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MODERN ELECTRONICS

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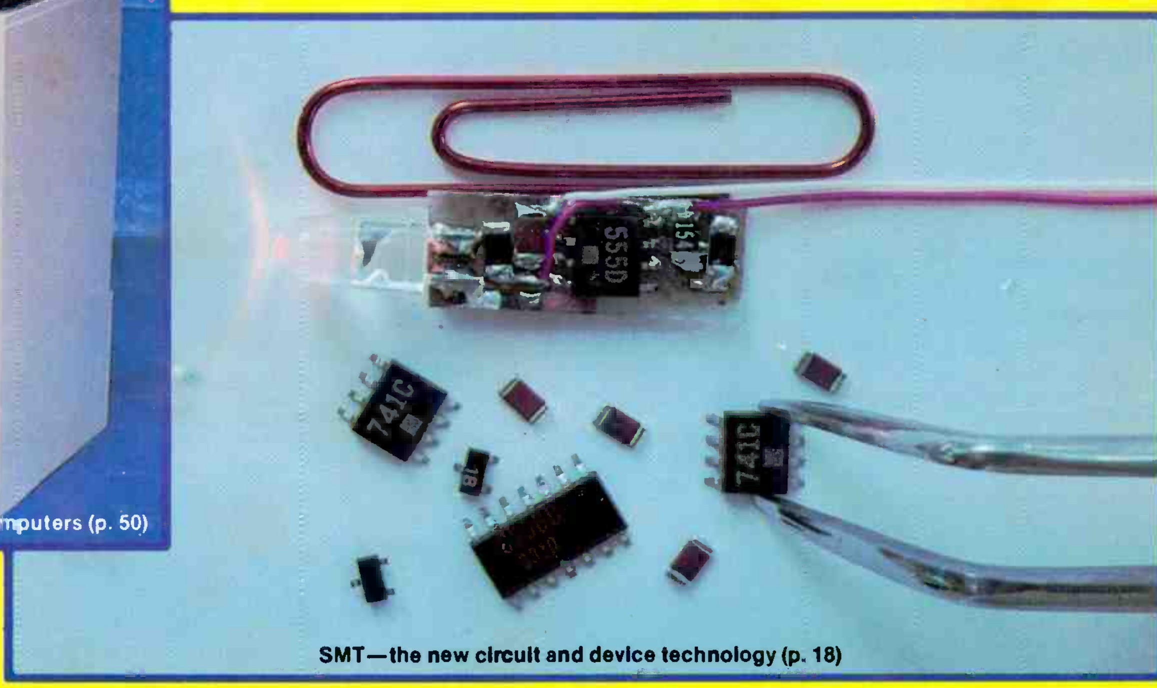
THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

- **SURFACE-MOUNT TECHNOLOGY—** ***The "New" Microminiature Way Of Building Circuits***
- **CLAP HANDS & TURN ON/OFF APPLIANCES**

Also:

- **Designing Ultra-Long Delay Timers**
- **A 4.5-MHz FM Receiving System**
- **Making Low-Cost Speaker Systems**
- **Laptop Computer Enhancements**
- **A $20 Drum Synthesizer**


Enhancements for laptop computers (p. 50)



SMT—the new circuit and device technology (p. 18)

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Plus: A review of Paradise's new AutoSwtich EGA system • Eric Grevstad's impressions of: Open Access II, the Big Kiss and No-Risk Trials • Don Lancaster's "Hardware Hacker" • The new Word Finder giant synonym finder • Electronic & Computer News . . . and more.

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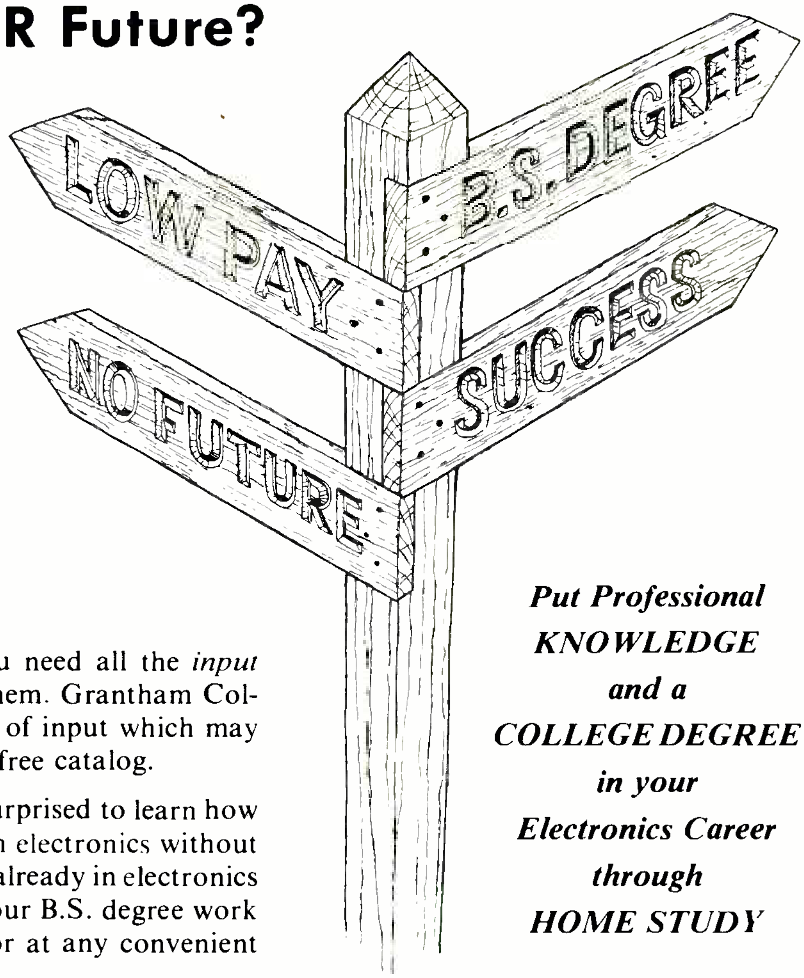
CIRCLE 32 ON FREE INFORMATION CARD

Which Way To YOUR Future?



Are you at a crossroads in your career? Have you really thought about it? Are you *planning* for your future, or perhaps refusing to face the subject? Which way will you go — down the same old road? Or are you ready for something else?

In electronics you can't stand still. If you are not moving ahead, then you're falling behind. At the crossroads of your career, various choices are available — and, yes, *decisions* have to be made.

Which road will you take — one that doesn't go where you want to be, or one that leads to hard work *but also* to the better life? Ah, decisions, decisions!

Career decisions are so important that you need all the *input* you can get before locking-in on one of them. Grantham College of Engineering offers you *one* source of input which may help you in making that decision. It's our free catalog.

Ask for our free catalog and you may be surprised to learn how it is easily possible to earn a B.S. degree in electronics without attending traditional classes. Since you are already in electronics (you are, aren't you?), you can complete your B.S. degree work with Grantham while studying at home or at any convenient place.

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But don't expect to earn that degree without hard work. Any degree that's worth your effort can't be had without giving effort to the task. And of course it is what you learn in the process, as much as the degree itself, that makes you stand out above the crowd — that places you in an enviable position, prestige-wise and financially.

Grantham offers this program, complete but without laboratory, to electronics technicians whose objectives are to upgrade their level of technical employment.

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All lessons and other study materials, as well as communications between the college and students, are in the English language. However, we have students in many foreign countries; about 80% of our students live in the United States of America.

Grantham College of Engineering
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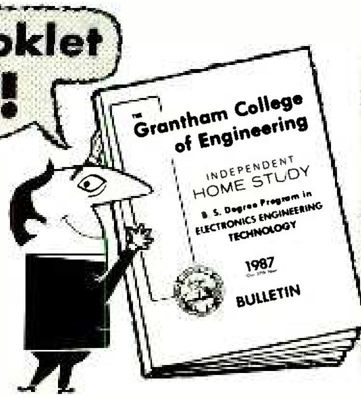
This booklet FREE!



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MODERN ELECTRONICS

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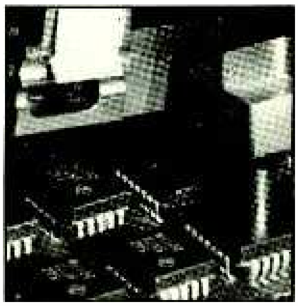
JANUARY 1987 **VOLUME 4, NUMBER 1**



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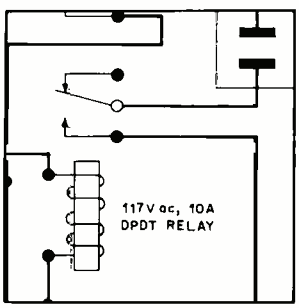

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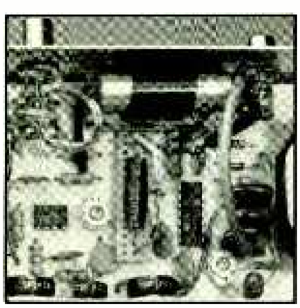

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EDITORIAL

When It Goes Bad

Repairing and maintaining electronic equipment and computers ranks high among the interests of *Modern Electronics* readers. We know this because 76.1% said so when we made an intensive readership study last year. This figure was corroborated by other responses. For example, 65.4% of respondents noted that they were professionally involved in electronics or a related industry, while 10.4% reported that they plan to make electronics a career. So the total here of serious readers—those who read *Modern Electronics* for both professional and avocational reasons—virtually matches the number who expressed a strong interest in electronic servicing.

From the foregoing, I assume that if one's own equipment—a TV receiver, personal computer, videocassette recorder—breaks down, this group will attack repairing of it themselves. If your experiences in this area are similar to mine, and why shouldn't they be, many of your personal-equipment problems fall into a "tough-dog" category that defies and stymies all your efforts.

This might be an intermittent problem that only occurs once a week or so at a very late hour. The next day, when you're bushy-tailed and ready to rip the equipment apart, it works just fine . . . for hours at a time. Or it might be a breakdown that defies the standard troubleshooting procedures that should illuminate the problem with dispatch.

I'll share one of my recent repair challenges with you to show you what I mean. My desktop computer, which goes through a self-check before the user can reach a screen prompt, startled me with a beep sound and a screen display that indicated there's an error, along with a numeric code number.

Well, servicing microcomputers is akin to servicing a home entertainment system. Actually, it should be easier I feel, though I have much more experience with the latter repairs. Like an audio/video system, a personal computer can be broken down into sections for repair purposes. Pinpointing the section, you then start isolating the problem until you discover a defective part that's causing the problem. Therefore, if you have a computer memory problem, you'll examine RAM boards and devices, not your printer, disk drive, I/O section, or whatever.

In this instance, I was working with an IBM PC that was converted to a hard-disk machine. Therefore, I pulled out my IBM hardware diagnostic disk and manual and looked up the code number that appeared on the screen. The "201" indicated a memory problem, but "1055" that preceded it wasn't listed! After some research, however, I did find the error code listed in an IBM operating manual. It meant that my internal switch settings were incorrect. But since the machine was operating fine for about a half-year since I made my last switch-setting changes (upping memory to 640K), this was impossible.

My next step was to run through the diagnostic disk's routines. It indicated on screen that the problem was in memory, threw up the same code number that wasn't listed in the accompanying service manual, and further displayed a new alphanumeric code (10BE) that pinpointed the memory location of the defective module. Fantastic? I thought so until I discovered that this code, too, was not listed in the IBM Hardware manual. Nor anywhere else!

Calling IBM itself resulted in them directing me to the dealer from whom I purchased the machine. Unfortunately, the dealer isn't around anymore. So it was suggested that I contact any other IBM dealer and tell 'em my story. Contacting some IBM dealers, however, didn't reveal what the codes meant either. But I did manage to get the dealer IBM technical assistance hotline phone number, which I quickly called. *They* didn't know what the codes meant, either, and redirected me to their dealers.

Tired of this round robin, I proceeded on my own, learning from the diagnostic disk that the computer's motherboard (64K) was fine. That left 576K of memory in add-on boards to check out.

I changed the board switch settings to set the machine for various memory banks, hoping that I'd see some change from one to another. The 128K switch setting brought up a new error code, Parity Check 2. Buying a single 64K-bit chip from a local Radio Shack store, I substituted it for the present chips in the parity locations. No changes. Then I checked out connections again, especially the wire strappings for IDCs (insulation-displacement connector). These are the pin openings with a slit that cuts into the wire's insulation. Connection points on an ohmmeter checked out fine again.

I knew that the problem was on this single board, so I wrote a little note in preparation for shipping it back to its maker for repair. Before wrapping it up in a package, I decided to check the connector points one last time. The very first check I made, the 128K connection points, did *not* show any continuity. I couldn't believe it! Pulling out the wires with long-nose pliers, and using an Xacto knife to scrape out residual insulation, I checked the one-inch-long piece. Again it did not have continuity. Replacing it with a new length in the IDCs (each end shoved into the appropriate hollow pin hole), double-checking it for continuity, which was there, I replaced the board in its computer slot, started it up, and bingo!—there was my display prompt. Fixed and ready to go.

Looking back, it was a simple intermittent wire break that didn't reveal itself by looking at the insulation or by resistance measurements. If there are any blessings, it was in the sockets that the RAM mounted in, which obviated any soldering work, and in a screen display that gives some indication of where the problem lies. If there are any curses, it's for a manual that does not cover all the error codes that its accompanying diagnostic disk spews out and the difficulty in getting service information from a manufacturer or dealer. Additionally, it was interesting to observe that the IBM manual requires fighting through the written matter to overcome unclear presentations. A similar manual by Zenith is a joy to behold, probably thanks to a Heath hand in it.

I'd be interested to know about your electronic servicing experiences, which can be shared with other *Modern Electronics* readers. Thanks.

Art Salsberg

MODERN ELECTRONICS NEWS

CONSUMER PROTECTION PROPOSALS. A California bill that requires consumer electronics manufacturers to retain functional replacement parts for seven years passed State Assembly and cleared a Senate committee. This is for merchandise that has a wholesale value of more than $100, with goods in the $50 to $100 range proposed to have only a three-year parts retention requirement. The full Senate must pass the bill, AB 3835, in order for it to be a go....Legislation is being considered in California, Connecticut, Florida, Iowa, New Jersey, New York City and San Francisco requiring retailers to label gray-market merchandise.

COMPUTER-AIDED-DESIGN VIDEO. A new videotape, "CAD to Reality," is available from CalComp in VHS or Beta format for $5. The eight-minute recording outlines CAD applications in engineering, architecture and facilities management. Write CalComp Videotape, P.O. Box 3250, M/S 60, Anaheim, CA 92803.

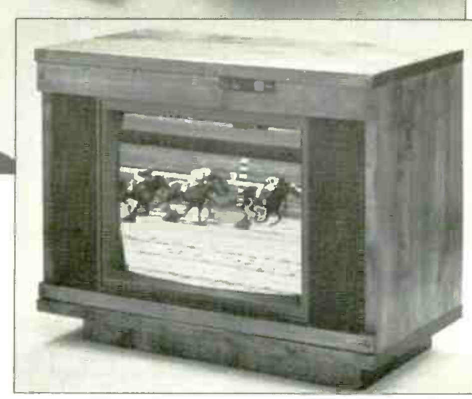
AUDIO SPEAKER DEVELOPMENTS. Matsushita Electric, parent of Panasonic, Technics and Quasar, has developed an ultra flat panel speaker for wall mounting. It's only abut 2 1/3" deep and features twin-cabinet construction to house two woofers and a mid-low speaker separately. Overall dimensions of the system are: 3½ ft. sq., plus the aforementioned depth of not much more than 2 inches. Impedance is 8 ohms, while power handling capacity is 350 watts (music power)....Speaker design is becoming less of an art today and more of a science. Techron (Elkhart, IN), for example, recently introduced its V-Box-Res software program to make designing and comparing low-frequency speaker systems more accurate, as well as faster and easier. The program also provides information on required enclosure parameters to attain performance goals. From collected data, its Polar program generates a polar display for up to 400 different frequencies and Output Sound Pressure Level (dB SPL) can be plotted at various angles on and off axis and measured at a single frequency or band of frequencies.

APPLE SWELLS EARNINGS. Apple Computer reports it doubled earnings and net income in fiscal 1986 (ending September 26). Though sales dollars were essentially the same ($1.9-billion+), net income rose 151 percent to $154 million.

MACHINE VISION. Use of machine vision in the electronics industry will outpace auto makers by 1990, according to a University of Michigan study. The market for automated vision overall is projected to grow from $58-million to $457-million over a five-year forecast period. Almost half of the specific machine-vision applications for electronics will be in inspection-related tasks. Color will be especially important....The one-millionth patent since the U.S. Commerce Department began using an automated patent printing system in 1970 was issued to Object Recognition Systems for a machine vision system developed by Joseph Wilder of PA Technology and Rajarshi Ray of AT&T. It's called "Robotic Acquisition of Objects by Means Including Histogram Techniques." In other words, it can see and choose specified parts from a jumbled heap in a bin or align thick-film ICs while cutting the task from 20 minutes to less than a second.

NEW

Only NRI gives you a 27" high-resolution stereo color TV you build to prepare you for today's video servicing careers.



Become one of America's most sought-after technicians . . . put your talents and spare time to work for you in the "explosive-growth" world of home entertainment electronics.

Train in state-of-the-art video/audio servicing and become a fully qualified service professional the uniquely successful NRI way. It's hands-on training, at home . . . designed around the latest electronic equipment you build and keep as part of your training. You start from scratch and "discover by doing." You conduct key experiments . . . perform vital tests . . . build your own systems . . . and do it all at the pace that suits you best.

There's no stopping the incredible boom in consumer electronics. Soaring sales, new and improved video products, entirely new technologies have opened up new opportunities for the trained technician as never before.

Now at $26 billion in annual sales, the consumer electronics industry is creating a whole new servicing, installation, and repair market. This year, TV sales alone are expected to hit 16.2 *million* units. Every day, sales of home VCRs, a product barely conceived of 10 years ago, reach 20,000 units. Every day!

And the revolution has spread to the business sector as tens of thousands of companies are purchasing expensive high-tech video equipment used for employee training, data storage, even video conferencing.

The Video Revolution Is Just Starting

Already, disc players can handle audio CDs and laser video discs. And now there are machines that will accommodate laser computer disks as well. Camcorders are becoming smaller, lighter, and more versatile . . . 8 mm video equipment produces high-resolution pictures and digital audio. By 1990 our TVs will become interactive computer terminals, giving us entertainment, information, and communications in one sophisticated video/computer/audio system.

Join the Future or Be Left Behind

Can you see the opportunity? The servicing and repair market that's there already . . . and the enormous future need created by the millions upon millions of electronic devices yet to come? If you're looking for a high-potential career . . . if you'd like to get started in a field that's still wide open for the independent businessperson . . . even if you'd like to find a way to make extra money part-time, look into NRI at-home training now.

Start Right and There'll Be No Stopping You!

NRI training in video/audio servicing is the perfect way for you to profit from the new explosive growth in consumer electronics. You study at home in your spare time at your own pace. No classroom pressures, no night school grind.

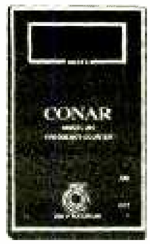
Even if you've never had electronics training, NRI prepares you properly with a thorough grounding in the fundamentals . . . a foundation that you build on to achieve advanced electronics skills. With this kind of understanding and practical bench experience built into NRI's exclusive training methods, you're on your way to take advantage of the new opportunities opening up every day.

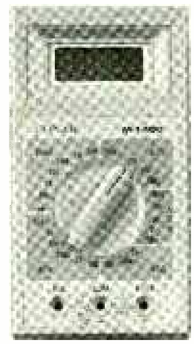
Totally Integrated Hands-On Training

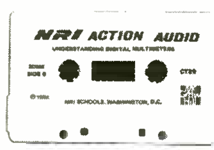
Since NRI training is built around "learn by doing," right from the start you conduct important experiments and tests with your professional digital multimeter. You assemble the remarkable NRI Discovery Lab and perform a complete range of demonstrations and experiments in the process.

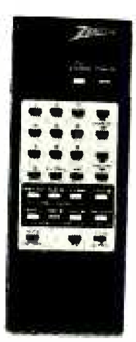
Hands-On Training As You Build a 27" Stereo TV

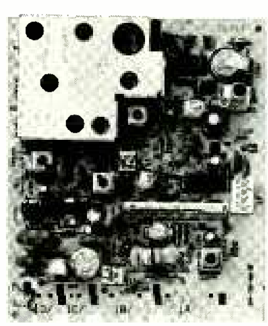
In just hours you assemble an exceptional state-of-the-art TV receiver using easy to follow, step-by-step instructions. During this assembly process, you learn to identify and work with components and circuits used in actual commercial circuitry. Then through tests, adjustments, and experiments you quickly master professional troubleshooting and bench techniques.











NRI's commitment to you goes beyond providing you with equipment appropriate to the latest technology. Of equal importance is our dedication to training techniques that let you master TV, video and audio troubleshooting and repair quickly and easily. Best of all, we ensure that in the learning process you acquire the very skills that will make you a professional service technician on the job.

NRI has purposely designed your training around equipment that has the same high-tech circuitry you'll encounter in commercial equipment. That means your training is real-world training. And *that's* unique.

Inside Your TV

This new state-of-the-art Heath/Zenith 27" TV included with your training has all the features that allow you to set up *today* your complete home video center of the future. Flat screen, square corners, and a black matrix to produce dark, rich colors. Cable-compatible tuning, built-in stereo decoder to give you superb reproduction of stereo TV broadcasts . . . even a powerful remote control center that gives you total command of video and audio operating modes.

Your NRI Training Has Another Special Element

Also built into your training is the enormous experience of NRI development specialists and instructors. Their long-proven training skills and enthusiasm come to you on a one-to-one basis. Available for consultation and help whenever you need it, your instructors ensure your success both during your course and after graduation.

Step Into the Future Today

The richest reward you gain from your NRI video/audio training is a firm grip on the future. Your knowledge and know-how provide you with the soundest possible foundation for keeping up with the rapidly evolving, highly innovative video industry.

Send For Free Catalog

Now is the time to act. Send the postpaid card to us today. You'll receive our 100-page catalog free. It's filled with all the facts you'll want to know about our training methods with full details on the equipment you'll use and keep as part of your hands-on training. You'll see how our more than 70 years of experience in uniquely successful at-home career training makes us the leading technical school today. (If someone has already used the card, write to us at the address below.)

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Washington, DC 20016

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.

Deluxe Car Stereo

Kenwood's Model KRC-999 car audio system offers 44 separate computerized functions controlled by an outboard 16-bit microprocessor module. Access to the preamp, tuner and tape functions programmed into memory are via buttons on a motorized control shelf. Two preset volume levels, a manual volume control and a −20-dB mute button are available.

A seven-band graphic equalizer provides a ±12-dB range at 60, 120, 150, 500, 1k, 3.5k and 10k Hz. Four factory preset equalization curves, three user-programmable curves and manual operation are offered. A peak-hold spectrum analyzer displays relative frequency levels.

The three-motor, auto-reverse cassette deck has a rated 20-to-22,500-Hz frequency response with metal tape. S/N is 62 dB with no noise reduction and 71 dB with Dolby B, 76 dB with Dolby C and 86 dB with dbx NR. Wow and flutter are 0.06% wrms. A multifunction indicator dis plays the operating modes, and a LED display indicates the amount of tape remaining.

The PLL synthesized AM/FM tuner section has 15 FM and five AM presets. A preset scan feature allows the user to sample the preset stations for 5 seconds. $1,300.

CIRCLE 8 ON FREE INFORMATION CARD

Personal Computer Scope/Analyzer Board

A moderately priced digital oscilloscope/spectrum analyzer peripheral plug-in for selected personal computers has been announced by Rapid Systems of Seattle, WA. Models are available for IBM, Apple and Commodore computers.

The digital scope has four diode-protected input channels and features: 100-Hz to 2-MHz sampling rate (14 steps); gain adjustable from 100 mV to 20 V/div. (8 steps); 500-Hz analog bandwidth; 2K data buffer; and separate adjustable trigger input. Software features include: menu-driven operation; a help file; color graphics; keyboard control of trigger, gain and timebase; assembly routines to speed data collection and display; zoom mode to view entire data buffer; active scrolling; grid display; store/retrieve functions; post trigger delay; multi-channel display; print screen; and user-definable interface routines.

The spectrum analyzer features: FFT sizes from 16 to 1024; 2-s (16-point) to less than 10-s (1024-point) execution time; 100-Hz to 500-kHz sample frequency; 1.6-to-320-V p-p inout range; rectangular or Hanning windows; baseband or vernier operation; power spectrum computation and averaging; better than 1-Hz resolution; disk save/recover spectrums; hardware/software/keyboard triggering; and transfer of digital scope

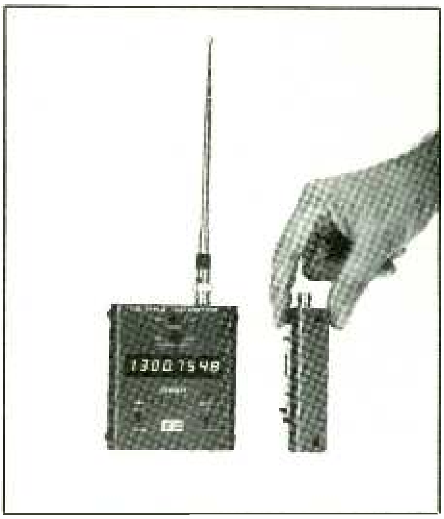
time series data to spectrum analyzer for frequency analysis.

