessary; use a length of hookup wire to make this connection.

Checkout & Use

With only *IC7* installed in the circuit, plug the project's line cord into a 117-volt ac outlet and use a dc voltmeter (or a multimeter set to measure dc volts) set to read at least 5.5 volts to measure the output from the regulator. Take your reading across *D8*. If the dc power supply is functioning properly, you should obtain a reading between 4.5 and 5.5 volts dc. If not, unplug the line cord and troubleshoot the circuit. Don't proceed until you've rectified the problem.

When you're certain the power supply is functioning as it should, proceed to final assembly.

The best way to interconnect the two boards together is to use light-gauge—say, No. 30—enameled wire. If possible, obtain a small quantity of the type of wire that can be directly soldered without having to scrape away the enamel insulation.

Tin about 3/16 inch of the end of the enameled wire and carefully tack-solder it to the end of the *IC4* pin trace. Route this wire over to the hole numbered 1 near *IC5*, trim it to length, insert it in the hole and solder it into place. Do the same with the remaining identified traces and the same-numbered holes in the main circuit-board assembly.

Now install the ICs in their respective sockets. Handle the CMOS devices with the same precautions you would use when working with any other type of MOS device.

As you install each IC, make sure it's the proper device number and

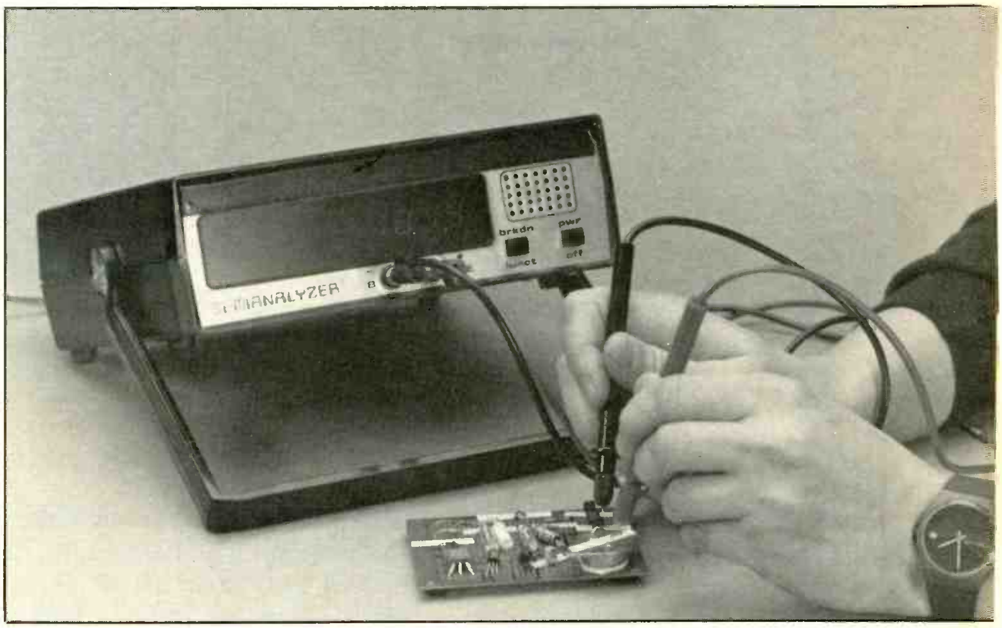
(Continued on page 89)

The Semianalyzer

(Part 1)

This versatile instrument tests semiconductors for type, condition and number of junctions, the circuitry around the devices, and other components

By David T. Miga, CET



If you troubleshoot electronic equipment, you are probably using a DMM or an inexpensive transistor tester to check transistors and diodes, with only marginal success. What you need is an instrument that can probe a semiconductor device while it is still in a circuit and read out in printed legends the type, condition and number of junctions of the device and give circuit conditions *around* the component under test. The instrument could beep different tones for important circuit conditions like a shorted or leaky component and might even check LEDs, capacitors, neon lamps and semiconductors for proper voltage breakdown. It might even let you listen to the breakdown so that you can identify noisy components.

You might think the instrument just described is pure fancy, but it does exist. We call it the "Semianalyzer." If you were to buy a commercial equivalent of this instrument, it would cost you more than $400. However, by building it yourself, you pay less than half that price.

This is a sophisticated piece of test gear that, with some patience, is not overly difficult to build. It requires both a double-sided printed-circuit board on which most of the components mount in a dense array and a smaller single-sided pc board for a legend/numeric display section. Believe me, it is worth the extra effort to build as compared to a simple project because it will pay off handsomely by saving so much troubleshooting time.

About the Circuit

Before examining the complex schematic diagram of the Semianalyzer, it is easier to visualize basic operation by examining the block diagram shown in Fig. 1. This diagram reveals that the Semianalyzer actually consists of two pieces of test equipment. The junction portion at the left contains a 6-volt ac signal that is sent through the test leads to the component under test. The component and its support circuitry will distort the signal in a certain manner. This signal is converted by the 8-bit comparator, which serves as an A/D (analog-to-digital) converter to form an 8-bit word. This word is level-shifted to the proper 0- to 5-volt signals that are then presented to the 2716 EPROM.

The EPROM must be programmed to recognize almost any circuit condition. It turns on the proper LEDs, through the LED driver circuitry, to illuminate the correct combination of legends in the LED display matrix. The EPROM also has five outputs that drive a tone oscillator at different frequencies that audibly alert the instrument user to shorted, leaky and multiple-junction devices.

The voltage-breakdown portion at the right in Fig. 1 generates a safe, isolated source of 150 volts dc. This voltage is applied to the component under test through a high-value resistor that limits test current to a maximum of 15 milliamperes. As the component breaks down at a certain threshold voltage, the potential is displayed on a DVM (digital voltmeter) IC and appears in the seven-segment numeric LED display shown at the upper-right.

Breakdown noise is monitored by the audio amplifier IC through the filter-protector circuit.

Now turn to the schematic of the junction circuit shown in Fig. 2. Red jack *J1* at the bottom of this circuit is connected to the *R19/R20* junction, which safely limits the inputs to quad comparators *IC8* and *IC9*. Also common to the junction point is insertion of a current-limited 6-volt ac signal that is derived from one of the secondaries of power transformer *T1* (see Fig. 4). Therefore, the signal sent through the red and black test leads connected to the Semianalyzer via *J1* and *J2* will have a peak-to-peak level of approximately 17 volts (6 volts ac rms × 1.414 = 8.8 volts peak, and 8.8 volts peak × 2 = 17.6 volts peak-to-peak).

You can think of the 17-volt p-p signal as being am alternating +8.5-volt and −8.5-volt signal. Since the semiconductor under test will pass much more current in one direction than it can in the other, the signal will be distorted into a clipped (lopsided) version of the original signal. This signal is fed into quad comparators *IC8* and *IC9* through resistors *R19* and *R20*, respectively.

The positive (+) reference string of resistors (*R26* through *R30*) and negative string of resistors (*R21* through *R25*) are biased at voltages that represent one, two, three and more than three semiconductor junctions of either polarity. (All reference resistors have 1-percent value tolerances.) Therefore, if the circuit under test is open, all four comparator outputs of *IC8* and all four *IC9* outputs will be brought low to the −9-volt dc rail. On the other hand, if the Semianalyzer detects a short circuit, all outputs will rise.

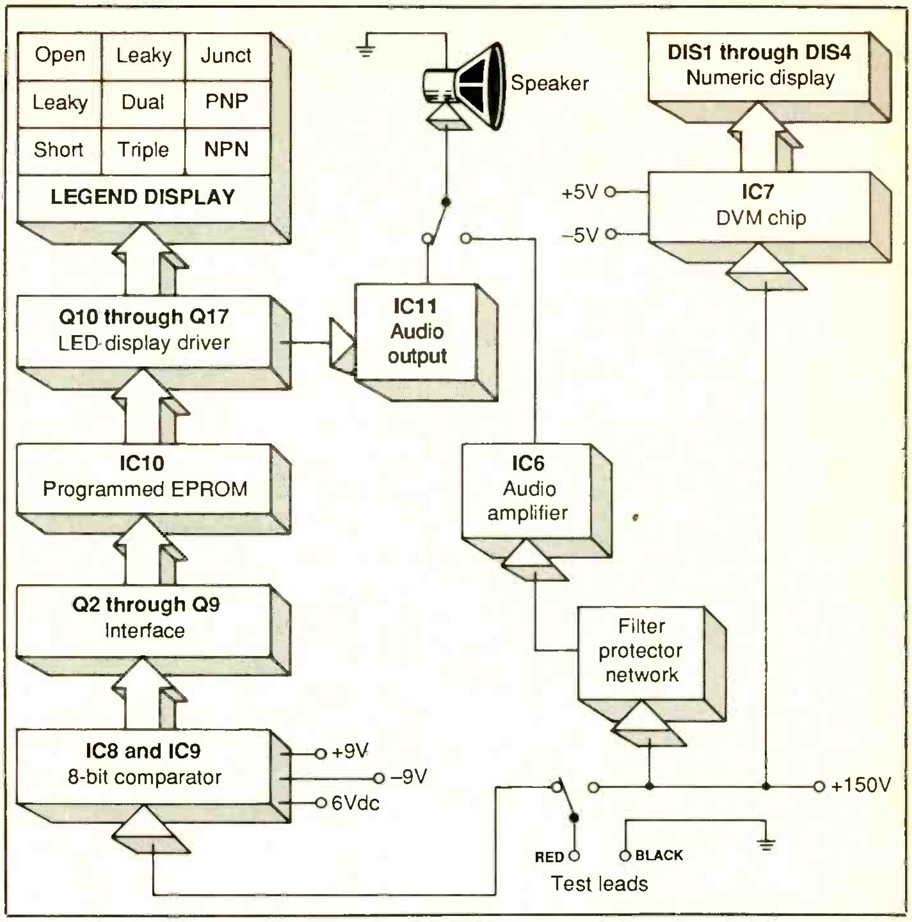


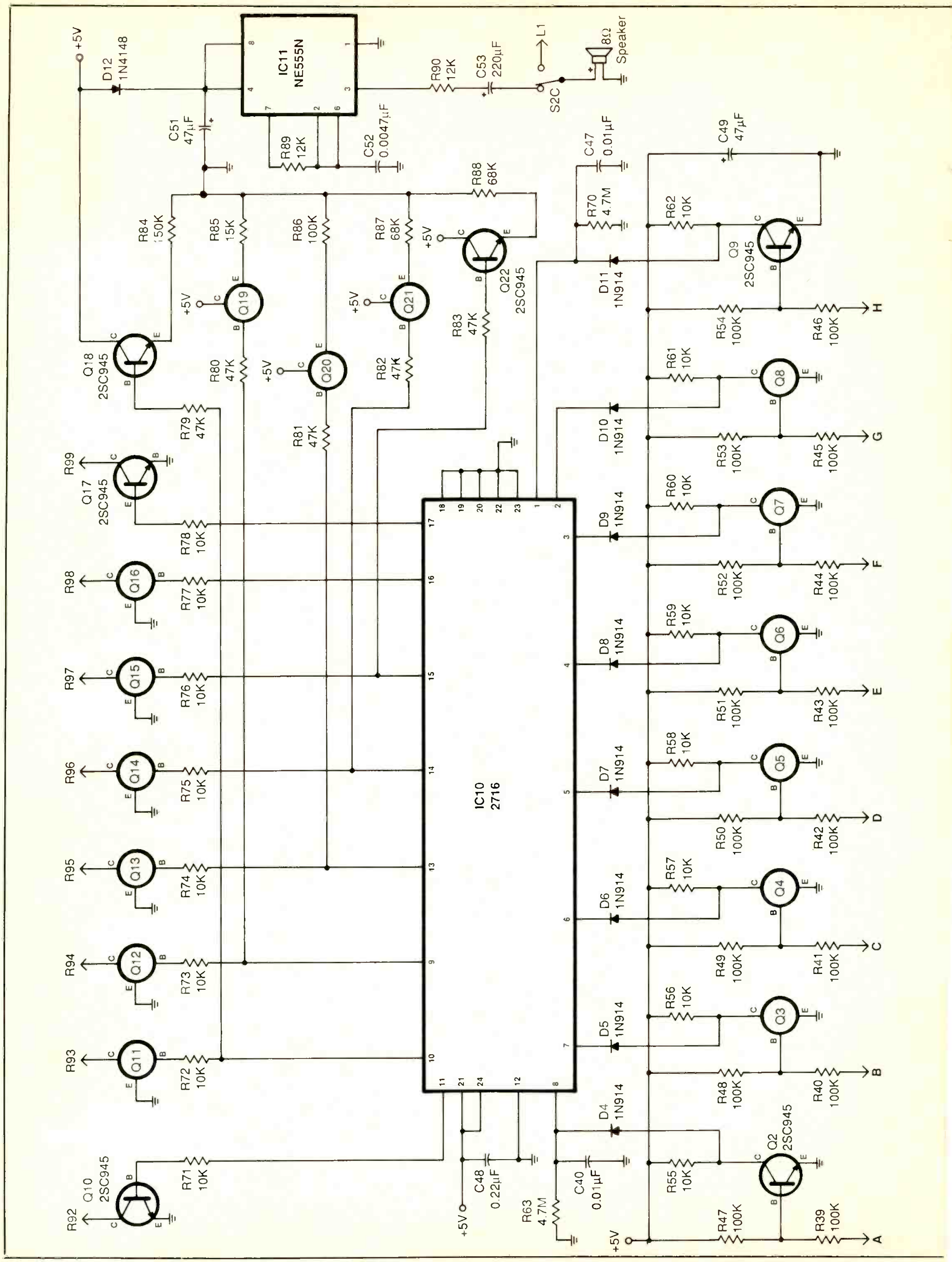
Fig. 1. Block diagram shows how Semianalyzer actually consists of two instruments that share the same chassis and power supply: junction test portion at left and voltage-breakdown portion at right.

Open-collector comparator outputs are used. These are biased by *R39* through *R62* so that the outputs will alternate between −9 and +5 volts to drive transistors *Q2* through *Q9*. These transistors serve as level shifters to provide the 0- to +5-volt signals required by EPROM *IC10*. Resistors *R55* through *R70* and capacitors *C40* through *C47* serve as integrators that smooth the pulsating voltages caused by the original 60-Hz ac signal into clean dc voltages for *IC10*'s inputs.

EPROM *IC10* is programmed to recognize 25 different circuit conditions, as shown in the Table. Its outputs drive *Q10* through *Q17*, which serve as open-collector drivers for *LED1* through *LED27*, via limiting resistors *R92* through *R99*. (Note in Fig. 2 that the same arrangement shown for *D4*, *C40* and *R63* for the *Q2* circuit is repeated for the *Q3* through *Q8* circuits, with different component designations, of course.)

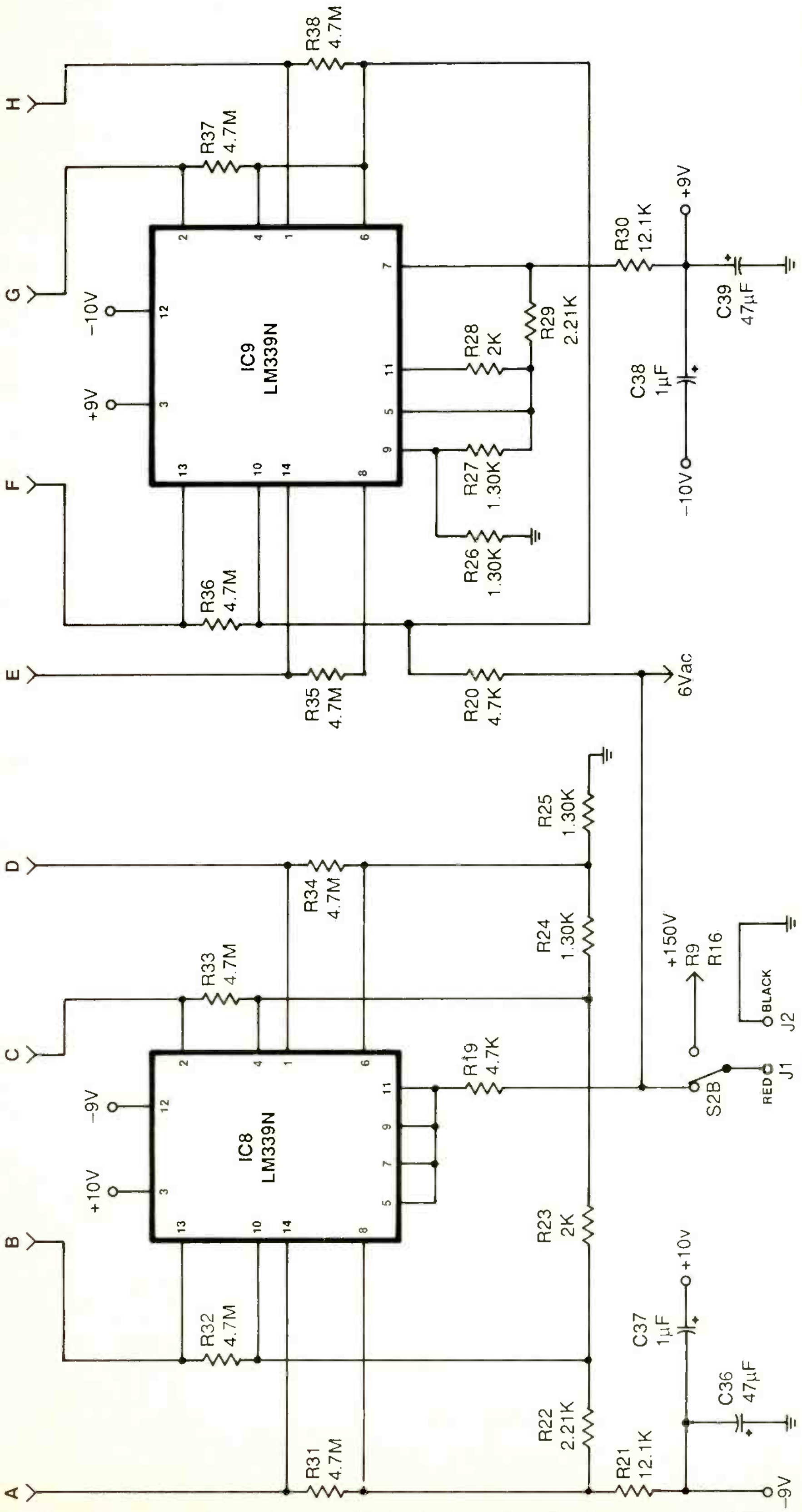
Shown in Fig. 3 is the schematic diagram of the Semianalyzer's display system. Note that three LEDs for each legend are wired in series with each other to reduce power consumption. All three LEDs in each case will glow at the same intensity because current flow through each LED in the string will be identical.

Returning to Fig. 2, *IC10* also drives *Q18* through *Q22*. These transistors provide the current needed to activate tone generator *IC11*. Values of *R84* through *R88* are selected to



IC11
NE555N
IC10
2716
+5V
D12
1N4148
C51
47μF
R89
12K
C52
0.0047μF
R90
12K
C53
220μF
L1
8Ω
Speaker
S2C
C47
0.01μF
C49
47μF
R70
4.7M
R62
10K
Q9
2SC945
D11
1N914
R54
100K
R46
100K
H
R84
150K
R85
15K
R86
100K
R87
68K
R88
68K
Q22
2SC945
Q19
Q20
Q21
R83
47K
R80
47K
R81
47K
R82
47K
Q18
2SC945
R79
47K
Q17
2SC945
R99
R78
10K
Q16
R98
R77
10K
Q15
R97
R76
10K
Q14
R96
R75
10K
Q13
R95
R74
10K
Q12
R94
R73
10K
Q11
R93
R72
10K
Q10
2SC945
R92
R71
10K
C48
0.22μF
R63
4.7M
C40
0.01μF
R61
10K
Q8
D10
1N914
R53
100K
R45
100K
G
R60
10K
Q7
D9
1N914
R52
100K
R44
100K
F
R59
10K
Q6
D8
1N914
R51
100K
R43
100K
E
R58
10K
Q5
D7
1N914
R50
100K
R42
100K
D
R57
10K
Q4
D6
1N914
R49
100K
R41
100K
C
R56
10K
Q3
D5
1N914
R48
100K
R40
100K
B
Q2
2SC945
D4
1N914
R55
10K
R47
100K
R39
100K
A

Fig. 2. Schematic diagram of junction-test circuit.



cause *IC11* to generate different tones. The output from *IC11* is dc isolated by *C53*, limited by *R90* and sent through *S2C* to loudspeaker *SPKR*.

The ac-operated dc power supply for the project is shown schematically in Fig. 5. Power transformer *T1* feeds full-wave bridge rectifier *D1*, whose pulsating dc output is filtered to pure dc by *C1*, *C2*, *C4*, *C10* and *C12*. After filtering, the dc is regulated to +9 volts by *IC1*, +5 volts by *IC3* and +12 volts by *IC4*.

To drive the Fig. 2 precision-resistor strings, precise sources of +9 and −9 volts dc are needed. To obtain the latter, a line is taken from the negative (−) side of *C1*, filtered by *C3* and regulated to −9 volts by *IC2*. The direct output of *IC2* is −9 volts dc. From this −9-volt rail, *R3*, *D2* and *C9* develop a −5-volt dc output as well.

Note that *IC1* and *IC2* are standard 8-volt dc regulators. By installing trimmer resistors *VR1* and *VR2* in the common-lead circuits of these regulators, the *IC1* and *IC2* outputs can be adjusted to provide exactly +9 and −9 volts dc, respectively.

As you can see, the +150-volt dc source needed for making voltage-breakdown tests, is derived from the +12-volt dc output from *IC4*. The +12 volts goes to the *IC5/Q1/T2* voltage-converter arrangement. After *IC5*'s ac output is current-amplified by *Q1*, and stepped up by *T1* it is half-wave rectified by *D3* and smoothed to dc by *C20*. The resulting +150-volts dc is then sent to the main circuitry through *R8* so that it is never more than 15 milliamperes. This +150 volts is switched through the component under test through *S2B* in Fig. 2.

In the Fig. 3 circuit, the +150 volts is digitized by DVM chip *IC7* and its value is displayed via LED numeric indicators *DIS1* through *DIS4*. It is also filtered by the high-pass filter made up of *C21*, *C22* and *R100*; low-pass filter *C23*; and clip-per/protector *D13* to amplifier *IC6*.

Gain of *IC6* is set by feedback resistor *R11* to produce an audio level that will let you hear minute changes of the breakdown voltage or noise. The problem here is that if a very-noisy component is causing a very large signal to be emitted by *IC6*, it would quickly destroy the small loudspeaker. Therefore, a form of alc (automatic level control) is needed. This is why indicator lamp *L1* is included in the circuit. In small-signal situations, *L1* acts as an ordinary 12-ohm resistor and passes most of the audio signal. If a large-excursion signal is encountered, the lamp quickly heats up to 150 ohms to protect the speaker and, lighting up, serves as a visual indicator of a noisy breakdown.

Program Listing For Data to be Burnt Into EPROM

Circuit Condition (Voltages)	Hex Address	Data Out	Display Legends
−0.00 to +0.00	00	01	SHORTED/JUNCT
−0.00 to +0.60	10	02	LEAKY/JUNCT
−0.00 to +1.20	30	02	LEAKY/JUNCT
−0.00 to +2.20	70	02	LEAKY/JUNCT
−0.00 to +3.20	F0	02	LEAKY/JUNCT
−0.60 to +0.00	08	02	LEAKY/JUNCT
−0.60 to +0.60	18	C2	LEAKY/NPN/PNP/JUNCT
−0.60 to +1.20	38	8A	LEAKY/SINGLE/NPN/JUNCT
−0.60 to +2.20	78	8A	LEAKY/SINGLE/NPN/JUNCT
−0.60 to +3.20	F8	88	SINGLE/NPN/JUNCT
−1.20 to +0.00	0C	02	LEAKY/JUNCT
−1.20 to +0.60	1C	4A	LEAKY/SINGLE/PNP/JUNCT
−1.20 to +1.20	3C	02	LEAKY/JUNCT
−1.20 to +2.20	7C	92	LEAKY/DUAL/NPN/JUNCT
−1.20 to +3.20	FC	90	DUAL/NPN/JUNCT
−2.20 to +0.00	0E	02	LEAKY/JUNCT
−2.20 to +0.60	1E	4A	LEAKY/SINGLE/PNP/JUNCT
−2.20 to +1.20	3E	52	LEAKY/DUAL/PNP/JUNCT
−2.20 to +2.20	7E	02	LEAKY/JUNCT
−2.20 to +3.20	FE	A0	TRIPLE/NPN/JUNCT
−3.20 to +0.00	0F	02	LEAKY/JUNCT
−3.20 to +0.60	1F	48	SINGLE/PNP/JUNCT
−3.20 to +1.20	3F	50	DUAL/PNP/JUNCT
−3.20 to +2.20	7F	60	TRIPLE/PNP/JUNCT
−3.20 to +3.20	FF	04	OPEN/JUNCT

Construction

Because of the relative complexity of this circuit, in terms of both functionality and component count, printed-circuit construction is highly recommended. You can etch and drill your own pc boards, using the actual-size artwork shown in Figs. 5 (main board) and 6 (display board).