$798 for Apple and IBM computers; $649 for Commodore computers.

CIRCLE 9 ON FREE INFORMATION CARD

1.3-GHz Frequency Counter

Though it is small enough to fit into a shirt pocket, OPTOelectronics' (Ft. Lauderdale, FL) Model 1300H frequency counter is not short on bandwidth. The 4″H × 3.5″W × 1″D counter has a specified bandwidth of



from 1 MHz to beyond 1.3 GHz. Measured frequencies appear in an eight-digit red 0.28″-high LED display. Input to the instrument is via a BNC connector.

Switches are provided for ac/battery operation, fast/slow gate time, high/normal sensitivity and 1-to-

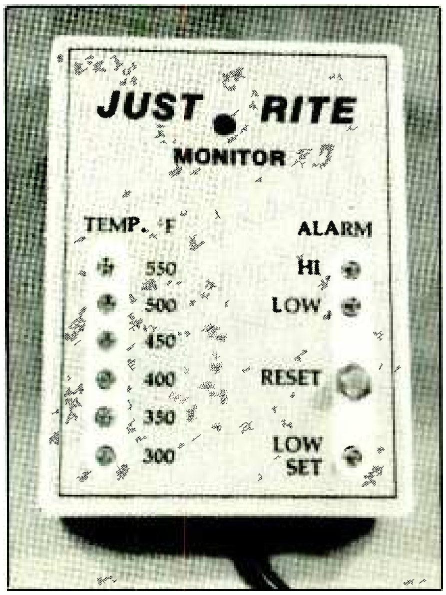
500-MHz and 500-to-1,300-MHz range selection. Additional features include a measurement-in-progress indicator and calibration adjustments that can be made without having to open the case.

Rated resolution is to 1 kHz in 0.25 second or to 100 Hz in 2.5 seconds over the entire range of frequencies. Accuracy is rated at ±0.0001% ±1 count LSD, achieved with an RTXO timebase. Supplied with the counter are internally installed rechargeable nickel-cadmium cells and an adapter for ac operation and battery charging. Optional accessories include a carrying case, probe and telescoping antenna. $150.

CIRCLE 10 ON FREE INFORMATION CARD

Wood-Stove Monitor

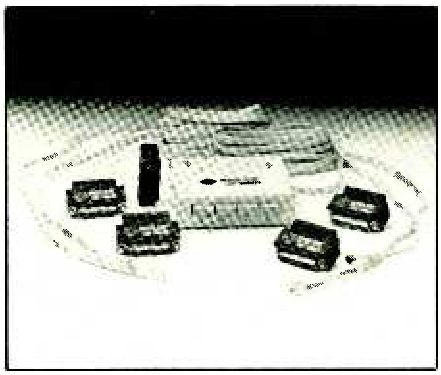
A new electronic device called the "Just Rite Monitor" from Inventex Inc. (Lehigh Valley, PA) gives the flue temperature of wood stoves so that conditions can be adjusted to maintain an even, comfortable temperature. Discrete light-emitting diodes display temperature over a 300° F to 550° F in 50° increments. Other LEDs provide visual indication when flue temperature rises above or falls below safe limits. A built-in alarm provides an audible alert when flue temperature gets hot enough to cause a chimney fire or it gets cool enough for the fire to go out. The Monitor can also drive a digital telephone dialer that can contact a central alarm station to send help in the event the alarm goes off when no one is at home. $79.95 plus $2.95 P&H.



CIRCLE 11 ON FREE INFORMATION CARD

RS-232 Interconnect Problem Solver

Eazy™ Connect from Black Box is designed to solve interconnect problems for users of equipment with RS-232 serial interfaces. It offers an easy-to-use cabling system for all types of connectors, including those used on IBM PC and compatible and Apple Macintosh computers to convert the various types of serial connectors now being used into a simple modular system. The adapters terminate with standard modular jacks



and are connected by telephone-type RJ-12 cable. This enables quick connect and disconnect of equipment and elminates the need to run large, unsightly cables between equipment.

Eazy Connect is a family of adapters. Each is designed to attach to the most popular computers, printers, modems and other peripherals to which they permanently attach. An Eazy Connect Switch then allows data routing between up to four computers and one peripheral or between four peripherals and one computer to which the Adapters are connected. Additionally, the system can be cascaded to provide a low-cost network capability.

CIRCLE 12 ON FREE INFORMATION CARD

VCR Adjustment Wrenches

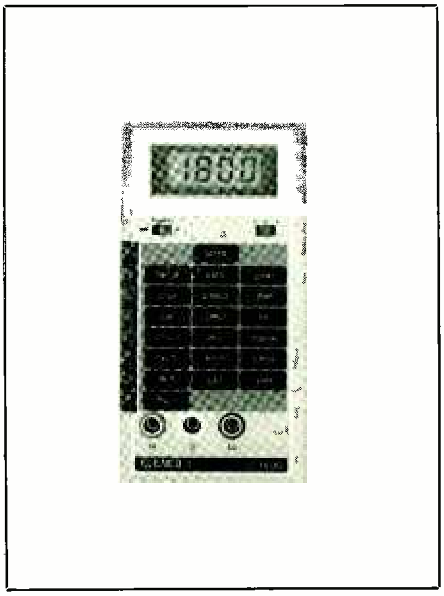
New from Philips ECG is a set of eight special-purchase wrenches that are designed to meet the adjustment

requirements of videocassette recorders. The wrenches are made to match the configuration of the recesses for adjusting tape feed, tape tension and various other functions in VCRs. They are available for both Beta and VHS machines.

CIRCLE 13 ON FREE INFORMATION CARD

Digital LCR Meter

A handheld digital instrument that measures the values of coils, chokes, transformers, capacitors and resis-



tors has been introduced by Elenco Electronics. The Model LC-1800 has an inductance range of 0.1 μH to 200 H, capacitance range of 0.1 pF to 200 μF and resistance range of 0.1 ohm to 20 megohms. Basic measurement accuracy is ±1% of reading, while resolution is 0.1 μH, 0.1 pF and 0.1 ohm.

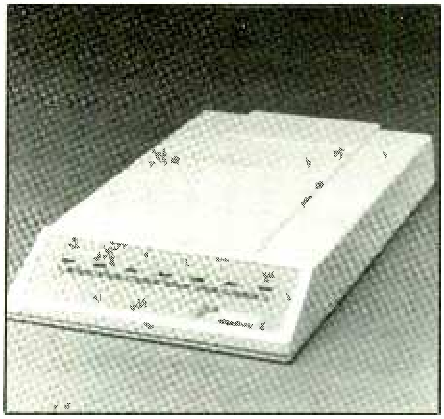
Convenient switches along the left side of the meter's case access seven each inductance and capacitance ranges and six resistance ranges. A separate slide switch located under the display is used for selecting the L, C and R functions. All measurement values are displayed on a liquid-crystal display. A 9-volt battery powers the instrument for up to 200 hours. The meter measures 6.8"H × 3.5"W × 1.4"D. $199.

CIRCLE 14 ON FREE INFORMATION CARD

Stand-Alone Modem

New from Practical Peripherals (Westlake Village, CA) is the Model 1200 SA fully Hayes-compatible stand-alone modem. This 300/1200-baud modem features auto-dial/auto-answer capabilities, supports all communications software and includes an upgrade path for a programmable enhancement card. Automatic adaptive equalization is built in for consistent and error-free operation over the telephone line. Other features include semipermanent storage of up to 10 telephone numbers, menu-driven configuration (no switches to be set), pulse or tone dialing, volume-controlled speaker, and two modular jacks to accommodate voice and data calls.

Operating modes include auto-



matic answer and originate selection, computer-controlled dialing and answering, autodial-from-memory and automatic speed mode detection. Indicators come on for Modem Ready, Receive Data, Hi-Speed 1200 Baud, Phone Off-Hook, Transmit Data, Carrier Detect and Auto-Answer. Included with the modem are a plug-in power supply, data interface cable, user manual and CMB Priority Response Card. The modem measures 10.5"D × 5.5"W × 1.3"H and is designed to fit under a desk-type telephone. $239.

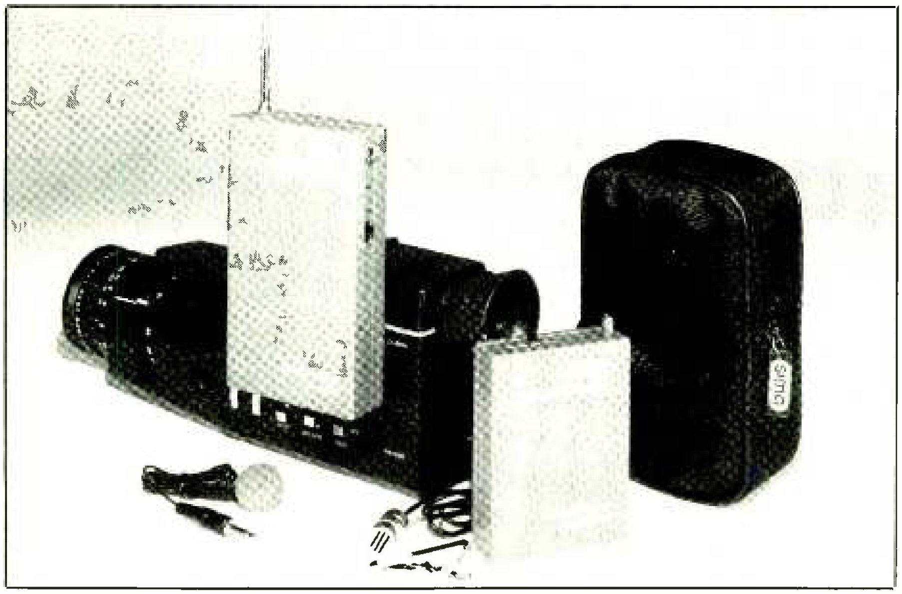
CIRCLE 16 ON FREE INFORMATION CARD

Wireless VCR Microphone

"SoundCatcher" is a remote microphone from SIMA Products Corp. (Chicago, IL) that allows the home video photographer to record sounds from subjects up to 200 ft. distant. It can be hand-held or clipped to a belt as desired. The receiver is compatible with any video camera. A Velcro attachment gives the user a choice of where to place the receiver on the camera.

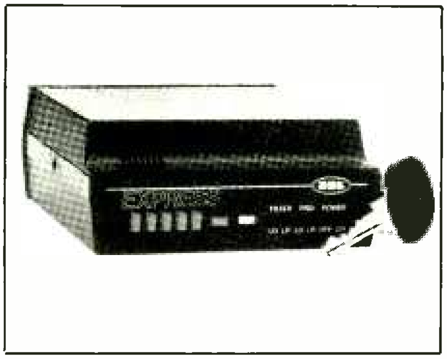
Plugging into the camera's input, the receiver also has an earphone that allows the user to audit the sound while shooting a scene. A dual LED panel signals when the unit is operating and sound is being received. Supplied with the SoundCatcher is a soft carrying case. $134.95.

CIRCLE 15 ON FREE INFORMATION CARD



X/K-Band Radar Detector

The Micro Eye Express from B.E.L.-Tronics Ltd. (Mississauga, Ont., Canada) is claimed to be the world's most sensitive automotive radar detector. It is said to be about 20 percent more sensitive than the company's previous XPR Long Range model detector. The new model uses a two-stage amplifier that examines a single sideband to reduce noise and increase sensitivity.

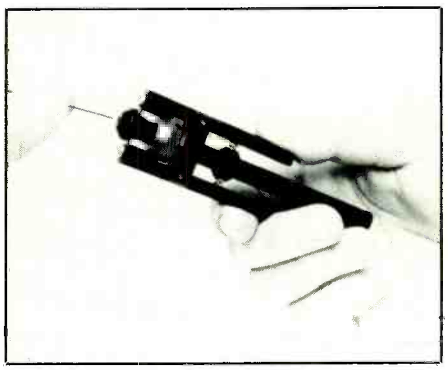


Micro Eye Express is designed to mount either on the dashboard (in an adjustable bracket) or on a visor. It comes with dash bracket, visor clip, Velcro strip and cigarette-lighter plug. $299.95.

CIRCLE 17 ON FREE INFORMATION CARD

Optical Fiber Stripping Tool

"Opti-Strip" from Davle Tech (Fairlawn, NJ) is a unique stripping tool designed specifically for removing the secondary coating from optical fibers. It handles both loose- and tight-fit fiber-optics cables of any length. Damage to the optic core during stripping is prevented with supplied front and rear guide bushings that exactly locate the cable in relation to the stripping blades and eliminate "sagging" during stripping.



Depth of cut is infinitely variable between 0 and 0.118″ (0 to 3 mm). The tool is light in weight and easy to use. It comes with its own storage case, a set of different-size guide bushings and full instructions.

CIRCLE 18 ON FREE INFORMATION CARD

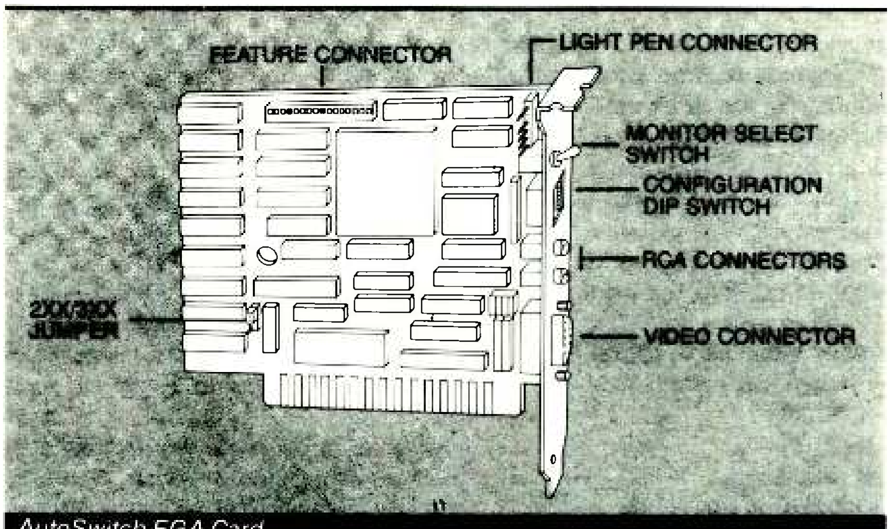
Circuit Design Program

CompDes from Esoft Software (Columbus, OH) is a low-cost electronic circuit design program that runs in IBM PC and compatible computers. Designed for students, technicians and engineers, this menu-driven software tool has menu selections that start with Basic Electricity and work up to Circuit Designs. The soft-

(Continued on page 85)

The Paradise AutoSwitch EGA: A video card that automatically changes displays to suit the software

A new EGA video card from Paradise Systems, Inc. is half the size of the IBM version, yet gives you more functionality at a lower price. The Paradise Auto-Switch EGA *automatically* senses the display needs of application software and changes to the correct operational mode (EGA, CGA, Hercules, etc.). Additionally, the card contains 256K of video RAM. The AutoSwitch EGA card is for the IBM PC, XT, AT and 100% compatibles and sells for a suggested retail price of $599.



AutoSwitch EGA Card

Overview

The Paradise AutoSwitch EGA board is about 5.5″ long and 4″ high, which means it can fit into a short expansion slot such as the one found on the IBM PC XT. Despite its size, it packs all the features of IBM's EGA board, foremost of which is the ability to drive a high-resolution EGA monitor and display 640 × 350 high-resolution graphics in 16 colors.

At the top center of the board is a 1.25″ square custom VLSI chip, which makes it possible to have a low chip count, low power consumption, and small board size. This chip not only is designed for EGA compatibility, but because it contains the equivalent of a Motorola 6845 CRT controller, it is also designed for IBM CGA and Hercules compatibility. Along the left-hand side are eight 4 × 64K video RAMs, which provide the card with 256K of display memory. Compare this to IBM's card, which has just 64K of video RAM on board and needs a piggyback board to expand to 256K.

At the rear of the board are several switches and connectors. The main switch is a 5-position DIP switch. Four of them are used to set the system configuration, just as with the IBM version, and the fifth is used to set the autoswitch feature on or off. A second switch is a toggle switch, which lets you select the type of monitor in use.

A monitor connects to the board via a DB-9 connector. Two RCA jacks on the board are not currently supported by the hardware. On theboard itself, there are a 6-pin connector for a light pen and a 32-pin connector that provides all monitor signals (six color bits, horizontal and vertical syncs, and blanking) and related adapter signals.

The AutoSwitch can coexist with either a monochrome display adapter or a color graphics display adapter and can be used as either the primary or secondary display. When used with another adapter, however, the autoswitch feature cannot be used.

The board can work with three different types of monitors: enhanced color, RGB color, and monochrome. And the card has downward compatibility with the IBM color graphics adapter and monochrome display adapter, the Hercules monochrome graphics card and Plantronics ColorPlus card.

Installing AutoSwitch

Installing the AutoSwitch is just like installing any other expansion board for the IBM PC series of computers. On the PC and XT, system-board switches must be set, and on the AT, a Setup program must be run.

Depending on the type of monitor you have, you must set the switches at the back of the AutoSwitch board. If you are using an EGA monitor, the toggle switch is set to the right, and positions 1 through 4 of the DIP switch are set on-off-off-on. These switches can be set from the rear of the computer without removing the cover. For a monochrome or standard RGB monitor, the toggle switch is set to the left, and the DIP switch is set to off-off-on-off and off-off-off-on, respectively. For an enhanced RGB monitor, the DIP switch would be set to off-on-on-off. Whatever monitor is used, one can select whether or not automatic mode switching is used by setting position 5 of the switch to on for "yes" or off for "no."

Using AutoSwitch

We tested the capabilities of the Auto-Switch with Lotus 1-2-3 Version 1A, inserting the board into an IBM-compatible AT and connecting it to a Princeton Graphics EGA monitor. The toggle switch on the board was set to the right and the DIP switch was set for the EGA mode. Normally, the 1-2-3 spreadsheet will work in the high-resolution mode, but will not display graphics. (EGA drivers are now available for V. 1A, but we did not use them.)

When we tried to display a graph, the AutoSwitch sensed it and immediately changed to RGB mode rather than blanking out, which the IBM version did. One minor adjustment had to be made in the vertical hold, however. Once this was done, we switched back and forth from the spreadsheet to graphics without any problems.

Our next test was done with a monochrome monitor. Since we changed monitor, we had to flip the toggle switch to the left and reset the DIP switch for monochrome. Normally, with IBM's monochrome card, 1-2-3 graphics cannot be displayed. We used the Lotus Utility disk to enable the monochrome drivers for 1-2-3. We could not display graphics, naturally, since the AutoSwitch was emulating the IBM monochrome card. We then used the Utilities disk to switch to install the Hercules drivers on the 1-2-3 program. Now we could display graphics, since the AutoSwitch sensed the new drivers and automatically changed to Hercules emulation.

We further tested the AutoSwitch by trying to run a game program called "Digger" that would not run under the IBM EGA. The program came up in CGA mode and ran perfectly.

AutoSwitch Software Utilities

A utilities disk is included with the AutoSwitch hardware. One program on the disk checks the BIOS ROMs in an IBM PC. If you have a PC manufactured in 1981 or 1982, you must upgrade the ROMs—the older ROMs do not support EGA. The other program lets you take control of AutoSwitch through software. This program overrides the default setting of the switch that controls the autoswitch feature. It also allows you to boot game disks with exotic copy-protection schemes.

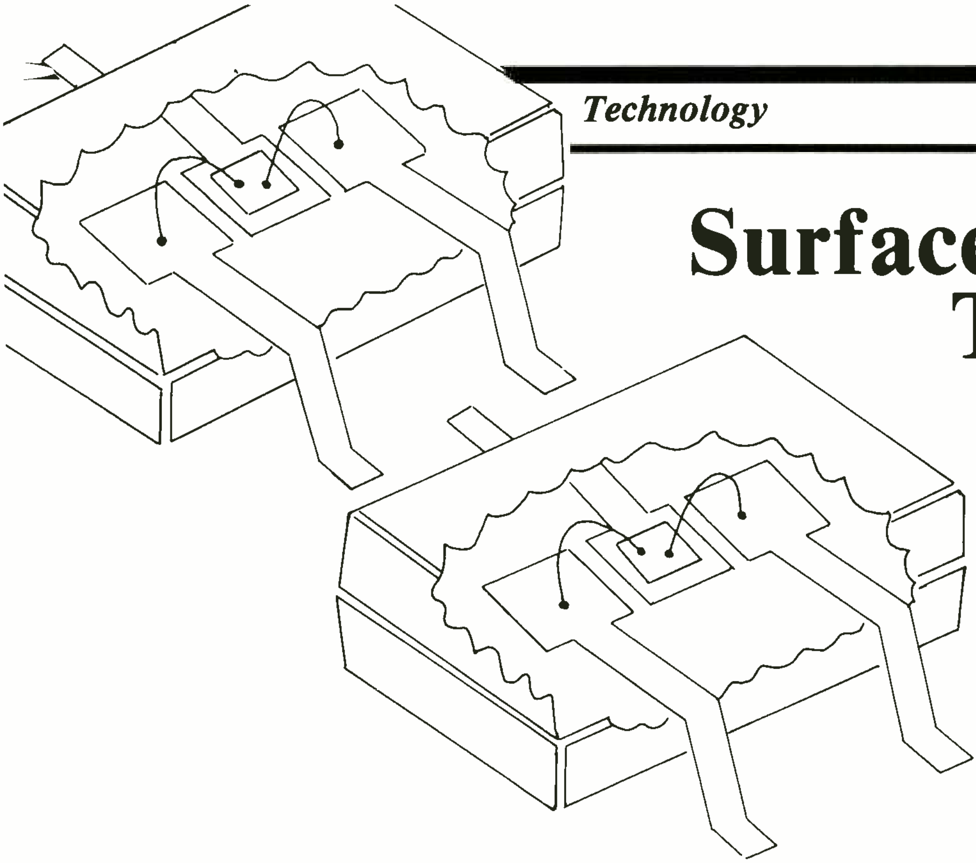
Comments & Conclusions

IBM's EGA card, which lets you display 640 × 350-pixel graphics in 16 colors, is certainly an attractive, though expensive, option for IBM PC, XT, AT and compatible computers. The Paradise AutoSwitch EGA card that we reviewed, however, gave us a display of equal quality at a substantially reduced price. Moreover, it added features not found on the IBM card that allowed us to run Lotus 1-2-3 and game programs without a problem. One could argue, however, that EGA drivers are now available for 1-2-3 V. 1A, and that games aren't important on a business computer. One might also argue that compatibility problems may exist between the two cards for certain applications. Although we did not experience these problems, we did not do extensive compatibility testing and cannot guarantee that they do not exist at all.

Since it is an EGA-compatible card, the AutoSwitch should also be viewed in relation to other compatible cards. In most cases, the AutoSwitch outperforms these products just as it does the IBM version. In addition, its low power consumption and size, which make it ideal for either the IBM PC or XT, could also make it a better choice than some of the other compatibles, though priced higher than some of them.

To conclude, the Paradise AutoSwitch card offers some unique features in addition to EGA compatibility, namely automatic switching. If your application has a need for these kinds of features, then the AutoSwitch is an excellent choice. However, if you are interested *only* in viewing an EGA display, have software that supports EGA (e.g. Lotus 1-2-3 V. 2.0), and are shopping for price, there are some less-expensive cards on the market. And, of course, if your application demands absolute IBM compatibility in every conceivable instance (which may be the case with Paradise's AutoSwitch, but, obviously we did not check out every piece of software extant) you may have to go with the original board. Chances are that you'll choose to bypass the original, though. *—Joseph Desposito*

At A Glance
Product: AutoSwitch EGA Card
Address: Paradise Systems, Inc.
217 East Grand Avenue
So. San Francisco, CA 94080
Phone: (800) 527-7977 (Ext. 370)
Requirements: IBM PC, XT, AT or 100% compatibles
Price: $599.



Surface-Mount Technology

This new electronics construction wave will change the way we all build circuits

By Forest M. Mims III

The development of ultraminiature hearing aids, pocket cassette recorders, slimline calculators, laptop computers tiny radar detectors, and many other highly miniaturized electronic devices has been made possible by the rapidly maturing field of surface-mount technology (SMT). This technology is now available to electronics experimenters, and it gives us the capability to hand-assemble in our own workshops or labs ultraminiature circuits that rival in size expensive hybrid microcircuits.