Notice that the main board requires a double-sided etch pattern and should have plated-through holes. If you fabricate this board at home, you will not be able to plate-through the holes. You can still etch and drill the double-sided pattern and use the board if you make certain adjustments in the assembly procedure and make some component changes. (The board in the kit from the source given in the Note at the end of the Parts List comes with plated-through holes.) The single-sided display board can be etched and drilled in the usual manner.

• *The Main Board.* Etch and drill the main pc board, using the artwork in Fig. 5. The notches at opposite ends of the board fit around the molded plastic posts in the enclosure used for the prototype. If you use a different enclosure that does not have these posts, drill mounting holes instead of these notches.

Use a very-fine drill bit—say a No. 60 or 61—to very carefully drill a hole through the board at the end of each trace on the edge of the board to the right of *IC7* with the bottom guide oriented as shown. There are 34 holes to be drilled here. Make sure these holes are centered in each trace. Do the same for the nine holes near the edge of the board to the right of *Q10* through *Q17*. There are nine holes here, including the rectangular one at the corner of the board.

Assuming you are using a home-made pc board, when you begin installing components, keep in mind that all component leads and pins that go into holes that have copper traces leaving them on both sides of the board *must* be soldered to the pads on both sides. In fact, make it a habit to solder *all* leads and pins to the pads on both sides of the board; this way, you will not inadvertently miss any as you go along. If you are using a board with plated-through holes, you need solder leads and pins to the bottom-of-the-board pads only.

There are a great many closely spaced pads and conductors on this board. If you are not careful, you can easily create solder bridges. Therefore, start with a low-power soldering iron equipped with a fine tip. When the tip comes up to soldering heat, thoroughly clean it. When soldering a connection, use only enough solder to make a good electrical and mechanical joint. Do not use excessive solder. Also, clean the tip of your iron frequently.

Start stuffing the main board by plugging the leads of the resistors into the appropriate holes and soldering them into place. Double check resistor values before soldering any leads to the copper pads. Once the re-

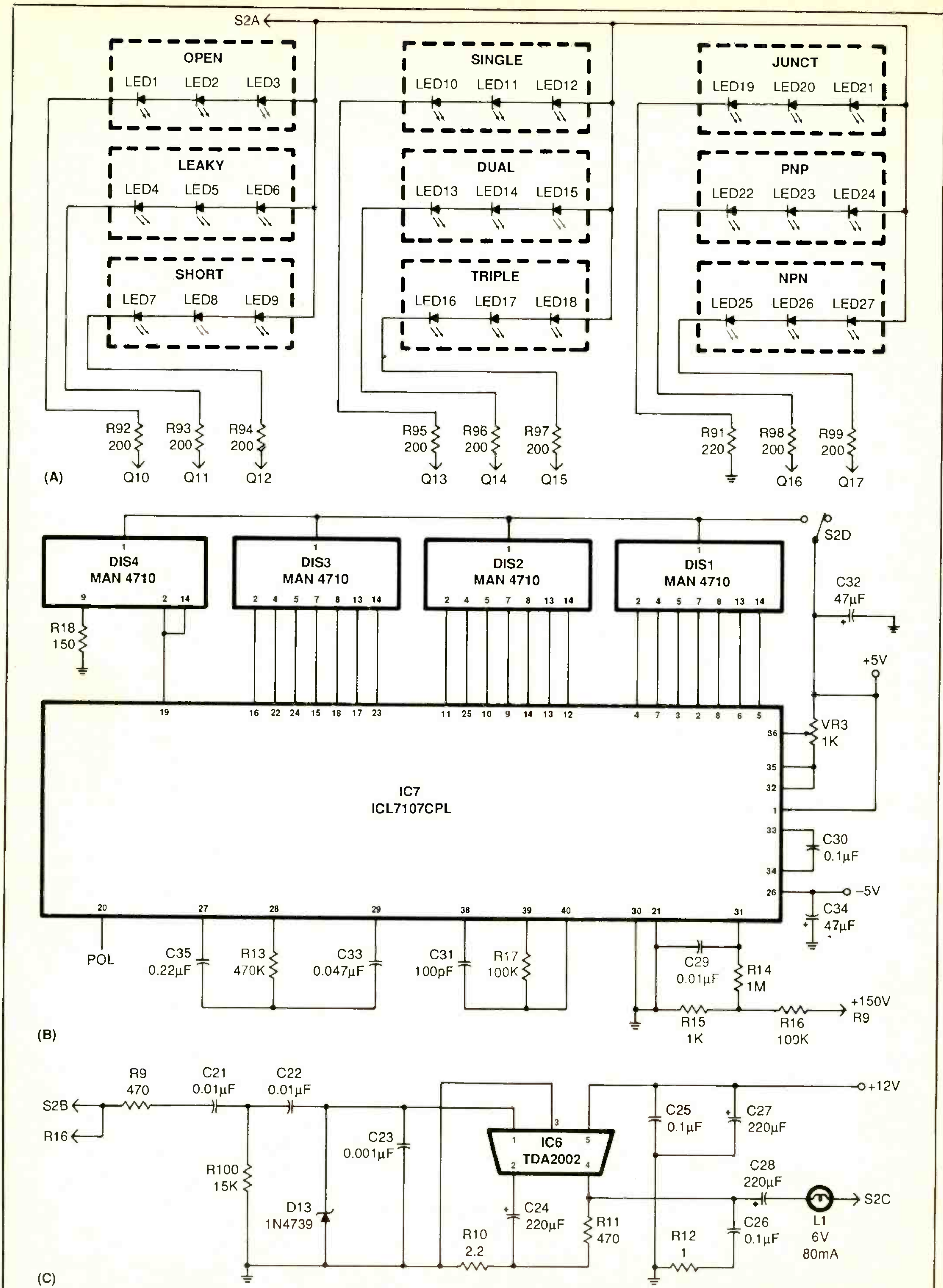


Fig. 3. Schematic diagram of project's legend and numeric display systems.

PARTS LIST

Semiconductors

D1—ECG 5304 or similar 1.5-ampere, 200-PIV round bridge rectifier

D2—1N4733 or equivalent 5.0-volt, 1-watt, 10% tolerance zener diode

D4 thru D12—1N4148 or 1N914 silicon switching diode

D13—1N4737 or similar 9.0-volt, 1-watt, 10% tolerance zener diode

DIS1 thru DIS4—MAN 4710 or equivalent 0.4" red common-anode 7-segment numeric display

IC1—7808 or similar +8-volt, 1-ampere regulator in TO-220 case

IC2—7908 or similar −8-volt, 1-ampere regulator in TO-220 case

IC3—7805 or similar +5-volt, 1-ampere regulator in TO-220 case

IC4—7812 or similar +12-volt, 1-ampere regulator in TO-220 case

IC5,IC11—NE555N timer

IC6—TDA2002 or equivalent 8-watt audio amplifier in TO-220 case

IC7—ICL7107CPL or equivalent 3.5-digit DVM/LED driver (Intersil)

IC8,IC9—LM339N quad comparator

IC10—2716 or similar 450-ns EPROM

LED1 thru LED27—T-1¾ 20-mA amber light-emitting diode

Q1—2SB633, 2SB595 or similar 100-volt, 5-ampere (40-watt) npn power transistor in TO-220 case

Q2 thru Q22—2SC945, 2SC1364, 2SC1000 or similar 50-volt, 100-mA (200-mW) npn power transistor in TO-92 case

Capacitors

Radial-Lead Aluminum Electrolytic:

C1,C2—1,000 µF (25-volt)

C3,C4,C11,C13—4.7 µF (50-volt)

C5 thru C8,C37,C38—1 µF (50-volt tantalum)

C9,C16,C32,C34,C36,C39,C49 thru C51—47 µF (16-volt)

C10,C12,C15—100-µF (25-volt)

C14,C24,C27,C28,C53—220 µF (16-volt)

Radial-Lead Film:

C17,C52—0.0047 µF (50-volt Mylar)

C18,C33—0.047 µF (50-volt Mylar)

C19,C21,C22—0.01 µF (250-volt Mylar)

C20—10 µF (250-volt)

C23—0.001 µF (50-volt Mylar)

C25,C26,C30—0.1 µF (50-volt, 5% stacked metalized film)

C29,C40 thru C47—0.01 µF (50-volt Mylar)

C31—100 pF (50-volt, 5% polystyrene)

C35,C48—0.22 µF (50-volt, 5% stacked metalized film)

Resistors (¼-watt, 5% tolerance)

R3—390 ohms

R5,R18—150 ohms

R6—5,600 ohms

R7—4,300 ohms

R9,R11—470 ohms

R10—2.2 ohms

R12—1 ohm

R13—470,000 ohms

R14—1 megohm

R15—1,000 ohms

R16,R17,R39 thru R54,R86—100,000 ohms

R19,R20—4,700 ohms

R31 thru R38,R63 thru R70—4.7 megohms

R55 thru R62,R71 thru R78—10,000 ohms

R79 thru R83—47,000 ohms

R84—150,000 ohms

R85,R100—15,000 ohms

R87,R88—68,000 ohms

R89,R90—12,000 ohms

R91—220 ohms

R92 thru R99—200 ohms

R21,R30—12,100 ohms (¼-watt, 1% precision metal-film)

R22,R29—2,210 ohms (¼-watt, 1% precision metal-film)

R23,R28—2,000 ohms (¼-watt, 1% precision metal-film)

R24 thru R27—1,300 ohms (¼-watt, 1% precision metal-film)

R1,R2—22 ohms (1 watt)

R4—12 ohms (1-watt)

R8—10,000 ohms (1-watt)

VR1,VR2,VR3—1,000-ohm top-adjust multi-turn cermet pc-type trimmer resistor

Miscellaneous

F1—500-mA pigtail fuse

J1,J2—Red and black banana jack

L1—6-volt, 80-mA pigtail incandescent lamp (GTE 5ES or similar)

S1—Spst switch

S2—4-pole pc-type push switch (Electronic Components Group No. TA4UEE or equivalent)

SPKR—8-ohm, 0.1-watt 1.5" speaker (Panasonic No. 2P15SA or equivalent)

T1—6-volt ac, 300-mA/30-volt ac with center tap, 1-ampere power transformer (Airline Mechanical No. EI: 57-28 or similar)

Printed-circuit boards (see text); sockets for DIP ICs (and optionally for numeric displays); ac line cord with plug; 3-lug (none grounded) terminal strip); materials for making IC heat sink, legend display shield and display mask (see text); line cord with plug; rubber grommet; button caps for S1 and S2; suitable enclosure (see text); red and black banana plugs, test probes and test-lead wire for test cables (see text); lettering kit; clear acrylic spray; machine hardware; hookup wire; solder; etc.

Note: The following items are available from Electronic Design Specialists, Inc., 951 SW 82 Ave., N. Lauderdale, FL 33068: Complete kit of all parts, including enclosure but not including sockets for displays, $139 + $7.50 P&H; double-sided main pc board with plated-through holes, and single-sided display board, $25.00; programmed EPROM, $20.00; molded-plastic matrix display shield, $5.00; cabinet kit, including hardware, $29.00. Prices for other available components can be obtained by writing to the kit supplier. Add $2.00 P&H for individual parts orders. Florida residents, please add state sales tax.

sistors have been installed, mount and solder into place all nonpolarized capacitors.

Next, install the sockets for the ICs in their respective locations. If you are using a board that has plated-through holes, simply drop the sockets into the holes at the indicated locations and solder into place from the bottom of the board. If you are using a board whose holes are not plated-through, you cannot use standard IC sockets because they do not provide top-of-the-board soldering access. In this case, use Molex Soldercon® socket strips that do. Break the Soldercon strips into as many strips as needed: four strips of 4 pins

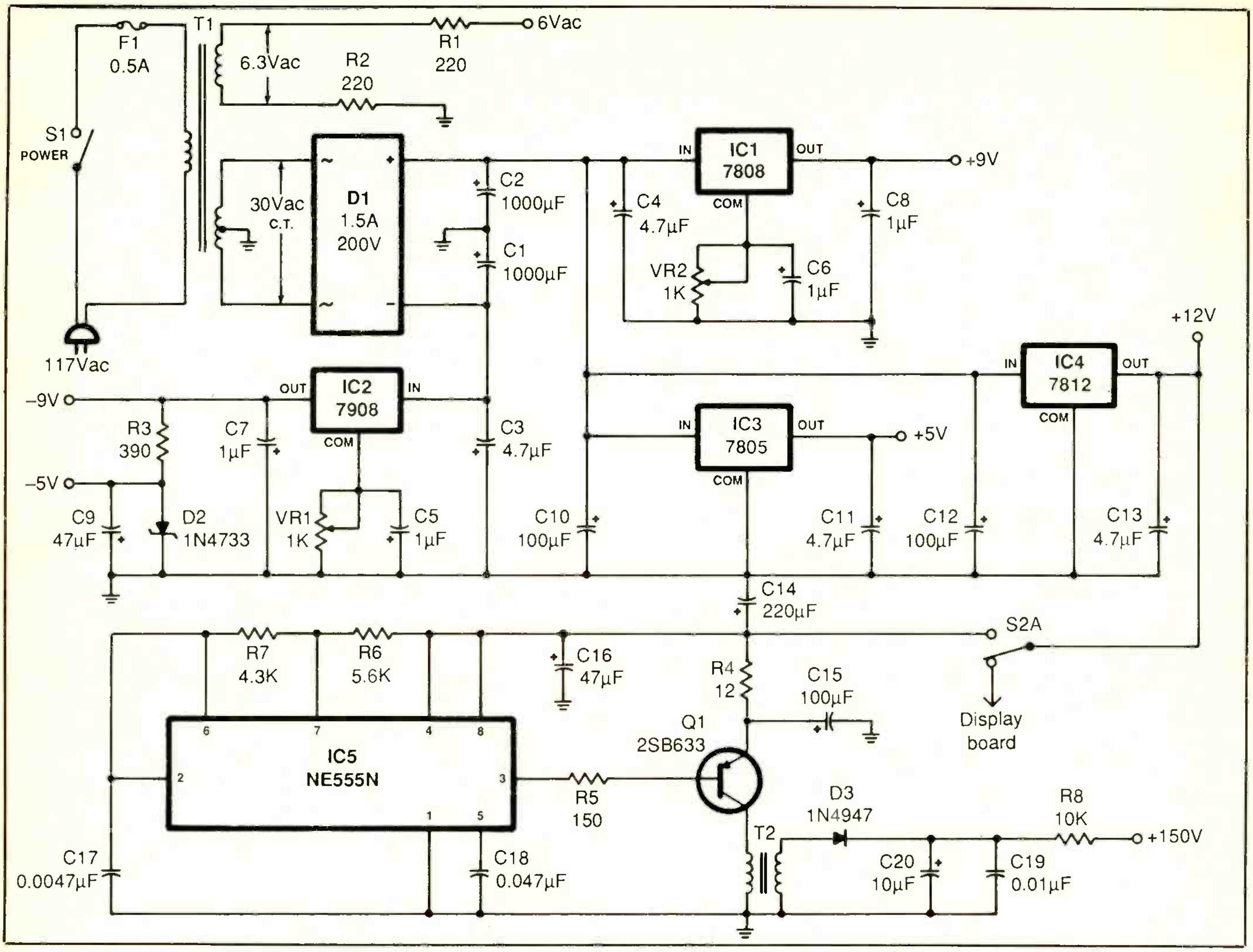


Fig. 4. Schematic diagram of ac-operated multiple-dc-output power supply.

for *IC5* and *IC11*, four strips of 8 pins for *IC8* and *IC9*, two strips of 12 pins for *IC10* and two strips of 20 pins for *IC7*. Do *not* remove the metal bridging pieces at the tops of the strips until after each strip is soldered in its respective location.

Plug a 20-pin Soldercon strip into one line of holes for *IC7* and solder the first and last protruding strip to the copper pads on the bottom of the board. Turn over the board and check that the strip is vertical to the surface of the board on the component side. If not, reflow the solder on both pins and hold it vertical until the solder sets. Then carefully solder all remaining pins to the pads on the bottom of the board.

Flip over the board and sparingly solder the Soldercons to the pads on the top of the board. Use only enough solder to make good electrical connections, and make sure that none of the solder clogs any of the pin sockets. Then repeat the entire procedure for all remaining strips and DIP IC locations. Gently flex the bridging metal strips from the tops of all Soldercon strips. Do *not* install any of the ICs in the indicated locations until after initial checkout has been performed.

Now install and solder into place the bridge rectifier and all diodes. Make absolutely certain that these components are properly oriented before soldering their leads to the copper pads. This done, install and solder into place trimmer potentiometers *VR1*, *VR2* and *VR3* in their respective locations.

You may have difficulty installing 4-pole pushbutton switch *S2* if you are using a board that does not have plated-through holes. To gain soldering access for the pin that must be soldered to the pad on the top of the board, the solution is to loop a length of No. 30 enameled wire (preferably the type that can be soldered-through and does not require the enamel to be scraped away to be made solderable) around and solder it to that pin. The free end of this wire should stick out from the rear end of the switch. Clip it to a length

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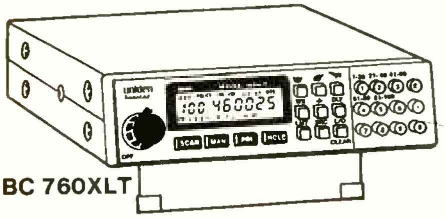

BC 760XLT

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10-Band, 16 Channel • No-crystal scanner
Priority control • Weather search • AC/DC
Bands: 29-54, 136-174, 406-512 MHz.
The *Bearcat* 145XL is a 16 channel, programmable scanner covering ten frequency bands. The unit features a built-in delay function that adds a three second delay on all channels to prevent missed transmissions.

Bearcat® 175XL-SA

List price $279.95/**CE price $156.95/SPECIAL**
11-Band, 16 Channel • Weather Search
Priority control • Search/Scan • AC/DC
Bands: 29-54, 118-174, 406-512 MHz.
The *Bearcat* 175XL has an automatic search feature to locate new frequencies. Priority, lock out, delay and scan speed are all included.

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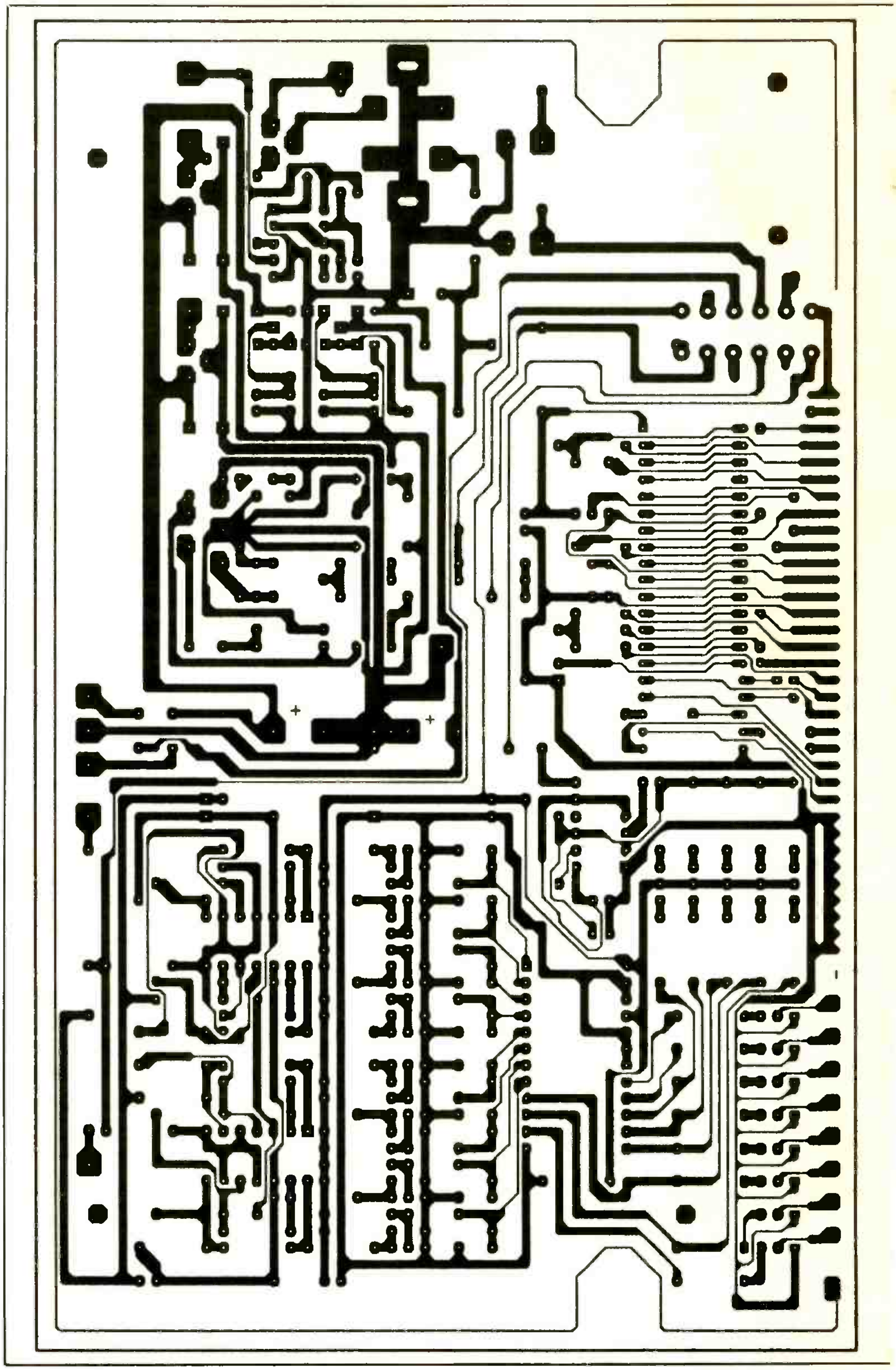
CIRCLE 72 ON READER SERVICE CARD

of 1 inch and, if necessary, scrape about ¼ inch of enamel insulation from its free end and tin with solder.

Plug the switch into the board holes where indicated, plunger shaft pointing away from the board, and press it as close to the surface of the board as you can as you solder one pin in each row to the copper pads on the bottom of the board. Flip over the board and carefully tack solder the wire tail to the appropriate trace. Make sure that neither the wire nor the solder comes in contact with any other trace on the board. Use an ohmmeter to check for continuity between the top and bottom traces for this switch pin. If you do not obtain continuity, desolder the switch from the board and repeat the process until you do. Once you obtain continuity, solder the remaining pins of the switch to the pads on the bottom of the board.

Now install the transistors on the board. Start with the circuit-board assembly oriented as shown. As you install each transistor, set it in place so that you have soldering access to all leads on both sides of the board. Install the transistors with the emitter (E), base (B) and collector (C) leads plugged into the appropriate holes. The E, B and C designators are shown independently for *Q1* and collectively for *Q2* through *Q9* near where *Q2* mounts, for *Q10* through *Q17* near where *Q10* mounts, and for *Q18* through *Q22* near where *Q18* mounts. The only transistor that is different from the others is *Q1*; so make sure you separate this one out and install it in the Q1 location first.

Taking care to properly orient them, install the electrolytic capacitors in their respective locations and solder their leads to the copper pads. Then mount audio coupling transformer *T2* on the board in the indicated locations. Make sure *T2*'s 8-ohm and 1-kilohm pins are plugged into the proper holes before soldering them or the metal mounting tabs to the board's pads.



Strip ¼ inch of insulation from both ends of an 8-inch length of stranded hookup wire. Tightly twist together the fine conductors at both ends and sparingly tin with solder. Plug one end of the wire into the hole labeled GND and solder into place.