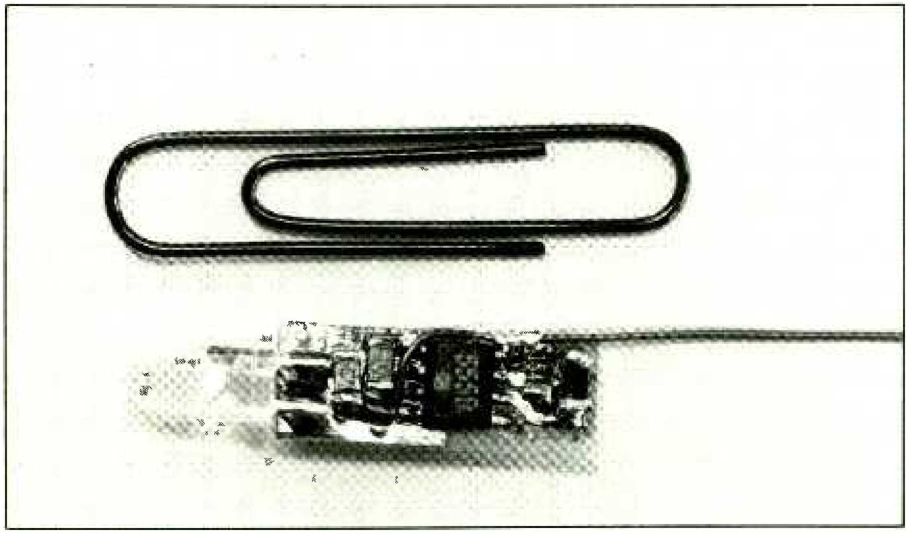
For electronics experimenters, this may be one of the most important developments in recent years. For electronic engineers and lab technicians, SMD construction represents the new manufacturing wave that can be simulated with prototype models. And electronic service technicians will face more and more equipment built with SMDs, presenting them with new challenges.

Let's face it, the plethora of microminiature consumer products that has flooded the market has surpassed our do-it-yourself, handmade abilities. Thanks to the availability of surface-mount technology, experimenters can again design and assemble circuits as advanced and as compact as those manufactured by anyone. That's why I consider this article and the one that will follow to be among the most important I have ever written.

The tiny LED pulse transmitter circuit in Fig. 1 illustrates why I am so enthusiastic about surface-mount technology. This midget circuit, less LED, measures only 0.7″ × 0.25″ and is thin enough to slip between the pins of a standard dual in-line IC. The circuit includes a 555 timer, three thick-film resistors and a chip capacitor. Despite its diminutive size, I assembled this circuit in less than three hours using standard etched-circuit techniques and an ordinary 15-watt soldering iron. Full details about this and other microminiature circuits will be given in a subsequent piece.

Even if you are not now interested in assembling ultraminiature circuits, you should become well informed about surface-mount technology. That's because this technol-

Fig. 1. An example of a subminiature LED transmitter assembled by the author from an assortment of surface-mounted components.



ogy offers several important advantages over conventional circuit-board assembly techniques. Already some major manufacturers of electronic circuit boards have switched from conventional circuit-board assembly techniques to surface-mount technology, and many others are considering the change. These changes will eventually affect virtually every area of electronics. Therefore, it is essential that electronics professionals and experimenters become familiar with this technology.

Here, I will explain in some detail why surface-mount technology is so appealing and then discuss various surface-mount components and assembly methods. Finally, I will discuss suppliers of surface-mount components and supplies and a new SMT training kit available from Vector Electronic Company. In the future, I'll provide construction details for some tiny surface-mount circuits you may wish to duplicate. Even if you don't assemble these circuits, the details about their assembly will help you to better understand the advantages and disadvantages of surface-mount technology.

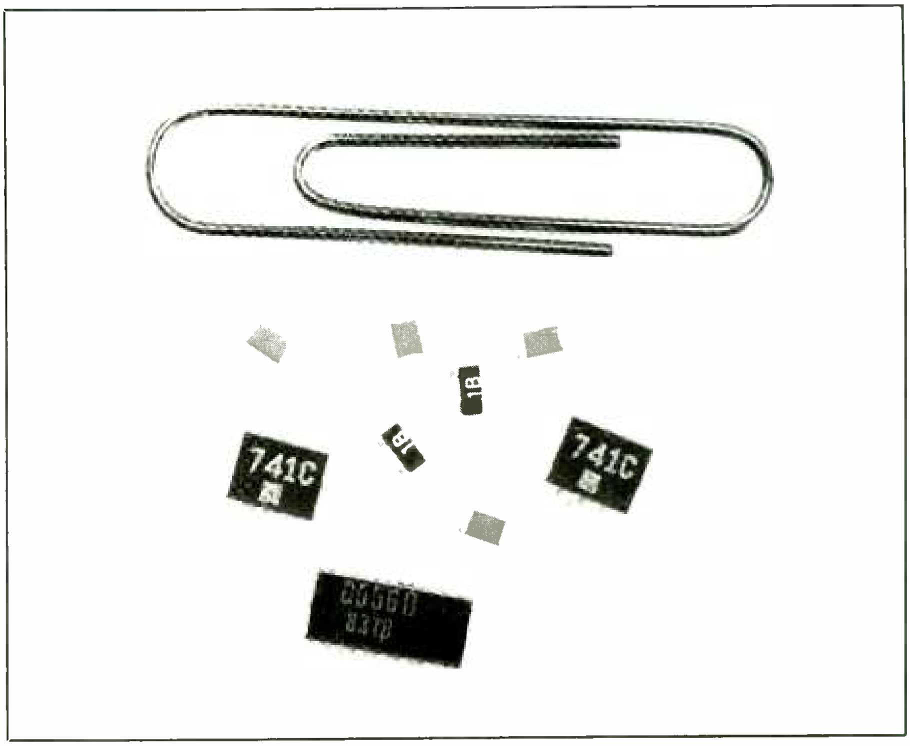


Fig. 2. Assortment of surface-mount ICs, transistors and chip capacitors.

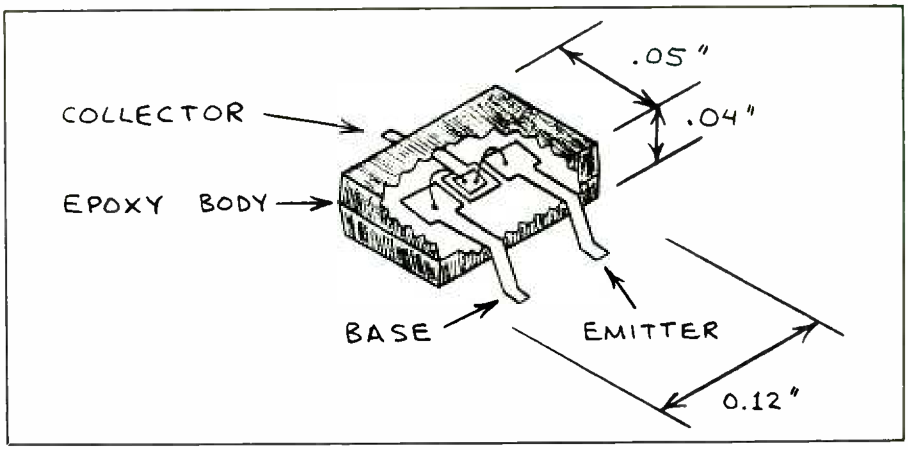


Fig. 3. SOT-23 surface-mountable transistor package.

What is Surface-Mount Technology?

Conventional circuit boards are assembled with components bearing electrically conductive leads or pins that are inserted through drilled holes. Generally, the leads or pins are soldered to copper foil traces on the side of the board opposite the component. When double-sided boards having plated-through holes are used, solder may be applied to both sides of the board.

In contrast, surface-mount circuit boards are assembled with components that have terminals or small pins that are soldered directly to copper foil traces on the foil side of a circuit board. Pins, if present, are *not* inserted through drilled holes. Surface-mountable devices are generally much smaller than conventional components.

It is important to understand that surface-mount technology is not new. The miniature flat-pack integrated circuits developed by Texas Instruments in the early 1960s, for example, were surface mountable. Surface-mountable ICs, LED displays, capacitors, transistors, and resistors were available in the 1970s. Many of the principles of surface-mount technology were borrowed from the well-established field of hybrid integrated circuits. Indeed, some of the capacitors and other components developed originally for hybrid microcircuits, are now being used in surface-mount roles.

Though surface-mount technology has a long history, only in the last few years have engineers and manufacturers fully realized its potential. One of the key factors in the high level of interest in surface-mount technology is its compatibility with automated manufacturing. The uniform shape of surface-mount devices or SMDs (SMD is a service mark of North American Philips Corporation) and their small size makes them ideally suited for automated manufacturing. Resistors, capacitors, trimmers, diodes, transistors and integrated circuits can be loaded in plastic magazines or packaged in sprocketed tape wound on reels. Depending on the equipment, automated pick-and-place equipment can select and place from 1,500 to 500,000 SMD components per hour! Equally important, manufacturers need no longer go through a hole-drilling procedure. An attractive byproduct is that pc board "real estate" is used more efficiently allowing a full complement of components to be easily mounted on both sides of a pc board.

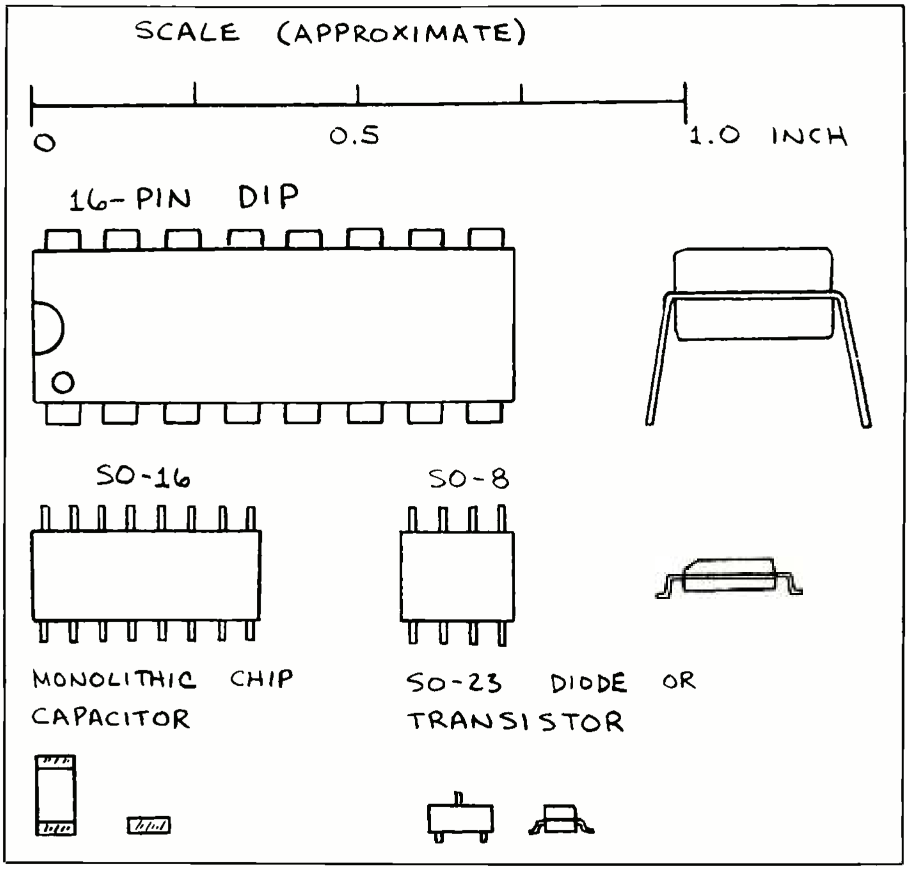


Fig. 4. Relative size of several SMD components.

Surface-Mount Devices

Figure 2 shows several surface-mount components placed near a paper clip on my desk. As you can see, components designed for surface-mount assembly are generally much smaller than conventional components. Capacitors and resistors, the small bar-shaped objects in Fig. 2, are only slightly larger than this letter "O" and have conductive terminals on either end. Transistors, the two devices with three small pins in Fig. 2, are slightly smaller than resistors and capacitors. Figure 2 also shows two 741 operational amplifiers and a 556 dual timer. These and other standard 4-, 8-, 14-, and 16-pin integrated circuits are about ⅛-inch wide. Pin separation is 0.05 inch, half that of standard dual in-line integrated circuits.

Surface-mountable semiconductors are often designated by an SO (for Small Outline) prefix. The transistors in Fig. 2 are encapsulated in SOT-23 (TO-236) packages. Figure 3 is a sketch that shows the interior of an SOT-23 transistor. One or two diodes can also be encapsulated in the SOT-23 package.

A 4-pin version of the SOT-23 package is designated the SOT-143. It can contain either two diodes, a 4-diode bridge rectifier, or a dual-gate MOSFET. The SOT-89 is a slightly larger 3-pin package designed for rectifiers and transistors having a die that is too large to fit the SOT-23 package.

Dual in-line integrated circuit packages are also given an SO prefix. Thus, an SO-16 IC has 16 pins. Surface-mountable packages having dozens of pins around the perimeter of a square case are also available. These packages are designed for large-scale integrated circuits, such as microprocessors, controllers, memory arrays and the like.

Figure 4 compares a standard 16-pin dual in-line package (DIP) IC with several common SO components. Note that two SOT-23 transistor/diode packages can be placed end-to-end on a single pin of a standard DIP.

Almost every category of electronic component is now available in a surface-mountable configuration. This includes various kinds of inductors, switches, LEDs, phototransistors, connectors, crystals, and trimmer resistors and capacitors. Like chip resistors and capacitors, many of these devices have been designed especially for surface-mount roles. Others are miniature versions of standard components with pins or terminals redesigned for surface mounting.

Because the large-scale implementation of surface-mount technology is a very recent development, manufacturers have yet to agree on all standards for the physical size of their components. This lack of stan-

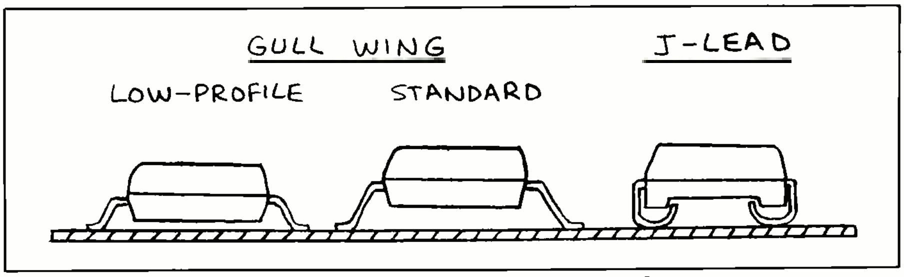


Fig. 5. Surface-mounted component lead configurations.

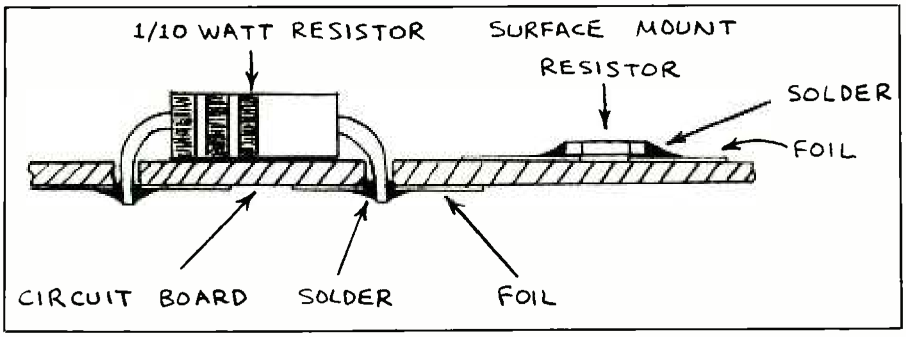


Fig. 6. Conventional through-hole and surface-mount resistor installation.

dardization can prove very frustrating when it's necessary to find a replacement part. Another area lacking final standardization is the pin configurations for ICs. Figure 5, for example, shows three common lead arrangements for SO dual in-line ICs. Each lead arrangement has its advocates. Proponents of gull-wing leads point to ease of soldering and simpler component replacement. J-lead advocates point to higher density boards made possible by the absence of protruding pins. In the end, perhaps both arrangements will be made standard.

Even though standards are lacking, there can be no doubt that surface mounting affords a substantial savings in space. Figure 7 shows a cross-section of a circuit board containing a standard ⅒ watt resistor and a chip resistor. The latter device isn't much thicker than the width of the leads of the standard through-hole resistor.

Advantages & Disadvantages of Surface-Mount Technology

Though some of the advantages of surface-mount technology (SMT) were cited above, to better grasp their significance, it is important to review them alongside other SMT advantages. Therefore, here is a listing of the major advantages of SMT:

(1.) The small size of SMDs permits circuit boards to be made considerably smaller than those designed for conventional components. Indeed, circuits made from SMDs can rival in size circuits made using hybrid microcircuits.

(2.) SMDs are well-suited for rapid turn-around, fully automated assembly.

(3.) Surface-mount circuits are potentially less costly than those made using conventional components. Recently, the cost of SMDs has dropped significantly. Simpler, smaller circuit boards and more compact production facilities contribute even more to the economy of surface-mount technology.

(4.) Circuits assembled from SMDs exhibit improved electrical performance. The absence of component leads and small size of SMDs enhances switching speeds and reduces stray inductance and capacitance. Noise pickup is also reduced.

(5.) SMDs can be easily installed on both sides of a circuit board, thereby further increasing their size advantage over conventional components.

(6.) Boards assembled with SMDs have higher resistance to shock and vibration due to their small mass and size.

The advantages of SMT are tempered by several drawbacks. Some of these disadvantages will fade away when SMT becomes more widely accepted. In the meantime, it's important to understand that:

(1.) SMT requires new approaches to component installation, soldering, storage, and purchasing. Persons experienced in designing and assembling conventional circuits will have to learn new procedures and techniques.

(2.) Special costly equipment is required for automated assembly of SMT boards.

(3.) Though it is possible to install SMDs by hand for assembly of prototype circuits, the very small size of SMDs makes the procedure tedious and subject to error.

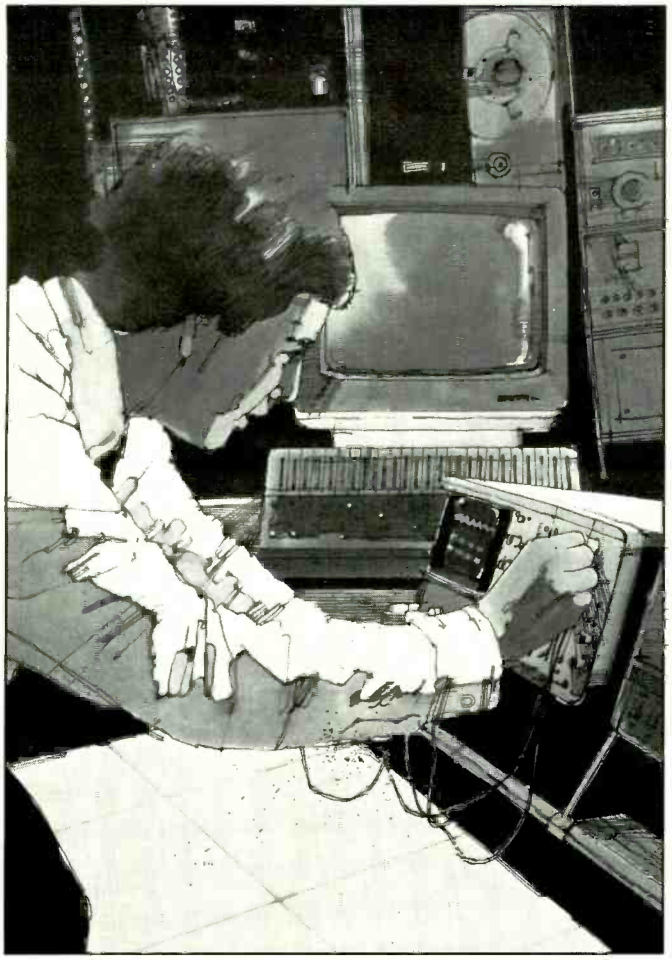
(4.) Troubleshooting circuits assembled with SMDs is difficult due to the small size of the components.

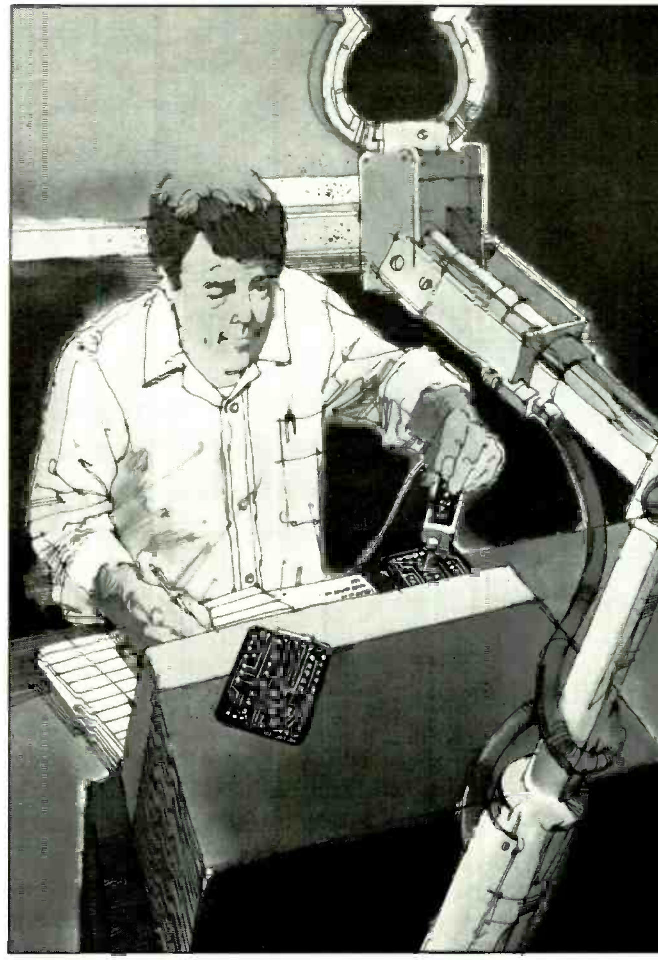
(5.) Removing an SMD from a circuit board and replacing it with a new device is more difficult and tedious than accomplishing the same task with conventional components.

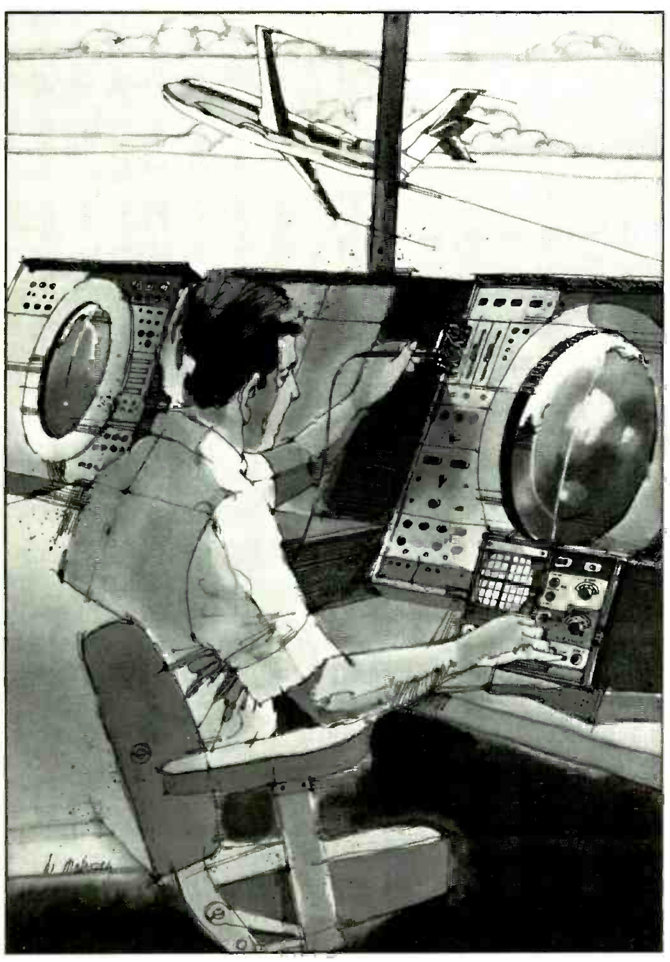
(6.) Some SMDs, particularly those made from ceramic, may fracture if the board to which they are attached is flexed excessively.

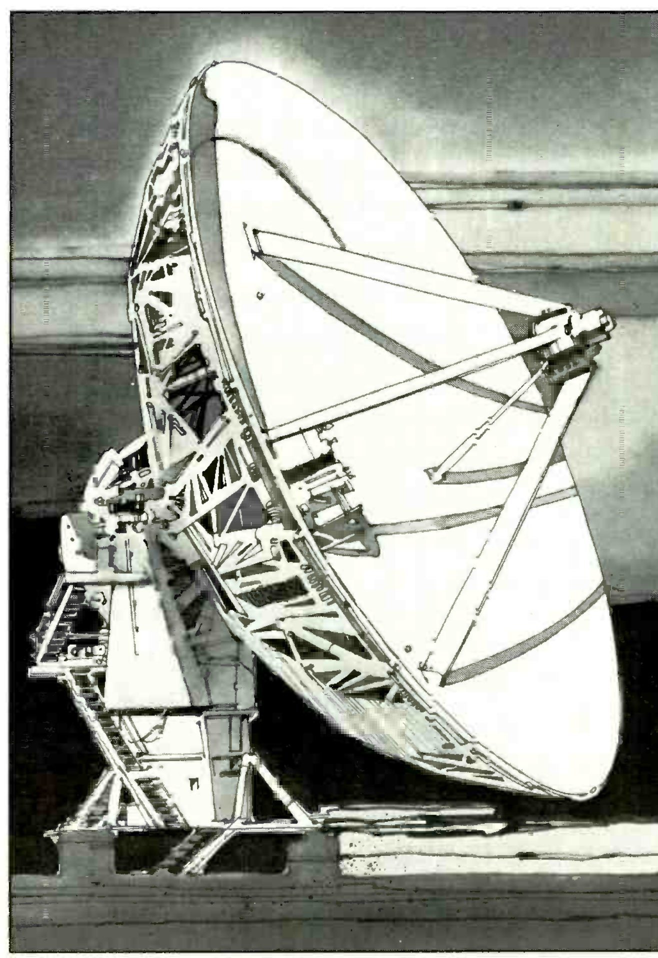
(7.) SMD design has not yet been standardized. For example, manufacturers make surface-mount integrated circuits having various kinds of lead arrangements, each of which requires somewhat different attachment techniques.