Now, disregarding the holes la-

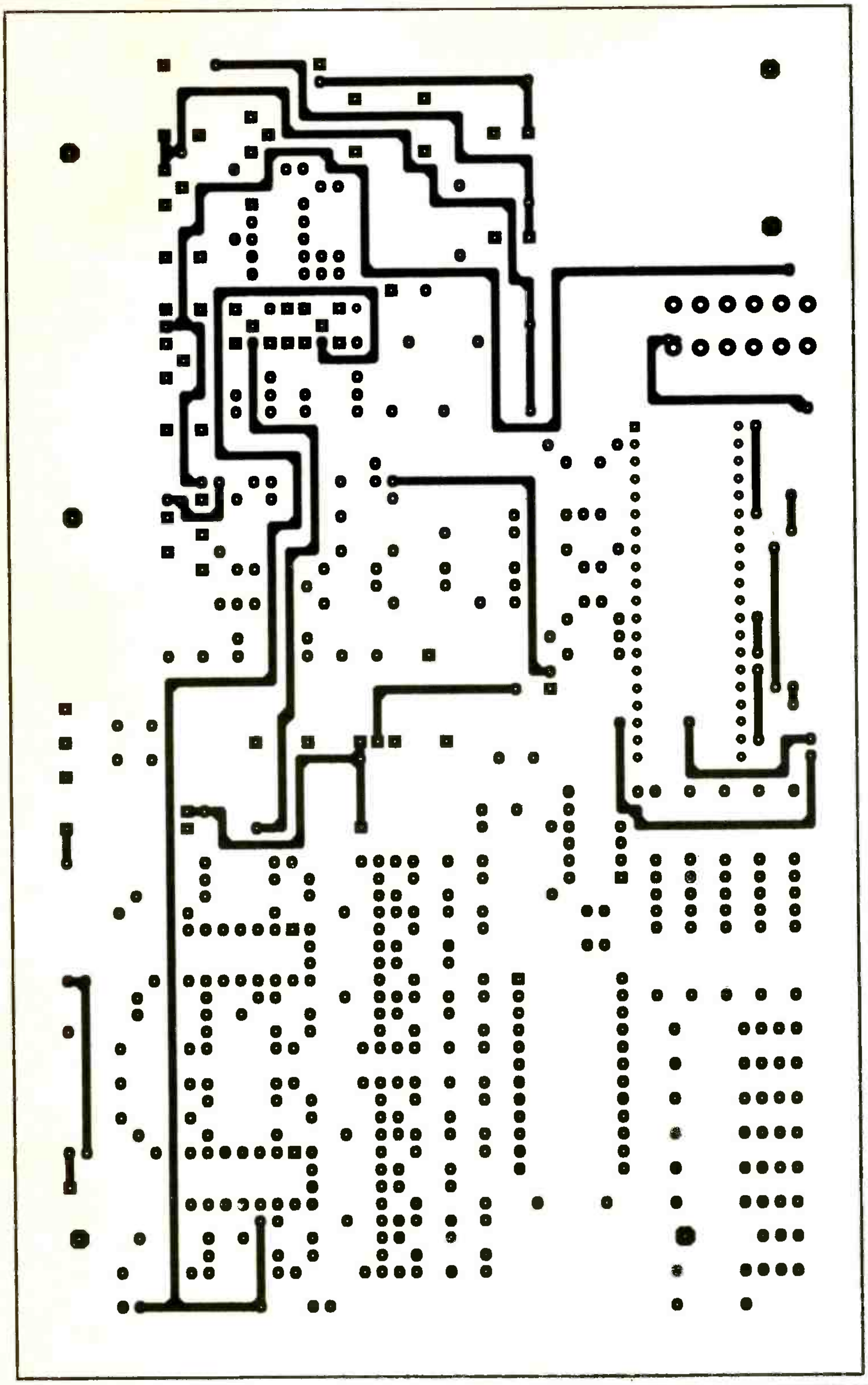


Fig. 5. Actual-size etching-and-drilling guides for double-sided main printed–circuit board.

beled 30VAC, CT and 6VAC, check the board for any unoccupied holes. As you locate these, check them against Fig. 7 to make sure you have not left out components in those locations. When you are certain that an unoccupied hole should not have a component lead or pin in it, plug the end of a bare hookup wire into it and solder it to the pad on the top of the board, flip over the board and solder it to the pad on the bottom and, finally, clip the wire close to the connection. Do this for all unoccupied holes where a jumper wire is need to bridge traces that alternate between top and bottom of the board. If you have a board that has plated-through holes, disregard the instructions in this paragraph.

Prepare a heat sink from ⅛-inch-thick or so aluminum stock as follows. First, cut the aluminum to 5 inches by 3¼ inches. Fold this sheet to form a U channel so that it has 2-inch legs and is 1 inch across the bottom, squaring up the corners. From the outside of the U channel, measure ¾ inch up one leg and strike a line here across the leg parallel with the bottom. Then strike lines ½, 1½ and 2½ inches across the first line, starting from the left end of the heat sink. The last line should be ¾ inch from the right end of the sink. The points where the lines cross identify the locations in which holes must be drilled for *IC3*, *IC4* and *IC6*.

Invert the heat sink and strike a line down the length of the channel. Measure ⅝ inch in from the edge of the channel where you drilled the hole on the leg ½ inch in and strike a cross line. Add another 2⅛ inch and strike a second line. These last two points are where holes are to be drilled for mounting the heat-sink assembly on the main circuit board. Drill a $^3/_{16}$-inch hole through the heat sink in all five indicated locations.

Liberally coat the rear (metal surface) of the 7805 regulator (*IC3*) with heat-sink compound. Push the neck of a shoulder fiber washer into the hole in the metal mounting tab of the IC and follow with 4-40 × ¼-

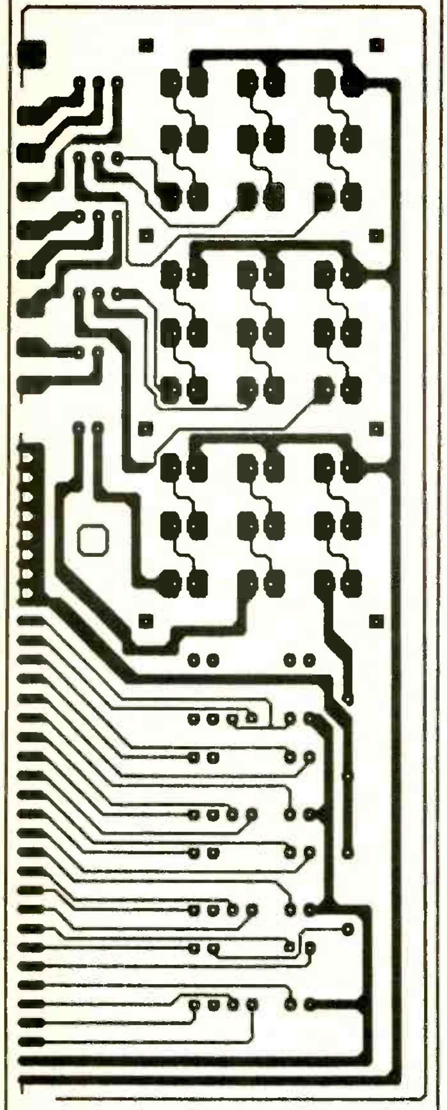
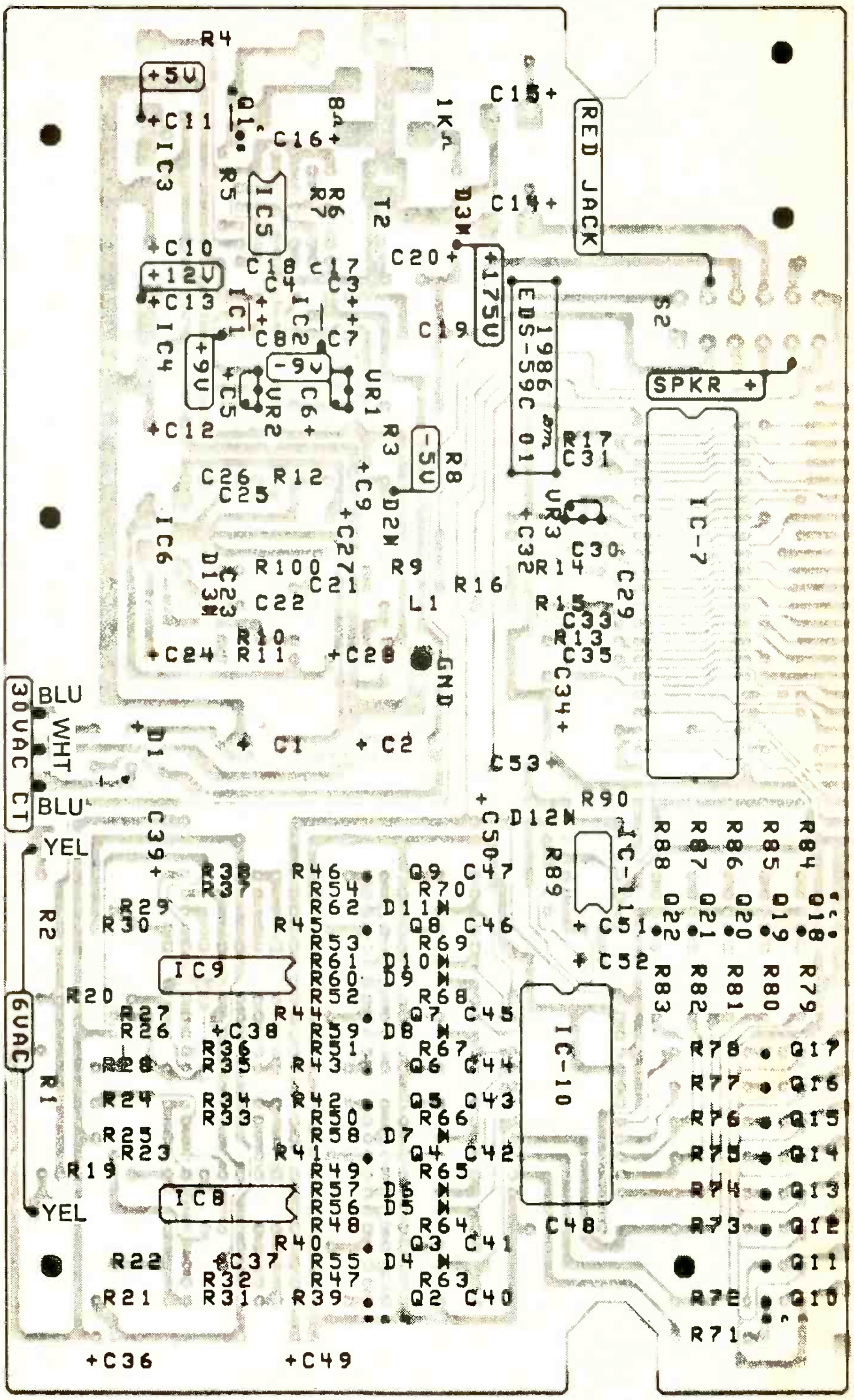


Fig. 6. Actual-size etching-and-drilling guide for single-sided display printed-circuit board.



Insulation color coding is for power transformer specified in Parts List. If you use a different transformer, make appropriate changes in insulation color coding.

Fig. 7. Wiring guide for main pc board.

inch machine screw. Mount the 7805 on the heat sink via the 1¾-inch-spaced hole at the right, using heat-sink compound, a mica insulator and No. 4 machine nut and lockwasher. Repeat with the 7812 *IC4* regulator, mounting it in the center hole.

Bend the center and two outer pins of the TDA2002 audio amplifier (*IC6*) 90 degrees toward the front of the IC ⅛ inch from the bottom of the case and then downward at 90 degrees ¼ inch from the first bend. Spread the two outer pins a bit and plug this IC's pins into the IC6 holes in the board to make them fit the hole pattern. Remove the IC from the board and bolt it directly to the left-most hole in the heat sink, using a 4-40 × ¼-inch machine screw, lockwasher and nut. Do *not* use heat-sink compound or a mica insulator with this IC.

With the IC mounting hardware only finger tight, plug the heat-sink assembly into the circuit board via the IC pin holes and position it so that the two interior mounting holes align with the holes in the board. Use 4-40 machine hardware to loosely mount the heat sink in place. Then tighten the hardware on the ICs.

It is imperative that *IC3* and *IC4* be completely insulated from the heat sink. To make sure of this, measure the resistance between each IC's metal tab and the heat sink. In both cases, the reading should be infinity. Any other reading indicates a short or partial short circuit and must be rectified before you solder any IC pins to the board's pads. Since the metal tab of *IC6* mounts directly to the heat sink, an ohmmeter reading here will be 0 ohms.

Solder all pins of theses ICs to the circuit-board pads. If you are using a board that does not have plated-through holes, solder the pins to the pads on both sides of the board.

The above method of mounting the IC/heat-sink assembly should be followed exactly as described. It will eliminate ground loops and thermal stresses when the project is put into operation.

Coming Next Month

Next month, in the conclusion of this article, we will finalize assembly instructions with wiring of the display board and chassis construction. We will also discuss checkout and calibration of the completed project and tips on using the Semianalyzer. **ME**

Automatic Audio Panner

Special-audio-effects device automatically creates dynamic stereo sound from monophonic audio signals such as produced by electric guitars

By C.R. Fischer

Special-effects devices have always been popular among modern-day musicians and tape recordists, whether professional or amateur. Among the creative sound effects they make possible is "panning," which is controlling a signal so that it is positioned at some perceived location between left and right speakers. Placing the sound somewhere within a stereo panorama (hence the name "panning") is often done manually with a mixer control called a "panpot." In home stereo systems, such a control is commonly called a balance control.

Making the audio move between two speakers *automatically* opens new, dramatic sound opportunities, especially when combined with signal level, depth and rate controls, as the subject of this project does. Devices that produce such special effects are called autopanners. Commercial ones are usually quite costly, The one presented here, which we call "Autopanner," is not. Yet it can inexpensively allow any mono electric musical instrument or other audio source to produce innovative sounds that spell the difference between amateur and pro.

About the Circuit

As shown in Fig. 1, the Autopanner is composed of six sections: an input buffer, a pair of voltage-controlled amplifiers (vca's), a low-frequency oscillator (lfo), a control-voltage processor and a power supply. These sections are designed to work together with a minimum of noise and distortion.

Figure 2, shown in two parts, is the complete schematic diagram (sans power supply) of the Autopanner's circuitry. The portion shown in Fig. 2(A) is an input buffer and preamplifier built around dual low-noise operational amplifier *IC1*. The buffer has a reasonably high input impedance to minimize loading down signal sources like electric-guitar pickups, which can result in a loss in high frequencies and overall volume when the signal is reproduced through the stereo system's speakers.

LEVEL control *R2* provides a means for adjusting the gain of the preamp from 0 to 5 so that the Autopanner can be used with a variety of input signal levels. The other half of the op amp is wired as a comparator that lights CLIP *LED1* whenever an excessively high input signal level is applied to the project's input via AUDIO INPUT phone jack *J1*. Therefore, *R2* should normally be set so that *LED1* never quite turns on.

The dual vca's are the center of action in the Autopanner. A voltage-controlled amplifier has variable gain that is controlled by an input voltage. (For more vca circuit designs, see "Using The Transconductance Amplifier" *Modern Electronics*, September 1986.)

Because building a high-quality vca is not an easy task, a quad vca chip (*IC2*) designed for music synthesizers was used in the Autopanner. This SSM 2024 IC features low noise, low distortion and wide band-

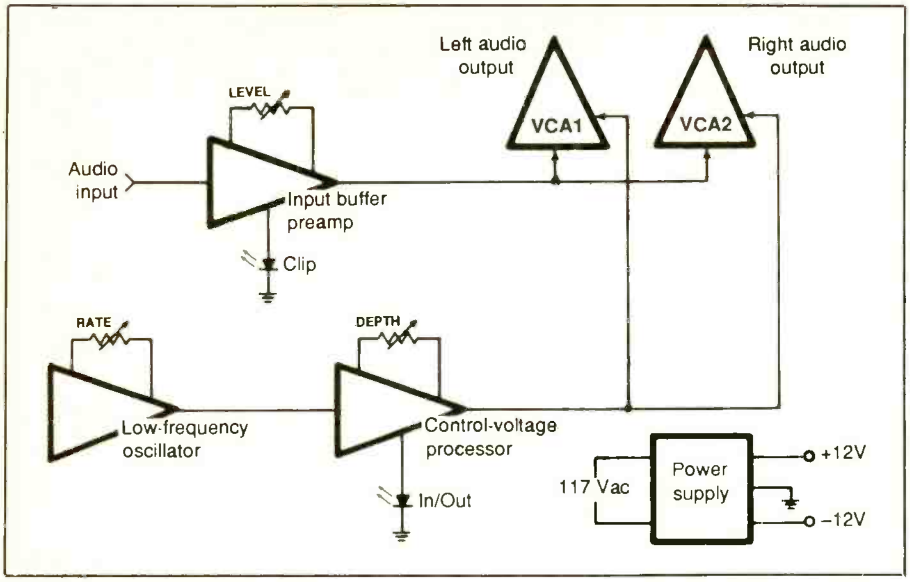


Fig. 1. Autopanner is composed of six circuit "blocks," including power supply, that work together with minimum noise and distortion.

width, and is reasonably priced. Although less-expensive alternatives to the SSM 2024 are available, their use would have resulted in unacceptable noise and distortion levels.

Since the two vca's are identical (except for the different control-voltage sources), we will examine only one in detail. Attenuator *R6/R7* prevents overloading the low-level vca input. Trimmer potentiometer *R9* allows you to null out any voltage offset that appears at the input. (Offsets tend to cause "thumps" in the output whenever the control voltage is changing rapidly. With proper calibration of *R9*, this thumping can be made inaudible.)

The SSM 2024 has low-level, high-impedance current outputs that require amplification so that they can be boosted to usable signal levels. Dual op amp *IC3* provides that amplification, with *R14* setting the output level and *C3* contributing to amplifier stability.

DEPTH potentiometer *R21* controls the amount of triangle-wave signal applied to both vca's. Lower-level settings result in a subtle "shimmering" effect, while higher-level settings cause the signal to alternate between the speakers.

Almost all effects devices require some sort of input/output switching to allow the musician or audio engineer to turn them on and off as desired. It is a good idea to use a control signal to switch in and out the effect to avoid running the audio signal

PARTS LIST

Semiconductors

D1—1N914 or similar silicon switching diode
IC1,IC3,IC4,IC5—TL 072 dual bi-FET operational amplifier (or 1458 or 4458 op amp for IC4 and IC5)
IC2—SSM 2024 quad voltage-controlled amplifier
LED1,LED2—T-1¾ red light-emitting diode
IC6—7812 + 12-volt regulator
IC7—7912 − 12-volt regulator
Q1—General-purpose n-channel field-effect transistor
RECT1—50-PIV, 1-ampere bridge rectifier

Capacitors (25 WV or greater)

C1,C6 thru C9—0.1 μF ceramic or polyester
C2,C3—100 pF mica
C4,C5,C13,C14—4.7 μF tantalum
C10—2 μF nonpolarized aluminum
C11,C12—2,200 μF electrolytic

Resistors (¼-watt, 10% tolerance)
(Note: metal-film resistors are preferred—see text)

R1,R25—220,000
R3,R22,R26 thru R29—100,000 ohms
R5,R23—1,000 ohms
R6,R10—4,700 ohms
R7,R11—220 ohms
R8,R12—1.5 megohms
R14,R15,R30,R31—10,000 ohms
R17—820 ohms
R18,R20—33,000 ohms
R19—12,000 ohms
R24—22,000 ohms
R2—1-megohm, linear-taper potentiometer
R4—50,000-ohm multi-turn pc-type trimmer potentiometer
R9,R13—100,000-ohm multi-turn pc-type trimmer potentiometer
R16,R21—100,000-ohm, linear taper potentiometer

Miscellaneous

F1—0.25-ampere slow-blow fuse
J1—Closed-circuit phone jack
J2 thru J4—Phone jack
S1,S2—Spst slide or toggle switch
T1—12.6-volt ac, 100-mA power transformer (see text)
Perforated board with holes on 0.1" centers, DIP IC sockets and soldering or Wire Wrap hardware for circuit board; holder for F1 (see text); ac line cord with plug; suitable enclosure; 2-lug terminal strip with neither lug connected to mounting tab; rubber grommet for line cord; knobs for panel-mount potentiometers; jack for plug-in power transformer (optional—see text); spst footswitch with phone plug (optional—see text); lettering kit; machine hardware; hookup wire; solder; etc.

Note: The SSM 2024 quad voltage-controlled amplifier chip is available for $6.25 PPD. (California residents, please add 6.5% state sales tax) from Mescal Music, P.O. Box 5372, Hercules, CA 94547.

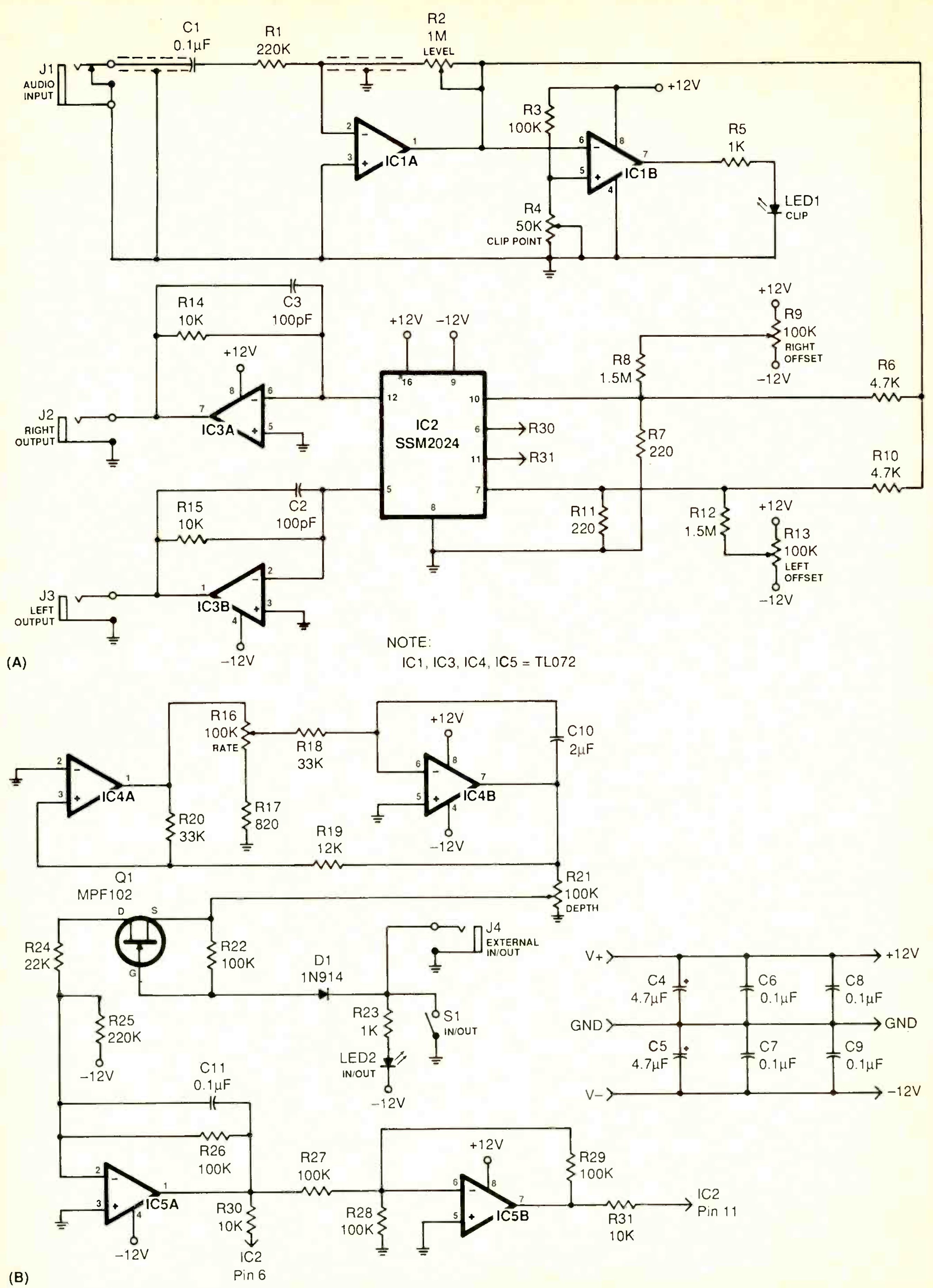


Fig. 2. Schematic diagram of audio (A) and control (B) sections.

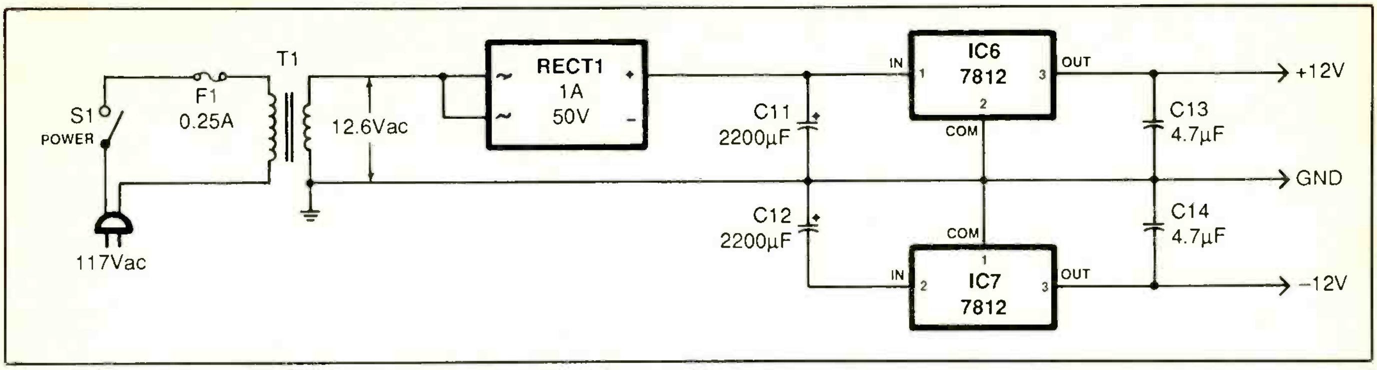


Fig. 3. Schematic diagram of a suitable ac-operated ± 12-volt dc power supply.

itself through long wires to and from a footswitch. To accomplish this, the lfo's triangle wave is applied to field-effect transistor *Q1*.

With INPUT/OUTPUT switch *S1* open, *Q1* is held in cutoff by the negative voltage across *D1/R23* and IN/OUT *LED2*, preventing the lfo waveform from reaching the vca's.

Closing *S1* grounds the I/O point. This causes *LED2* to light, reverse-biases *D1*, and allows the triangle wave to control the vca's.

Since the I/O circuit is a simple logic design that is either grounded or floating, an spst footswitch can be connected to the circuit via EXTERNAL IN/OUT jack *J4*. A cable as long as needed can be used without causing signal degradation. You can then use the footswitch instead of *S1* to switch in and out the Autopanner's effect. IN/OUT *LED2* will glow slightly when off due to leakage current from *Q1*. However, the difference between the "on" and "off" settings is large enough to avoid confusion. With the effect off, the Autopanner sends the input signal to both outputs.

Dual op amps in *IC3* serve as inverting amplifiers that drive the vca. Amplifier *IC3A* sets the proper gain range with *R24*, *R25* and *R26*, and *C11* acts as a crude filter to eliminate any small glitches that might be generated whenever one vca is at full gain and the other is off. Current limiting to the vca control-voltage inputs is provided by *R30* and *R31*.

A bipolar power supply that has outputs between +9 and +15 volts is needed to power the Autopanner. The schematic diagram for a suitable +12-volt power supply is shown in Fig. 3. Instead of using the center-tapped power transformer usually found in bipolar power supplies, this one uses a transformer with an untapped secondary winding. This gives you the option of using a plug-in ac transformer if you wish, allowing the Autopanner to be built into a smaller enclosure than would otherwise be needed and preventing any ac field from showing up in the project's outputs.

Construction

For best results, use perforated board that has holes on 0.1-inch centers on which to mount the components that make up the project's circuitry. Use sockets for the ICs and appropriate soldering or Wire Wrap hardware for component-lead connections. Keep all component leads as short as possible, and make sure to include bypass capacitors *C6* through *C9* in Fig. 2. (As you wire the board, install only the IC sockets —*not* the ICs themselves—and save IC installation until after initial voltage checks have been performed.) With a little care in laying out the components and routing the wiring, you should be able to obtain professional-quality operating results.

If you demand the very highest in operating quality, several improvements can be made for a slight increase in the cost of the project. For example, you can use metal-film resistors and high-quality mica and polystyrene capacitors in the audio circuitry around *IC1*, *IC2* and *IC3*. Because resistor noise is proportional to resistance, it is an especially good idea to use a metal-film resistor for input resistor *R1*.

After wiring your circuit-board assembly, you can mount it inside a metal or plastic enclosure, an example of the latter illustrated in the lead photo. If you are using an internal power supply, mount it in a location at the rear of the enclosure where it and the incoming ac line cord will be as far away from the input and output jacks on the rear panel and the input audio circuitry on the board. Use a two-lug terminal strip (neither lug grounded) to make the line-cord to transformer primary connections. If you use an external plug-in supply, mount on the rear panel a suitable jack to accommodate the connector at the end of its cord.

All controls and the light-emitting diodes mount on the front panel and all input/output jacks mount on the rear panel of the enclosure. After drilling the required holes, deburr them if the enclosure is of metal construction. Then label the controls, LEDs and jacks with appropriate legends (see lead photo).

Fuse *F1* can be mounted inside the enclosure using an inexpensive chassis-mount fuse block. Alternatively, you can mount the fuse in a bayonet-type holder mounted on the rear wall of the enclosure. POWER switch *S2* can be a slide or toggle type and can be mounted either on the front or rear (preferred location) of the enclosure or can be eliminated altogether if you prefer.

Keep in mind that the cables between INPUT jack *J1* and the circuit board and between LEVEL control *R2* and the junction between *R1* and pin 1 of *IC1* must be shielded. Ground the shields of these two cables at only one end to avoid feedback.

When you wire the various panel-mounted and trimmer controls into the circuit, make sure that the wiring is done so that their effect *increases* when they are adjusted clockwise!

Figure 4 is a photo of the interior of the author's completed Autopanner prototype. Note the neat layout of the components on the circuit-board assembly and off the board. Try to emulate this layout as much as possible to avoid interference effects when the project is put into service.

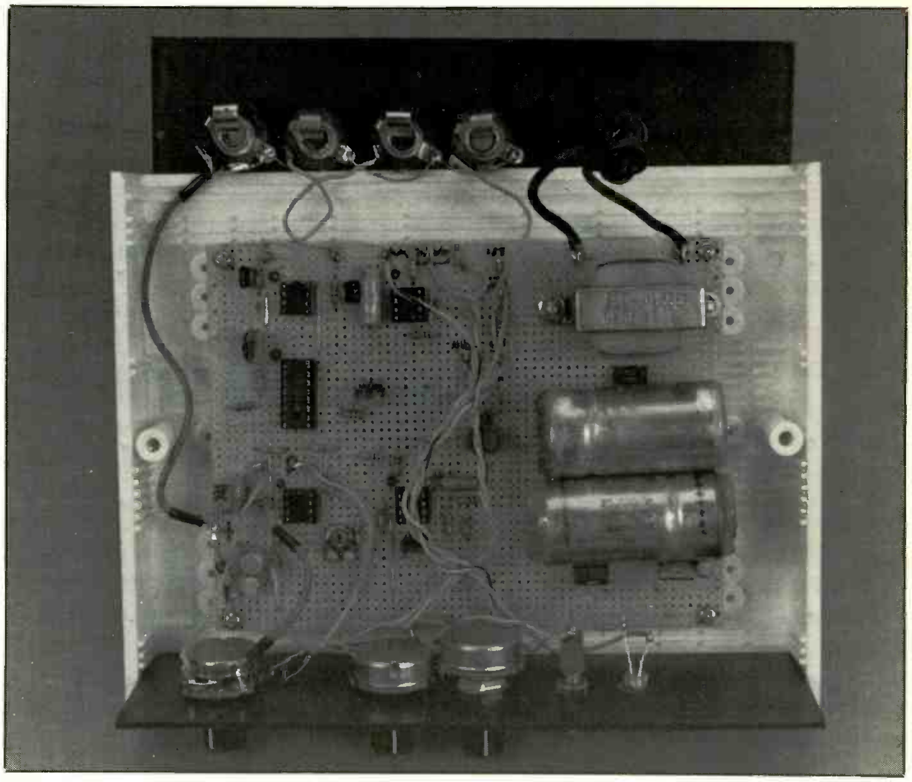


Fig. 4. Interior view of assembled prototype. Note clean layout of components both on and off the board.

Test & Calibration

With the ICs still not installed in their sockets, plug the Autopanner's line cord into an ac outlet. Set a multimeter to the dc volts function and its range switch to a setting that will allow you to measure up to 20 volts or so. Connect the meter's common probe to any circuit ground point and leave it there as you make your preliminary voltage checks.

Touch the meter's "hot" probe to the positive (+) lead of *C1* and then the negative (−) lead of *C2*, noting the readings obtained in both cases. Your meter readings should be +12 volts on the positive lead of *C1* and −12 volts on the negative lead of *C2*, assuming you are using the Fig. 3 power supply. If you are using an external plug-in power transformer that has a different voltage on its secondary, the readings should be between +9 and +15 volts on the positive lead of *C1* and between −9 and −15 volts on the negative lead of *C2*.

Touching the meter's hot probe to the pin 8 socket terminals for *IC1*, *IC3*, *IC4* and *IC5* should yield the same positive voltage reading obtained on the positive lead of *C1*. The same applies when taking a reading at the pin 16 socket receptacle for *IC2*. Similarly, you should obtain the same negative voltage reading as measured on the negative lead of *C2* when you touch the meter's hot probe to the pin 4 socket receptacles for *IC1*, *IC2*, *IC4* and *IC5* and the pin 9 socket receptacle for *IC2*.

If you do not obtain the proper reading at any or all of the IC socket pin receptacles, power down the circuit and carefully recheck your wiring against Figs. 2 and 3. Also, check particularly for proper electrolytic capacitor orientations.

When you are certain that your wiring and component installation are correct, power down the project and allow the charges to bleed off the electrolytic capacitors. Then install the ICs in their respective sockets. Make sure you properly orient each IC as you install it and that no pins overhang the sockets or fold under between ICs and sockets.

If you have a sine-wave generator, turn its level control completely down and plug its line cord into an ac outlet and its output cable into the Autopanner's AUDIO INPUT jack. If you do not have a sine-wave generator, use a musical instrument instead.

Turn the volume control of your stereo amplifier all the way down and connect the Autopanner to the inputs of the amplifier. Turn on the generator, amplifier and Autopanner. Turn up the Autopanner's LEV-

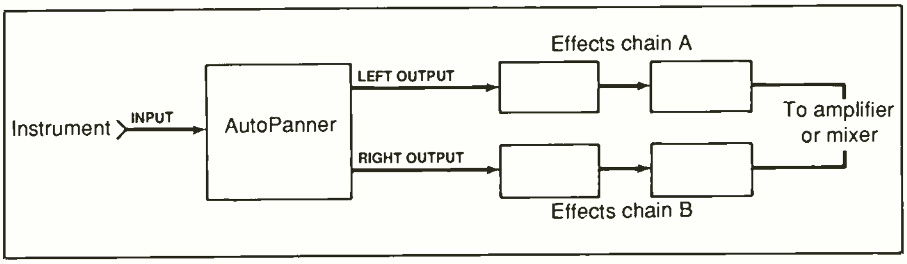


Fig. 5. In addition to stereo panning, Autopanner can be used to fade between groups of special-effects devices.

EL control to about mid-position and set its RATE and DEPTH controls fully clockwise. Set the project's IN/OUT switch to "on" (or step on the foot-switch, if you are using it, to close its contacts). Slowly raise the setting of the amplifier's volume control. Then adjust the generator's level control until you hear its signal coming from the speakers.

If everything is working as it should, you should now hear the input signal rapidly alternate between the two speaker systems in your stereo setup. If you hear any distortion at this time, lower the Autopanner's LEVEL control setting until it disappears (ignore the CLIP LED for now; it has not yet been calibrated).

As you adjust the Autopanner's controls the effects should increase. If it is just the opposite, power down the project, disconnect it from the signal generator and stereo amplifier, and transpose the connections going to the two outer lugs of the offending control. Then reconnect the project to the generator and amplifier, repower the system and continue with calibration.

Now adjust both vca's for minimal offset voltages as follows. Lower the setting of the project's LEVEL control to minimum and set your stereo amplifier so that only the right channel can be heard. Adjust the amplifier's volume control upward until you hear a clicking sound and adjust RIGHT OFFSET control *R9* for minimum audible noise. Then set the amplifier so that only the left channel is audible and repeat the procedure with LEFT OFFSET control *R13*.

Final trim involves adjusting the reference voltage at comparator *IC1B* so that the CLIP LED turns on just before the onset of distortion. Turn up the project's LEVEL control setting once again until distortion returns and adjust CLIP POINT control *R4* so that the CLIP LED turns on. It is a good idea to set *R4* so that the CLIP LED comes on just before the onset of distortion to obtain optimum signal-to-noise ratio.

In the event the Autopanner is not operating properly, troubleshooting should be performed in a logical manner. First determine if the input signal is reaching OUTPUT jacks *J2* and *J3*. If there is no output with the LEVEL control turned fully clockwise, immediately power down the project, remove the ICs from their sockets, and recheck the power-supply rails to each IC socket.

Once you have an output signal, troubleshooting the circuit becomes a lot easier to do. You should then determine if the lfo is oscillating and if *Q1* is biased so that the lfo's triangle wave cannot reach the vcas. If there is no "movement" between the outputs, the problem probably lies around *IC3* and/or *IC4* or the input/output circuit.

Using the Autopanner

The most obvious use for the Autopanner is to create a "ping-pong" effect from a mono input. Electric guitars, pianos, organs and synthesizers can all benefit from the animation that dynamic panning provides. While high DEPTH settings may immediately attract the attention of listeners, lower settings can add subtle enhancement that will more readily benefit the music being played. Different rates can be selected, depending on the tempo or "mood" of the music being played.

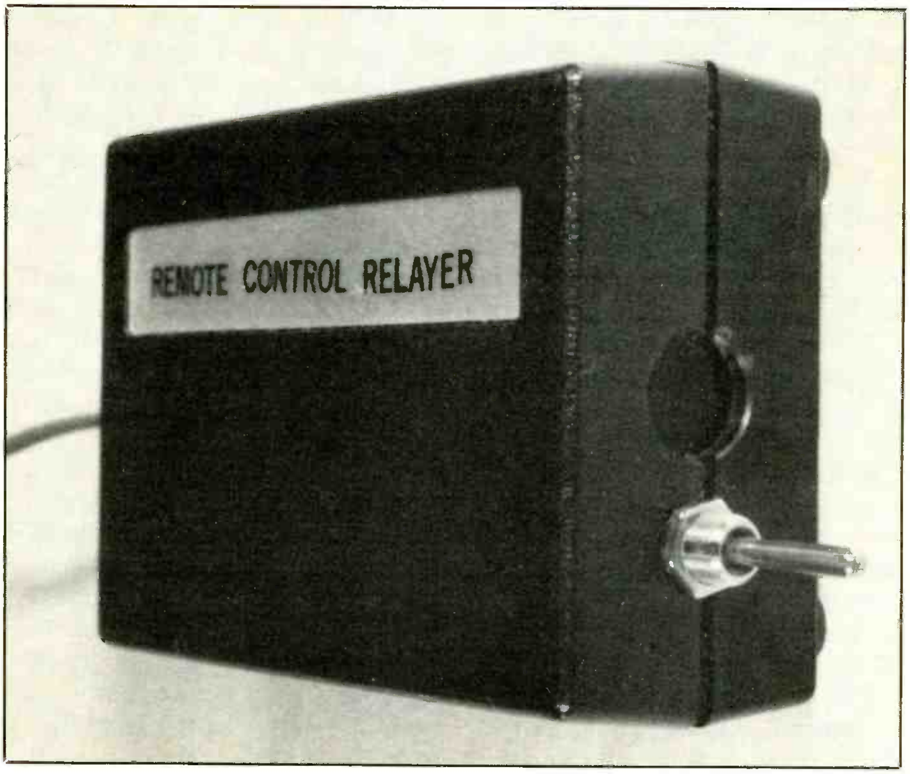
A more unusual use for the Autopanner's automatic effects is illustrated in Fig. 5. The Autopanner's outputs can be connected to any number of other special-effects boxes, such as phasers, fuzz boxes, echo units, chorus units, etc. As the Autopanner sweeps between outputs, two different sets of effects will be heard with an arrangement like this. This is an interesting way of getting some new sounds.

As with any special effect, that of the Autopanner requires a little practice and experimentation to obtain best results. **ME**

An Infrared Remote Control Relayer

$10 project provides wireless VCR control to remote TV sets

By Joseph O'Connell



The Infrared Remote Control Relayer is a simple project that can be built for under 10 dollars. It will send the command signals of a hand-held infrared remote-control unit from one room to another. Therefore, if you have a VCR and TV receiver in one room and a second TV set installed in another room, as in Fig. 1, this project will save you the time of running back and forth between the second TV set and the VCR machine that is controlling it. Without it, you'd have to leave the room just to change channels or operate the VCR.

This device isn't only limited to video systems. Stereo systems with infrared controls can also use the relayer to send commands from another room. Even some computer keyboards, electronic scales, and household appliances transmit information over an infrared beam. With the RC Relayer, one of those devices could be used in another room or the components could be kept farther apart than otherwise.

It would cost you about 50 dollars to buy a commercial device that does the same thing. But for one-fifth of that cost, you can make this device, which has somewhat less range, but is more versatile.

Although the relayer box can be many rooms away from the VCR, the hand-held remote must be held within a foot or two of the relayer for the control signal to be received properly. The relayer box is small, though, and can be moved around easily, so this shouldn't pose much of a problem.

The restriction on range can't be avoided if the project is going to be simple because infrared intensity from a hand-held remote control diminishes greatly with distance. A range of more than a few feet would require a very sensitive receiver. Commercial remote-control devices have a shielded assembly containing a photodiode and sensitive high-gain circuitry that wouldn't be practical to build yourself. If long range is imperative, therefore, you'd be better off buying the required circuitry than making it yourself. But if the limited range of this project is tolerable, which it will be for most applications, a $10 alternative and some fun building it is attractive.

Adapted from *Twenty Innovative Projects Electronic Projects for Your Home* by Joseph O'Connell, to be published July 1988 by Tab Books, Blue Ridge Summit, PA 17214.

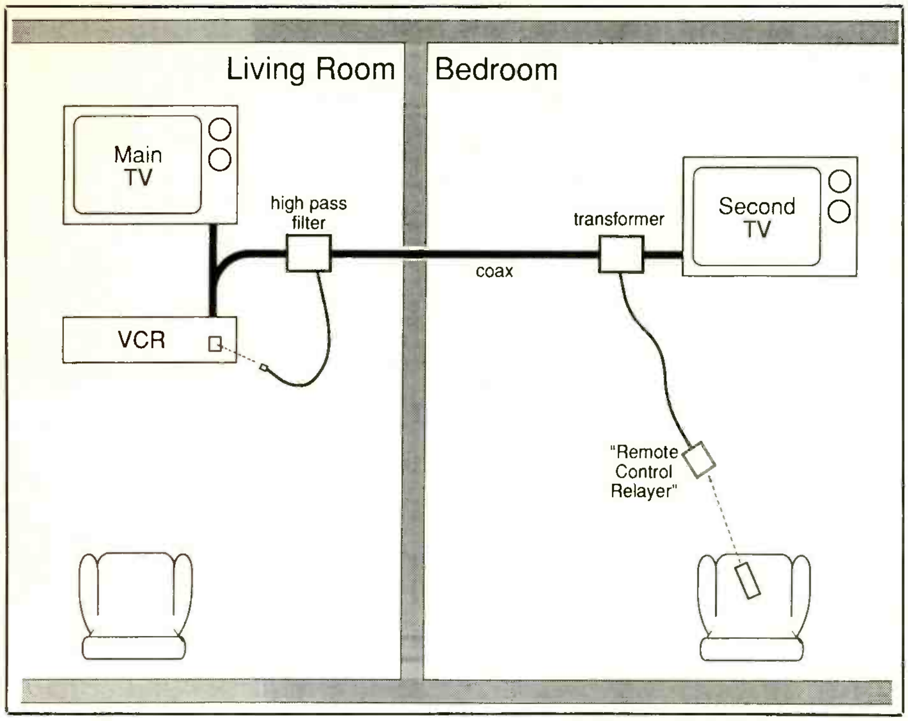


Fig. 1. The remote-control relayer will send control signals from one room to another using the same wire that carries the video signals.

How It Works

Like its commercial competition, this project sends its control signals over the same coaxial cable that carries the video signal to the extension TV. (See Figs. 1 and 2.) This allows you to use the cable wire that's already installed, which is much easier than installing a new one. And just as the commercial models do, this device allows normal use of the remote control with the VCR or other video source at all times.

The circuit is quite simple. Figure 2 is the complete schematic. When power switch *S* is on, phototransistor *Q* modulates the current that flows through the infrared *LED* from the battery. Every pulse of infrared radiation received at *Q* is duplicated by the infrared LED's output.

The phototransistor is shielded from ambient light by a small piece of infrared filter plastic. This material looks dark red to the eye and is nearly opaque to visible light. It is sold at low cost by some surplus dealers. If you can't obtain the correct filter material, a thin piece of translucent red plastic can be used instead.

The purpose of shielding is to ensure that the infrared phototransistor doesn't draw excessive current from the battery in response to visible light. Although the circuit is quite sparing of power when shielded this way, the switch extends the battery's life additionally if it is turned off when the relayer is not in use.

The purpose of the transformer and the high-pass filter shown in the schematic is to block control signals from entering the video equipment. This is necessary so that the relayer's control signals can travel over the same wiring as the video signal. There are two ways to split the control signal from the video signals. Either can be used at both ends, although the best way is to use a transformer at the TV end and a high-pass filter at the VCR end, as follows:

1. A Radio Shack high-pass filter designed to eliminate amateur-radio interference from video signals can be slightly modified.

2. An ordinary 75-ohm to 300-ohm video matching transformer to block infrared signals to the TV set in addition to its usual function. Transformers are cheap, readily available, and often necessary anyway to match the 75-ohm output of modern video equipment to older TV sets.

Construction

Any small case can house the relayer circuitry as long as it will block visible light falling on the phototransistor. The prototype shown in Fig. 1 used an enclosure sold by Radio Shack. It comes with a pre-drilled perfboard insert to which components can be mounted.

Using this enclosure or another suitable one, install the power switch so it can be reached from the front of the enclosure. Cut out a piece of the infrared filter material to glue behind a ½-inch hole in the front. Mount the phototransistor directly behind the filter. Be sure to observe polarity when connecting the components or the phototransistor may be damaged.

Run a piece of thin, two-conductor wire from the relayer box to the high-pass circuit. Directions follow for hooking up the other end of that wire to each of the alternative high-pass filters, and for connecting the LED to the other filter.

Connections

Some video matching transformers provide two screw terminals as an FM output. These are the best transformers to use because the screw terminals are a convenient place to attach the wire connecting the relayer to the coaxial cable.

To modify one of these transformers, open it up by removing the metal ring around the F-connector input. Cut away the thin transformer wires that go to the FM terminals. Now

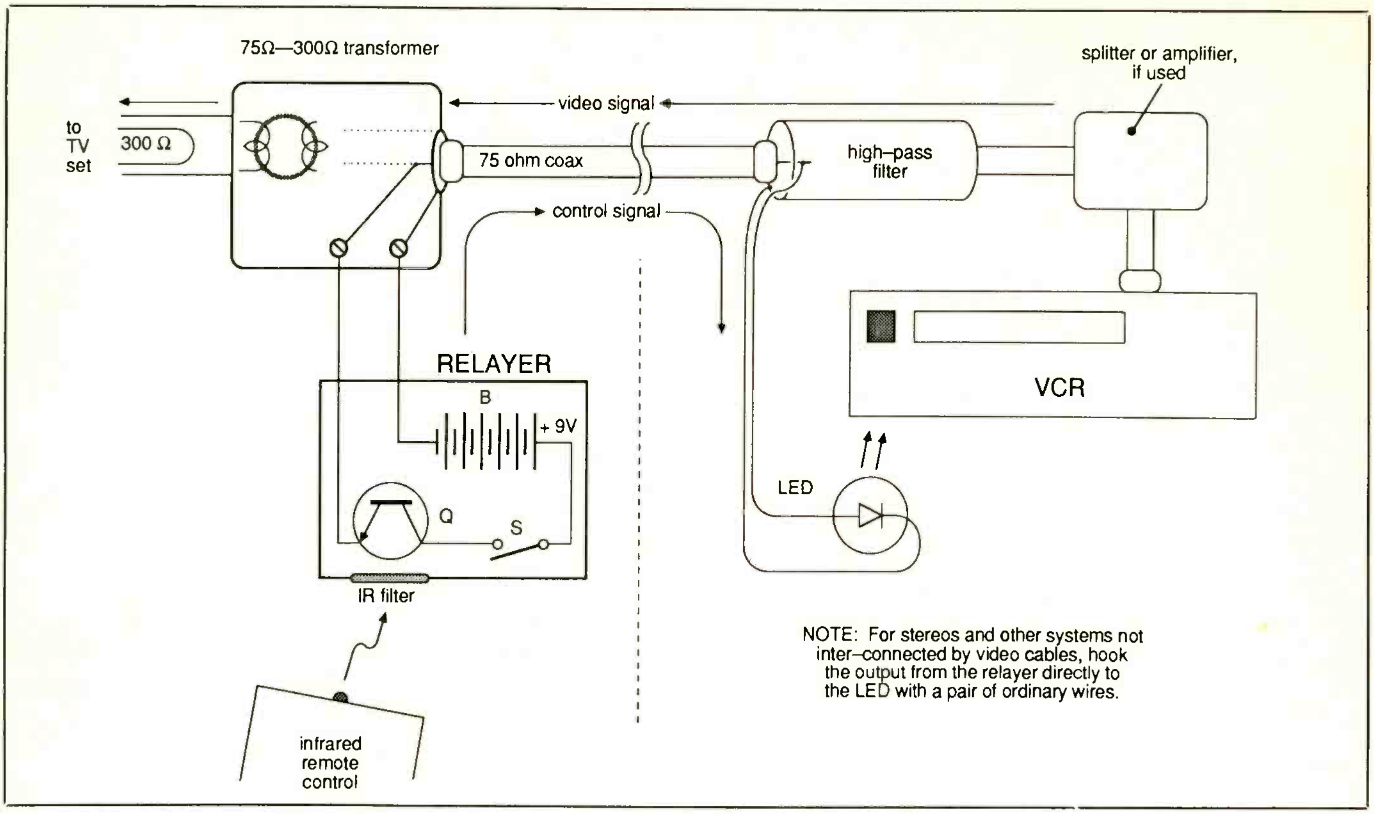


Fig. 2. The complete remote-control relayer has a very low parts count.