(8.) Currently, it is difficult for the average experimenter or proto-









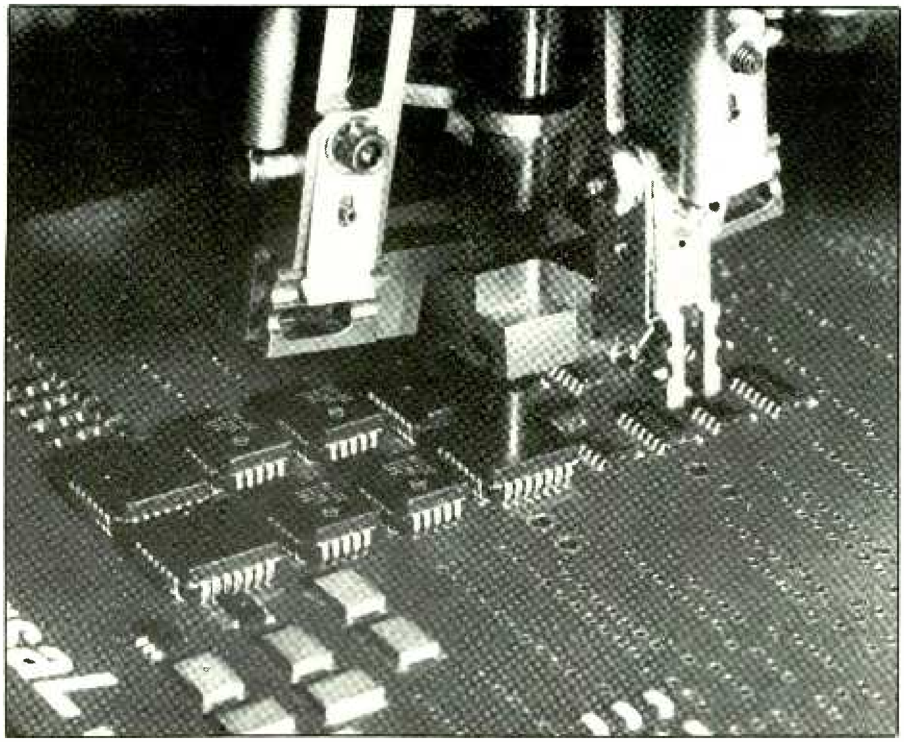


Fig. 7. Surface-mount components being positioned by an automated pick-and-place machine. (Courtesy Universal Instruments, Inc.)

type shop to locate and purchase small quantities of SMDs.

Assembly Techniques

Let's say that a company has developed a digital data logger, and that it now wishes to manufacture several hundred of the devices each month. Assume you have been hired to design the circuit board for the new product. Also assuming that the company has complete facilities for producing both types of boards, conventional and surface-mounted, which production approach should you choose?

First, let's review the steps in the design and assembly of traditional circuit boards. The board is designed and the traces are photographically transferred to copper foil-coated production boards. The boards are then etched and rinsed, and holes for the component leads are drilled. The leads and pins of components are inserted by hand or by machine through their respective holes and the "stuffed" boards are loaded on a moving conveyor track. The bottom (foil side) of the board is then passed over a spray of rosin and a protruding wave of molten solder.

Other steps may also be involved. For example, a test circuit may be assembled to determine if the design of the board subjects the circuit to adverse noise. Also, a protective coating may be applied to the copper traces of the finished board.

The surface-mount approach, on the other hand, will provide a board that is considerably smaller and lighter than the conventional board. Moreover, assembly of the surface-mount board is more readily automated than that of the conventional board. Designing the foil pattern for a single-sided surface-mount board is usually simpler than designing foil patterns for conventional boards, since interconnections are on the top side of the board. Therefore, components can be placed on both sides of a double-sided board.

Should you select the surface-mount approach, one of your chief decisions will be how to attach the SMDs to the board. While conventional boards are either hand or wave soldered, several other options are available for SMDs:

(1.) *Hand Soldering.* The SMDs are cemented or taped to the foil side of the board and carefully soldered in place using a low-wattage iron and small-diameter solder. Having assembled surface-mount boards in this fashion, I can assure you that hand soldering is tedious. Nevertheless, with a magnifying lens and a little patience, hand soldering can be mastered. It is commonly used to assemble prototype surface-mount boards.

(2.) *Wave Soldering.* The SMDs are cemented in place over the respective foil footprints on the board. The board is inverted and run through a wave-solder machine. To avoid excessive thermal stress, the board must be preheated before it passes over the solder wave.

(3.) *Solder Paste or Cream.* Solder paste contains microscopic particles of solder suspended in a flux. It's applied with a syringe or silk-screened on the footprints for each SMD. The SMDs are then placed in position, manually or by automated pick-and-place equipment. There is usually no need to cement the SMDs to the board, since the solder paste holds them in place. Next, the entire board is baked for 30 to 45 minutes at 50 to 80 degrees C to force out some of the solvents from the solder paste. Finally, the entire board is briefly heated to the melting point of the solder. When the solder melts, its surface tension tends to center the SMDs directly over their footprints, thereby correcting slight errors in component placement.

There are several ways to heat a board bearing solder-pasted SMDs. The simplest is to place the board in a convection oven and increase the temperature until the solder melts.

Another is to place the board on a hotplate until the solder melts. The vapor phase reflow method is more complicated, but is faster and applies less thermal stress to the board and its components. Here the board is placed over a pool of boiling liquid fluorocarbon in a closed chamber. Some of the vaporized fluorocarbon condenses on the board and the SMDs, and the heat given off by the condensing vapor heats the solder paste to the melting point. Still other heating methods employ lasers or heating coils.

(4.) *Conductive Adhesive.* This procedure uses an electrically-conductive adhesive. In one method, both the foil footprints on the board and the terminals of the SMDs are coated with a thin film of activator material. The adhesive material is then applied to the footprints, and the SMDs are placed in position. The adhesive cures in a minute or so.

As you can see, mounting components on surface-mount boards involves many more options than accomplishing the same task with a conventional circuit board. And we've not even discussed the various kinds of pick-and-place systems (robotic arms, if you will) that are now available for automated assembly of surface-mount boards. Figure 6 is a photograph of the business end of one such system that's placing SO devices on a circuit board.

Where To Buy SMDs and Supplies

Small-quantity buyers have been able to purchase surface-mountable semiconductors from manufacturers like Signetics for several years. Until recently, however, it was difficult to purchase small quantities of such passive SMDs as chip capacitors and resistors. Hopefully, electronics parts suppliers will eventually stock SMDs and supplies. Until then, the small-quantity purchaser has other options.

The first is to contact electronic parts distributors that represent makers of SMDs and supplies to see if they will sell these items in small quantities. Several companies have published lists of SMD manufacturers complete with addresses and telephone numbers. One is "Surface Mount Technology: Equipment, Supplies, and Services," a brochure published by Texas Instruments (P.O. Box 225012, MS-54, Dallas, TX 75265). Another listing of SMD manufacturers and suppliers is given in "Guide to SMT," a manual supplied with the SMT2000™ surface-mount training kit from Vector Electronic Company (described in detail below).

Most electronic parts manufacturers now supply their devices in SMD form. Many of them advertise this fact in the electronics trade publications. Therefore, if all else fails, simply ask distributors if any of their client companies make SMDs.

Another way to obtain SMDs and supplies is to purchase them from a packager. There are at least two such companies, both of which are described below.

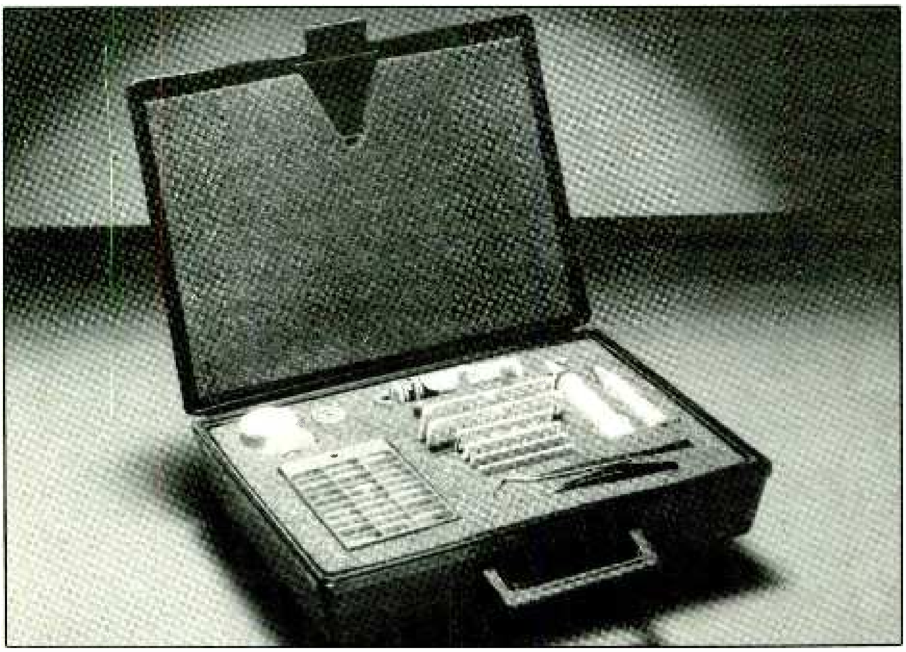
SMD Technology Service Center

The SMD Technology Service Center (5855 North Glen Park Road, Milwaukee, WI 53209; 800-431-4444), a subsidiary of North American Philips, gives comprehensive in-house seminars on SMD technology and sells a wide variety of SMDs and supplies. Here are some representative devices and prices for magazines and tape reels of SMDs:

Device	Qty	Price
74LS00	50	$33.00
74LS04	50	35.00
4001	50	28.00
40161	25	32.25
LM324D	50	29.00
LM339D	50	22.50
NE555D	100	46.00
uA741CD	100	72.00
non transistor	50	19.00
pnp transistor	50	18.00
1k resistor	100	40.00
10k resistor	100	40.00
.01 μF capacitor	100	27.00
.1 μF capacitor	100	38.00

The SMD Technology Service Center also sells solder paste (50 grams for $42.00) and other sup-

Fig. 8. Vector Electronic Company's SMT2000 surface-mount training kit.



SMT on the Move

Conceived to meet the urgent need of manufacturers for extremely miniaturized circuitry, surface-mount technology was first commercially used in 1975 to produce digital wristwatches. But the growth of SMT has been slow over the years due to the initial high cost of automated assembly equipment, lack of industry standards, and a limited variety of surface-mount components.

Industry's failure to fully capitalize on the benefits of SMT is about to come to an abrupt end. Organizations like the Surface Mount Technology Association based in Los Gatos, CA, the Electronics Industries Association (EIA) in Washington, DC, and others are working with manufacturers and component suppliers to establish standards. Meanwhile, the electronics manufacturing industry is revving up for SMT production.

Forecasts indicate that surface-mounted circuitry will be used in nearly 30 percent of electronic equipment being manufactured by the end of 1988. This represents a 300-percent increase over the 1985 figure and this technology is likely to become the primary means by which electronic products are produced in 10 years or so.

A 64-pin surface-mount LSI device is used for display drivers in a Keithley Model 175 DMM, saving 5 to 6 times the space that would be required for throughhole devices.

On the Manufacturing Floor. Surface-mount devices are physically only a fraction of the size and weight of their standard-size counterparts. An SMD integrated circuit, for example, requires only 30 percent of the surface area and has only 10 percent of the mass of the same IC in a traditional DIP device. A typical SMD that replaces a standard DIP IC with 0.10" pin spacing would utilize a standard SMD pattern with lead spacing of only 0.05".

Size differences and space savings are even more dramatic with discrete resistors and capacitors (*see main article for more details—Editor*). However, due to their tiny sizes, the critical nature of the assembly procedure just about eliminates the possibility of hand assembly in large-volume manufacturing. Hence, semiautomatic and automatic high-speed machines are almost always used for component placement.

Types of equipment used in commercial manufacturing plants in which SMT is used range from human-operator-loaded semiautomatic machines that can secure and simultaneously solder all pins of a four-sided LSI flatpack IC, right on up to fully automated high-speed component-placement machines. The latter remove individual SMDs from pre-loaded tapes and accurately position them on the circuit board's conductor pattern. Such machines can perform up to 8,000 pick-and-place operations per hour, hour after hour without a break.

plies. Minimum order requirement is $150.00. Contact the company for a comprehensive wall chart that lists all the SMDs and supplies, as well as their prices.

Vector Electronic Company

Vector Electronic Company (12460 Gladstone Avenue, Sylmar, CA 91342; 818-365-9661) is a well-known supplier of high-quality, conventional prototyping printed-circuit boards and supplies. Recently, the company entered the surface-mount era with a breakthrough product, a self-contained training kit that permits even the novice to design and assemble working surface-mount circuits. The SMT2000™ training kit, shown in Fig. 8, includes six pre-etched and plated double-sided epoxy-glass prototype boards, soldering aids, tweezers (2), solder paste (in a convenient syringe), and conductive adhesive.

The kit also includes two compartmentalized boxes containing a generous assortment of SMDs. The resistor box includes 10 each of 30 thick-film resistors having values ranging from 22 ohms to 150K. The capacitor box includes 10 each of 27 monolithic ceramic chip capacitors having values ranging from 100 pf to 0.33 μF. Also included in the capacitor box are 10 2N2222 transistors and 10 1N914 diodes, all in SOT-23 packages. Vector does not include surface-mountable ICs in the SMT2000 kit, since they can be purchased from distributors and because including a sufficiently wide variety would have made the kit prohibitively expensive.

Finally, the SMT2000 kit includes an excellent 52-page training manual that describes in detail how to assemble working circuits using the SMDs included in the kit. The manual closes with an "SMT Resource Directory" that lists dozens of manufacturers and suppliers of surface-mount devices and supplies.

The SMT2000 training kit is available from Vector distributors for $348. A version of the kit that does not include the SMD assortments, the SMT1000, is available for $215. If these prices are beyond your means, you might wish to consider assembling your own SMD kit by purchasing from Vector portions of the SMT2000 kit. The 300-piece thick film resistor assortment (SMT1206R) is $62.00, for example. Its 300-piece chip capacitor, transistor, and diode assortment (SMT1206CDT) is $71.50.

To be Continued

For several years, I have been assembling a small collection of SMT ICs. Vector's SMT2000 training kit has opened up a new world of circuit possibilities since it has allowed me to use some of these chips to assemble some tiny circuits that rival in size expensive hybrid microcircuits. In a subsequent article, I will describe in detail how these circuits can be duplicated using conventional soldering methods, conductive adhesive, and solder paste. In the meantime, I encourage you to begin preparing for the surface-mount era by collecting additional information on surface-mount technology from the sources given, as well as above articles and ads in electronics trade magazines. A new era of miniature electronic construction techniques and opportunities awaits. **ME**

Editor's Note: This article was prepared in place of the author's "Electronics Notebook" column.

Manual assembly of SMD circuits, while certainly not impossible, does require special tools and a very steady hand. A typical toolkit would contain tweezers or similar component-handling utensil, a low-wattage soldering pencil equipped with a microfine tip and an accompanying vacuum-type solder extractor, an inspection magnifying lens (preferably one with a built-in inspection lamp), a quick-set cement like cyanoacrylate and a good-quality 0.015″-diameter rosin-core solder, such as Kester's #44.

Hand soldering of multiple-lead SMDs is an exercise in dexterity. It requires a good eye (use the magnifying lens), a steady hand and a lot of patience. Because of the very close pin spacing of SMD ICs, it is much easier to create solder bridges with these devices than with the pads into which the pins of standard DIP ICs plug.

When servicing an SMT board, even after removing the solder and breaking away device leads from the pads, adhesives may still secure SMDs to the board. It is easy to detach the devices at this point, though, with a little prying. To avoid part movement when reinstalling an SMD, a small daub of cynaocrylate cement (Krazy Glue is an example) should be used to secure the part. A freon-based flux remover should be used if cleaning is necessary.

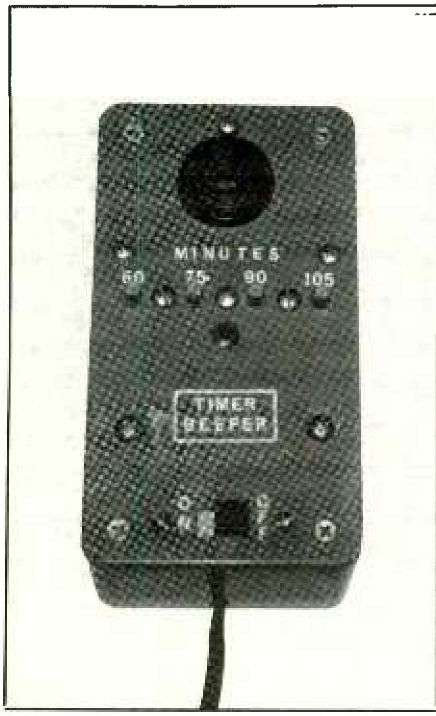
Irresistible Attractions. Not the least of the attractions of SMT is a considerable reduction in manufacturing cost. Here is an analysis: A double-sided printed-circuit board using plated-through plug-in technology designed to accommodate standard dual-inline-package (DIP) integrated circuits with the pins on 0.1″ centers and pin rows spaced 0.3″ apart and ¼-watt passive components might require 60 square inches of board. In contrast, using the down-sized SMD component equivalents, this same circuit would require only 12 square inches of board space. With good-quality pc boards selling for about 20 cents per square inch in the U.S., the reduction in board space offered by SMT represents a saving of $9.60 for one board alone. Even for equipment manufactured off-shore, this reduction ratio holds, since production is not too labor-intensive.

Cost, of course, is the most important factor in the manufacturing process. Other cost-saving benefits the manufacturer accrues from SMT include: reduced plant size and inventory space (smaller products require less storage space); a more effective and controlled manufacturing process; and reduced freight and handling.

The customer who buys products in which SMT is utilized benefits, too. His price, if not lower at this time, gets him more sophisticated design for his investment. The product he buys will provide better frequency response, better electrical noise (emi/rfi) shielding, lower component mass that improves shock and vibration characteristics, and improved reliability owing to fewer soldered connections.

Most equipment using SMT today are hybrids. That is, both SMD and through-hole components are used. As more SMDs become available, 100-percent SMT electronic products will be common. As a byproduct, they will also be smaller, more reliable and less costly than the present crop of models.

—Patrick J. Chick



How To Design Ultra-Long-Delay Timers

Timing delays of from a few microseconds to almost 30 days can be obtained with an inexpensive programmable timer chip from Exar . . . plus a Timer Beeper you can build

By John T. Bailey

Virtually all electronics enthusiasts are familiar with the ubiquitous general-purpose 555 timer integrated-circuit chip. This device has deservedly gained an excellent reputation as the timer of choice in a wide variety of applications and ranks among the most widely used ICs of all time. The 555 has its limitations, though. For example, when accurate time delays ranging from microseconds to up to a month are required, the 555 cannot match the performance of Exar's twice-the-price ($1.29 retail) XR-2240 programmable timer/counter.

Contained within the XR-2240 is a time-base oscillator that uses an external RC network. This oscillator is followed by an 8-bit binary counter that can be programmed for delays ranging from 1RC to 255RC.

In this article, we will discuss the design of ultra-long delay timers and options that can meet a diversity of applications. Also included is a "Timer Beeper" that can be used for a special application. Other applications will be evident as each option is described.

Inside the XR-2240

Shown in Figs. 1 and 2 are the logic diagram and pinout details, respectively, of the XR-2240 programmable timer chip. The time-base section (Fig. 1), which is quite similar to that in the general-purpose 555 timer chip, produces negative-going clock pulses at pin 14. These pulses have a period of T = 1RC.

A timing cycle is initiated by a positive-going trigger pulse applied to

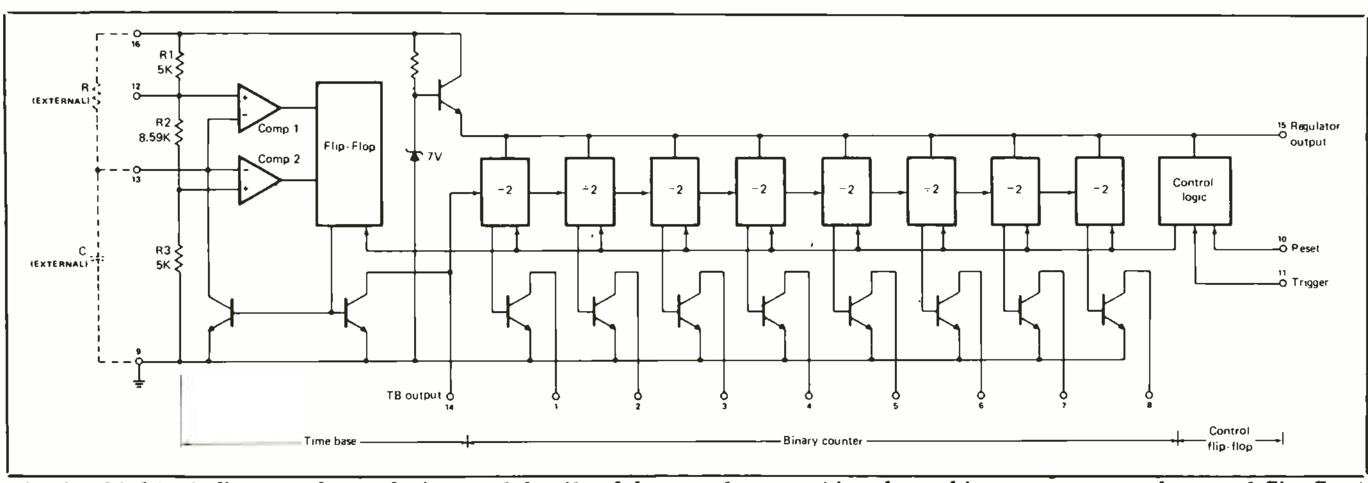


Fig. 1. This block diagram shows the internal details of the XR-2240 programmable timer chip. Note the three basic elements (time base, binary counter and control flip-flop) that make up this 16-pin dual in-line integrated circuit.

pin 11. This pulse starts the time-base oscillator, enables the counter section and sets all counter outputs to their low states. Clock pulses at pin 14 are counted by the binary counter section. Figure 3 is the timing diagram of the waveforms after a trigger pulse is applied.

All eight binary counter outputs are open-collector stages that can be tied to a common pull-up resistor (R_L) to form a wired-OR connection. With this arrangement, as long as one output is low, the combined output will be low. The combined delay can be summed simply by adding the outputs connected to the load (pull-up) resistor. For instance, if only pins 2 and 5 are connected to the load resistor and the other pins are left open, total delay time would be $T_o = (2 + 16)T = 18T$. For maximum delay, all eight pins would be connected to give $T_o = (1 + 2 + 4 + 8 + 16 + 32 + 64 + 128)T = 255T$, where $T = RC$.

External connections, including those for the trigger circuitry, for the XR-2240 as used in the Timer Beeper to be discussed are shown in Fig. 4.

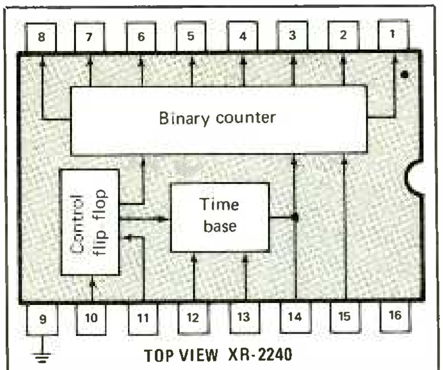


Fig. 2. The pinout diagram of the XR-2240 chip.

Determining Delay Time

Determining the dealy time and the limits that apply to the components being used is the first order of business. The formula for determining delay time is TD = NRC, where *TD* is the delay time in seconds, *N* is an integer equal to the total binary counts selected, *R* is resistance in megohms, and *C* is capacitance in microfarads.

For a T_D of 1 hour, for example, an N of 204 (4 + 8 + 64 + 128), an R of 4 megohms, and a C of 4.4 microfarads would give a delay of $204 \times 4 \times 4.4 = 3590$ seconds. This is just 10 seconds shy of 1 hour, though for critical timing it would be inadequate. Another combination that gets closer to the mark might be N = 255, R = 3 megohms and C = 4.7 microfarads. This combination works out to 3596 seconds, which is now only 4 seconds short of 1 hour. Neither of these value combinations should be regarded as practical, especially if a highly accurate delay period is desired.

Though you can obtain 1-percent tolerance resistors, values of 3 megohms and 4 megohms are not standard. Fortunately, both can be had simply by connecting in series three or four 1-megohm, 1-percent tolerance resistors, which are common values. Going this route, you can obtain a series tolerance that is much less than 1 percent simply by selecting 1-megohm resistors that have negative and positive tolerances that cancel out to give a tolerance approaching zero percent.

Resistors are not the problem when it comes to selecting components for the timing networks. The problem is with the capacitors. For stable timing applications, the capacitor should always be tantalum types, regardless of the value required. But even tantalums are not exactly "tight" tolerance components, considering that their values

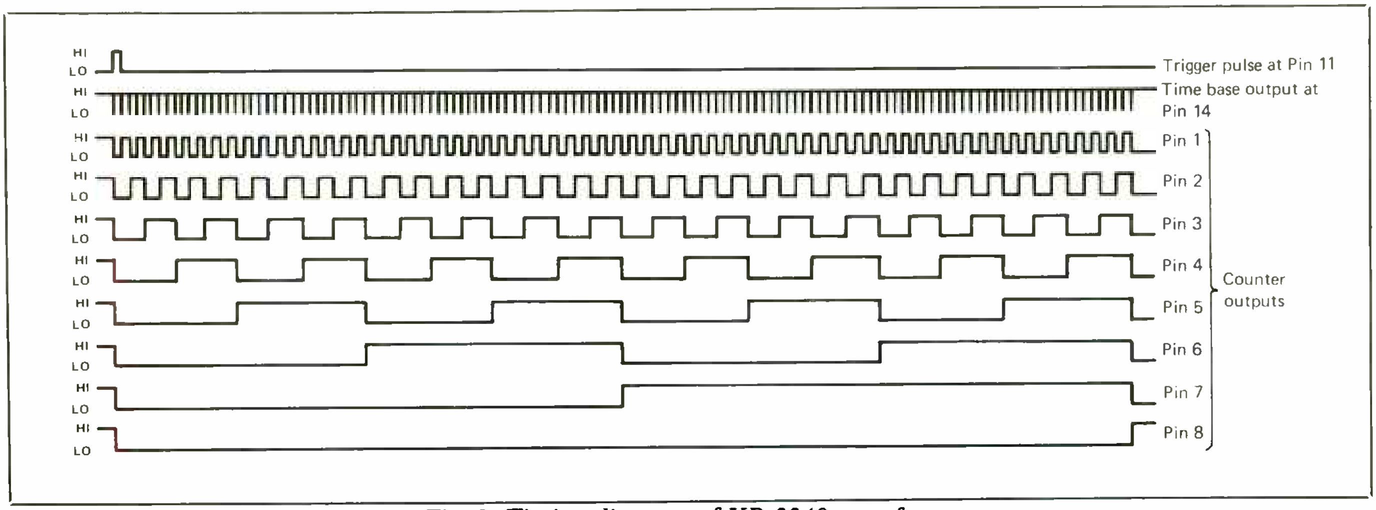


Fig. 3. Timing diagram of XR-2240 waveforms.

can vary by as much as ±20 percent of rated capacity.

Tantalum capacitors in the 35-volt rating category are available in 10 capacitances ranging between 0.1 and 3.3 microfarads. Therefore, by connecting as many tantalum capacitors in parallel as are needed, taking into account positive and negative tolerances, you can put together the value needed.

Generally, it is recommended that the calculated value of *R* be achieved as described above. For the calculated value of *C*, you will have to do some "tweaking" as will be described under Calibration later in this article.

Listed on the XR-2240's specifications sheet are the recommended ranges of values to use for *R* at 10 megohms maximum and 1,000 ohms minimum, and for *C* at 1,000 microfarads maximum and 0.007 microfarad minimum. Using these component limits, the range of delays can be calculated. Maximum delay = 255 × 10 megohms × 1,000 microfarads = 2,550,000 seconds. This translates to 708.33 hours or 29.5 days. Minimum delay = 1 × 0.001 megohm × 0.007 microfarad = 0.000007 second, which translates to 7 microseconds. From this you can readily see that the XR-2240 has a delay range from a few microseconds to almost a full month.

If you were to refer to the literature on the XR-2240, you would find a maximum delay of 5 days referenced. This is at variance with the 29.5-day delay calculated using the manufacturer's own maximum component values. No attempt was made to verify either delay, since waiting even 5 days for the circuit to time out was not enticing. In any event, a 5-day delay is more than adequate for most applications.

Also listed on the specification sheet is a typical timing accuracy of 0.5 percent, exclusive of errors attributable to external components. The dominant external components that can contribute to significant errors are the resistor(s) and capacitor(s) in the RC timing network in the time-base section. Employing *R* and *C* selection techniques recommended here, errors due to these components can be virtually eliminated, leaving the 0.5% timing error of the XR-2240 chip itself as the error-determining device in the circuit.

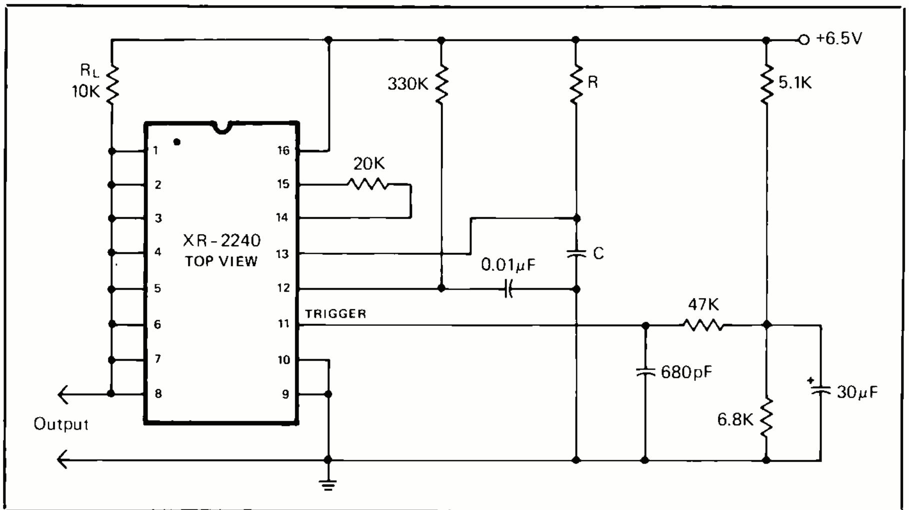


Fig. 4. External circuitry for using an XR-2240 as a Timer Beeper.

Timer Beeper

To make a timer useful in practical real-world applications, some circuitry beyond the XR-2240 is needed to convert the timer's waveform to drive a lamp, buzzer or other attention-getting device or to initiate an event upon which another circuit acts. The Timer Beeper mentioned earlier contains all the circuitry needed to sound an audible alert when the count-down cycle has timed out. The audible alerter in this circuit is a piezoelectric buzzer that is driven in a manner that produces an attention-getting "chirp" at the end of the timing cycle.

Shown in Fig. 5 is the oscillator circuit used in the Timer Beeper to generate the system's characteristic chirping sound. This portion of the circuitry uses a dual 555 timer, housed in the usual 556 dual-timer chip, and just a few external components. The values of the external components have been selected so that the circuit generates brief groups of current pulses that, when sent to a piezo buzzer, creates the chirping sound. With the component values shown, there will be two or three chirps per second.

With the first timer in the 555 connected in the astable mode, the wave-

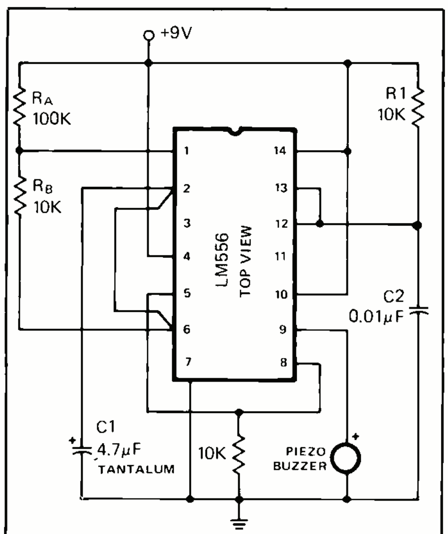


Fig. 5. This circuit produces a steady chirping. Disconnecting link between pins 2 and 6 of LM556 silences buzzer. Link between pins 2 and 6 starts buzzer, which is basis of Timer Beeper's operation.

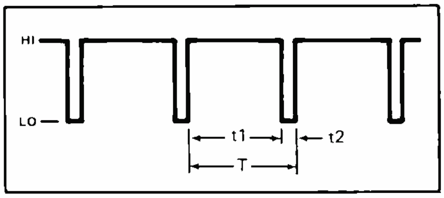


Fig. 6. Waveform at pin 5 of LM556.

form at pin 5 will be a continuous stream of pulses like that shown in Fig. 6. High time $t_1 = 0.693(R_A + R_B)C1 = [0.693(100{,}000 + 10{,}000) \times 4.7]/10^6 = 0.358$ second. Low time $t_2 = 0.693(R_B)C1 = [0.693(10{,}000) \times 4.7]/10^6 = 0.0326$ second. Therefore, $T = t_1 + t_2 = 0.386 + 0.0326 = 0.3906$ second, and $F = 1/T = 1/0.3906 = 2.56$ chirps per second.

Connected in its monostable mode, the second timer in the 556 is triggered by a negative-going pulse from the first timer. This pulse is applied to the second timer at the pin 5 trigger input. From the second timer is generated a 110-microsecond pulse that is fed to the piezo buzzer. Pulse width $= 1.1R1C2 = (1.1 \times 10{,}000 \times 0.01)/10^6 = 110$ microseconds.

The first timer in the 556, in its astable mode, determines the repetition rate of the chirps. With the external component values shown, the repetition rate was calculated above to be 2.56 chirps per second. The second timer, in its monostable mode, determines the duration of the chirps, which was calculated to be 110 microseconds.

Shown in Fig. 7 is the complete schematic diagram of the full Timer Beeper circuit, including its ac line-operated power supply. This diagram shows how the long-delay waveform generated by the XR-2240 is coupled to *IC3* through 4066B analog switch *IC2*. Pins 1 and 2 of the normally open 4066B switch are connected to pins 6 and 2 of *IC3*. When the connection between pins 2 and 6 of *IC3* is opened, this chip is disabled and the piezo buzzer is silent. When *IC1* times out and goes high, the 4066B's control pins (pins 13 and 14) are activated, the switch closes, pins 2 and 6 of *IC3* are shorted together and the buzzer starts chirping.

In the power supply section, a half-wave rectifier supplies the two voltages required by the Timer Beeper circuit. These are +9 volts for the 556 and CD4066B and +6.5 volts for the XR-2240 and light-emitting diode *LED1*, which serves as a power-on indicator.

Construction

There is nothing critical about component layout or construction. The relatively simple Timer Beeper circuit shown in Fig. 7 lends itself to just about any traditional type of wiring, including printed-circuit, Wire Wrap and point-to-point. You can fabricate a printed-circuit board using the actual-size etching-and-drilling guide shown in Fig. 8.

If you decide to use a pc board, wire it exactly as shown in Fig. 9, taking care that ICs, electrolytic capacitors, LED and piezoelectric beeper are oriented or connected as shown. If you choose to use perforated board and Wire Wrap or solder-type

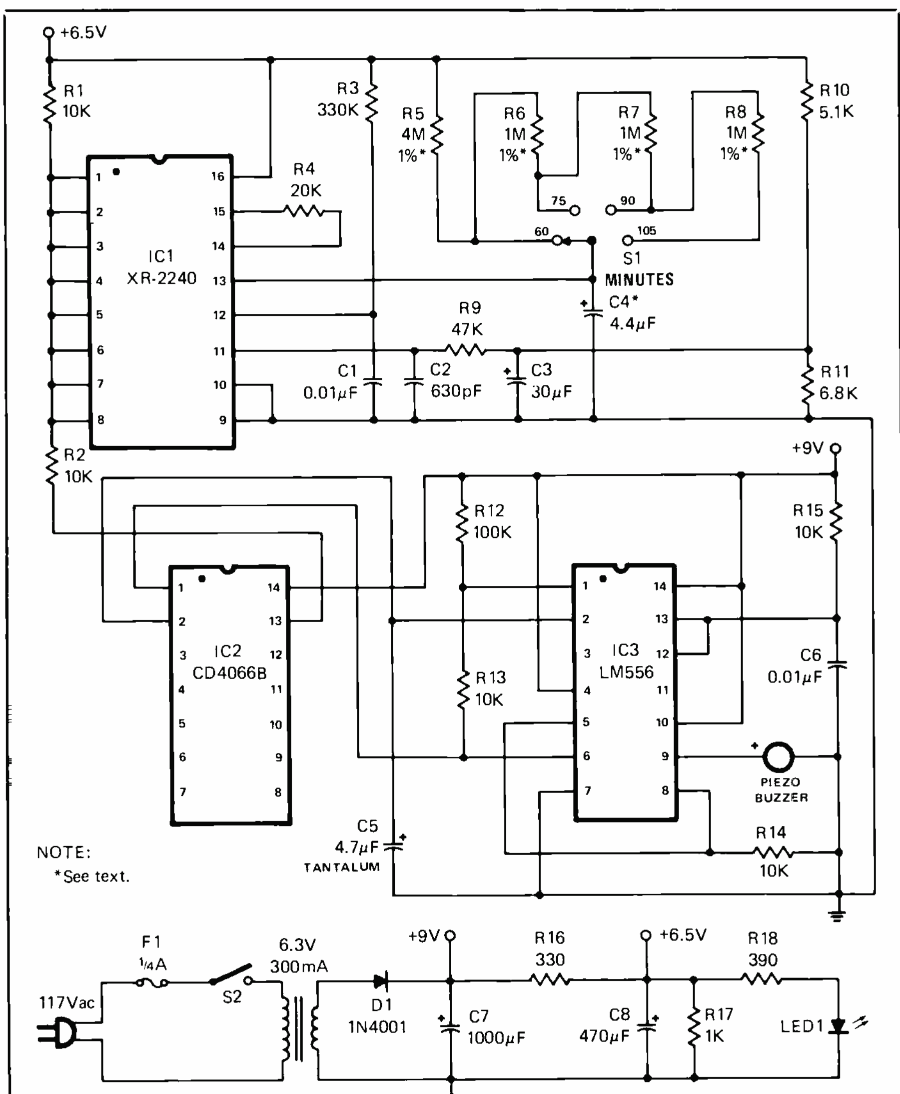


Fig. 7. Schematic diagram of Timer Beeper and its power supply.

PARTS LIST

Semiconductors
D1—1N4001 rectifier diode
LED1—Light-emitting diode
IC1—XR-2240 programmable timer
IC2—CD4066B analog switch
IC3—LM556 dual timer

Capacitors
C1,C6—0.01-μF, ceramic disc
C2—630-pF ceramic disc
C3—30-μF, 10-volt electrolytic
C4—4.4-μF tantalum timing capacitor (see text)
C5—4.7-μF tantalum electrolytic
C7—1,000-μF, 16-volt axial-lead electrolytic
C8—470-μF, 16-volt electrolytic

Resistors (¼-watt, 5% tolerance)
R1,R2,R13,R14,R15—10,000 ohms
R3—330,000 ohms
R4—20,000 ohms
R9—47,000 ohms
R10—5,100 ohms
R11—6,800 ohms
R12—100,000 ohms
R16—330 ohms
R17—1,000 ohms
R18—390 ohms
R5 thru R8—1-megohm, 1% tolerance timing resistors (see text)

Miscellaneous
F1—¼-ampere slow-blow fuse
S1—4-position switch (see text)
S2—Spst slide or toggle switch
T1—6.3-volt, 300-mA transformer
Piezoelectric buzzer (Radio Shack Cat. No. 273-065 or similar); printed-circuit board or perforated board and Wire Wrap or soldering hardware; suitable enclosure; sockets for ICs (optional); fuse holder; LED panel clip or small rubber grommet; ac line cord with plug; lettering kit; insulating tubing; machine hardware; hookup wire; solder; etc.

Note: If you cannot obtain the XR-2240 programmable timer IC locally, it is available from Circuit Specialists, Box 3047, Scottsdale, AZ 85257 for $2.49.

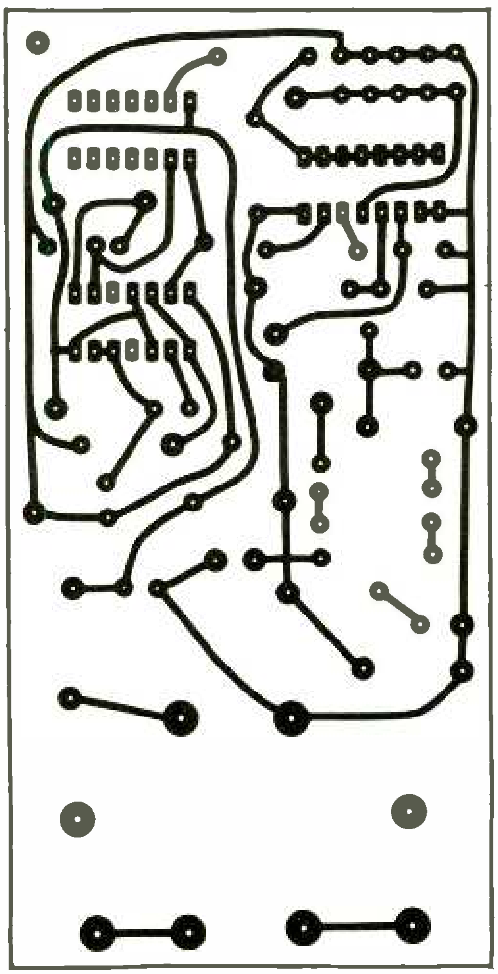


Fig. 8. Actual-size etching-and-drilling guide.

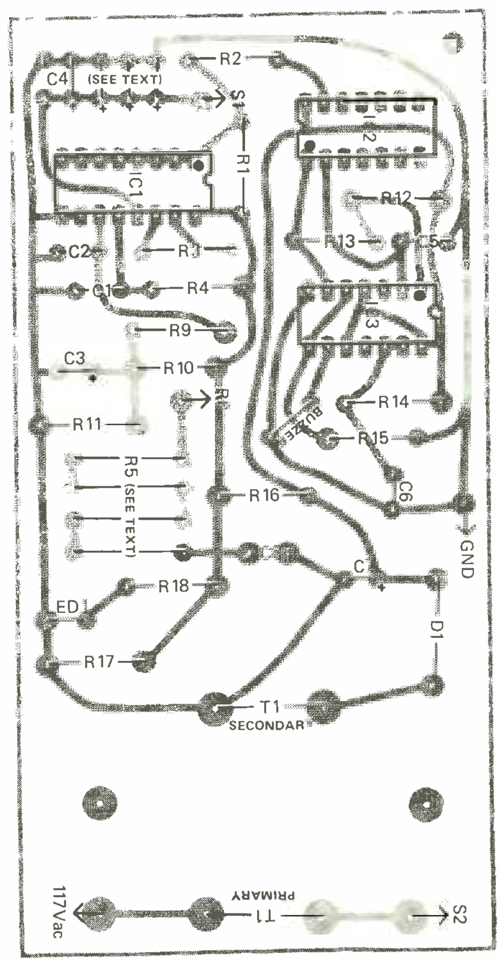


Fig. 9. Wiring guide for pc board.

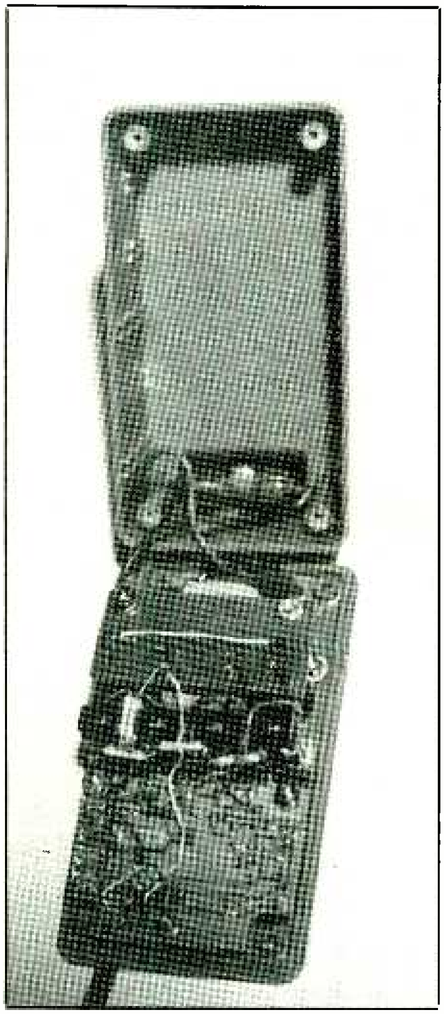


Fig. 10. The finished Timer Beeper assembled on a pc board and housed inside a common plastic enclosure.

hardware, you can use Fig. 9 as a rough guide to component layout and refer back to Fig. 7 for instructions on wiring the components together. Whichever method of wiring you choose, though, it is a good idea to use sockets for the ICs.

Note that the pc board has facilities on it for the four 1-megohm resistors that make up *R4* and five capacitors for timing capacitor *C4*. The remaining timing resistors (*R6, R7* and *R8*) mount directly on time selector switch *S1*. If more than five capacitors are needed for *C4*, you can accommodate them by twisting together the leads of two capacitors at a time and installing both in the same hole pair. Note, too, that the piezo buzzer, LED, switches and fuse mount off the board.

House the project in any type of enclosure that will accommodate it. Bring the ac line cord through a hole drilled in the rear of the enclosure, and tie a knot in it about 4" from the end to serve as a strain relief. Then strip about ¼" of insulation from both conductors, tightly twist together the fine wires in each conductor and lightly tin with solder.

Machine the enclosure to permit mounting of time selection switch *S1*, power switch *S2*, light-emitting diode *LED1*, the fuse holder for *F1* and the circuit board. Solder short lengths of wire to the holes labeled S1, LED1, and BUZZER, using color-coded wires, if possible, to keep track of the anode and cathode connections for the LED and positive and negative connections for the buzzer. Mount the fuse holder and then the circuit board with 6-32 × ¾" machine hardware and ¼" spacers via *T1*'s tab holes and the hole at the other end of the board.

Mount the switches and LED in their respective locations, using a panel-mount clip or small rubber grommet. Slip over one of the wires coming from the circuit board holes labeled LED1 a 1" length of insulating tubing. Carefully solder the LED1 wires to the LED's leads, taking care to connect the cathode (K) wire to the cathode and anode wire to the anode. When the connections have cooled, slip the tubing up over the selected lead to insulate the two from each other.

Referring to Fig. 7 wire the fuse holder and power switch in the power transformer's primary circuit as shown. Mount the piezoelectric buzzer on the front panel of the enclosure and wire it into the circuit (see Fig. 9), making sure to observe proper polarity. Then wire the time selection switch into the circuit.

Shown in Fig. 10 is the finished Timer Beeper, wired on a pc board. Note that this prototype has a push-button switch assembly for the time selector. If you wish to use this type of switch arrangement, you can do so. However, for purposes of machining the enclosure, it might be more prudent to use an ordinary rotary switch. This type of switch is more readily available and affords a simple means for mounting the timing resistors directly on its lugs.

After assembling the project, use a dry-transfer lettering kit or tape labeler to label the front panel (see lead photo). If you use dry-transfer lettering, spray on three or four *light* coats of clear acrylic to protect it. Wait for each successive coat to completely dry before spraying on the next.

If after final assembly your Timer Beeper does not work, check out the beeper section first. To do this, temporarily connect a jumper wire between pins 2 and 6 of *IC3*. If the beeper section and power supply are operating properly, the buzzer will chirp. The problem then lies in *IC1* or *IC2* or both.

Calibration

Only one component in the timer circuit must be adjusted to achieve the desired time delay. This is *C4* (*C* in Fig. 4). In the case of the Timer Beeper, the 60-minute delay requires a 4.4-microfarad capacitor. To obtain this value, start with 3.3 microfarads and parallel it with lesser values. This trial-and-error procedure will require you to monitor the circuit until it times out and the buzzer sounds. It may be quite time-consuming if you wish to obtain a high degree of timing precision, unless you are lucky enough to hit a good combination of capacitors early on.

If you work carefully and use a highly accurate standard to monitor the timing cycle, you can tweak the composite value of the capacitors

(Continued on page 87)

Hand-Clap Electronic Control

Clap your hands, and this electronic "servant" turns on and off lights and other electrically operated devices

By James H. Brown

Legend has it that wealthy sultans simply clapped their hands to have servants do their bidding. You can do the same with our "Sultan's Servant." This electronic "servant" will turn on and off virtually any type of electrical or electronic device with the clap of your hands. Clap twice to turn on a device; clap twice again to turn it off.