PARTS LIST

B1—9-volt battery
Q/LED—Infrared emitter/detector pair [Radio Shack Cat. No. 276-142. (For additional phototransistors, use TIL-414, Radio Shack Cat. No. 276-145 or equivalent)]
S—Miniature spst toggle switch
T—75-to-300-ohm video matching transformer (Radio Shack Cat. No. 15-1139 or similar)
Misc.—High-pass filter (Radio Shack Cat. No. 15-579 or equivalent); suitble enclosure; snap connector and battery clip for B1; thin 2-conductor cable; hookup wire; solder; etc.

wire the F-connector directly to those terminals. Close up the case, leaving the rest of the internal circuitry untouched.

Connect the modified transformer between the VCR and the TV set on the end with the TV. The screw-type FM-output terminals should be connected to the wire from the remote-control relayer box.

To use a Radio Shack #15-579 or similar high-pass filter to split the infrared and video signals, you must open its case and connect a wire. First remove the outer plastic jacket that encloses the filter. Then use a knife to remove the rubber grommet from around the short length of coaxial cable protruding from one of the ends. This should reveal a metal washer fitted into the aluminum body of the splitter. Remove the washer with needle-nosed pliers, setting it aside. With a few taps on the F-connector at the other end, slide the inner circuitry out of the aluminum sleeve.

Observe that the circuitry is encased in some kind of potting compound and wrapped in plastic. Cut the plastic wrap off and chip away just enough potting compound around the F-connector to make its terminal accessible. Solder a few feet of thin two conductor wire to the connector. This wire will later be connected to the infrared LED (or to the remote relayer box if you are using a second of these splitters instead of the transformer described above). Using hot-melt glue or epoxy cement, re-pot the filter and place it back in its aluminum sleeve.

The wire you added should exit the case alongside the piece of coaxial cable. It should pass through the washer that previously held the grommet. Figure 4 shows this type of splitter modified and connected to an infrared LED.

Installation

Placement of the infrared LED depends on the VCR (or other equipment) it will be used with. It should be mounted a short distance from the sensing window on the equipment,

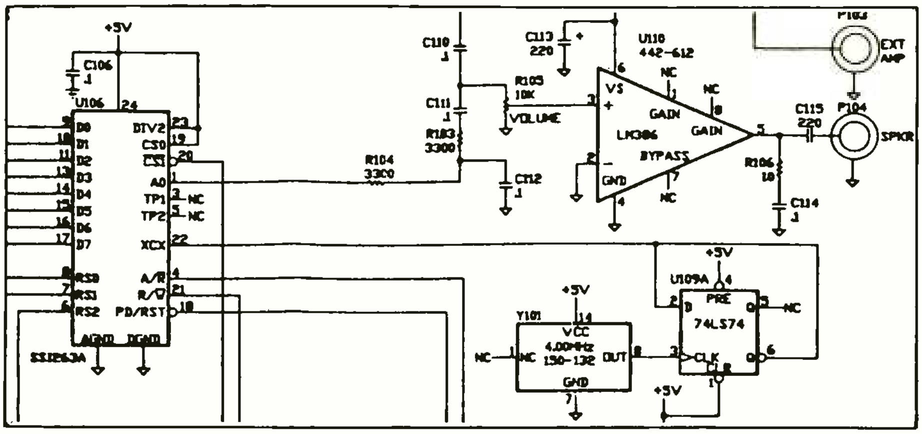
(Continued on page 90)

PRODUCT EVALUATIONS

Heath Computer Voice Card

Heath's new HV-2000 computer-voice kit is an $89.95 half-size plug-in card for use with any IBM or compatible PC, XT or AT model. It comes with a small external speaker and housing, and includes software, a 69-page construction and operation manual, and 10 pages of kit-building pictorial information, plus appropriate parts and pc board.

The Heath Voice can add human-sounding male voice, music and sound-effect capabilities to your computer. Assembly is easy, requiring only 1 hour and 10 minutes to complete, doing so without a hitch. Plugging in the card, closing up the computer case, then plugging in the external speaker to an RCA-type jack (there are two in the event one wishes to use an output for a hi-fi system), we were ready to install the software.



Heart of the Heathkit Voice is an SSI-263 IC, U106, which contains five write-only registers to select phonemes and attributes. It makes use of a 4-MHz clock whose output is divided in two by a 74LS74 chip, U109A. The synthesizer's audio output is filtered and fed to two RCA-type jacks. One is a direct line output to drive an external amplifier, while the other is fed, through a volume control, to an LM386 audio amplifier for output to the external 8-ohm speaker supplied with the kit.

Following instructions, which included adding a DEVICE = VOICE.SYS 300 driver to our CONFIG.SYS file, SPEAK SPEAKME.-TXT was typed at the DOS prompt, upon which the instructions indicated that the computer should "congratulate you." What we heard, however, was a computerized voice speaking gobbledygook!

What went wrong? Were the pc board's address ports selected incorrectly? Was there a defective component? A different way to generate speech from the computer was the next step, which directed the typing of SPEAK followed by a string enclosed in quotes. So I typed SPEAK "Hello" and pressed the RETURN key. Sure enough, the computer voice said "Hello." In fact, using any options available, the voice always worked properly except in rare single-word instances. I can only conclude that Heath has a foul-up in its demonstration file, which I haven't found time to rewrite.

There are a number of ways to use the Heath Voice. Typing SPEAK and a "string" is one cited earlier; SPEAK [filename] is another mentioned (the .txt demo file that didn't work properly). With this command you can have a file, say, a WordStar one, read to you. Path names can be used, but wild cards cannot. The SPEAK command can also generate voice when text is received from a serial port (COM1 or COM2) with baud rates from 150 to 38,400. Thus, you can listen to data being received through your modem. You can also listen to matter that you're transmitting. Use of function keys F1-F10 simplifies operations. A 60K buffer is provided in the event that communications "handshaking" is not established.

Alternatively, you can use the DOS COPY command to speak a file or the DOS TYPE command to do the same. Moreover, voice can be added to a BASIC program. Additionally, you can write your own voice programs, inserting pauses, inflections, articulation, etc.

A few options can be included in the CONFIG.SYS file established in the root directory by appending a slash (/) that's followed by one or more "switch" characters. The letter W inserts a pause between words; an I sets automatic inflection; a P causes the Voice to speak punctuation marks; a D makes numbers to be spoken digit by digit; and an L locks in the chosen actions so that you can't modify them by preceding a string with special characters.

A very few words aren't spoken properly by the Voice. An example that is given for this in the Heath manual is the word "read." This word might be used as the sound, "reed" or as the sound, "red." The Voice selects the most commonly used one. Such words can be placed in a special file called WORDS.EXE. When such a word is listed, you are given an opportunity to edit the mnemonics to make changes so that it sounds right to you before it's listed as an exception to the Voice pronouncing rules. The maximum number of words that can be stored is one hundred.

Writing text is done in mnemonic form to represent sounds. A listing in the manual is provided for this purpose. The mnemonic "er," for example, represents the "i" in the word "bird." Thus, it would be written as "berd" instead of "bird." Mnemonic strings must be enclosed in opening and closing braces ({and }) on the same line, and the letters must be in lower case. A variety of other sound-creation rules are included in the manual, including combination sounds, voice attributes such as amplitude, duration, and others.

The Heathkit Voice kit is a welcome, low-cost enhancement device for MS-DOS computers. The "voice" sounds fine, though it's a bit crude as far as modern computerized voices go. It's also a very versatile package, allowing the user to produce spoken material in a variety of ways. The manual's guide to writing mnemonically can be improved, though. This information is not as clearly presented as it should be. Nevertheless, the Voice makes a worthwhile addition to one's computer system for only $90 and about an hour of work. Then it'll certainly keep you occupied and entertained.

—Art Salsberg

CIRCLE 93 ON FREE INFORMATION CARD

Experimenting With Liquid Nitrogen

By Forrest M. Mims III

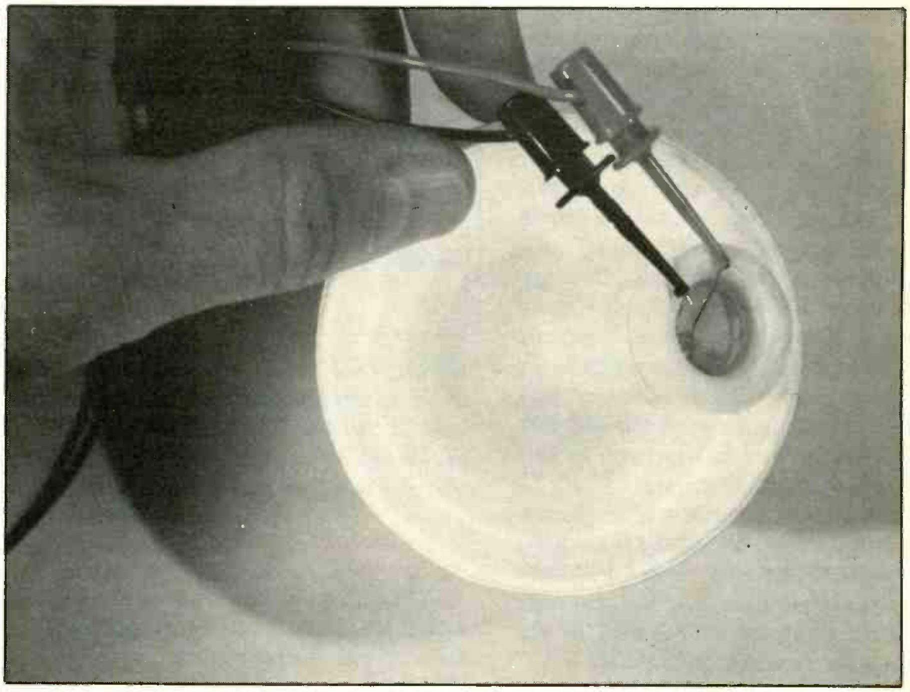


Fig. 1. Immersing an LED in liquid nitrogen.

You are probably wondering what an article about liquid nitrogen is doing in an electronics magazine. As you will soon see, there are some very important reasons for its appearance in these pages. After reading the following, you may even want to obtain some liquid nitrogen to duplicate the experiments I'm about to describe or try some of your own.

If you read last month's "Electronics Notebook" on experimenting with a superconductor, you already know that I had to obtain liquid nitrogen to perform the experiments I described. The dewar the supplier lent to me held 30 liters of liquid, considerably more than needed to experiment with a superconductor. That was fine with me since there were a number of other tests and experiments I've long wanted to try.

Those experiments will be described below. First, however, let us consider the importance of liquid nitrogen to everyday electronics. Some of the solid-state components we take for granted today could once be operated only when cooled by liquid nitrogen.

Liquid Nitrogen and Solid-State Components

Perhaps the best example of a component whose development was impacted by liquid nitrogen is the semiconductor laser. Prior to 1970, laser diodes could operate continuously only when cooled to the temperature of liquid nitrogen. The fact that these lasers could be operated continuously when cooled was an important hint that room-temperature operation might someday be achievable. Laser diodes that operate at room temperature and above, *without* cooling, are the key component of today's desktop laser printers, compact-disk players, optical disk memories and long-haul optical fiber communications links.

The light-emitting diode is another component whose development was influenced by liquid nitrogen. In the early 1960s, LEDs operated at room temperature were very inefficient. However, their efficiency increased by as much as ten times when they were cooled by liquid nitrogen. As we'll soon see, today's room-temperature LEDs match and even exceed the efficiency of yesterday's LEDs cooled with liquid nitrogen.

Photodetectors provide still another example of how improved performance at liquid nitrogen's temperature was an indication of what would eventually happen at room temperature. Random noise is an important limiting factor in the operation of all kinds of photodetectors. Cooling can greatly reduce this noise level. Though today's photodetectors are still plagued by noise, better processing technologies have reduced the noise levels to far below those of early devices.

Recent developments of ceramic superconductors is the latest example of the vital role played by liquid nitrogen in the development of solid-state technology. Prior to 1987, the only superconducting materials available had to be cooled to or near the temperature of liquid helium or liquid hydrogen. The present availability of superconductors that exhibit zero resistance at the temperature of liquid nitrogen holds great promise for highly efficient electromagnets, electric motors and lossless power transmission lines. As in the case of the laser diode and LED, however, the triumph of achieving superconductivity at the temperature of liquid nitrogen has only whetted the appetites of researchers. Their ultimate goal is room-temperature superconductors.

These are only some of the examples in which liquid nitrogen has played a key role. Besides its ongoing role in ceramic superconductor research and development, liquid nitrogen has many other applications in electronics today. One of the most important is its role as a coolant for ultra-sensitive radiation detectors and infrared sensors used in some astronomical telescopes.

Cooling LEDs With Liquid Nitrogen

Figure 1 shows an LED being immersed in liquid nitrogen in a miniature evacuated dewar flask placed inside a foam-plastic cup on my workbench. This miniature dewar is used to store liquid nitrogen for high-altitude balloon payloads. While it holds the liquid far longer than a foam-plastic cup alone, a cup is perfectly satisfactory for the experiments that follow.

The wavelength of the radiation emitted by an LED is directly related to the temperature of the diode's junction. In most cases, the wavelength is directly proportional to temperature. That is, wavelength of the LED decreases as temperature decreases.

This phenomenon is best illustrated by immersing an AlGaAs near-infrared emitter in liquid nitrogen. The most common commercially available AlGaAs devices emit radiation having a wavelength of 880 nanometers at room temperature. This wavelength is generally considered to be beyond the range of human vision. However, most, but not all, people can see a dim red glow by viewing an AlGaAs device straight-on in a darkened room. When the diode is immersed in liquid nitrogen, the wavelength shifts *downward* and the red glow becomes brighter.

The temperature coefficient of a typical AlGaAs LED is about 0.22 nm per degree Celsius. The difference between the temperature of liquid nitrogen (– 196 degrees C) and room temperature (22 degrees C) is 21 degrees C. Therefore, the wavelength of a typical AlGaAs LED shifts downward some 48 nm when the diode is cooled with liquid nitrogen. This means that a diode that emits radiation having a peak wavelength of 880 nm at room temperature emits at a peak wavelength of 832 nm when cooled to – 196 degrees C with liquid nitrogen.

Radiation emitted by GaAs LEDs and diode lasers experiences a slightly greater downward shift when these devices are cooled with liquid nitrogen. For example, the room-temperature wavelength of a GaAs laser diode is 905 nm, but its liquid-nitrogen wavelength is 845 nm.

More dramatic than the downward wavelength shift of cooled LEDs is the significant increase in the efficiency with which these devices transform an electrical current into photons. I performed two kinds of experiments to illustrate this phenomenon.

Simpler of the two—a demonstration, actually—was to apply a small forward current to an inexpensive GaAsP red LED and visually compare its brightness before and after immersing the diode into liquid nitrogen. Even though I have worked with LEDs for more than 20 years, it was an astounding experience to observe the amazing increase in brightness that occurred after the LED was cooled in liquid nitrogen.

I tried this demonstration with several LEDs. First, I poured liquid nitrogen into a foam-plastic cup. Then I connected clip leads to an LED and applied a forward current of 5 to 10 milliamperes. I then extinguished the room lights and dipped the LED into the liquid nitrogen. For several seconds, the brightness emitted by the LED appeared to remain unchanged as the liquid nitrogen boiled violently in response to the "hot" (by liquid-nitrogen standards) LED.

As the bubbling slowed down when the junction of the LED began to cool, the soft red glow from the LED became as bright as the beam from a two-cell flashlight. When the LED was first immersed in the liquid nitrogen, its dim glow could barely be seen through the wall of the cup. After it reached peak power, the en-

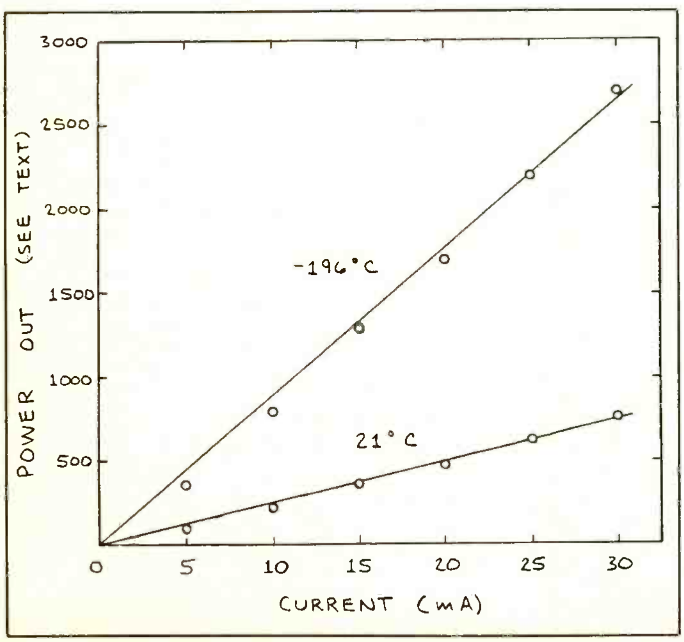
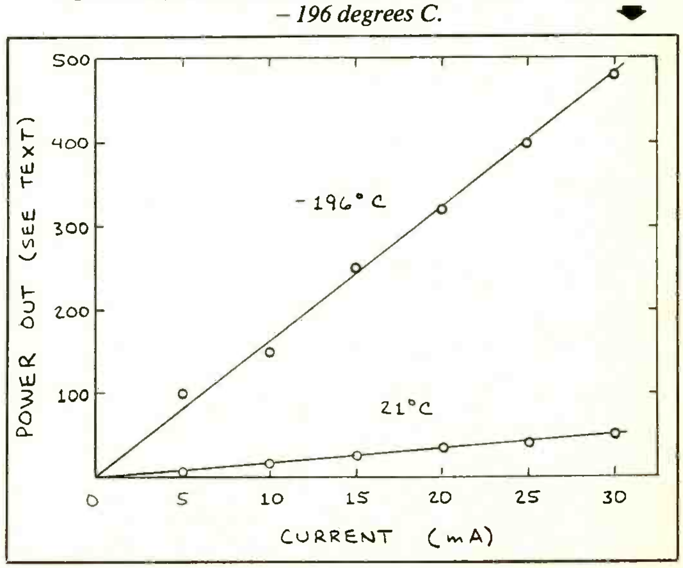


Fig. 2. Output of GaAsP red LED at 21 and – 196 degrees C.

Fig. 3. Output of AlGaAs super-bright red LED at 21 and – 196 degrees C.



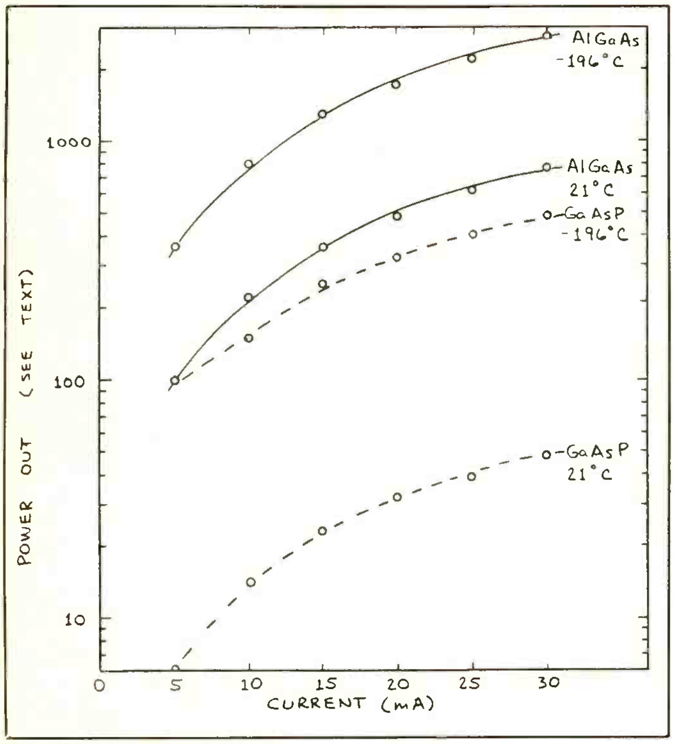
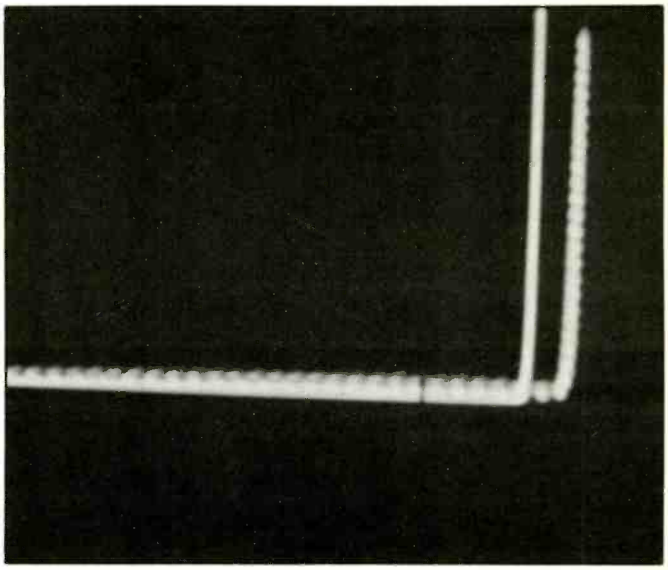


Fig. 4. Comparison of AlGaAs and GaAsP LEDs at 21 and – 196 degrees C.

Fig. 5. Current (vertical axis) versus voltage curves of two 1N914 silicon switching diodes at room temperature (22 degrees C).



tire cup glowed like a Japanese lantern. The nonlinear response of the human eye notwithstanding, I estimated a factor of 10 brightness increase.

The second experiment is to measure the output power from LEDs at both room temperature and the temperature of liquid nitrogen and to compare the results. For quantitative results, a calibrated, large-area silicon photodiode or solar cell should be used. However, since their response to incident radiation is linear over several orders of magnitude, an ordinary silicon solar cell can also be used. All that's necessary is to connect the output from the solar cell to a milliammeter.

Incidentally, keep in mind that the spectral response of a silicon solar cell will affect your results if you measure LEDs that emit at different wavelengths. Peak response of most silicon solar cells is near 900 nm.

For consistent results, it's important to make all power measurements under the same physical conditions. You can do this simply by touching the end of the LED to the same spot on the detector when making each measurement. Since the cooled LED will continue to operate at its increased power level for several seconds after you remove it from the liquid nitrogen, you can measure its output simply by removing it from the liquid nitrogen and quickly placing it against the monitoring solar cell.

Figure 2 is a graph that compares the output power of a cheap GaAsP red LED for a range of forward currents at both 21 and – 196 degrees C. The vertical power-output axis is labeled in uncalibrated or arbitrary units. In this illustration, the units represent output current of the monitoring solar cell in microamperes.

It's interesting to observe that this graph verifies my "factor of 10 increase" guess based on simply observing the increase in the light level emitted by the cooled LED. Indeed, when the forward current was 30 milliamperes, the diode emitted 10.2 times more power when cooled than when it was at room temperature. The following tabulation summarizes the increase in power for each of several forward currents (room temperature output in each case is normalized as 1.00):

Current (in mA)	Power Increase (at – 196° C)
5	16.67 times
10	10.71 times
15	10.87 times
20	10.32 times
25	10.26 times
30	10.21 times

The substantial increase in radiant power from cooled LEDs inspired early scientists to develop more efficient room-temperature devices. Their latest success is AlGaAs super-bright LEDs that emit 20 times or more the power of conventional GaAsP LEDs.

Shown in Fig. 3 is a graph that compares the output power of an AlGaAs super-bright LED for a range of forward currents at both 21 and – 196 degrees C. As in Fig. 2, the vertical scale is labeled in arbitrary units (output current in microamperes from the monitoring solar cell).

Though this LED does exhibit an increase in output power when cooled, the increase is not nearly as great as for the GaAsP LED used for Fig. 2. The following summarizes the increase in power for each of several forward current levels (again, room temperature output is normalized as 1.00):

Current (in mA)	Power Increase (at -196^0 C)
5	3.61 times
10	3.64 times
15	3.61 times
20	3.54 times
25	3.55 times
30	3.55 times

Figure 4 compares the performance of the GaAsP and AlGaAs LEDs on the same graph. Since the power emitted by the two diodes differs by as much as two decades, it was necessary for the scale of the power-output axis of the graph to be logarithmic. This graph clearly shows that the room-temperature performance of a modern super-bright LED slightly exceeds that of older GaAsP LEDs.