About the Circuit

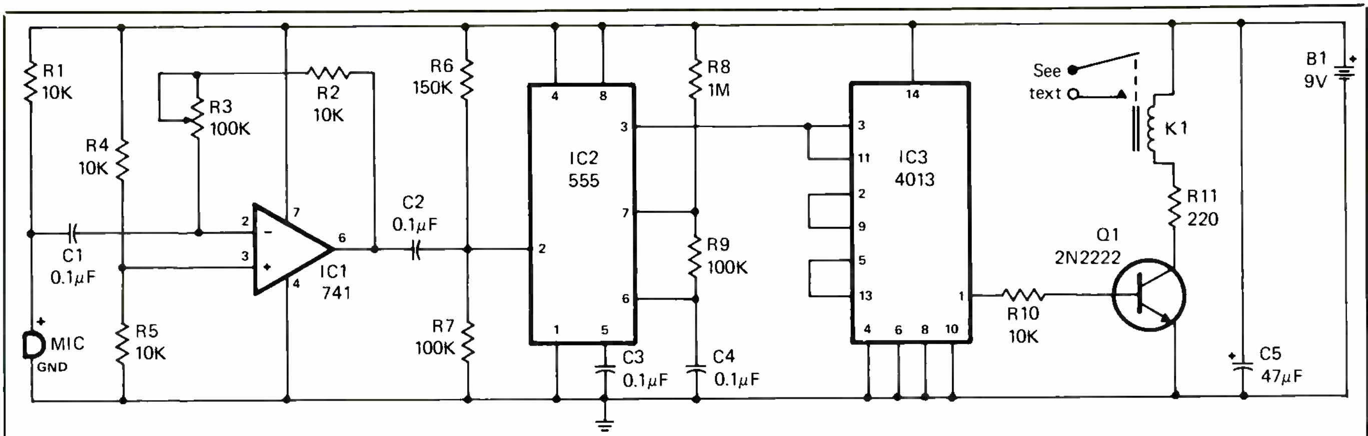
Sharp-attack sound triggers the Servant. Such sounds can be generated by the clap of hands, snap of fingers and a variety of different conditions. The Servant requires at least two sharp-attack pulses to activate. This greatly reduces the possibility of undesired random noises causing the circuit to trigger.

A single sharp-attack hand clap in the vicinity of the Servant is picked up by the input electret microphone (*MIC* in Fig. 1) and is coupled through *C1* into operational amplifier *IC1*'s inverting (−) input at pin 2. The negative peak of the signal at the pin 6 output of *IC1* then triggers 555 timer *IC2*, which is configured as a monostable multivibrator. The trigger pulse that appears at the pin 2 input of *IC2* is internally stretched to clock dual D flip-flop *IC3*.

Because of the three-state counter arrangement of *IC3*, two sharp-attack pulses are required to generate a positive output at pin 1 that will send *Q1* into conduction. When *Q1* conducts, it completes the circuit from the positive side of battery *B1* through the relay's coil to ground. This causes the relay to energize and pull its contacts closed. Any electrical device connected to the relay's contacts will now turn on.

Once pin 1 of *IC3* goes high, it remains in that condition until another pair of sharp-attack hand claps are detected and processed by the previous circuitry. Therefore, it takes two such pulses to turn off the electrical device connected to the relay's contacts once the circuit has been triggered.

Specified in the Parts list is a light-duty reed-type relay for *K1*. If you plan on using this project to switch



PARTS LIST

Semiconductors
IC1—741 operational amplifier
IC2—555 timer
IC3—4013 dual D flip-flop
Q1—2N2222 or similar general-purpose npn transistor

Capacitors (15 volts or more)
C1,C2,C3,C4—0.1-μF ceramic disc
C5—47-μF electrolytic

Resistors (¼-watt, 5% tolerance)
R1,R2,R4,R5,R10—10,000 ohms
R6—150,000 ohms
R7,R9—100,000 ohms
R8—1 megohm
R11—220 ohms
R3—100,000-ohm pc-type trimmer potentiometer

Miscellaneous
B1—9-volt transistor battery
K1—Spst reed relay with 5-volt dc coil (Radio Shack Cat. No. 275-232 or similar)
MIC—Electret microphone element (Radio Shack Cat. No. 270-090 or 270-092; see text)
Printed-circuit board, perforated board and soldering or Wire Wrap hardware, or solderless breadboarding socket (see text); sockets for ICs; 2-lug screw-type terminal strip (see text); snap connector and mounting clip for 9-volt battery; quick-set epoxy cement or silicone adhesive; ½" spacers; machine hardware; hookup wire; solder; etc.

Note: The following items for moderate-to-heavy power switching are optional, as explained in the text: Power relay; chassis-mount ac receptacle (eliminate the 2-lug screw-type terminal strip if this option is used); ac line cord with plug; rubber grommet; plastic or heat-shrinkable (preferable) tubing; double-sided foam tape.

Fig. 1. Overall schematic diagram of the Sultan's Servant.

on and off moderate-to-heavy-duty appliances, you must use a second relay whose contacts are rated to handle the amount of power drawn by the load you plan to switch. There are a number of relays on the market suitable for this purpose, some of which will switch loads of 10 amperes and more. Should you decide to use a power relay, use the project's relay (*K1*) contacts to switch coil power to the power relay.

Potentiometer *R3* in the feedback path of *IC1* serves as a sensitivity control for the circuit. This control can be set as needed for positive triggering and to optimize operation.

Construction

There is nothing critical about circuit layout. Hence, any traditional wiring technique can be used. If you wish, you can etch and drill your own printed-circuit board using the actual-size etching-and-drilling guide given in Fig. 2. Otherwise, you can use perforated board and appropriate Wire Wrap or soldering hardware or a solderless breadboarding socket. Unless you use the solderless breadboarding socket, it is a good idea to use sockets for the ICs.

Wire the board exactly as shown in Fig. 3, taking care to properly orient electrolytic capacitor *C5*. When installing the transistor, make sure its basing is correct before soldering its leads to the board. Similarly, make sure the sockets are properly plugged into the board, with the reference pins in the IC pin 1 locations. Do not forget to install the three wire jumpers in the locations indicated. You can use the cut-off resistor leads for these jumpers. If you are using a solderless breadboarding socket, you can use the Fig. 3 wiring guide as a rough layout for the components and refer back to Fig. 1 to wire the circuit.

Solder the battery snap connector into the circuit. Make certain that the red connector lead goes to the point in the circuit labeled B1 + and the black lead goes to B1 –. Similarly, solder the electret microphone's leads to the appropriate points, the indicated + lead to + and the – lead to GND, in the circuit. You have a choice of either of two microphone elements here, both from Radio

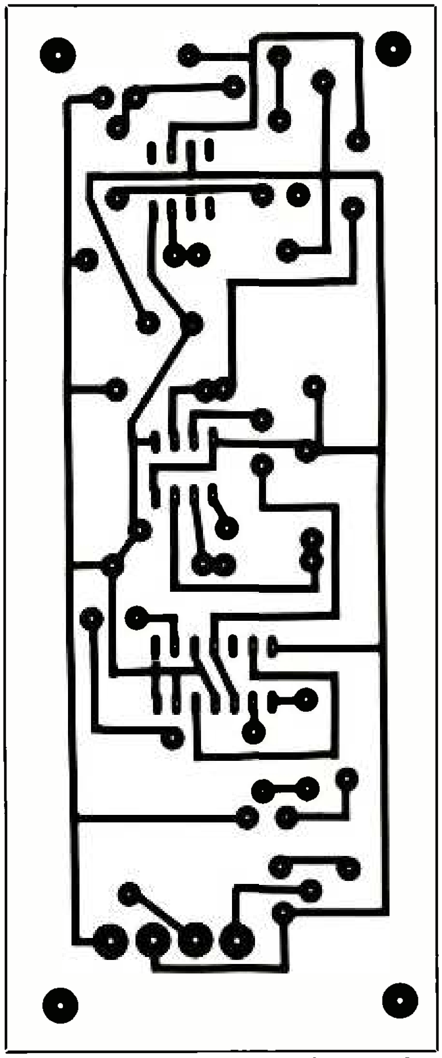


Fig. 2. Actual-size etching-and-drilling guide for the pc board.

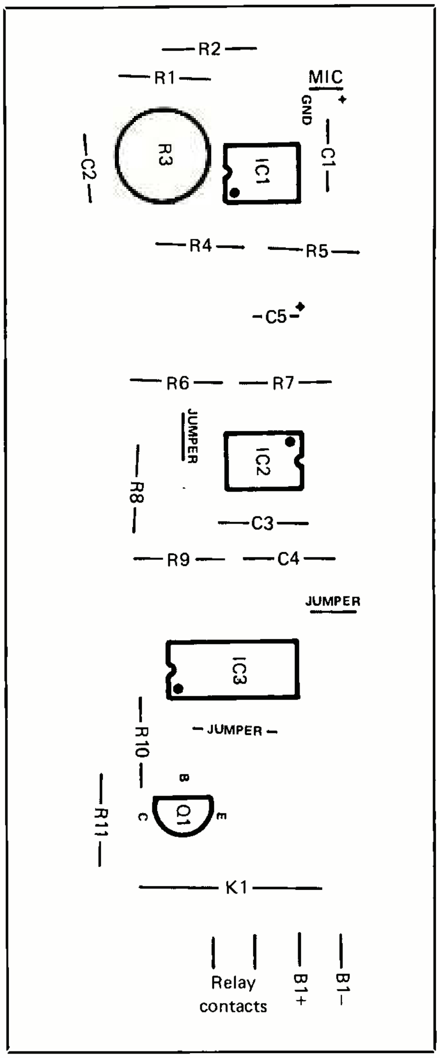


Fig. 3. Wiring guide for the pc board.

Shack. If you use the Cat. No. 270-090 element, you can plug it directly into the holes in the board or prepare short wire leads to allow it to be mounted off the board. The alternative is to use the Cat. No. 270-092, which comes with its own color-coded leads. Also, the light-duty relay specified for *K1* mounts directly on the board.

Prepare two 3″ lengths of No. 22 stranded hookup wire by removing ¼″ of insulation from both ends. Tightly twist together the fine wires at each end and sparingly tin with solder. Connect and solder one end of each wire to the points labeled RELAY CONTACTS in Fig. 3. The other ends will be connected later.

House the project in a suitable-size plastic or metal enclosure that is large enough to accommodate the circuit assembly and power relay if you include it. Drill a hole for mounting the battery clip and holes and slot for a 2-lug screw-type terminal strip. Drill four more holes for mounting the circuit board and a hole in the front panel just a bit larger than the microphone element's diameter. Test fit the microphone element. If the fit is too tight, enlarge the hole.

If you are using a power relay, mount it on one of the walls of the box. A good choice is Radio Shack's Cat. No. 275-220 dpdt 120-volt ac relay, which has contacts rated at 10 amperes for switching relatively high-power loads via their ac lines. Wire the power relay into the circuit as shown in Fig. 4, using the free ends of the stranded wires previously installed on the board to connect it to *K1*'s contacts. (Otherwise, connect the wires to the screw-type terminal strip after mounting the circuit board in place.)

When adding the power relay you must also add to the circuit an ac line cord with a plug and a chassis-mount ac receptacle. This allows you to plug in the device to be controlled and drive it from the ac line via the project's ac line cord, obviating the need to make changes to the device itself.

If you are adding the power relay to the basic project, machine the box for the chassis-mount ac receptacle and drill a hole for entry of the line cord. Deburr all holes. Then line the line cord hole with a rubber grommet.

When wiring the Fig. 4 power switching circuit to the basic Servant, use heavy-duty stranded wire for all connections between *K1* and the power relay and the power relay's contact lugs and the chassis-mount ac receptacle. You can use short lengths of the stranded wires clipped from the ac power cord.

Before connecting and soldering the ac line cord into the circuit, pass the free end of the cord through the grommet into the box. Strip ¼″ of insulation from the free end of each of the line cord's conductors, tightly twist together the fine wires in each conductor, and sparingly tin with solder. Tie a knot in the line cord about 3″ from the free end inside the box and connect and solder its conductors to the appropriate points in the power-relay circuit. (*Note*: use plastic tubing, preferably heat-shrinkable tubing, over all 117-volt ac line level connections.)

Mount the circuit board assembly in the box with the spacers and ma-

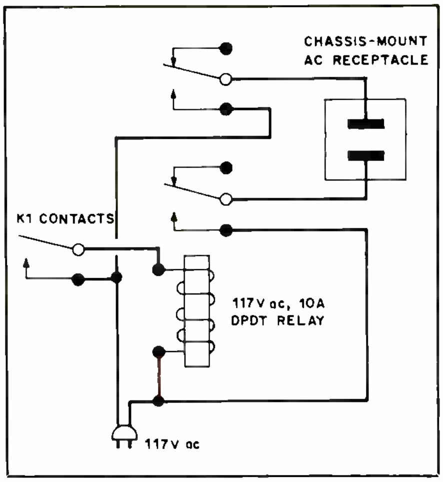


Fig. 4. High-power switching option.

chine hardware. Then mount the battery clip with machine hardware. Use one or two strips of double-sided foam tape to mount the power relay to the wall of the box. Make certain that no part of the 117-volt ac portion of the circuit can come into contact with the basic circuit or the metal of the box in which the project is housed.

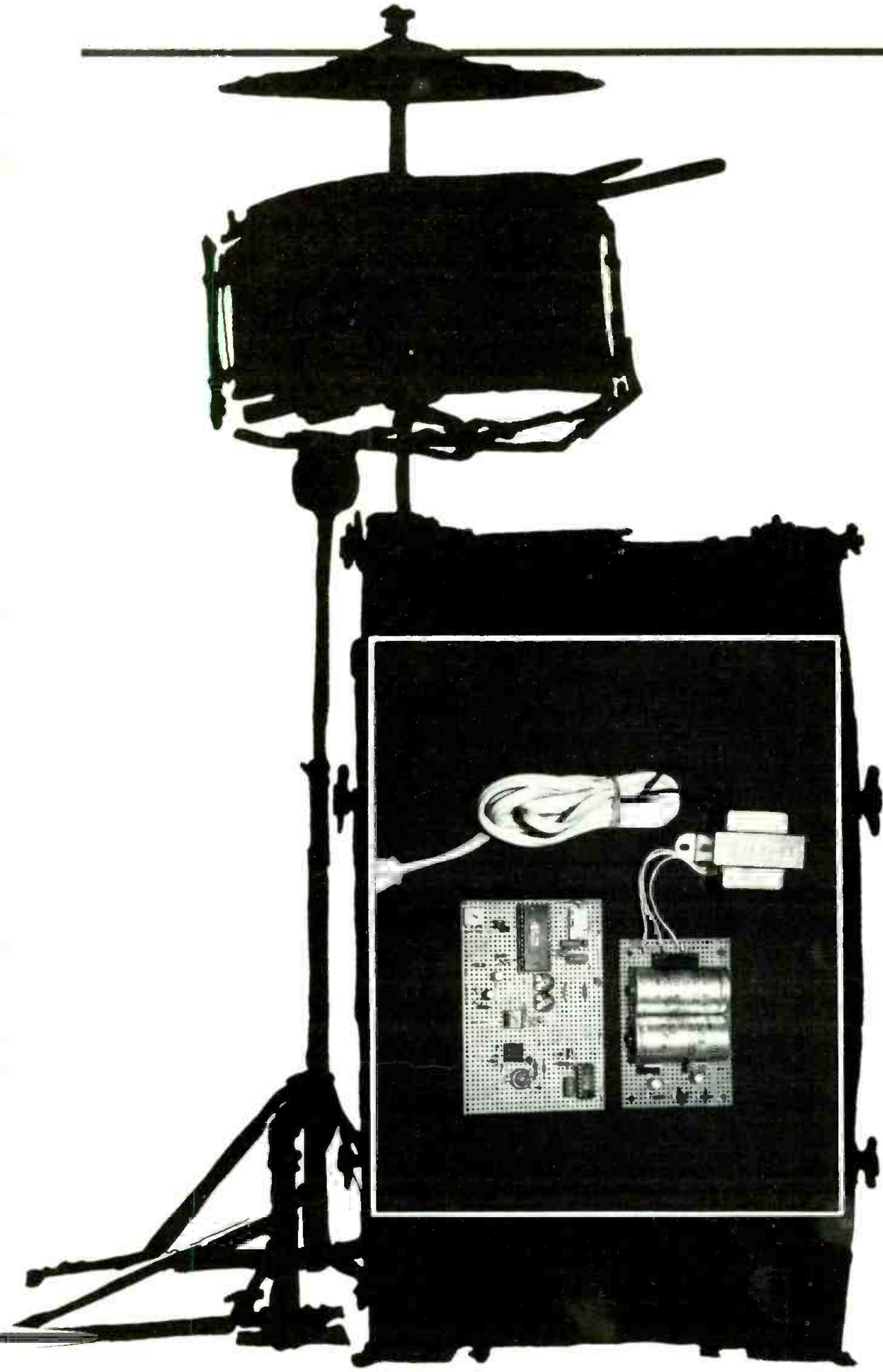
Set the microphone element in its hole and arrange its front surface flush with the outer surface of the box. Run a thin bead of quick-set epoxy cement or silicone adhesive around the element inside the box to anchor it in place.

Calibration and Use

Connect a 9-volt transistor battery into the circuit via the battery snaps. Now, connect a multimeter set to the lowest resistance range across *K1*'s contacts. Set *R3* to about mid-rotation and step back about 10 feet. Clap your hands sharply twice, pause, and then clap twice again. If the circuit is operating properly, and *R3* is set correctly, the meter should indicate infinite resistance after two claps and then zero resistance after two more claps as the relay's contacts open and close. Repeat the clap test several times to make sure. If you do not obtain these results, adjust *R3* for higher sensitivity (more gain from *IC1*).

It may take several claps to synchronize into the on/off cycle. Bear in mind, too, that the circuit can be accidentally triggered by any other sharp-attack sound. So make sure when performing the test that you do so in a quiet environment.

When using the Servant, position it so that there is an unobstructed "view" from the sound source to the project's microphone pickup element. Then just sit back and you can be a modern-day sultan. **ME**



A $20 Drum Synthesizer

This easy-to-build device produces percussion sounds for amateur musicians and experimenters

By C.R. Fischer

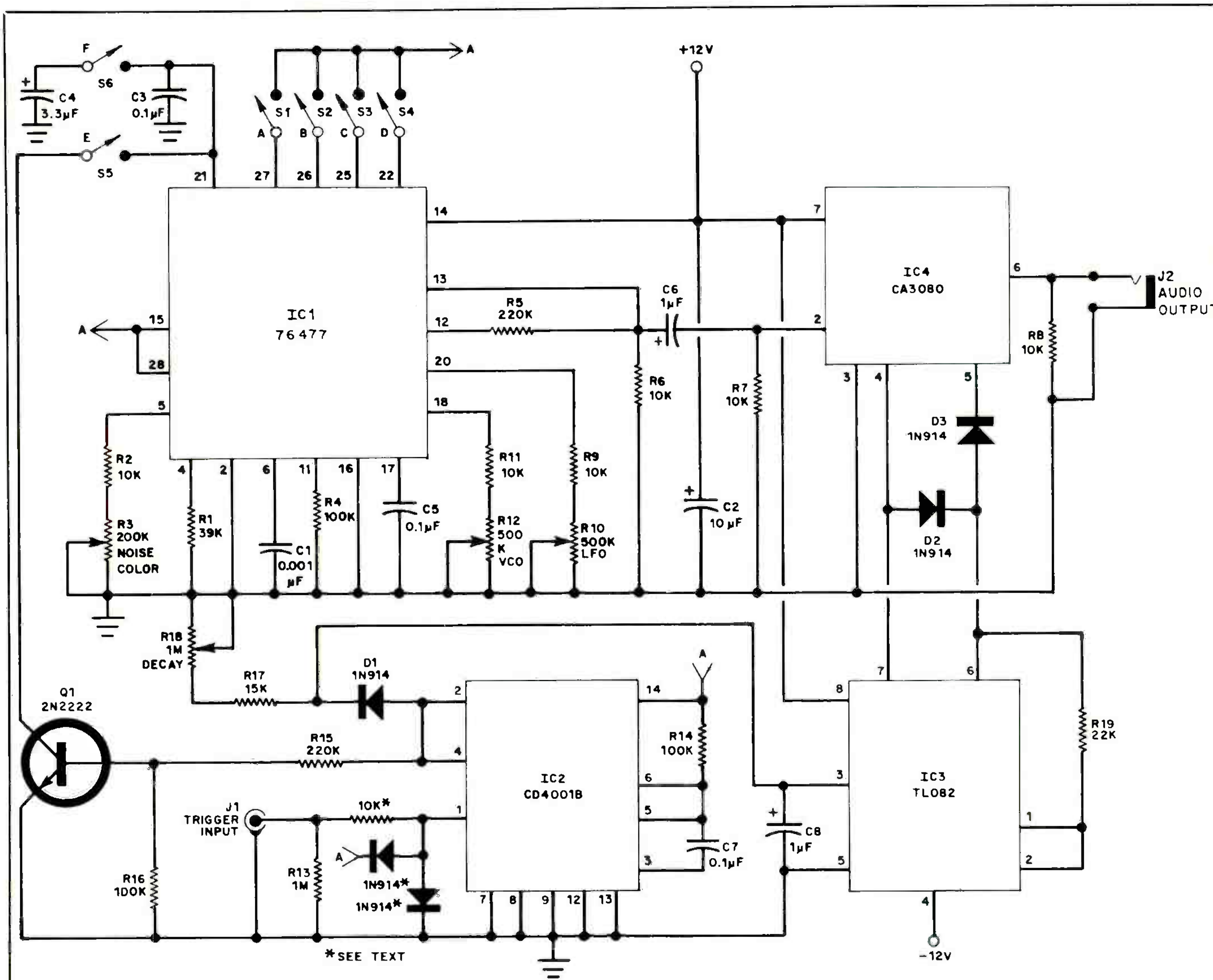
Electronically synthesized percussion has been a notable development in modern pop and rock music. This electronic equipment can be directly played by a drummer or be triggered by a programmable rhythm box or sequencer. Commercial synthesizers that use this technology are costly. But if you're willing to forego a bit of sound quality and control sophistication, you can get a useful taste of electronically produced percussive sounds by building our low-budget (about $20) Drum Synthesizer.

With this Drum Synthesizer, you can emulate the sound of a snare drum, tom-tom and gong, for example, while setting repeats and echoes. Quality is high enough for use in recording and other professional applications, though some people might find the sound quality to be a bit "tacky" when compared with a $2,000 synthesizer. But at a hundredth of the price of the commercial unit, one can easily adjust to a sound that's a bit "off-color" and even use it to advantage. On the plus side, our Drum Synthesizer offers some very interesting and useful sounds, different methods of triggering and expansion possibilities.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the Low-Budget Drum Synthesizer, minus its power supply. At the heart of the circuit is the *C1* 76477 complex sound generator (CSG) chip made by Texas Instruments. The 76477 was originally developed for generating video-game sounds and similar mischief, which accounts for the slight tackiness of its sound that some people find appealing. With a few additions, as we shall soon see, this chip can perform as a musical "instrument."

Contained within the 76477 CSG



PARTS LIST

Semiconductors
D1,D2,D3—1N914 diode
IC1—SN76477 complex sound generator (Texas Instruments)
IC2—CD4001B CMOS quad NOR gate
IC3—TL082 or LF353 dual JFET-input operational amplifier
IC4—CA3080 operational transconductance amplifier
Q1—2N2222 or similar general-purpose npn transistor

Capacitors
C1—0.001-μF disc
C2—10-μF, 15 volt electrolytic or tantalum
C3,C5,C7—0.1-μF polystyrene (preferred) or disc
C4—3.3-μF, 20-volt tantalum
C6,C8—1-μF, 20-volt tantalum

Resistors (¼-watt, 5% tolerance)
R1—39,000 ohms
R2,R6,R7,R8,R9,R11—10,000 ohms
R4,R14,R16—100,000 ohms
R5,R15—220,000 ohms
R13—1 megohm
R17—15,000 ohms
R19—22,000 ohms
R3—200,000-ohm linear-taper potentiometer
R10,R12—500,000-ohm linear-taper potentiometer
R18—1-megohm linear-taper potentiometer

Miscellaneous
J1—Phono jack
J2—Phone jack
S1 thru S6—Spst slide or toggle switch (or 6-position DIP switch; see text)
Printed-circuit board or perforated board and suitable Wire Wrap or soldering hardware; suitable enclosure; sockets for ICs; ±5- to ±12-volt power supply (see text); control knobs; normally-open, momentary-action spst pushbutton switch (see text); 10,000-ohm, ¼-watt, 5%-tolerance resistor and two 1N914 diodes (see text); lettering kit; clear spray acrylic; spacers, machine hardware; hookup wire; solder; etc.

Fig. 1. Schematic diagram of Drum Synthesizer minus power supply.

Sound Selection Code Table			
Switch			
A	B	C	Sound Selected
0	0	0	vco
0	0	1	noise
0	1	0	lfo
0	1	1	vco/noise
1	0	0	lfo/noise
1	0	1	lfo/vco
1	1	0	lfo/vco/noise
1	1	1	inhibit (no sound)

are two oscillators (one voltage controlled), a noise generator for sound sources, an envelope generator and an amplitude modulator. The last two are not useable in this application. However, by using other ICs to generate an envelope and process the output, you're rewarded with a wider range of envelope times, wider dynamic range and lower level of leakage when the sound is supposed to be off. Also contained on-chip is a precision regulator that outputs a stable +5 volts.

The various sounds are generated by *IC1*. NOISE COLOR control *R3* is used to set the bandwidth of the noise source to create sound effects ranging from wind to cannon-fire. Initial frequencies of the LFO (low-frequency oscillator) and VCO (variable-frequency oscillator) are set with *R10* and *R12*, respectively.

A few loose ends were left when the 76477 was put together. For example, although three pins are provided for selecting the various sounds, there isn't a separate specific pin one can use to enable a given source. Instead, a somewhat irrational code must be used, requiring that you perform some mental acrobatics whenever you want to change the sounds. These are summarized in Sound Selection Code Table.

Switches *S1*, *S2* and *S3* are used to select the desired sounds; *S4* applies the lfo to the vco for a variety of frequency-modulation effects; *S5* is used to synchronize the lfo to the trigger pulse; and *S6* places the lfo in either the audio or the subaudio range to increase the sound possibilities. Figure 2 shows one practical way to simplify selecting the sound sources. The nonshorting rotary switch and diode array make the different sound sources available at the twist of a knob. Note, though, that the "inhibit" function listed in the Table isn't available at any switch position setting.

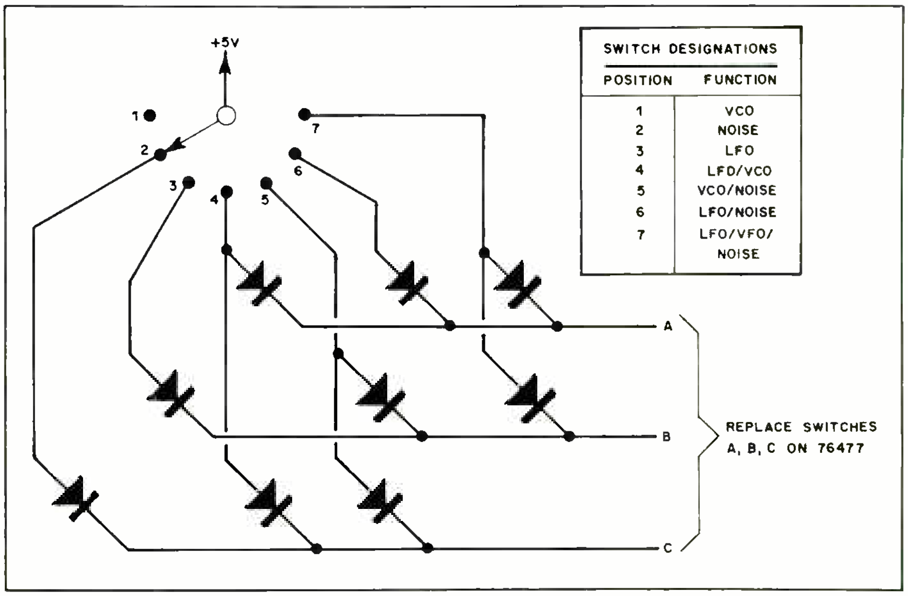
To activate a sound, a 5-volt TTL-level pulse is applied to the trigger input. Since the 76477 contains a 5-volt regulator for internal use, this can be accomplished with a momentary-action spst switch located between pin 5 of *IC1* and the TRIGGER INPUT. Of course, anything that puts out a pulse of the proper level can be used as a triggering source, including a rhythm box, a synthesizer and even a computer.

After *IC1* generates it, the signal is ready for envelope shaping by the vca (voltage-controlled amplifier) portion of the circuit. Applying a pulse to the TRIGGER INPUT at *J1* causes the monostable multivibrator circuit made up of gates in *IC2* to output a pulse of constant amplitude and duration to simplify interfacing requirements. This pulse is coupled through *D1* and charges *C8* with a positive voltage. As soon as this pulse ends, the capacitor discharges at a rate set by *R17* and DECAY control *R18*.

Note that a 10,000-ohm resistor and two 1N914 diodes in the pin 1 circuit protect *IC2* from damage due to excessive high positive pulses and negative trigger input voltages. Any input pulse greater than +5 volts causes the upper 1N914 to limit the input to +5 volts. Conversely, any input more negative than about 0.7 volt causes the lower diode to conduct the negative voltage away from *IC2*. You *must* install these components in the circuit unless you are certain that the trigger source outputs a safe pulse for the Drum Synthesizer.

Note also that only half the gates in *IC2* are used in a single Drum Synthesizer circuit. If you wish, you can add a second such circuit without

Fig. 2. Use this circuit to select the various sounds without having to remember selection codes listed in the Table. The lines labeled A, B and C go directly to pins 27, 26 and 25 of IC1, *eliminating* S1, S2 *and* S3.



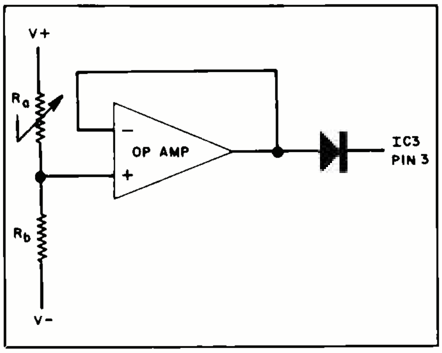


Fig. 3. A simple touch-sensitive envelope generator using a pressure-sensitive resistor (R_a) and op amp.

having to repeat *IC2* (if you do, make sure to add another 10,000-ohm series resistor and 5-volt shunt zener diode if needed). When building only one Drum Synthesizer, the inputs of the unused gates in *IC2* must be tied to either circuit ground (as shown) or to the positive supply line to assure stable circuit operation.

Because of the very high input impedance of *IC3*, the time it takes for the sound effect to fade out is variable over a wide range. The first amplifier in *IC3* buffers *C8*, the second drives operational transconductance amplifier (OTA) *IC4*. The CA3080 used for *IC4* functions as a vca with a high-level output that's directly proportional to the current flowing into pin 5. The audio output is taken from pin 6 for amplification and additional processing if desired.

Whenever *IC2* is triggered, the collector of *Q1* is briefly brought to ground. If *S5* is closed, this causes the lfo's timing capacitor to be reset. If the lfo is then used to control the pitch of the vco, it may produce the familiar synthesized drum sound used in so many recordings and shows.

If your Drum Synthesizer is to be played by a drummer, a touch-sensitive pad for dynamic control of the sounds becomes almost mandatory. The pressure-sensitive resistors discussed in Forrest M. Mims' November 1985 "Electronics Notebook" in *Modern Electronics* are ideal for this purpose. A circuit arrangment to produce this type of dynamic envelope is shown in Fig. 3. This circuit is built around a general-purpose operational amplifier, with R_a being the pressure sensor and R_b a fixed resistor whose value is the same as R_a when it is not touched. The R_a/R_b arrangement keeps unwanted offset voltages out of the main circuit's vca. The diode at the output of the op amp in the Fig. 3 circuit vca. The diode at the output of the op amp in the Fig. 3 circuit allows both the original trigger input and the touch-sensitive function to be used independently and simultaneously.

The Drum Synthesizer requires a bipolar power supply that can deliver between ±6 and ±12 volts dc. A typical ac-line-operated power supply is shown in Fig. 4. Since current drain is relatively low, the circuit can also be powered by a pair of 9-volt transistor batteries for portable operation, as shown in Fig. 5. Keep in mind, though, that the positive side of the supply, operating at a drain of 18 milliamperes, will run down at a much faster rate than will the negative side, which normally has a drain of only 3.5 milliamperes. The solution, of course, is to swap the batteries every few hours of playing the Drum Synthesizer to equalize power consumption and extend battery life.

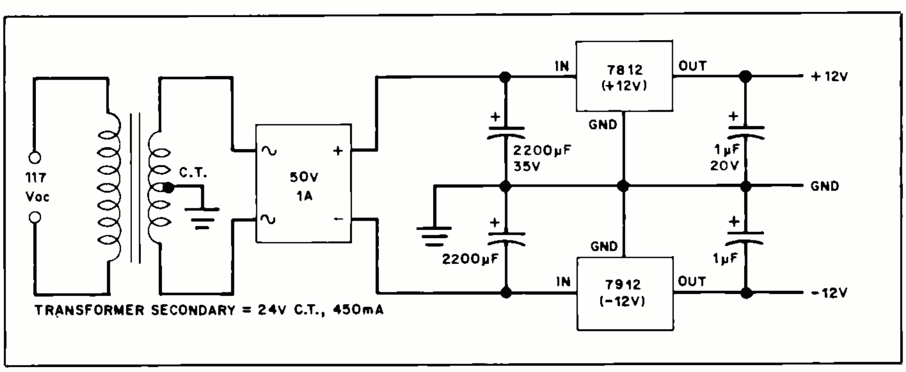
Construction

There's nothing critical about laying out and assembling the Drum Synthesizer circuitry. Hence, just about any traditional wiring approach can be used. If you feel ambitious, you can design and fabricate a printed-circuit board. Otherwise, use perforated board and Wire Wrap or soldering hardware. Whichever method you choose, a 4½" × 3" board should suffice for the main circuitry of a single Drum Synthesizer system, and a smaller board can be used to accommodate the power-supply circuitry. If you're planning on building more than one Drum Synthesizer into a single box, you can increase the size of the main board to accommodate the additional circuitry or use individual boards for each synthesizer module. It's a good idea to use sockets for all ICs.

Examining the prototype of the project shown in the lead photo, you will note that controls *R3*, *R10*, *R12* and *R13* are pc-type trimmers and switches *S1* through *S6* are all contained in a single 6-position DIP switch module. If you're planning on housing the project in an enclosure, it's much more convenient to use miniature or full-size panel-type potentiometers and toggle or slide switches for easy accessibility and convenient operation, especially if you're planning to build more than one synthesizer module into the box.

Wire the Fig. 1 circuitry as shown, leaving installation of the ICs until after you've powered up the project

Fig. 4. A typical ac power supply for the Drum Synthesizer.



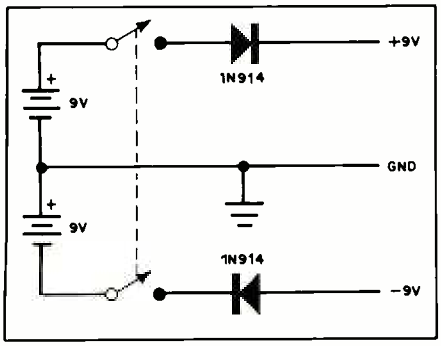


Fig. 5. Battery operation makes possible portable synthesizer operation.

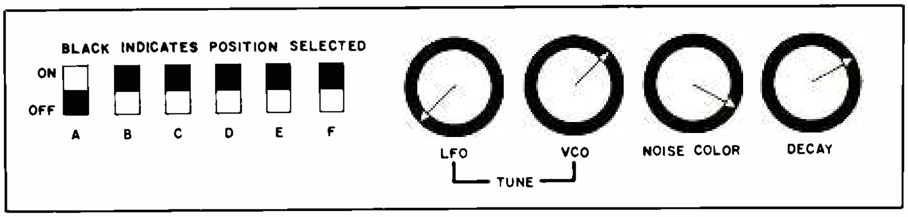


Fig. 6. Switch/control arrangement for initial testing of Drum Synthesizer that can be used to determine if all three sources are operating.

and checked for the correct voltages at the various power and ground pins of the IC sockets. Make sure that when you install them, the polarized capacitors and diodes are properly oriented and that the transistor's basing is correct before soldering. Also, when wiring the ac version of the power supply, make certain that you insulate all leads of the power transformer from all other points in the circuit and double check bridge rectifier, voltage regulator and electrolytic capacitor orientations before soldering.

If you're planning on incorporating the touch-sensitive option in your Drum Synthesizer, install its circuitry on the Synthesizer's board and wire it into the main circuitry. The cathode of the Fig. 3 circuit goes directly to pin 3 of *IC3* and the free end of R_b goes to the negative power supply line. Touch switch R_b connects to the op amp's noninverting (+) input via a panel jack whose other contact goes to the positive supply line. Use and *insulated* jack for this circuit.

When the circuitry is completely wired (ICs still not installed in their sockets), connect the Drum Synthesizer and power supply modules together as detailed in Fig. 1. Turn on the power and connect the negative or common lead of a multimeter to circuit ground. Set the meter to dc volts and measure the voltage at pin 14 of *IC1*, pin 8 of *IC2* and pin 7 of *IC3*. You should obtain about +12 volts (or approximately the positive voltage of whatever other power supply you're using) at all three points. Without moving the common lead of the meter from ground, measure the voltage at pin 4 of *IC3*. This should be about −12 volts (or whatever negative voltage your power supply is putting out).

If you obtain the appropriate readings, power down the Drum Synthesizer and allow the charges to bleed off the capacitors. Then install the ICs in their respective sockets, making sure each is properly oriented before pushing it home. Practice safe handling procedures when installing the ICs to prevent damaging them with static electricity.

Select an enclosure large enough to accommodate the Drum Synthesizer and power supply modules, with plenty of room left over for the controls, switches, jacks and ac line cord if you're using an ac power supply or a pair of battery holders if you're using an ac power supply or a pair of battery holders if you're using a battery supply. Machine the box's front panel so that the switches and controls for a single synthesizer circuit all mount in a single line across the panel (see Fig. 6 for a typical panel layout). Then drill holes through the rear panel for *J1* and *J2* and for either the ac power cord or the battery holders and in the floor of the enclosure for mounting the synthesizer and power supply boards. If you're building more than one synthesizer module into the box, make accommodations for the additional holes needed for their controls, switches and jacks.

If you've decided to use the touch-switch option, drill a suitably sized hole for its jack through the rear panel. *Caution*: One side of this jack goes directly to the +12-volt power supply line. Therefore, it is essential that this jack be fully insulated from every portion of the circuit—including case and circuit ground—and that there is no possibility that it can be confused with the TRIGGER INPUT and/or AUDIO OUTPUT jacks. Therefore, it's best to use a plug/jack arrangement other than the phono type for the TRIGGER INPUT and phone type for the AUDIO OUTPUT.

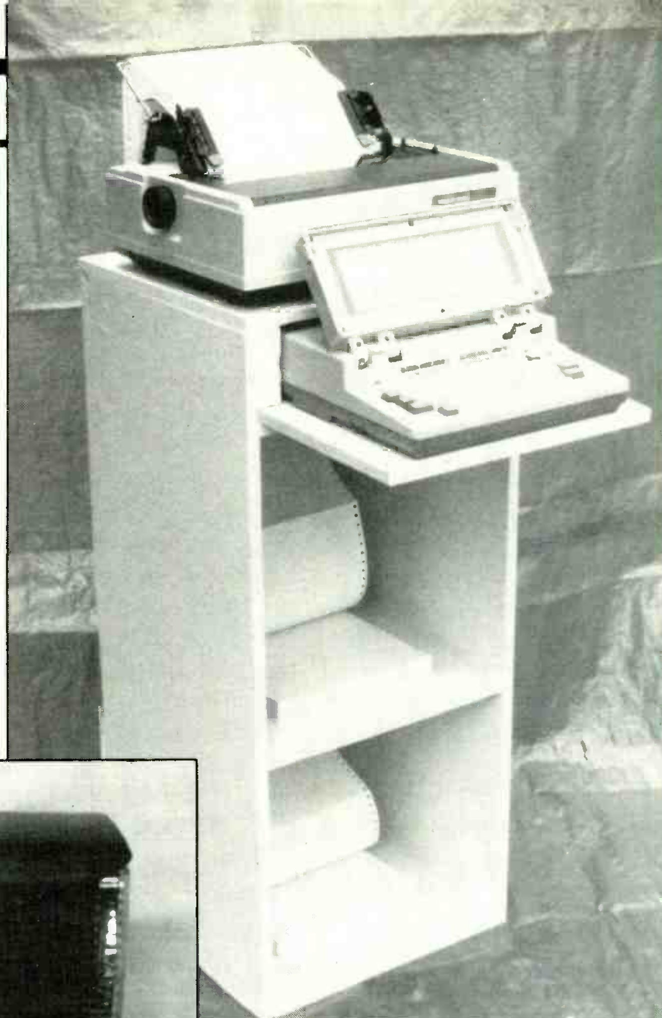
After machining the enclosure, deburr all holes. If you're using a raw aluminum box, thoroughly clean it with soapy steel wool and label the front and rear panels with the appropriate legends. (Figure 6 shows a typical panel arrangment for one Drum Synthesizer circuit.) If you use a dry-transfer lettering kit, label the panels as soon as the box is dry and then spray three *light* coats of clear acrylic over all exterior surfaces, waiting until each coat is dry before spraying on the next, to protect the lettering. If you're using a tape labeler, spray on the acrylic first and apply the labels after the acrylic has completely dried.

Mount the switches, controls and jacks in their respective locations, line the ac power cord hole with a rubber grommet, and mount the circuit boards with ½" spacers and machine hardware. Referring to Fig. 1, wire the controls, switches and *J1* and *J2* into the circuit. If you've incorporated the touch-pad into your

(Continued on page 86)

Laptop Computer Enhancements

Ideas to relieve the special woes often faced when using a laptop computer



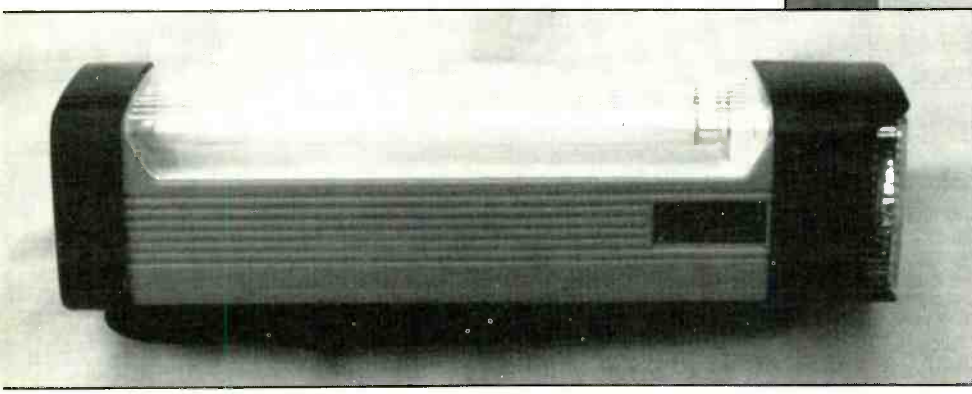


Fig. 1. The three-way lamp before conversion.

By Brent Gloege

Radio Shack, NEC and Epson led the way with portable laptop computers. Now a bevy of other manufacturers offer such machines. Laptops, however, often pose several special problems. If you are one of the increasing number of people who owns one, here are a few project "fixes" that will make life with your portable computer more enjoyable.

Battery-Powered Fluorescent Lamp

Most laptop computers have liquid-crystal-display (LCD) screens which are not "backlit"—they require good lighting to read what's on the screen. Since you have gone to the trouble of buying a computer that frees you from a cord, it would be a shame to tie yourself down with a lampcord whenever the lighting is inadequate. However, you can overcome such a problem by building a battery-powered fluorescent light to provide smooth, even illumination for your LCD screen. It's built from a widely available style of fluorescent lantern. A few simple alterations will convert this battery-operated light into a gooseneck lamp that you can take with you whenever you need portable light for your computer.

The particular flashlight you need for this project is a three-way type that has a 9″-long fluorescent tube. A typical example of such a light is the Sears Stock No. 4823, but any similar model from another source will do as well. You will also need an old "high-intensity" gooseneck desk lamp. The gooseneck on this lamp should be about 14″ long and ½″ in diameter. Whether or not the gooseneck lamp works does not matter, since all you want from it is the gooseneck portion. If you do not have such a lamp lying around, you can probably pick one up inexpensively at a local thrift shop or flea market.

Begin modifying the flashlight by removing the two end caps and all the circuitry not related to the fluorescent part. (See Fig. 1 for the three-way lamp before conversion.) What you will be removing are the incandescent circuitry, the flasher for the incandescent lamp and the built-in

Fig. 2. The finished gooseneck fluorescent lamp.

buzzer and its circuitry, if it has the last. Remove the fluorescent tube, its holder and its reflector assembly. Cut the wires that connect this section to the circuitry inside the flashlight, taking careful note of which wires were cut from each point. The fluorescent tube/holder/reflector assembly will become the top of your portable lamp.

Disassemble the gooseneck lamp. However, do not remove the wiring that routes through the gooseneck to the lamp socket. Prepare about 24″ of light-duty lamp cord by stripping away ⅜″ of insulation from both conductors at both ends. Tightly twist together the fine wires in each conductor and sparingly tin with solder. Securely tape one end of this lamp cord to the lamp-socket end of the wire in the gooseneck and carefully pull on the other end of the original lamp cord until the new lamp cord protrudes from both ends of the gooseneck. Remove the tape and set aside the original lamp cord.

Drill a hole in the center of the fluorescent tube's reflector. Make this hole large enough to accommodate the threaded part of the gooseneck. Secure the gooseneck in place with the nut that originally held it in place on the lamp.

Now drill the same size hole in the clear plastic lens that covers the fluorescent tube and fasten to it the other end of the gooseneck with the other nut you removed during disassembly. Solder the other ends of the new lamp cord to the points in the flashlight circuit from which you clipped the wires coming from the fluorescent fixture. Snap the lens cover back in place and replace the end caps. The finished battery-powered fluorescent light is shown in Fig. 2.

If you wish, the extra positions on the flashlight switch can be used as "safety" positions to prevent the light from being turned on accidentally. Just be sure to disconnect from the switch any unused wires, since some of the flasher circuitry, if powered, can slowly drain the battery, even with the incandescent lamp removed, if it is left in the flashlight.

If you plan to use rechargeable nickel-cadmium cells to power your portable lamp, you may discover that they provide too low a voltage for proper operation. This is because the Ni-Cd battery outputs only 1.2 volts per cell, as opposed to the 1.5 volts obtainable from ordinary carbon-zinc and high-energy alkaline cells. With six Ni-Cd cells in the lamp, only 7.2 volts (6×1.2 volts) is available to power a system designed to operate from a 9-volt dc source. To compensate for the lower voltage, you can replace the end cap that held the incandescent lamp with a two-cell D-type battery holder. These battery holders are almost the same size as the end caps and, thus, are easy to install.

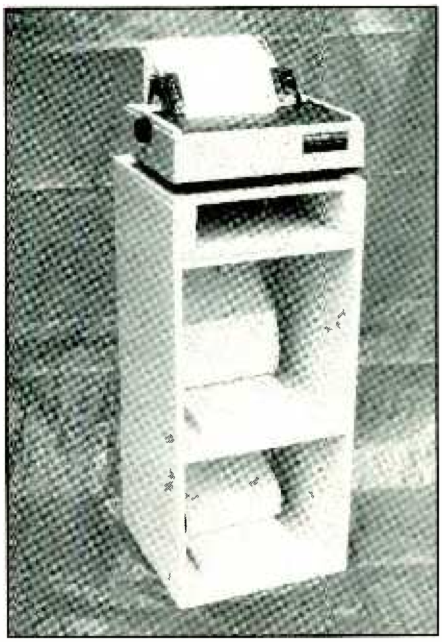


Fig. 3. Front view of the laptop printer stand.

Bring the wires from the battery holder through the rear of the assembly and cement the holder, battery opening side out, to the end of the flashlight housing. Break the connection leading from the original battery compartment to the lamp circuitry and wire the two-cell holder in series with it. With this modification, you can use eight D-size Ni-Cd cells, which now gives you $8 \times 1.2 = 9.6$ volts, which is almost perfect to drive the fluorescent lamp.

A Versatile Printer/Work Stand

Most desktop computers are left connected to their printers, with the latter usually on its own stand. With the laptop computer, however, your lap is your "desk" and has no room for a printer. Hence, there is no need for a special stand for your laptop computer—except when you want a printout of your work. Our second project is a printer stand designed just for the laptop computer owner. It's relatively inexpensive to build.

Because it is designed for use with your laptop computer, the printer stand shown in Fig. 3 has several features not found in other printer stands. For example, it has a special pull-out shelf for your laptop computer. With the shelf pushed in, your laptop computer is stowed safely out of the way. Pull out the shelf, flip up your computer's case top/display screen, and you are ready to print. If you make the printer stand so that

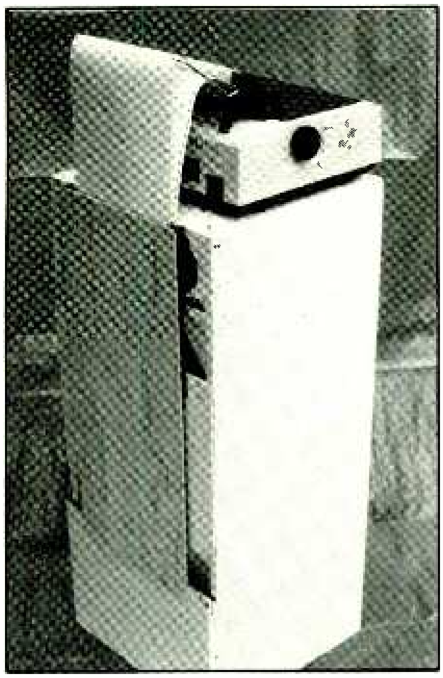


Fig. 4. Rear view of printer stand. Paper is guided back under supply paper by way of a "chute."

the shelf is at the proper height, you can even use it as a work desk for your computer if you wish to compute at home or in your office where the printer stand is located. For this application, you would want the shelf to be positioned so that the computer's keyboard is between 27″ and 30″ from the floor. This height leaves room below the computer shelf for separate shelves for a carton of printer paper and the paper-return.