The results plotted in Fig. 4 have not been corrected for the spectral response of the solar cell. The response of a typical solar cell at the 670-nm wavelength emitted by a GaAsP LED is about 77 percent of the cell's response at its peak sensitivity point near 900 nm. The response at the 880-nm wavelength emitted by an AlGaAs LED is about 98 percent of the response at the peak-sensitivity point. Therefore, the performance of the GaAsP LED is actually somewhat better than that plotted in Fig. 4.

Incidentally, most LEDs are not rated for operation or storage at − 196 degrees C. Of the dozen or so epoxy-encapsulated LEDs I immersed into liquid nitrogen, four developed a single crack completely across the epoxy in the plane formed by the two wire leads. Though the cracked LEDs continued to function, their performance may eventually degrade if moisture enters the crack and reaches the LED chip. As an aside, the soft plastic used to insulate alligator clips also cracks when immersed in liquid nitrogen. Often, a popping sound is heard when LEDs and plastic immersed in liquid nitrogen develop fractures.

Diodes & Transistors at − 196 Degrees C

The noise level of diodes and transistors is reduced when these devices are cooled. However, there is a tradeoff. In the case of transistors, at least the ones I tried, the tradeoff was reduced gain. Here is the H_{fe} for two 2N2222 transistors before, during and after immersion in liquid nitrogen (temperature is in degrees C):

2N2222 Transistor	H_{fe} Temperature at: 21°	−196°	21°
A	23	2	20
B	140	4	138

I intentionally selected these transistors due to their significant difference in H_{fe}. At 21 degrees C, transistor B has an H_{fe} that is six times that of transistor A. But at − 196 degrees C, the advantage falls to a factor of two.

I also measured the forward voltage of several 1N914 silicon switching diodes at 21 and − 196 degrees C. The diodes exhibited a slight increase in forward voltage when cooled. The Fig. 5 photo is of the screen of a Heath Model 2232 Component Tracer showing the current (vertical axis) versus voltage curves of two 1N914 diodes at room temperature. Figure 6 shows the curves for the same two diodes when the one represented by the right trace has been immersed in liquid nitrogen.

If you carefully compare the curves in Figs. 5 and 6, you will see that the forward voltage of the cooled diode has been slightly increased. You may also note that the diode has a sharper "knee" when cooled to − 196 degrees C than when it is at room temperature.

Unlike silicon pn-junction diodes, germanium point-contact diodes don't appreciate being cooled to − 196 degrees C. If you have an oscilloscope, connect an ac signal to a germanium diode and monitor the amplitude of the rectified signal when the diode is at room temperature. Then immerse the diode in liquid nitrogen and observe the difference. The amplitude of the signal will be substantially reduced when the diode is cooled.

If you don't have access to an oscilloscope, connect a high-impedance crystal earphone across a germanium diode and connect one lead to an antenna to make a simple all-wave radio receiver. When you're listening to a station, immerse the diode in liquid nitrogen. The amplitude of the received signal will fall substantially. If you try this experiment with a silicon diode. The volume of the signal will decrease only slightly.

The results of the experiments with germanium diodes certainly run counter to those with silicon diodes. Perhaps it was the point contact of the germanium diodes I tested and not the semiconductor crystal that caused the degraded performance of the diodes I tested.

Radioactivity

Earlier, I noted that cooled semiconductors exhibit less noise than do uncooled semiconductors. Do radioactive materials become less radioactive at − 196 degrees C?

The final experiment I performed was to compare the radioactivity of a substance at 21 and − 196 degrees C. The radioactive source I used was a thorium-impregnated lantern mantle. First, I placed a radiation monitor on my desk and measured a background count of 11 counts per minute. I then placed a lamp mantle in a foam-plastic cup next to the radiation monitor, which then indicated 100 counts per minute. Next, I poured liquid nitrogen into the cup. After waiting a minute or so to allow the mantle to cool completely to − 196 degrees C, the monitor indicated 46 counts per minute.

Finally, I removed the cup containing the mantle and again measured a background count of 11 counts per minute. Subtracting the background count from the two readings gave 89 counts per minute when the sample was at room temperature and only 35 counts per minute

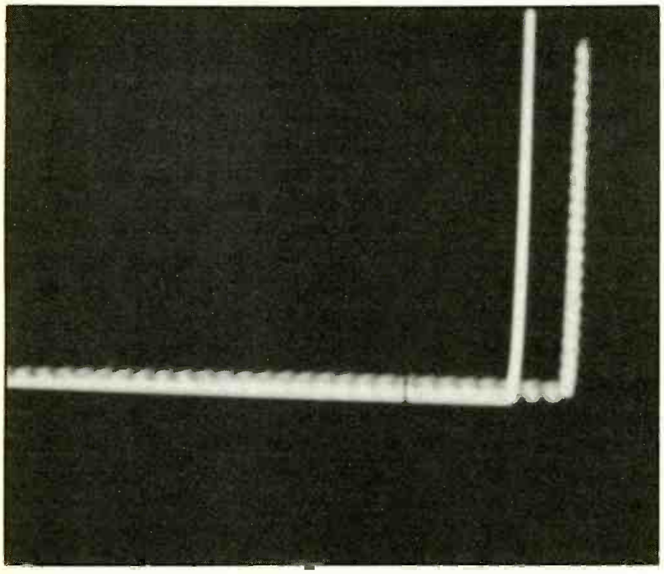


Fig. 6. *Current versus voltage curves for the two diodes in Fig. 5 when the one represented by right trace has been immersed in liquid nitrogen.*

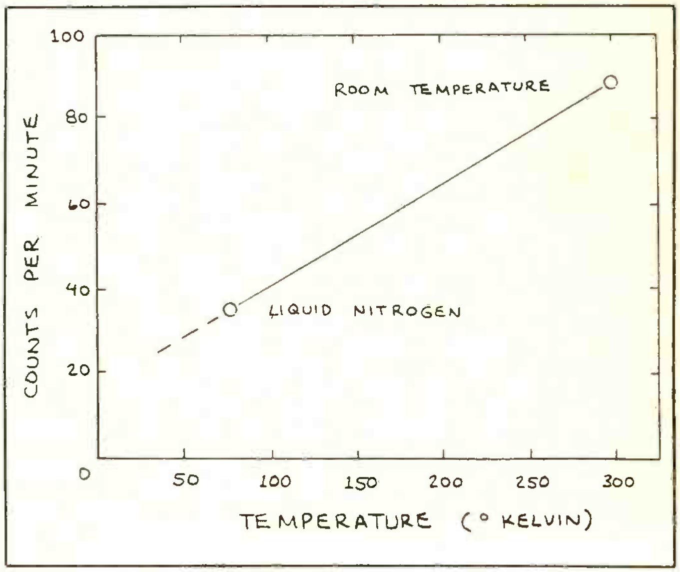


Fig. 7. Radioactivity of a thorium lamp mantle at 21 and − 196 degrees C.

when the sample was cooled to − 196 degrees C. Therefore, the radioactivity of the cooled thorium lamp mantle was reduced to 39 percent of its radioactivity at room temperature.

Figure 7 is a graph of these results. I've included this graph with some trepidations, since ordinarily it's not good practice to plot a trend from only two data points. However, in this case it's quite interesting to note that when the line between the two measured points is extended downward, it almost intersects the origin of the graph. In other words, at absolute zero, the thorium lamp mantle would cease to be radioactive.

Where to Acquire Liquid Nitrogen

Liquid nitrogen's commercial applications include freeze drying of food, refrigeration of produce during transport, cryosurgery, production of ultra-high vacuums and storage of various kinds of biological materials. This wide range of applications means that liquid nitrogen is widely available, especially in large metropolitan areas.

You can conduct all the experiments described here with only a liter or so of liquid nitrogen. Some welding shops will sell small quantities of liquid nitrogen for a dollar or two per liter. You might also be able to obtain liquid nitrogen from some doctors (particularly podiatrists), hospitals, research laboratories and the physics department of a university. If none of these sources is willing to sell you some liquid nitrogen, ask for the name of their supplier. As I explained in last month's column, I purchased liquid nitrogen and rented a large dewar from a man whose business is artificial insemination of cattle. I paid $30 for 30 liters of liquid nitrogen and $20 to rent the dewar for three days.

A dewar is a cryogenic flask having an evacuated double-wall construction. Often, the flask is lined with an insulating blanket of foamed plastic. An ordinary thermos bottle is a dewar. The dewar I rented is called a liquid-nitrogen refrigerator. It will store a full load for as long as 150 days. Some dewars will store liquid nitrogen for as long as six months.

Unless you are able to borrow or rent a dewar or liquid-nitrogen refrigerator, you will not be able to transport or store liquid nitrogen. One possibility is to have the supplier fill a 1-quart thermos bottle with the liquid nitrogen and perform your experiments nearby. Perhaps the supplier will be interested in watching what you do.

Caution: Under *no* circumstances should you place a stopper in the mouth of a thermos bottle containing liquid nitrogen! If you do, the pressure of the evaporating nitrogen gas will become exceedingly high, and the bottle will *explode*! You can place cotton loosely in the mouth of the bottle and/or invert a foam-plastic cup over the mouth of the bottle to reduce evaporation of the liquid nitrogen.

An ordinary 1-quart or 1-liter evacuated glass thermos bottle that costs from $5 to $10 will easily store liquid nitrogen for a day or two when the mouth is covered by an inverted foam-plastic cup—*not* a stopper. Several gallons of liquid nitrogen will last half a day or more inside a foam-plastic ice bucket. Don't use a plastic-lined ice chest; the extreme cold temperature will weaken and probably crack the lining.

If you plan to use liquid nitrogen on a regular basis, it's best to purchase your own suitable storage container. Various kinds of plastic, glass and metal liquid-nitrogen storage containers and dewar flasks are available from scientific supply companies like Fisher Scientific (711 Forbes Ave., Pittsburgh, PA 15219) and Cole-Parmer Instrument Co. (7425 N. Oak Park Ave., Chicago, IL 60648).

Safety Precautions for Liquid Nitrogen

Liquid nitrogen can quickly freeze exposed flesh, and its vapor can quickly develop extremely high pressure inside a closed container. For these reasons, in last month's column I included a list of safety precautions to follow when transporting and using liquid nitrogen. They are as follows:

(1.) *Never* place liquid nitrogen in a tightly closed container. If you do, the container will certainly explode!

(2.) Do not transport an open container of liquid nitrogen in a vehicle.

(3.) Wear eye protection when pouring liquid nitrogen and when immersing objects into liquid nitrogen.

(4.) Liquid nitrogen boils violently when it is poured into a container that is at room temperature. So stand clear to avoid being splashed.

(5.) If liquid nitrogen splashes onto your clothing, quickly grasp a *dry* section of the fabric and pull the wet area away from your skin. The liquid will soon evaporate from your clothing.

(6.) It is so important that I feel obliged to repeat the first admonition: *Never* attempt to store liquid nitrogen in a tightly sealed container!

Incidentally, the sale, use and transport of liquid nitrogen may be regulated by law or local statutes in some areas. Be sure to inquire about any local regulations that might apply.

Going Further

You can perform many other experiments with liquid nitrogen besides those described above. For example, you can transform the 905-nm radiation emitted by GaAs single-heterostructure laser diodes into visible red light that has a wavelength of 845 nm.

You can also perform many non-electronic experiments and demonstrations. Second in fascination only to a demonstration of the Meissner effect (a magnet floating above a superconductor) is what happens to an inflated balloon slowly immersed into liquid nitrogen. As the air inside the balloon contracts and itself liquefies, the balloon contracts and becomes completely deflated. Then, when you hold it in your hand, the balloon will reinflate. Be sure to obtain several kinds of balloons, since some types will simply explode when they reinflate. My daughter and I had good results with balloons designed to be twisted into animals and other shapes.

If you live in an area inhabited by fire ants, you'll find that a cupful of liquid nitrogen will instantly kill thousands of these dangerous pests. Just disturb the ant mound with a stick, wait for the ants to swarm out and then pour the liquid nitrogen onto them. Since air is 80 percent nitrogen, liquid nitrogen has no effect, ill or otherwise, on the environment. Too, its cost is comparable to that of the dangerous chemicals ordinarily used to eradicate fire ants.

You'll also find that normally soft objects, like bananas, flowers, leaves and wieners (hot dogs), become rock solid at −196 degrees C. My daughter skewered a wiener on a steel rod, dipped it in liquid nitrogen and used it to hammer a nail into wood!

In parting, let me remind you to always be sure to follow the safety precautions outlined above when working with liquid nitrogen. ME

Digitally controlled potentiometers/ Sematech finds a home in Texas and more

By Harry Helms

The past three decades have seen remarkable changes in the components of electronic circuits. The vacuum tube, a mainstay of electronic design back in 1958, today is virtually unknown except in a few high-power r-f applications. The transistor was once the cutting edge of technology, yet it is rapidly approaching the status of a specialty item. Even standard ICs are threatened by the growth of custom and semicustom IC products. Yet one device has remained remarkably constant over the years—the potentiometer. In fact, potentiometers have remained essentially the same for over 50 years.

They must be controlled by humans, using ears and/or eyes as feedback circuits. Thus, precise setting or resetting of a "pot" is often a hit-or-miss affair. Several approaches have been tried to "automate" control of potentiometers, with the most popular being the use of stepper motors to set detented or "stepped" potentiometers. Such efforts have not proven satisfactory since each solution creates more problems (power consumption, voltage transients, excessive space and heating, etc.) than they solve.

However, Xicor, Inc. has recently introduced three devices that allow digital selection of different levels of resistance. These devices—the X9103, X9104 and X9503—are called *digitally controlled potentiometers* by Xicor. Each device contains 99 resistive elements, with 100 power tap points selected by a digital control signal. The last setting of the wiper can be stored in an internal nonvolatile memory and will automatically be recalled when the device is again powered up. The supply voltage of each of the three devices is +5 volts, and each is capable of handling from −5 to +5 volts. Each device is packaged in an 8-pin DIP, and Fig. 1 shows the package outline and pin identification of all three devices.

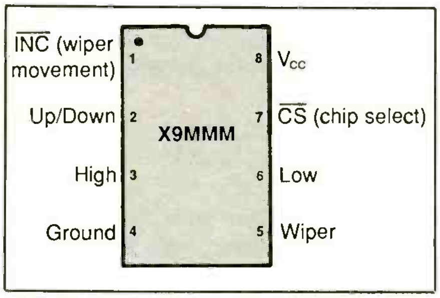


Fig. 1. Pinout details for X9MMM series of digitally controlled potentiometers.

The high, low and wiper pins correspond to the three terminals on a conventional potentiometer. Movement of the wiper is controlled by the INC input at pin 1 and the UP/DOWN CONTROL INPUT at pin 2. Direction of the wiper's movement along the resistive array is determined by the signal at pin 2. If this signal is high, the wiper will move "up" the resistive array, but it will move "down" the array if the signal is low. Since the resistive array is not one continuous resistive element (as in a conventional potentiometer), resistance increases and decreases in a series of discrete steps. The X9103 can be varied from 40 ohms to 10 kilohms in 101-ohm steps, the X9104 from 40 ohms to 100 kilohms in 1,010-ohm steps, and the X9503 from 40 ohms to 50 kilohms in 505-ohm steps.

The pin 1 INC INPUT controls the rate at which the resistance is increased or decreased. The INC signal is a negative-edge trigger (the edge of a signal going from a high to a low logic state) and can be up to 100 kHz in frequency for normal operation. However, once the device reaches either the upper or the lower end of its resistance range, it will ignore any further INC inputs until the pin 2 UP/DOWN CONTROL INPUT is reset to allow "travel" in the opposite direction.

Once a desired setting of resistance has been found, it can be stored in an internal nonvolatile memory by making the pin 7 CHIP SELECT INPUT low and then returning it to high while the INC INPUT is also high. (This occurs because the CHIP SELECT INPUT is positive-edge triggered.) To change the setting, the CHIP SELECT

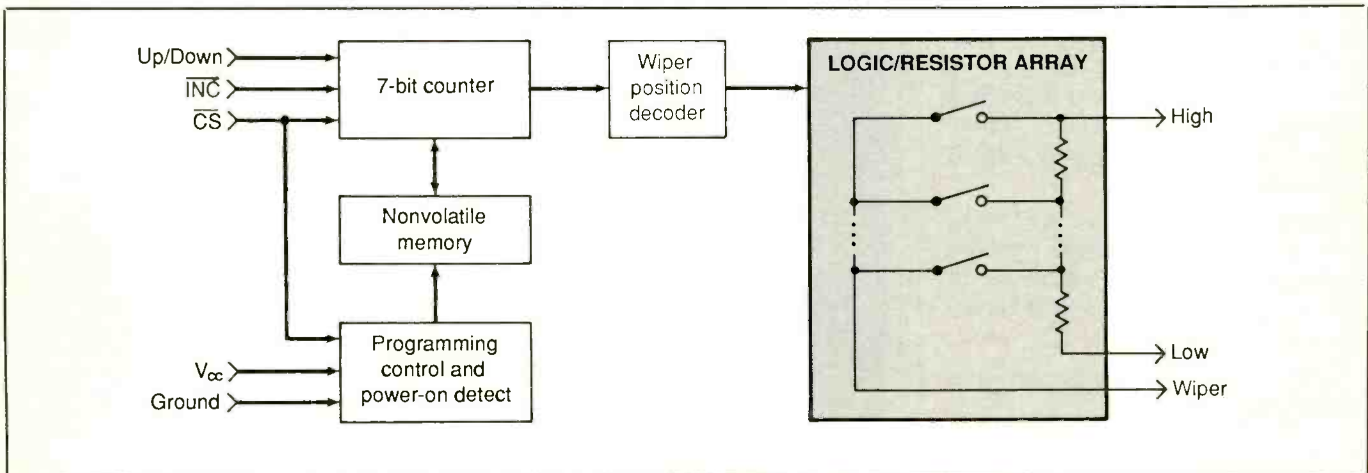


Fig. 2. Block diagram of circuitry contained within X9MMM series digitally controlled pots.

X9103/X9104/X9503 Specifications
Supply voltage: 5 volts
Terminal voltages: -5 to $+5$ volts
Supply current: 25 milliamperes
Wiper current ± 1 milliampere
Wiper resistance: 40 ohms typical
Power rating: 10 milliwatts.

INPUT must be kept low. If the device's supply voltage is removed or interrupted while the CHIP SELECT INPUT is low, contents of the nonvolatile memory may be lost. Xicor claims that contents can be retained more than 100 years!

Figure 2 is a block diagram of the internal circuit in each device. The Up/Down and INC control signals are applied to a 7-bit counter, while the Chip Select signal is applied both to the counter and to a programming control and power-on detection circuit. The Chip Select signal enables the counter and also signals the memory through the programming control and power-on detection stage to save the current memory contents. The supply voltage and ground point for the circuit "enter" through the programming control/power-on detection section.

The counter stage can read or write to the memory, while the programming control and power-on detection stage can only write to memory. Output of the counter goes to a wiper position decoder, which produces a 1-of-100 output signal. This signal selects one of the 100 possible wiper tap points. Each of the 99 resistive elements has equal value, or 1/99th the resistance of the total array.

These digitally controlled potentiometers can be used in virtually any applications where mechanical pots are used, up to the voltage and current limitations stated in the specifications sheets that accompany the devices. Digital noise introduced by these devices is typically 65 dB below a 1-volt signal, which is satisfactory for most audio applications. For the experimenter and hobbyist, these devices can open up new vistas in microprocessor control of analog circuits. For example, circuits could be adjusted or calibrated from remote locations by radio or modem, or a stereo system could be controlled from a microcomputer's keyboard. They also have several advantages even if microprocessor control is not a major consideration since they can be precisely reset to a desired value and their value cannot be altered by vibration or jarring. Moreover, they can be directly mounted on circuit boards in the same manner as other DIP ICs, which is a much simpler task than mounting mechanical potentiometers. (For an exercise in frustration, try using a conventional pot with a solderless breadboard!)

Production samples of these devices are available from Xicor sales representatives and are beginning to appear on the "surplus" devices market. Hints on using the X9103, X9104 and X9503 can be be found in Application Note #AN-106, titled "E2POT Digitally Controlled Potentiometer Brings Microprocessor Control to Audio Systems—Adds Features," available from Xicor sales offices or directly from Xicor, Inc., 851 Buckeye Court, Milpitas, CA 95035.

Other New Devices

GE/RCA Solid State announced a 5-volt low-power dual-tone multi-frequency (DTMF) receiver IC that requires only a bias resistor and 3.58-MHz color-burst crystal as external components. The CD22202E detects either 12 or 16 standard DTMF digits and can provide output in 4-bit hexadecimal code or in binary coded 2-of-8 formats. The data sheet for the CD22202E gives a schematic diagram for a DTMF receiver with guard-time circuit. (GE/RCA Solid State, Rte. 202, Sommerville, NJ 08876.) . . . Teledyne Semiconductor has announced the TSC170/171, a switch-mode power-supply controller based on CMOS technology. It can operate on a supply potential from $+8$ to $+16$ volts, with a quiescent-mode supply current of only 3.8 milliamperes, which is exceptionally low for this category of device. The device's outputs can directly drive MOSFETs, and the TSC170/171 is pin-compatible with the popular UC3846/3847 from Unitrode. (Teledyne Semiconductor, 1300 Terra Bella, Ave., Mountain View, CA 94039-7267.)

Literature

Available from GE/RCA Solid State at the address given above is Application Note SS-8766, "Transient Voltage Suppression in Automotive Vehicles." While the orientation is obviously toward automotive electronics, much of the information in the Ap Note can be applied to other situations where voltage transients are a problem . . . . Why did this take so long? Motorola recently became the first company to make some of its data sheets and applications notes available on-line to anyone who has a modem. The name of the bulletin board is "Dr. DuB," and it is operated by Motorola's Austin, TX facility. Its subject matter is digital signal processing (DSP0), and it includes current data sheets and applications notes and a question-and-answer forum on DSP. To access Dr. DuB, you need a 1,200-baud Bell 212A or V.22 modem. If your modem is Bell 212A, dial 512-440-DSP1; if your modem is V.22, call 512-440-DSP2. The log-on code is simply *quest*, and Motorola makes the bulletin board available without charge. Hopefully, other companies will follow Motorola's lead!

Sematech Goes to Austin

In addition to Dr. DuB, Austin, TX will also be the home of the Sematech consortium. Sematech is a cooperative effort of such companies as IBM, National Semiconductor, Motorola, Advanced Micro Devices, and Texas Instruments to pool their resources (both financial and human) in order to develop what they hope will be the finest IC manufacturing capabilities in the world by 1993. The Sematech consortium arose out of concerns by member companies and the Department of State that foreign prowess in semiconductor manufacturing, particularly in Japan, would place the U.S. industry at such a competitive disadvantage in the next decade that national security could be threatened. The major goals of Sematech are to improve IC yield and quality as well as to perfect "sub-micron" technologies necessary to manufacture the billion-transistor ICs of the next decade. The fruits of Sematech's work will be equally shared by all members of the consortium.

Congress has allocated $100-million to fund Sematech for this year and will be asked to maintain approximately that level of funding over the next decade. Twelve states competed to be Sematech's site, with the various states putting together funding and incentive packages to supplement congressional funding. Austin is believed to have beat out such strong contenders as Massachusetts and California because several Sematech members already have facilities in the area, its central location, reasonable living costs, and the presence of the University of Texas. Another factor may well have been Rep. Jim Wright of Ft. Worth, who as Speaker of the House helped secure Sematech's congressional funding and will be in a key position to maintain the funding.

Regardless of how it came to be, many semiconductor industry observers are convinced that the continued health of the U.S. industry is linked to Sematech's success. We wish them well. ME

Shortwave Listening

By Curt Phillips

The worldwide dissemination of information is taken for granted nowadays. When you turn on a television receiver, you are likely to see such things as snow skiing live from the Alps, news footage from the Middle East and a stock-market report from Japan.

This easy access to the world can lead to a casual attitude about worldwide communications. But all these sources of information are filtered through an intermediary, often based in New York City. Shortwave broadcasts, in contrast, give you direct access to the news-making areas of the world and often provide a level of intimacy and immediacy that more closely approaches Marshall McLuhan's concept of the planet as a "global village."

Shortwave listening has been a popular hobby since the early days of radio, but semiconductor technology has brought the price of a good receiver within the means of even someone interested in casual listening. The shortwave frequencies are generally considered to be those from 3 to 30 MHz (listening to the vhf and uhf frequencies above 30 MHz with scanners is a specialized activity usually differentiated from shortwave listening). Many *Modern Electronics* readers are already shortwave listeners (SWLs), and they are served by the periodic English broadcast frequency listings published. For those of you not already involved in this area of electronics, here are some basics on this special-interest field.

What You Can Hear

The international broadcasters are the best-known and easiest-to-find stations on the shortwave bands. They are often sponsored by governments, who are willing to spend substantial sums to spread their viewpoints around the world. Their booming signals, often running in the half-megawatt range, provide music, news (sometimes tainted with propaganda), educational and other entertainment programming. Their signals are usually strong and reasonably clear, and their transmissions are generally confined to identifiable frequency ranges (Table I).

These bands are based upon agreements drawn up under the auspices of the International Telecommunications Union (ITU). The various frequency ranges are traditionally referred to by using the wavelength in meters of one of the component frequencies; that is, 49 meters is the wavelength of 6,122 kHz, and the 49-meter band extends from 5,950 to 6,200 kHz.

One of the stations you are sure to hear if you listen much is the BBC. The British Broadcast Corporation's worldwide network of shortwave transmitters was established to serve the "empire" back in the days when the sun never set on it and remains the standard by which all shortwave broadcasting operations are often measured. The thrill of hearing Big Ben's toll is one of the initiation rites of shortwave listening.

Among the other powerhouses of the airways are the Voice of America, Radio Moscow, Radio Netherlands and HCJB in Ecuador. Many of these stations offer music programming, but be aware that the fidelity is at best barely equivalent to the AM broadcast band and the signals are subject to fading due to the long distance they are traveling to reach you. The diversity of music and programming available is far greater than that available on the local broadcast bands and that easily outweighs these factors. Listen to viewpoints from Cairo and Jerusalem on the latest mid-east events, Rome's and the Vatican's contrasting attitudes, etc.

Many other types of signals are also accessible on the shortwave frequencies. You can tune in ham-radio operators (Table II) engaged in such diverse activities as emergency message handling and technical discussions.

Military and government operations can often be found on the shortwave frequencies, including Air Force One, which I have heard on several occasions. The National Bureau of Standards station, WWV, broadcasts minutely timed announcements that allow you to set your watch with absolute precision (well, absolute if you adjust for the radio waves traveling at the speed of light).

Many unusual and mysterious signals appear on occasion, including some reputed spy and drug-smuggling operations. Some SWLs were able to find the correct frequencies and listen to transmissions from *Voyager*'s historic nonstop flight around the world. "Pirate" radio stations broadcasting without licenses in defiance of radio law can be heard operating intermittently on the shortwave bands.

Shortwave listeners with computers can get equipment to interface their computers with a shortwave receiver and receive radioteletype transmissions from AP, UPI and others, as well as automatically copy and print out Morse-Code transmissions, weather-satellite transmissions and news-service photographs transmitted via facsimile.

TABLE I. International Shortwave Broadcast Bands

Frequency range (in kiloHertz)	Meter Band
3,200-3,400	90
4,750-5,060	60
5,950-6,200	49
9,500-9,775	31
11,700-11,975	25
15,100-15,450	19
17,700-17,900	16
21,450-21,750	13
25,600-26,100	11

Receivers & Antennas

In the old days (about 15 years ago), shortwave receiver performance was measured by "Three S's": sensitivity, selectivity and stability. In modern receivers, excellence in sensitivity (the ability to read weak signals) and stability (the ability to hold steady on the frequency tuned) is common; so selectivity is the parameter to be most alert for.

Big circular dials or long ruler-type dials characterized the shortwave receivers of yore, but the digital LED readouts of most modern receivers are much more

ELECTRONICS OMNIBUS . . .

accurate and easy to tune. When you see a frequency listing, you can merely spin the dial until the numbers match and feel confident that you have tuned it correctly. The old style analog dials required interpolation of frequency and bandspread dials, and you still might not be tuned where you thought you were.

Shortwave receivers priced below $100 will probably not give satisfactory performance. There are several receivers priced in the $100 to $200 range, however, that can provide excellent performance and have many features to enhance reception. In the more rarefied air above $500, you can buy receivers with computerized control and specifications that exceed those of military and communications receivers of not too many years ago.

You are fortunate if you have a local store that sells high-quality shortwave receivers. If you do not live in such an area, you can get catalogs from a number of mail-order suppliers, such as the Electronic Equipment Bank (516 Mill St., Vienna, VA 22180). Many other good sources for shortwave receivers can be found in *Popular Communications* magazine (76 N. Broadway, Hicksville, NY 11801).

Good receivers can be found on the used market, too, especially at hamfests. Be aware, though, that the older receivers often do not have the sensitivity or stability of recent models and may have been manufactured by a company that has long since gone out of business. Nonetheless, these old tube-powered monsters (some weighing over 50 pounds) have an undeniable appeal and are sometimes full of extra features such as a notch filter, variable agc control, S-meters, etc. A '50's vintage Hammarlund HQ-180C has a spot on my (sturdy) operating desk. *Shortwave Requiem Past and Present*, a nice 8½" × 11" soft-cover book recently published contains fine coverage on used SW receivers, including new and used-model values. It sells for $5.95 plus $1 postage from Universal Shortwave, 1280 Aida Dr., Reynoldsburg, OH 43068.

What kind of an antenna do you need? The answer to that question is to put up

TABLE II: Amateur Radio Bands

Frequency range (in kilohertz)	Meter Band
3,500-4,000	80
7,000-7,300	40
14,000-14,350	20
21,000-21,450	15
28,000-29,700	10

as much wire as you can, as high as possible. Practically, any convenient length of wire between 30 and 100 feet long and placed approximately 20 feet high or more will yield good results. If you are using a portable receiver with a telescoping "whip" antenna, ignore that antenna if you can. If the radio does not provide a connection for an external antenna, use an alligator clip to connect a wire to the "whip" antenna.

The antenna wire can be strung between any two convenient supports. A long straight run of wire will be best, but if bending it around a support will allow you to put more wire in the air, do so. Trees work well as supports, as long as they do not sway enough to break the wire. Often, one end of the antenna can be anchored to the eaves of a house, at a location chosen to make the lead-in wire as short as possible. Do *not* place the antenna over or under electric power lines, of course. Not only can power lines cause interference to shortwave reception, but a mishap during installation can be fatal to you. Also, a falling or swaying wire can damage your antenna or destroy your receiver (and you).

The wire should be insulated from the supports (ceramic insulators are a cheap way to do this) and from touching any object that will short it to ground. It does not matter whether you use insulated wire or not for the antenna, but using insulated lead-in wire makes it easier to avoid shorting out the antenna on window sills and the like. An antenna wire of sufficient diameter to withstand the rigors of the weather will forestall antenna repairs; No. 12 or 14 hard-drawn copper wire is a good choice. Any connections or splices, such as where the lead-in is connected to the antenna, should be soldered to provide good electrical connection.

If you live in an apartment or condominium, all this talk about eaves and trees may seem alien to you. Indoor antennas can work acceptably well, though; so do not be discouraged. A length of wire strung around the room, preferably on an outside wall and near a window, will yield plenty of received signal. If you can drop an insulated wire out a window, that can work even better.

Listening Notes

A final piece of equipment that is helpful is a set of headphones. If you already have stereo headphones, you can use them for this purpose, although if you become a serious listener you will probably want to get a specialized set for communications. These are monophonic and have the narrower bandwidth that is desirable. Even with headphones, it is useful to locate the receiver in an area that is away from the distractions of the TV, kids, etc. if possible. In searching for weak signals, the ability to concentrate that headphones afford is a powerful ally.

When you see a listing of shortwave broadcasting times and frequencies, the time will most often be listed in UTC, expressed using the 24-hour clock. Here, 3 AM is 0300, 1 PM is 1300, 5 PM is 1700, etc. UTC stands for Universal Coordinated Time (the initials come from the French) and is the modern-day equivalent of Greenwich Mean Time (GMT). Using this time-keeping system allows people all over the world to easily determine when a station will be on the air. To convert UTC to U.S. local time, subtract 5 hours from UTC to get EST (Eastern Standard Time), 6 hours to get CST (Central Standard Time), 7 hours to get MST (Mountain Standard Time) and 8 hours to get PST (Pacific Standard Time). Daylight savings time requires that you subtract one hour less in each time zone; that is, 4 for EST, 5 for CST, etc.

Although much of shortwave broadcasting is aimed at a non-English speaking audience, plenty of English-language programming can be found. For the adventuresome, many of the foreign stations offer broadcasts to aid in the learning of their native tongues. Otherwise, high-school level language mastery is probably not enough to decipher foreign-language broadcasts, since they assume more-than-conversational fluency.

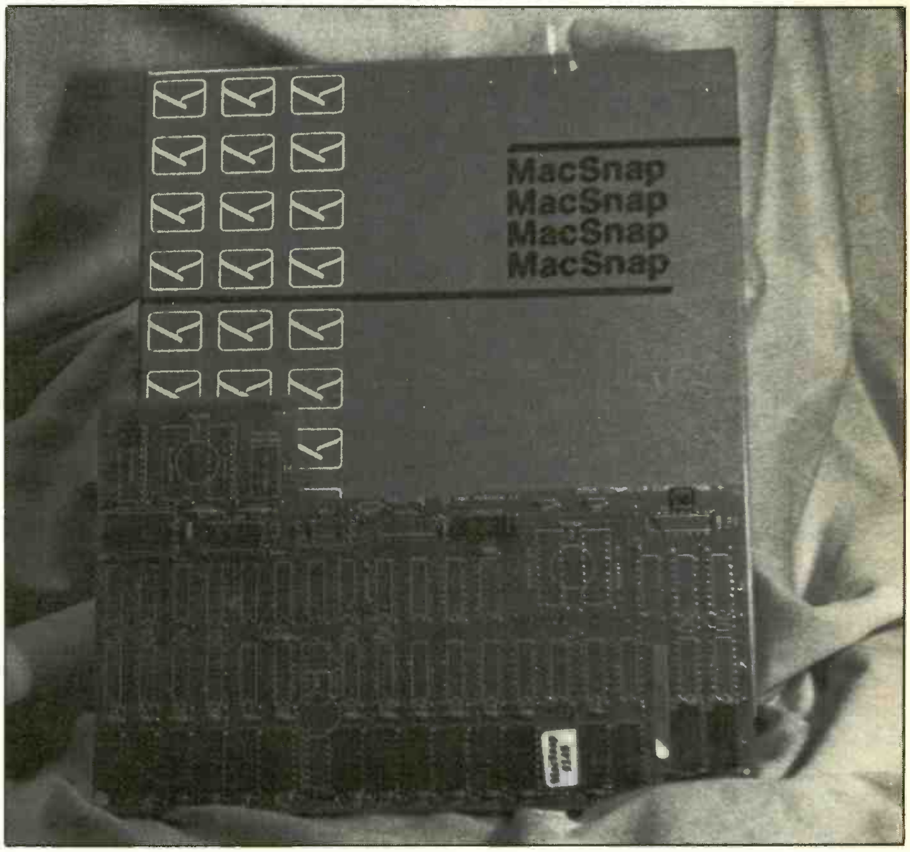
Finally, listeners can receive a variety of reception acknowledgment cards, some very colorfully illustrated, by writing to the broadcaster with some information about the program heard, including reception quality.

Shortwave listening is a fascinating and enjoyable facet of hobby electronics. I hope this column has encouraged you to get started.

Your comments and ideas for this column are welcome. Contact me at P.O. Box 678, Garner, NC 27529, or by computer on Delphi (CURTPHIL) or The Source (BDK887). ME

Clone Upgrading

By Ted Needleman



On re-reading last month's column, I find that I left out an important consideration when buying a compatible or clone computer. Actually, it was a fortuitous omission, as it bears directly upon this month's main subject, a third-party Apple Macintosh memory upgrade.

This consideration has to do with being left in the lurch when the company that produced or marketed your computer system goes under or decides they'd rather produce dishwashers than computers. The "orphan" computers are something I have, unfortunately, too much experience with. My Apple ///, for example, now resides in a good home with someone who gets a kick out of playing with Visicalc 3 and doesn't much care that there will never be any new software that can run on the system.

Today's clones, in contrast, generally give you good insurance against the orphan syndrome. This is true even if they're made by the "Three Guys and a Goat Computer Company" because just about any clone you buy today is a *generic* PC. Therefore, no matter where the parts come from, they can most likely be replaced by an equivalent one made by someone else.

Even If the clone you purchased uses a proprietary BIOS that fails to give you the degree of compatibility you expected, it too can be replaced with a BIOS from one of the major suppliers. Accordingly, with clone assemblers largely following IBM's designs on its earlier pc models, no longer made by IBM, you get a good amount of peace of mind.

Chances are you'll be able to keep the new clones going almost forever. And you'll also be able to enhance their performance as you go along (until you reach the economic point of no return). As you want more performance, you can even swap out an 8088 motherboard for an 80286 one. By the end of this year, it's expected that 80386 motherboards will be down in the realm of affordability. And all the other components of your system, from the case and power supply to the floppy-disk controller card, are still usable.

Big Red

This brings me to this month's product focus. While PCs (Big Blue's and other's) are designed to be upgradable throughout their usable life, many of the models from Big Red (Apple Computer) are not. Until recently, for example, Apple Macintosh models were all closed-architecture types.

Apple Computer's past Apple /// and Lisa fared even worse. The Three was just abandoned. And the plan Apple came up with for trading in a Lisa, originally costing $10,000, on a Macintosh, was an insult to the owner's intelligence (in the vein of "if you were foolish enough to buy the machine in the first place, maybe you'll be foolish enough to go for this upgrade!").

Looking back over the past, where does that leave those of us with 512K Macintoshes? When Apple introduced the Macintosh, I had no intention of ever buying one. After all, I still remembered how I got stuck with the Apple ///. Then I started getting requests to review Macintosh software, but held off purchasing a system until they brought out the 512K Mac (also known as the "Fat Mac"). In the two years I've had the system, I've spent about $400 upgrading it—adding enhanced ROMs, an 800K internal drive, and buying a Mac-Plus keyboard.

Today's Macs, though, come with a minimum of 1 meg of RAM, and a completely different interface—SCSI (Small Computer Systems Interface)—for hard disk drives. And much of the great software coming out lately, such as Hypercard and Multifinder, run poorly, if at all, in less than a meg. It looked like an expensive motherboard swap was my answer until I received a MacSnap to review from Dove Computer.

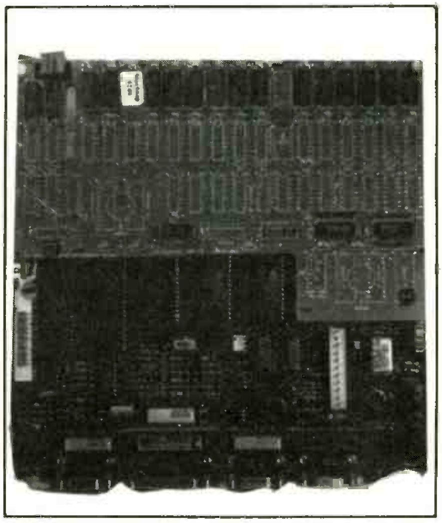
MacSnap

MacSnap, available in several different models for 128K, 512K, and Mac Pluses from third-party developer, Dove Computer, is a memory-upgrade board. Also available from Dove are ROM upgrade boards and an SCSI interface board. The Model 524S kit they sent me contained a memory board to upgrade my 512K enhanced system to a Meg of RAM, and a small board to add an SCSI interface to the system. Since I don't have an SCSI hard disk to test out this interface, I installed only the memory upgrade.

The MacSnap installation guide is well illustrated and comprehensive. It also has some glitches and needs upgrading, though no error is serious enough to damage your system. The guide also mentions several tools, including a No. 15 Torx screwdriver, case opening tool, and a grounding strap. These are contained in an *optional* tool kit, not included with the review unit. If you buy the Dove kit, be sure to also purchase the tool kit. You'll need it! Installing the board is about an hour's work. Most readers of *Modern Electronics* should be more than competent to do it.

The first step is to read through the entire manual at least once, then open up the Mac's case. There are five Torx screws holding it closed; the two located in the recessed carrying handle require a screwdriver with a long shaft. I was able to cobble something together for this purpose, but the screwdriver included in the optional tool kit would have saved some time. Next you must gently pry open the case. Again, the optional kit's special tool makes this easy. Lacking it, and necessity being the mother of invention, I used a butter knife. With the back of the case removed, you must disconnect two cable sets from the motherboard at the bottom of the system. Then slide the motherboard back and out.

A confusing instruction section followed. The manual has installation instructions that include additional instructions, italicized for emphasis, for



MacSnap mounted in place on Apple Macintosh motherboard.

owners who have a HyperDrive hard disk installed (which I don't). However, the hardware illustrated to attach the Dove card to the Mac's motherboard bore no relation to what was included with MacSnap upgrade kit.

The manual showed several different sizes of standoffs, some of which were supposed to be used as nuts, and both flat and lockwashers. My hardware kit had two standoffs, four nylon screws, and six flat nylon washers. In reality, the screws screw into the standoffs, which are placed on the bottom of the MacSnap toward the front. It's really the only place for them, but it did give me a few minutes pause. Not as much, though, as the next step. The MacSnap has six special sockets on the bottom which snap over and onto six ICs on the Mac's motherboard. The installation addendum states that if you have NEC DRAMs on your motherboard you need to *cut* away the plastic separators between the contacts on two of these sockets. Of course, my Mac had the NEC DRAMs!

I'm not all that happy about cutting things even when I've bought the adapter. When it's a review unit, I'm even less inclined to do so. After some thought, I figured, "what the heck," and went looking for a "cutting tool" as specified in the instructions. I finally decided that a razor knife qualifies as one and hacked away with it for a few minutes to prepare for installing the adapter.

Installation consists of positioning the adapter over the motherboard and pressing down hard with your thumbs on places marked (there are three spots noted) on the MacSnap. With 200-plus pounds concentrated onto two thumbs, I quickly felt three satisfying "snaps" as the board clicked into place. Putting in two more nylon screws to finish the mounting process, I was ready to reinstall the motherboard.

Here, again, the instructions were wrong. The installation guide states that the standoffs don't allow the MacSnap/motherboard combination to slide into the system. You are supposed to position the board into one set of guides, then pry the other set into place. Maybe I have a rogue Mac, but the motherboard combination slides back in as easily as it came out. I reconnected the two cables, put the case back together, and was ready to power up and see if I had done irreparable damage to my Mac.

Powering up with the RamSnap disk included with the board, I was thankful to see the smiling Mac face come up on the screen. RamSnap, by the way, is a handy RAM disk and disk-cache utility that Dove includes with all of its Snap upgrades. Launching the program, I was gratified to see almost 900K available for a RAM disk (Apple's operating system for the Mac Finder is a real memory hog).

The only thing left to worry about now are the scattered reports of Macintosh power supplies going up in smoke when memory upgrades (including Apple's own) are added. Dove states that its upgrade uses less power than Apple's, and Apple denies that smoked power supplies are much of a problem, so maybe I'll be lucky on this score.

Is Dove's MacSnap a good deal? I believe it is. Fortifying this view, my friendly Apple dealer quotes $599 for an upgrade of a 512K motherboard to a 1-meg Mac-Plus motherboard. Dove's Model 524S gives you the same thing (including the SCSI interface) for $339 or almost 40 percent less. Thus, MacSnap represents a substantial savings.

Moreover, if someone like myself, who has yet to get an assembled Heathkit, terrific instructions and all, working on the first try, can do a faultless installation, chances are good that you won't have any difficulty with MacSnap. For more information on MacSnap, contact Dove Computer Corp., 1200 N. 23 St., Wilmington, NC 28405 (phone: 919-763-7918) or circle the number indicated below on the postpaid Free Information Card included in this issue. ME

CIRCLE 83 ON FREE INFORMATION CARD

CIRCLE 30 ON FREE INFORMATION CARD

Mastering Digital Control by William G. Houghton. (Sybex. Soft cover. 374 pages. $24.95.)
This book is directed to engineers or technicians who need to design microcontroller-based systems, as well as to the hobbyist who is interested in this area. It focuses on single-chip microcontrollers and practical design problems and solutions.

At the outset, the author lays the groundwork with an introduction to microcontroller concepts, defining the differences between microprocessors and microcontrollers and introducing two families of Intel devices and one family of Motorola devices. Devices discussed in this chapter are the foundation upon which later chapters are built.

Each chapter is devoted to a specific topic: external program memory expansion, external data memory expansion, expanding I/O, use of interrupts, single-bit operations, external clock sources, adding an RS-232 port, etc. By the ninth chapter, more sophisticated subjects are introduced: interfacing a microcontroller as a peripheral device in multi-processor systems, scanning keypads, interfacing to display devices and the like. There are also chapters devoted to table translation, ac control and zero-crossing detectors and analog measurements and interfacing procedures.

Chapter 15, which concludes the main text material, offers an application example that covers the programming needs of EPROMs, required interfaces, an EPROM programmer circuit and software drivers.

Two appendices are also included. The first is an assembly-language source code listing of the software drivers for the EPROM programmer previously described. It not only gives the listing, it describes it in detail. Listed in the second appendix are the names, addresses and telephone numbers of microcontroller/peripheral device manufacturers from whom readers can obtain additional information needed to build microcontroller-based digital control systems.

This well-written book clarifies the skeleton information provided by data sheets and application notes, and is appropriately supported with logic and block diagrams, tables and subroutines listings. Thus, it should serve exceptionally well as a hands-on guide to microcontrollers and designing digital device controllers, assuming the reader has a working knowledge of basic digital logic elements. Therefore, if you really want to learn how to create digital control circuits, this is the book for you.

Complete Guide to Stereo Television (MTS/MCS) Troubleshooting and Repair by John D. Lenk. (Prentice-Hall. Hard cover. 174 pages. $29.95.)
More and more TV sets with stereo sound and second audio programs (SAP) are finding their way into U.S. homes. Generally called MTS (multichannel TV sound) systems, service technicians should know how to troubleshoot these circuits, which is this book's subject. Beginning with a brief history of stereo TV, the book quickly gets down to cases discussing the methods used to create and demodulate two-channel audio in a TV broadcast, a noise-reduction system, the troubleshooting approach and basic troubleshooting functions.

Since it is the basic troubleshooting tool used in servicing stereo TV, the MTS TV stereo generator is given its own chapter. The focus here is on the B&K Precision Model 2009 generator. This chapter not only tells you what an MTS generator is, it also tells you, in step-by-step detail, how to use it for performing various tests. For the newcomer to MTS TV servicing, this may very well be the most valuable part in the book.

Later chapters deal with the specifics of Mitsubishi's MTS TV and hi-fi/stereo VCR circuits, Sony's MTS adapter and TV stereo and General Electric's multichannel sound decoder. Each of these chapters contains sections that deal with circuit descriptions, typical test/adjustment procedures, the troubleshooting approach and, where applicable, additional circuits.

The author, who has a long-time background in the electronics servicing area, provides lucid, easy-to-follow text and excellent supportive illustrations (photos, block diagrams and schematics). This is a hands-on *user's* guide, as well as a good theoretical overview of MTS.

Though this book's coverage might at first appear to be too product specific, the reader can relate details for any given product to any other not covered that operates on the same principles. Consequently, this book can serve as a general guide to the test and reception equipment encountered in the MTS stereo TV consumer product category. An understanding of basic TV principles is assumed by the author.

NEW LITERATURE

SMD Resistor & Capacitor Kits. Communications Specialists offers a data sheet that describes the company's new CC-1 Chip Capacitor and CR-1 Chip Resistor kits for prototyping and repair work that require surface-mount devices. Tables on both sides of the card-stock sheet list specs of each device type included in a kit (10 each of 154 types of resistors, plus 10-chip bonus; 5 each of 73 types of capacitors, plus 5-chip bonus). For a free copy, write to: Communications Specialists, Inc., 426 W. Taft Ave., Dept. ME, Orange, CA 92665-4296.

Electronic Parts & Equipment Catalog. All Electronics' 52-page Winter 1988 catalog lists and fully describes, including prices, a wide range of electronic components, tools, chemicals, project cases, books, intruder alarms and more. In addition to the usual line-up of resistors, capacitors, chokes and transformers, diodes, transistors and ICs, the catalog contains listings for relays, switches, microphones, speakers and tone transducers, crystals, fans, batteries, circuit-prototyping and -building items, and wires and cables. Individual products listed include multimeters, black-light assembly, light-activated motion sensor, keyboards, telephones and accessories. An extensive line-up of circuit-board and ribbon-cable connectors and assemblies are also listed. For a free copy, write to: All Electronics Corp., P.O. Box 567ME, Van Nuys, CA 91408.

Test & Instrumentation Product Guide. United States Instrument Rental's 400-page 1988/1989 Product Guide provides information on more than 5,000 different models from well over 100 major manufacturers of electronic test and measuring instruments, data-processing equipment and telecommunications test devices available for rent, lease and sale. The Guide contains full specifications, descriptions, photos and technical data on a broad variety of product categories.

(continued on page 96)

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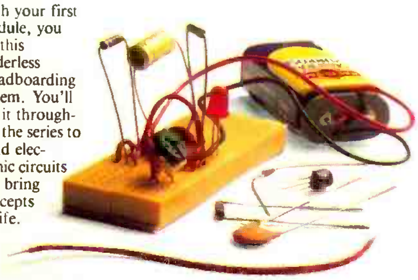

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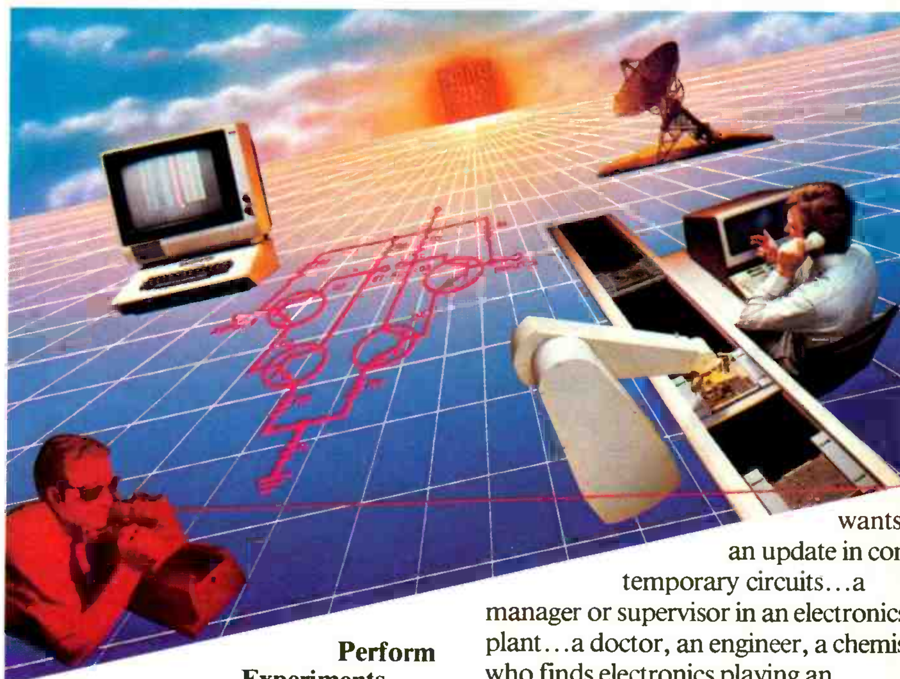

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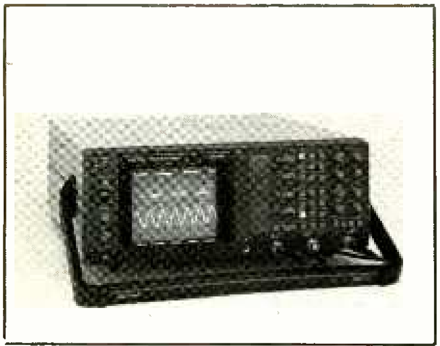
ting of amplitude, timebase and triggering parameters for any signal applied to the scope's input(s).

Cursor measurements include peak-to-peak, frequency and period, risetime, and dV and dt between any defined points. Cursor positioning is defined by softkeys, and all associated control functions and measuring options are displayed on-screen. A



zoom function automatically calculates delay and timebase settings and allows for capture of signal details out of complex waveforms.

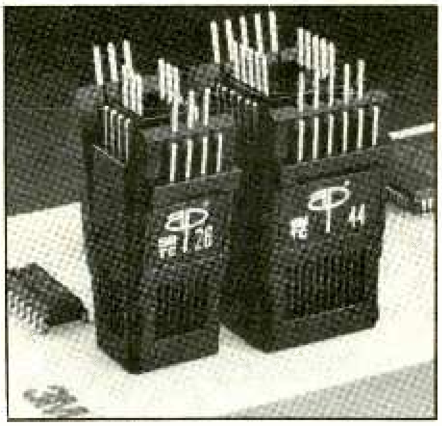
Both channels are clocked simultaneously, with real-time resolution of up to 10 ns to permit accurate time measurements between channels. Record lengths can be up to 4K.

Rocker switches enter ranges and settings, and a back-lit LCD panel displays instrument status and current parameter settings. Remote operation is via an optional IEEE-488 or RS-232 interface, the latter supporting a plotter or printer. $3,990.

CIRCLE 42 ON FREE INFORMATION CARD

PLCC Test Clips

Convenient testing of 28- and 44-pin PLCC (plastic leaded chip carrier) devices has been added to the 3M line of AP Products test clips. These new clips have a wedge design that permits all four sides to open simultaneously. Heavy-duty compression springs provide firm contact pressure. An insulating contact comb prevents accidental shorts, while a patented wiping action ensures contact integrity. Narrow body design permits testing of ICs with as little as 0.200″ row-to-row spacing between devices.



Visible probe access points permit fast, safe testing of individual leads. Staggered contact rows are on 0.1″ centers for easy probe attachment. Industry-standard 0.024″ square contact pins accept single row female socket connectors and Wire Wrap connections for interfacing with test equipment.

The test clips are available with alloy 764 or gold-plated leads. $23.89 and up for 28-pin, $30.95 and up for 44-pin versions.

CIRCLE 43 ON FREE INFORMATION CARD

PC Drawing Tablet

Easyl PC from Inforite Corp. (San Mateo, CA) is a new pressure-sensitive tablet designed for desktop publishing, presentation systems, art, animation, CAD and other touch-control applications. Its 8.5 × 12.875-inch active surface contains a matrix of 1,024 × 1,024 switches to allow the user to draw or trace directly into a computer with an ordinary pen or pencil on paper. The system is designed to run in any IBM

PC/XT/AT or compatible computer using popular graphics software, including PC Paintbrush and Dr. Halo, in CGA or EGA mode. Easyl PC operates under the GEM or Windows environment.

Easyl PC can emulate other digitizing tablets. It is supplied with emulation drivers for Summagraphics's Model MM961 and Bit Pad One. The tablet has everything implemented in software. Hence, there are no DIP switches to set to select certain features.

Secondary pointing device support is also provided. Easyl PC comes with support for the Microsoft Mouse, Logitech Mouse, PC Systems Mouse and ITAC Trackball, which plug directly into the product's board. Other secondary pointing devices can be supported as well.

Supplied with a standard RS-232 serial port, Easyl PC's hardware comes on a printed-circuit card that simply plugs into the computer's expansion bus. Extra hardware support enables the Easyl PC tablet to work in conjunction with a serial mouse or any other serial pointing device. The serial connector can be used for any standard serial device and can be configured as either COM1: or COM2:. Two-button mouse emulation is provided on the tablet, making it possible to perform any mouse action directly from the tablet.

Registration pegs that are locatable on the tablet frame are designed to accommodate ordinary punched paper to keep the paper surface in place while drawing or tracing.

CIRCLE 44 ON FREE INFORMATION CARD

Hand-Held CB Radio

Fanon Courier's Model CWT-40 hand-held 40-channel CB transceiver features better than 70 dB adjacent-channel rejection, an automatic noise limiter, and adjustable squelch. A selectable r-f-power level/battery-saver switch allows switching from full output to 0.4 watt of power.

Convenience features include a bright LED channel-number display with battery-saver on/off switch, LED meter to indicate relative signal strength, transmit, receive power and modulation percentage. Other features include an automatic Channel 9 switch, transmit/battery "low" indicators, separate condenser microphone and speaker, and jacks for earphone, external antenna and external 12-volt dc power supply.

The transceiver operates on 12 volts dc, which can be from from either 10 1.2-volt rechargeable Ni-Cd rechargeable cells or eight standard 1.5-volt alkaline cells (not included). $109.95, including carrying case and auto-lighter adapter.

CIRCLE 45 ON FREE INFORMATION CARD

Cordless Soldering Gun

A new rechargeable soldering gun has been introduced by Ungar. The Ungar 1200 Rechargeable gun is suited to all types of quick soldering tasks and for use wherever ac line power is not available. It features a general-purpose tip that heats up rapidly and provides up to 250 solder joints on a single charge of its nickel-cadmium battery.

Supplied with the soldering gun is a UL-listed recharger that refreshes the battery overnight. A safety lock prevents accidental turn-on, and a trigger-activated light illuminates the connection being soldered. A bail on the handle permits the gun to hang on a wall during recharging.

Optional accessories include a fine tip for electronics applications and a 60-watt heavy-duty tip for heavy electrical work and metal repair.

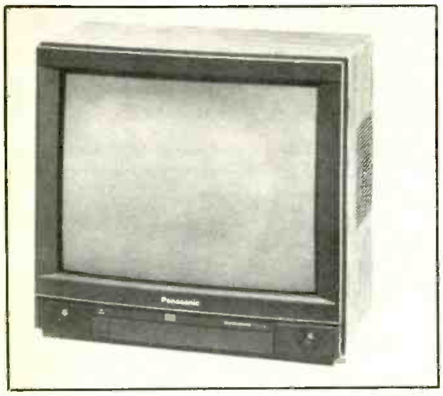
The 1200 is also available in a seven-piece kit (No. 2200) that includes accessory tip, flux brush/pick, 60/40 rosin-core solder and carrying case.

CIRCLE 46 ON FREE INFORMATION CARD

NEW PRODUCTS • • •

Feature-Laden Color TV

An S-video input jack provides Super-VHS (S-VHS) compatibility on Panasonic's 155-channel, cable-ready Model CTK-2063S 20" color TV receiver. The 4-pin S-video jack



enables users to connect an S-VHS VCR directly to the receiver's luminance and chrominance circuits to reduce mixing of color and luminance information and prevent cross-color interference. S-VHS capability gives this TV set the capability of reproducing more than 400 lines of horizontal resolution, depending on program source.

A flat-faced picture tube with hyperbolic curvature places the center and outer edges of the viewing surface in approximately the same plane to reduce color imperfections. The built-in decoder allows the CTK-2063S to receive broadcast stereo and SAP (separate audio programs), and features dbx noise-reduction circuitry. A stereo amplifier features separate bass, treble and balance controls.

Additional features include: audio and video input jacks, variable audio output jacks, 12/24/48-hour parental lockout, sleep timer, Color Pilot, sharpness control, and comb, SAW and notch filters. An on-screen function displays volume level, channel selection, time of day and sleep timer, sound mute and stereo, mono or secondary audio source.

CIRCLE 47 ON FREE INFORMATION CARD

CB Receive Preamp

Electron Processing, Inc.'s (Medford, NY) RFTR Signal Intensifier wideband receiver preamplifier is designed to improve reception of CB transceivers. It installs in the antenna lead of any AM or SSB CB transceiver and connects to the unit's 12-volt dc power supply. In use, received sig-

nals are amplified a minimum of 13 dB. On transmit, an internal relay automatically bypasses the preamp. Insertion loss and VSWR are said to be negligible, and power drain is rated at 80 mA at 10 to 15 volts dc. $49.95.

CIRCLE 48 ON FREE INFORMATION CARD

Flat-Panel Displays *(from page 19)*

and the fact that the input and output are in the same location, touch-screen displays are ideal in situations where users are completely untrained in the use of computers and keyboards. Touch screens are currently gaining popularity as display/input devices for controlling a wide variety of high-technology equipment in industry. They're also very useful where a computer must interface with a complete cross-section of the public, such as in automatic bank-teller machines and computerized library-card catalogs. "Hardening" of these displays to the effects of moisture, dust and dirt is a necessity to assure long life and reliable operation under a wide variety of environmental conditions.

Touch screens usually have pairs of emitter/detector transducers arranged around their perimeter so that the X and Y location of the touch point can be accurately determined. In optically-based screens, the location is pinpointed when X and Y light beams are interrupted. Other detection schemes are based on capacitive, resistive and ultrasonic transducers.

With the capacitive technique, for example, a transparent coating layered over the screen acts as one capacitor plate, the screen itself serving as the other plate. Touching the screen causes a current drain at the touch point. This current is sensed by X-Y electrodes located around the periphery of the screen. With a resistive device, two conductors, separated by a dielectric, form a "sandwich" that covers the entire screen. Touching the screen closes a circuit that identifies the touch point.

Wells-Gardner Electronics Corp.'s recently introduced touch screen is aimed at driving down the typically high cost of touch-screen devices. Its Cyclops system uses a CCD (charge-coupled detector) device that is an adaptation of the photodiodes commonly used in 35-mm cameras. Light from a single source (a light-emitting diode) is focused across the touch screen. When the light strikes the retroreflective material placed on two sides of the screen, it is reflected back to the CCD. The CCD then measures the angle of the returning light of each diode and compares it to an average value with a microprocessor that is part of the system. A diode output that is significantly different from the average value indicates a break in the beam and, thus, the touch point's location.

As you can see, some exciting advances are being made in flat-panel and touch-screen displays. Expect to see more of them used for specialized applications. **ME**

Without Magnetic Tape *(from page 33)*

that it's correctly oriented. Gently but firmly, push each IC home in its socket, taking care to prevent any pins from overhanging the socket or folding under.

To perform final checkout of the project, plug the line cord into an ac receptacle and the telephone cord into the ac line via its modular connector. Set *S3* to STANDBY; green ANSWER *LED2* should now be extinguished but red STANDBY *LED1* should be on.

Set VOLUME control *R16* to about mid-rotation and press and release RECORD switch *S1*. The STANDBY LED should now be off and the ANSWER LED should be on, confirming that a connection to the telephone line has been made. If your project has call-screening capability, you should also now hear a dial tone.

Speak in a normal-level voice into the microphone element until the STANDBY LED comes on again. Now, to hear the recording you just made, press PLAY switch *S2*, at which time you should hear your voice coming from the project's loudspeaker. If you incorporated the call-screening function, you'll also hear the dial tone in the recording. This won't occur during recording of your outgoing message since *S3* will be OFF during recording.

If your project doesn't function as described, check the logic circuits that feed *IC4* to determine if they're operating properly. The best way to do this is with an oscilloscope, but a high-impedance (1-megohm or more) dc voltmeter can be used to measure logic levels. A logic-0 condition is indicated by an approximately 0-volt reading, while a logic-1 condition is indicated by an approximately +5-volt reading.

Check pin 34 of *IC4* to determine if the start pulse occurs when the RECORD pushbutton is released. This is a positive-going pulse of about 25 milliseconds in duration. Also check that pin 32 of *IC4* goes to logic 1 when PLAYBACK is pressed.

If you don't obtain the proper logic levels, check the wiring of the pushbutton switches and the components associated with *IC1* and *IC2*. If possible, try new ICs. Also, make sure that you haven't inadvertently interchanged the two ICs.

The ring-detector circuit can be checked by momentarily shorting pin 2 of *IC3* to circuit ground while measuring the logic level at pin 3. The voltage at pin 3 should go to logic 1, remain at this level for about 5 seconds and then return to logic 0. If *IC3* doesn't operate as described, check the components associated with the chip to verify that they're correct in value and properly oriented on the circuit-board assembly. Also, try a new chip.

The final test is to make a recording and check operation of the project when a call comes in. If your project has call-screening, remember to set *S3* to OFF before pressing the RECORD button. Record a message and then play it back to verify that what you said was indeed recorded. Then call a friend and have him or her call you back. When the telephone rings, the call will be answered in about one second. You'll hear the recording from the project's speaker, and the ANSWER LED will light. After 8 or 16 seconds (depending on the message-length selection made), the project should revert to its standby mode. You now have up to 10 seconds to pick up your telephone's handset before the telephone system disconnects your caller.

To preserve any recording you've made, always keep the project's line cord plugged into an ac receptacle. You can use the STANDBY/OFF switch to allow the project to answer or not answer your incoming calls as you require.

When you want to make a new recording, press the RECORD button and speak directly into the microphone at a conversational level. Set *S3* to STANDBY, and the project is ready to answer your calls. **ME**

Infrared Remote Control Relayer *(from page 60)*

but should be kept as unobtrusive as possible. It should not block the window totally since you will probably want to use the remote control directly. One possibility is mounting the LED in a flat piece of clear plastic, and taping or gluing the plastic to the side of the VCR. If the VCR is kept in a cabinet, the sides of the cabinet can make a good mounting surface for the LED.

Be sure to connect it the right way. The correct polarity can be determined by retracing the wiring back to the relayer box or by trial and error using a visible-light LED as an indicator and having someone press the buttons on the remote controller in the remote location.

Due to its short range, the remote relayer should be kept as close to one's favorite viewing position as possible. Its small size should make this easy to do. Leave the transformer mounted on the back of the TV set to keep the video signal path as short as possible. The extra distance should be made up by the wire from the relayer. If this wire is too long, it will get in the way. However, a long wire will allow the relayer box to be moved to different locations within the room to overcome the range limitation.

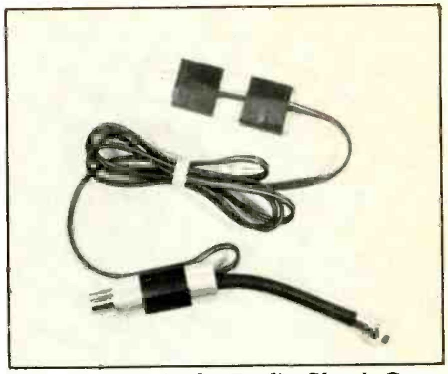


Fig. 3. Here is the Radio Shack Cat. No. 15-579 filter modified for use with the prototype.

If you have video signal splitters or a distribution amplifier connected to the output of your VCR, be sure to connect the infrared splitter after all that. The coaxial cable that runs between the high-pass filter at the VCR and the transformer at the TV end should have no interruptions.

Conclusion

More and more home electronic devices are being sold with infrared remote controls. This project can relay their control signals from room to room. The coax cable and the splitters aren't absolutely necessary, but in their place you will need a two-conductor wire to connect the relayer to the LED. Correct polarity is still essential.

If you have more than one remote TV set playing off the same VCR, more than one remote control relayer can be used with a single infrared LED. The signal splitters and relayer boxes will have to be duplicated at each TV, of course, but only one LED is needed at the VCR end. **ME**

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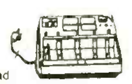

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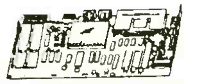

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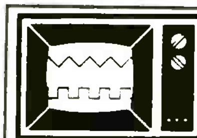

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7420	25
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7427	25
7429	25
7430	.25
7432	25
7437	25
7438	.25
7439	25
7440	30
7442	25
7445	.50
7447	75
7450	.60
7451	25
7454	30
7474	30
7475	.45
7476	45
7482	85
7483	50
7485	55
7486	40
7490	.45
7491	85
7492	45
7493	35
7495	45
7496	55
74107	35
74109	40
74116	1 00
74121	35
74123	40
74125	45
74126	40
74128	55
74145	45
74148	1 00
74151	50
74153	50
74156	70
74157	50
74161	60
74163	60
74164	80
74173	70
74174	.50
74175	50
74177	60
74180	70
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74LS10	20
74LS11	25
74LS12	25
74LS13	25
74LS14	35
74LS15	25
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74LS158	30
74LS160	25
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74LS163	45
74LS164	45
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74LS173	.45
74LS174	30
74LS191	.45
74LS192	60
74LS194	60
74LS195	.60
74LS221	.55
74LS240	65
74LS241	60
74LS242	60
74LS244	65
74LS245	70
74LS247	1.90
74LS251	40
74LS253	40
74LS257	.35
74LS258	40
74LS259	85
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74LS262	40
74LS266	40
74LS273	45
74LS290	75
74LS293	75
74LS295	75
74LS298	60
74LS299	1.35
74LS356	75
74LS365	35
74LS366	35
74LS367	40
74LS368	.35
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74LS374	75
74LS375	85
74LS377	70
74LS378	1.10
74LS393	70
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74SC139	35
74SC237	60
74SC239	60
74SC240	50
74SC241	50
74SC244	65
74SC245	50
74SC373	50
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74SC563	1 50
74SC564	60
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4006	60
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4012	25
4013	25
4015	30
4016	25
4019	30
4022	60
4023	20
4024	45
4025	20
4035	.60
4040	.60
4041	.70
4042	.50
4046	80
4047	65
4049	25
4050	25
4051	35
4052	60
4060	60
4066	.30
4068	60
4069	20
4070	25
4071	20
4072	20
4073	35
4076	50
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4081	20
4082	20
4085	35
4086	45
4093	45
4160	45
4163	45
4416	45
4428	45
4449	45
4497	.45
4502	.65
4511	70
4516	70
4517	75
4518	85
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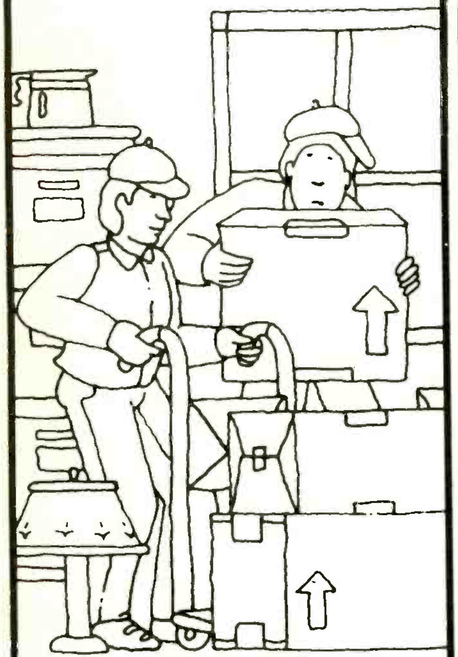

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(from page 82)

Products listed include analyzers, CAE/CAD equipment, generators, meters, recorders, oscilloscopes, signal amplifiers, microcomputers and general telecommunications test equipment. For a free copy, write to: United States Instrument Rentals, 2988 Campus Dr., San Mateo, CA 94403.

Computer Accessories Catalog. Catalog #10 from B&B Electronics introduces eight new computer accessories products. Included are newly designed four- and eight-channel RS-232-to-RS-422 converters, receive-only RS-422-to-RS-232 converter, 10-mile short-haul modems, serial-to-parallel converter and two-position parallel and serial scanning switches. In addition to these items, the catalog lists and describes a wide range of stock and custom-designed electronic devices. For a copy, write to: B&B Electronics Mfg. Co., 1500P Boyce Memorial Dr., P.O. Box 1040, Ottawa, IL 61350.

Computer-Based Interfaces Catalog. MetraByte's Winter 87/88 handbook includes listings for a complete line of data-acquisition, industrial control and monitoring, signal conditioning and communications products for IBM PC/XT/AT, PS/2, Apple II and VME bus computers. Listings in this catalog are included for IBM's PS/2 Models 50, 60, 80 and other Micro-Channel computers. Other products listed include: data-acquisition boards for process control, laboratory and analytical data-collection applications; a variety of serial, parallel and IEEE-488 communications interfaces; the MetraBus industrial I/O product family; several families of intelligent modules for local and remote sensor conditioning; and a wide range of software support products. The 208-page color catalog provides complete technical and pricing information and includes helpful application and product configuration guides. For a copy, write to: Terry Persun, MetraByte Corp., 440 Miles Standish Blvd., Taunton, MA 02780.

IEEE-488 Bus Products Catalog. This new literature from ICS Electronics lists and fully describes a broad line of IEEE-488 bus enhancement products. Included in the listings are interfaces, analyzers, extenders and controllers. For a copy of the catalog, write to: ICS Electronics Corp., 2185 Old Oakland Rd., San Jose, CA 95131.

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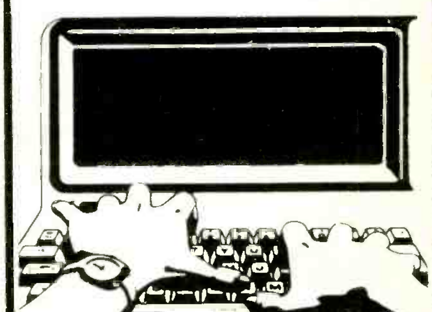

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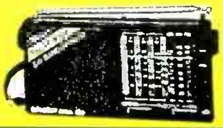

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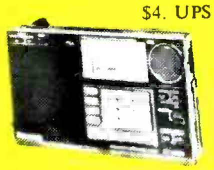

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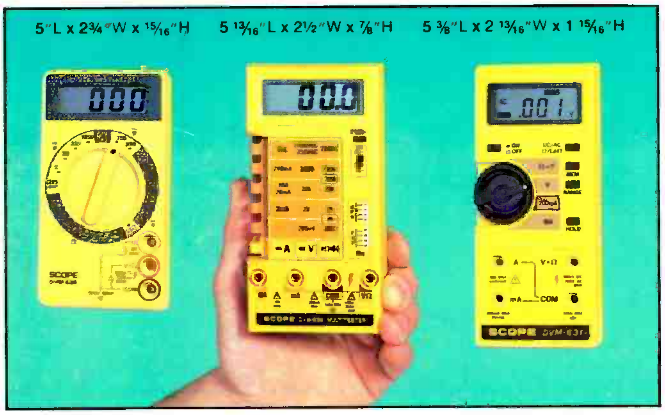

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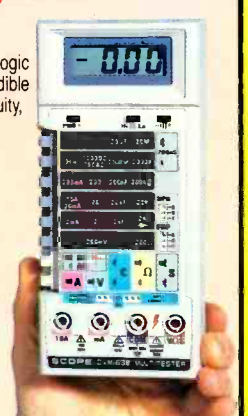

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