In keeping with the streamlined dimensions of the laptop computer, our printer stand has a slimmer profile than most similar stands on the market. In fact, it need be no more than 3″ wider and only about 6″ deeper than your laptop computer. This takes into account the thickness of the stand's walls, maneuvering room on both sides and the rear of the computer and the 11½″ depth of a carton of printer paper.

With the typical laptop computer measuring only about 12″ to 13″ wide by 9″ or so deep, your printer stand need be only 16″ maximum in width and 16″ deep. The extra depth allows the shelf to be pulled out far enough for the computer's display panel to be flipped to the operating position while still retaining a good 5″ of the shelf inside the slot for rigidity. Of course, if your printer is wider and/or deeper than this, minimum stand width and depth will be limited more by the footprint of your printer than by the dimensions of your computer.

A slimmer profile is achieved mainly by guiding the return paper back under the supply paper (see Fig. 4), rather than having it drop directly behind the stand as most printer stands do. A thin "chute" on the rear of the stand guides the return paper to the lowest shelf, allowing it to fan-fold in the normal manner, without requiring 6″ or more space to be left between the stand and the wall behind it as would normally be the case.

Fabrication of the printer stand is quite easy and lets you use a choice of materials. You can use either ½″ or ¾″ plywood or "furniture-grade" particle board for the sides, shelves and upper rear panel. The lower chute panel can be ¼″ plywood or Masonite or even heavy Bainbridge board if you desire.

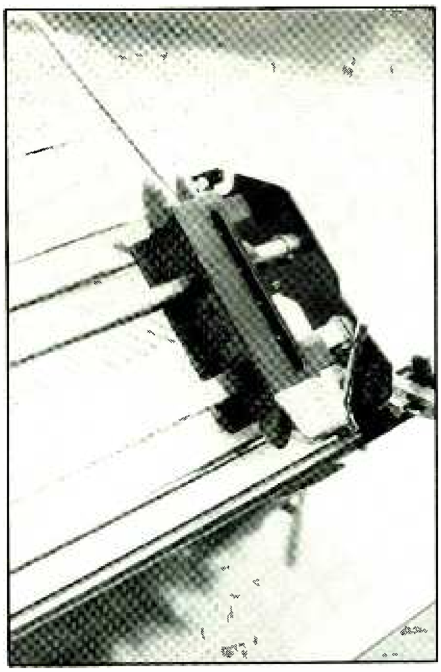


Fig. 5. Epoxy putty adds paper guides to printer tractor feed for smoother paper handling.

All panels for the stand can be cut from a single sheet of plywood or particle board. Lay out on the board all panels and carefully cut to size. If you have a power router, you can make fitted joints that allow you to assemble the entire stand with wood glue and just a few finishing nails. Otherwise, you may have to butt-join the panels and use woodscrews and perhaps even bracing hardware. Devise some means for preventing the computer shelf from pulling completely out of the stand. If you do not fit the chute to the rear of the stand in a routed slot, use thin lumber and nails or L brackets and short screws to anchor it at an angle that will assure smooth paper feed.

Finish the printer stand by sanding all surfaces smooth. If you use open-grain plywood or particle board, cover all surfaces with a thin layer of DAP. When the DAP is completely dry (allow 24 hours or more for this), lightly sand smooth and wipe away all dust. Then either spray or brush on an enamel paint in your choice of color. Apply at least two coats of paint to assure a smooth finish, allowing each coat to fully dry before applying the next and rubbing down with fine steel wool between coats.

Printer Tractor

If you are like most laptop computer owners, you use your machine heavily for writing purposes. When you print out your work, it's nice to have a "letter-quality" appearance. Rather than feeding in separate sheets of typing paper one at a time, you'll likely want to use a tractor feed with your printer and the newer "clean-perforated" paper. The latter, when separated, does not have the serrated edges that immediately identifies ordinary fan-fold computer paper. However, this type of paper has a disadvantage—its fine perforations are more fragile than those of ordinary paper. Sometimes, the perforations partially separate and cause the printer's tractor to jam. If you find this happening with your printer, there is an easy fix, as follows.

As you are printing out a multiple-page document, carefully monitor the paper's travel through the tractor to determine just where the binding that causes jamming occurs. You will probably discover that the paper is not being properly routed into the tractor pins. By using epoxy putty to mold paper guides, as shown here, you can fix things so that the tractor handles so-called "clean-perf" paper without a hitch.

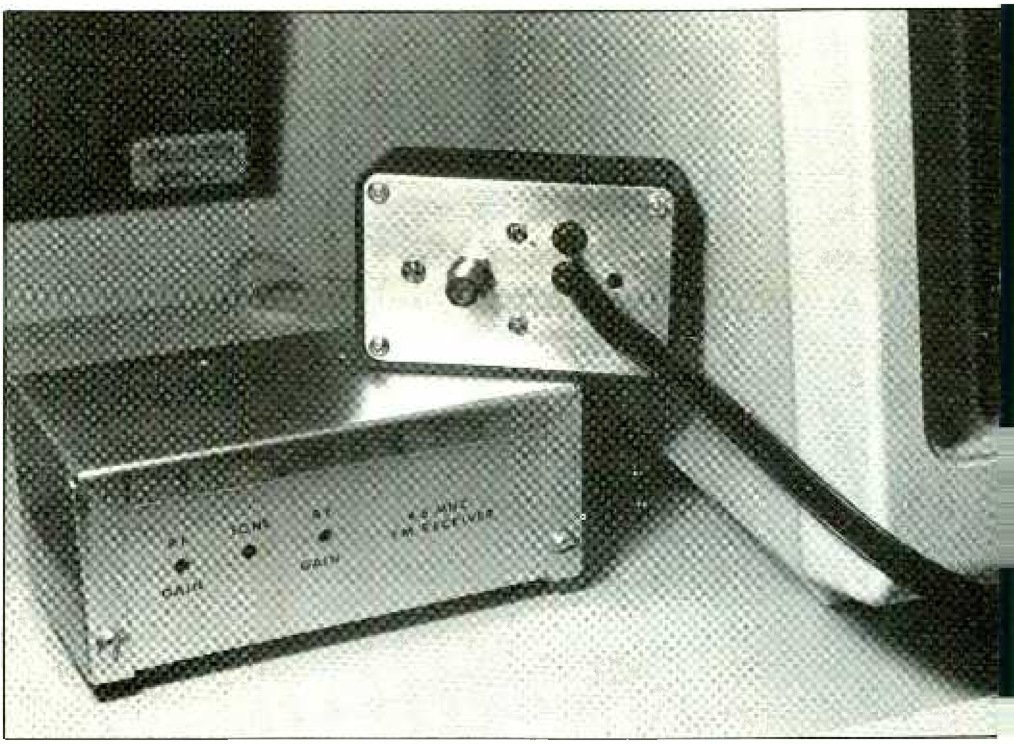
As you observe the paper's travel, be especially careful to look for and fill in any snags that occur in the paper's path.

Once you apply the epoxy putty, allow it to set for at least 24 hours. At the end of this period, run the paper through the tractor again while observing how it behaves. It will probably take you two or three tries to catch and rectify all the snags. The effort is worth it, though, because when you are done, you will have a printer that can be left unattended as it flawlessly churns out page after page of copy. **ME**

A 4.5-MHz FM Receiving System

This simple system picks up sound from TV receivers and other sources that have 4.5-MHz signals and delivers an amplified output suitable for driving an audio amplifier

By Duane M. Perkins



The FM receiver to be described has many possible uses. It can pick up sound from your TV set or any other source with a 4.5-MHz sound carrier. It also makes a perfect companion for the cable communications receiver described in the September 1985 issue of *Modern Electronics*. The output of that receiver includes the 4.5-MHz audio carrier, which will be amplified and demodulated by the receiver described here. The two units working together could be used to extract the video and audio signals from a personal computer to drive a video display monitor.

Our 4.5-MHz FM Receiver is a complete stand-alone system. It even includes its own built-in ac power supply. You can hard-wire the Receiver's input directly to the signal source. Alternatively, you can build and use an optional inductive pickup unit that eliminates hard wiring.

About the Circuit

Shown in Fig. 1 is the schematic diagram of the 4.5-MHz Receiver minus its ac power supply. The MC1350 i-f amplifier (*IC1*) boosts the level of the input signal applied to the circuit through *J1*. Thereafter, the MC1358 FM receiver (*IC2*) provides additional amplification, limiting, detection and audio amplification. The large amount of amplification provided makes the receiver very sensitive. Therefore, RF GAIN control *R3* is included to permit operation over a wide range of input signal levels.

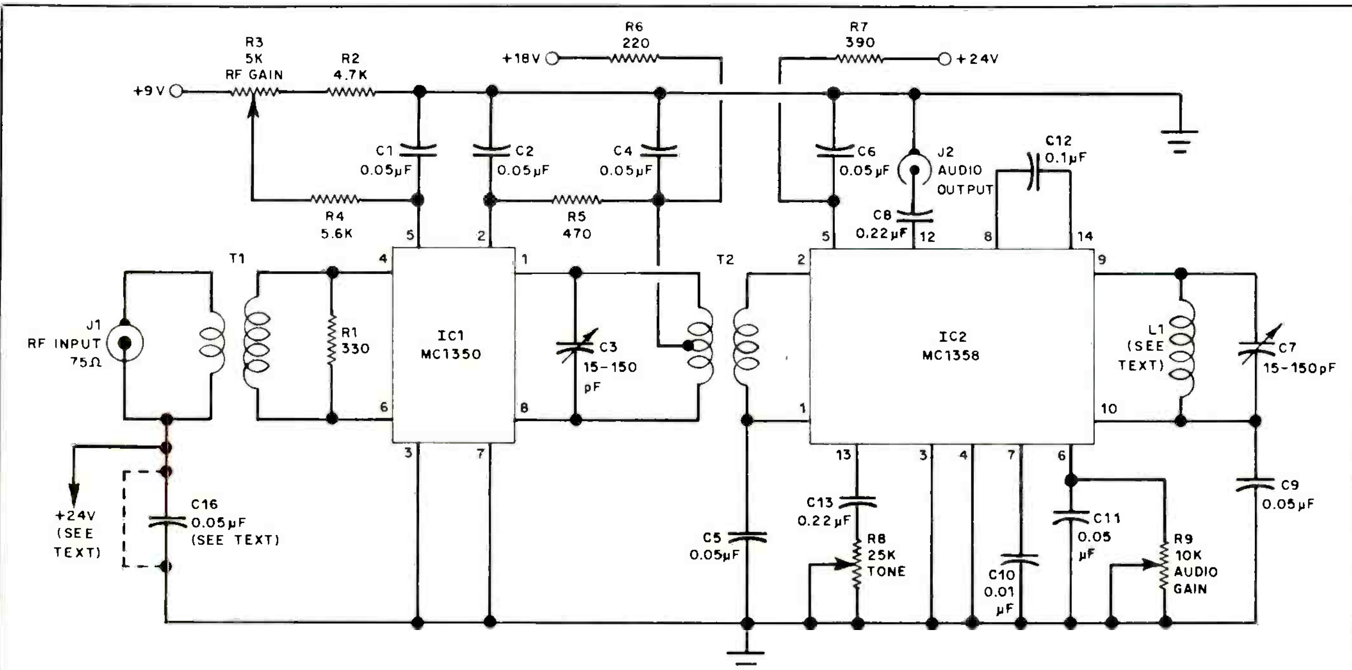
Receiver input impedance is 75 ohms with the 330-ohm value specified for *R1* to match RG-59/U coaxial cable. If you prefer a 50-ohm input to match RG-58/U coax, you must change *R1* to 220 ohms.

Transformer *T1* supplies a differential input to *IC1*. The output to the tuned primary of *T2* is coupled to the input of *IC2*. Trimmer *R3* permits adjustment of the signal level for proper limiting action by *IC2*.

Resonant circuit *L1/C7* must be tuned to the carrier frequency. The deemphasis needed to compensate for the standard 75-microsecond preemphasis of FM radio and TV sound is provided by *C10*. If the output of the receiver, at *J2*, is coupled to a stereo adapter, or the receiver is used to detect signals that have no preemphasis, the value of *C10* must be changed to 0.001 microfarad.

Audio output from the receiver can be taken from pin 8 rather than from pin 12 of *IC2* if additional amplification isn't needed. AUDIO GAIN trimmer *R9* controls an electronic attenuator that increases output signal level as its resistance is reduced. TONE control *R8/C13* doesn't affect the output from pin 8 and can be omitted if it's not needed.

Output signal level from pin 12 of



RECEIVER PARTS LIST

Semiconductors
D1,D2—12-volt zener diode
D3,D4—9-volt zener diode
IC1—MC1350 i-f amplifier (Motorola)
IC2—MC1358 FM receiver (Motorola)
RECT1—VM08 bridge rectifier
Capacitors
C1,C2,C4,C5,C6,C9,C11,C16—0.05-μF disc
C3,C7—15-to-150-pF trimmer
C8,C13—0.22-μF disc or Mylar
C10—0.01-μF disc
C12—0.1-μF disc
C14—2,200-μF, 35-volt electrolytic
C15—220-μF, 35-volt electrolytic
Resistors (½-watt, 5% tolerance)
R1,R10—330 ohms
R2—4,700 ohms
R4—5,600 ohms
R5,R11—470 ohms
R6—220 ohms
R7—390 ohms
R12—560 ohms
R3—5,000-ohm pc-type trimmer potentiometer
R8—25,000-ohm pc-type trimmer potentiometer
R9—10,000-ohm pc-type trimmer potentiometer
Miscellaneous
J1—F-61 chassis-mount male coaxial connector
J2—Shielded phono jack
L1—20-μH choke (wound on 10-μH choke—see text)
T1,T2—See text
T3—25.2-volt, 300-mA power transformer (Radio Shack Cat. No. 273-1386 or equivalent)
Printed-circuit board; aluminum chassis box (Radio Shack Cat. No. 270-238); sockets for ICs (optional); 26-gauge magnet wire; ac line cord with plug; rubber grommet; rubber feet; labeling kit; clear acrylic spray; machine hardware; hookup wire; solder; etc.

Fig. 1. Receiver schematic diagram minus power supply.

IC2 is sufficient to drive a low-power audio output stage. It can be connected directly to the base of the power transistor to provide both bias current and signal current (use an emitter resistor to limit the current). Dc blocking for those applications that require it is provided by *C8*.

Figure 2 is the schematic diagram of the ac power supply for the receiver. Shunt regulation using zener diodes *D1* through *D4* is adequate for this project. This supply is almost identical to that used in the Cable Communications System featured in the September 1985 issue. So both receivers can be housed inside the same enclosure and can share a common power supply. If you do this, make sure that you upgrade the power transformer secondary's current rating to 450 milliamperes to handle the drain of the additional circuitry. Also, use the Cable Communications System's regulator to obtain the +9 and +18 volts required by the 4.5-MHz FM Receiver.

Input signals to the 4.5-MHz Receiver can be supplied through a coaxial cable feed wired directly into the source. The optional pickup unit shown in Fig. 3 can be used to inductively couple the signal from the source into the receiver, obviating the need for direct connection.

The pickup unit goes between the

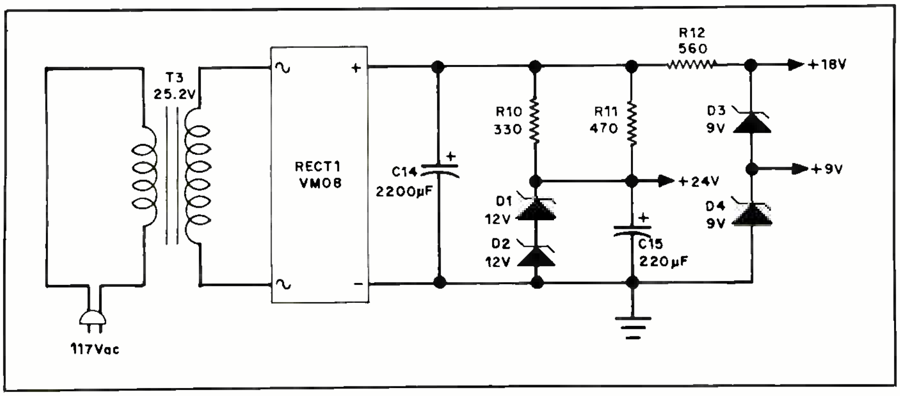


Fig. 2. Ac power supply schematic diagram.

signal source and receiver, where it serves as a high-impedance front end for the latter. It's simply a broadband voltage follower that reduces the impedance to match the receiver's input. The output can be connected to the receiver through RG-59/U cable. It's best to locate the pickup unit near the signal source. The coax both supplies power from the receiver to the pickup unit and carries the signal from the pickup unit to the receiver.

The relatively high impedance of *L2* prevents shunting of the output signal to ground while permitting dc to flow to the collector of *Q1*. Placing inductive pickup *L1* near a coil or transformer in the signal source couples the signal through *C1* into the base of *Q1*.

Construction

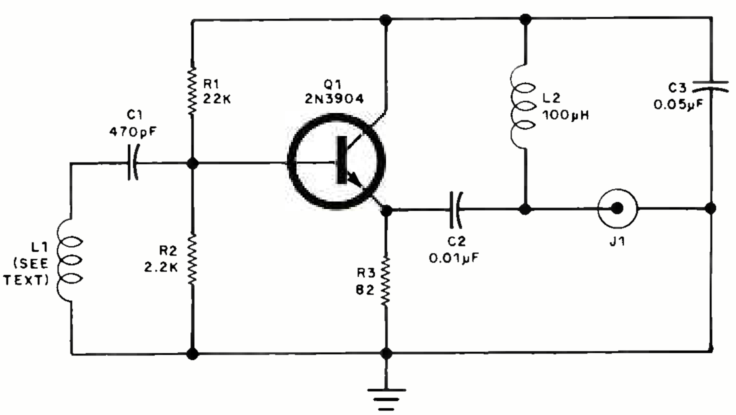
The coil and transformers in the receiver are nonstandard components that are easily home-fabricated using readily available standard r-f coils as cores on which you wind additional turns of 26-gauge magnet wire. For *T1*, you use the existing turns of a 100-microhenry choke as the secondary, while for *T2* and *L1* you use 10-microhenry chokes.

Starting with *T1*, count the number of turns in the existing 100-microhenry choke. To obtain the number of turns you must wind, divide by 2 the number of turns counted. To calculate the number of turns needed for the windings of *T2* and *L1*, first count the number of turns on the existing 10-microhenry chokes and multiply by 1.4. Round off the result to the nearest *even* number of turns. For *T2*, divide the result by 2 to determine where to make the center tap.

Use strips of perforated board as supports for *T1* and *T2*. Make the strips long enough for the existing leads to fit through the end holes. Add short lengths of heavy solid wire to serve as leads for the primary windings of the transformers.

Wrap the 100-microhenry choke with plastic tape and wind the primary turns over this. Scrape ¼" of enamel from the ends of the magnet wire, tin with solder and solder them to the added leads. Strip the existing windings off the 10-microhenry chokes and rewind them with the number of turns calculated above. Solder the ends to the existing leads and spray each reworked choke with clear acrylic.

Wrap a layer of plastic tape over the windings of one of the reworked chokes. Over the tape, wind the number of turns of magnet wire calculated for the primary of *T2*. Keep in mind that each half of this center-tapped winding consists of half as many turns as there are in the secondary winding. Scrape ¼" of enamel from the ends and center tap of this



PICKUP UNIT PARTS LIST

C1—470-pF disc capacitor
C2—0.01-µF disc capacitor
C3— 0.05-µF disc capacitor
J1—F-61 chassis-mount male coaxial connector
L1—Pickup coil (see text)
L2—100-µH choke
Q1—2N3904 or equivalent transistor
R1—22,000-ohm, ½-watt, 5%-tolerance resistor
R2—2,200-ohm, ½-watt, 5%-tolerance resistor
R3—82-ohm, ½-watt, 5%-tolerance resistor
Misc.—Printed-circuit board; suitable metal enclosure (Radio Shack Cat. No. 270-230 or similar); 300-ohm twinlead cable; small rubber grommets (2); ½" spacers (2); machine hardware; hookup wire; solder; etc.

Fig. 3. Schematic diagram of optional pickup unit.

winding, tin the exposed wires with solder and solder to the carrier leads. Spray the windings of the coil and both transformers once again with a light coat of clear acrylic.

The receiver (and optional pickup unit, if used) is best assembled on a printed-circuit board, but you can use perforated board and suitable soldering hardware if you prefer. In either case, it's a good idea to use sockets for the ICs. If you decide on pc wiring, use the actual-size etching-and-drilling guides given in Fig. 4 to fabricate one or both boards.

After drilling the etched receiver board, plug *T3* into it and mark on the board its tab hole locations. Drill a 5/32" hole at both marked locations and a third hole midway between the two long edges and about ¼" in from the short edge at the opposite end of the board.

Set the board, centered all around, on the floor of the bottom half of the aluminum chassis box that is to house the receiver. Mark on the box the locations of the three board mounting holes. Remove and set aside the board. Drill 5/32" holes at all three locations.

Wire the receiver pc board as shown at the left in Fig. 5, except do *not* plug the ICs into their sockets if you are using them. (If you use perforated board instead of a pc board, use Fig. 5 as a rough guide to component layout.) Pay careful attention to the orientations of the electrolytic capacitors, bridge rectifier, diodes and ICs (or their sockets) before soldering them into place.

Place *C14* and *C15* side by side with the + lead of one near the − lead of the other and tape them together. With *C15* on top, plug *C14*'s leads into the appropriate holes in the board (observe polarity) and solder them into place. Repeat for the leads on *C15*.

Be especially careful to install *T3* in the proper direction, and don't forget to install the insulated-wire jumpers. Note that the long jumper shown dashed in Fig. 5 is needed only if you use the optional pickup unit. Also, *C16* is needed only if your application requires dc blocking at the input. Otherwise, replace *C16* with a wire jumper. If you're using perforated-board construction, keep *T1*, *T2* and *L1* widely separated to avoid feedback that can result in oscillation.

Trim ¼" of insulation from both ends of a 2"-long piece of stranded hookup wire. Twist together the conductors at both ends and tin with solder. Loop one end through the eyelet hole in a No. 6 ground lug and solder. Plug the other end of the wire into the hole labeled SHIELD GROUND in Fig. 5 and solder into place.

Voltage Checkout Table

Measurement Point	Expected Voltage*
D1 cathode	24
D3 cathode	18
D2 cathode	12
D4 cathode	9
IC1 pins 1 and 8	16
IC2 pin 5	12
IC1 pin 2	12
IC2 pin 7	7
IC2 pins 8 and 13	6.5
IC2 pin 12	6
IC1 pin 5	5.5 to 7 (as R3 is rotated)
IC2 pins 9 and 10	4.5
IC1 pins 4 and 6	4
IC2 pin 6	3 (with R9 wiper at ground)
IC2 pins 1 and 2	2
IC2 pin 14	1.5

*All voltages are positive with reference to circuit ground.

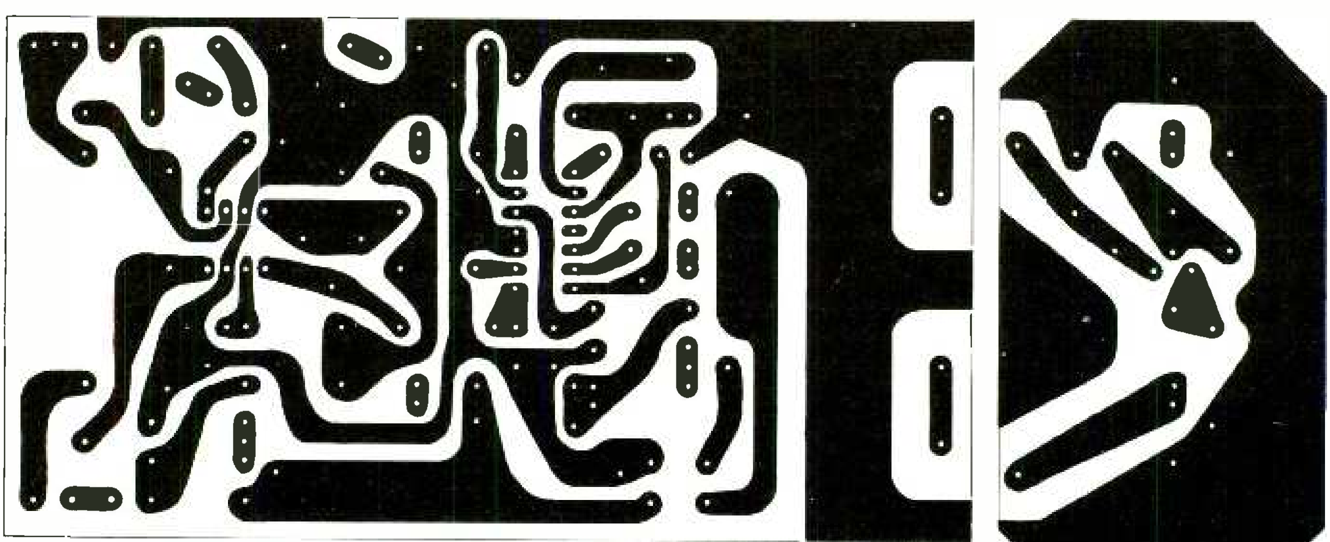


Fig. 4. Actual-size etching-and-drilling guides for receiver/power supply and pickup unit, shown at left and right, respectively.

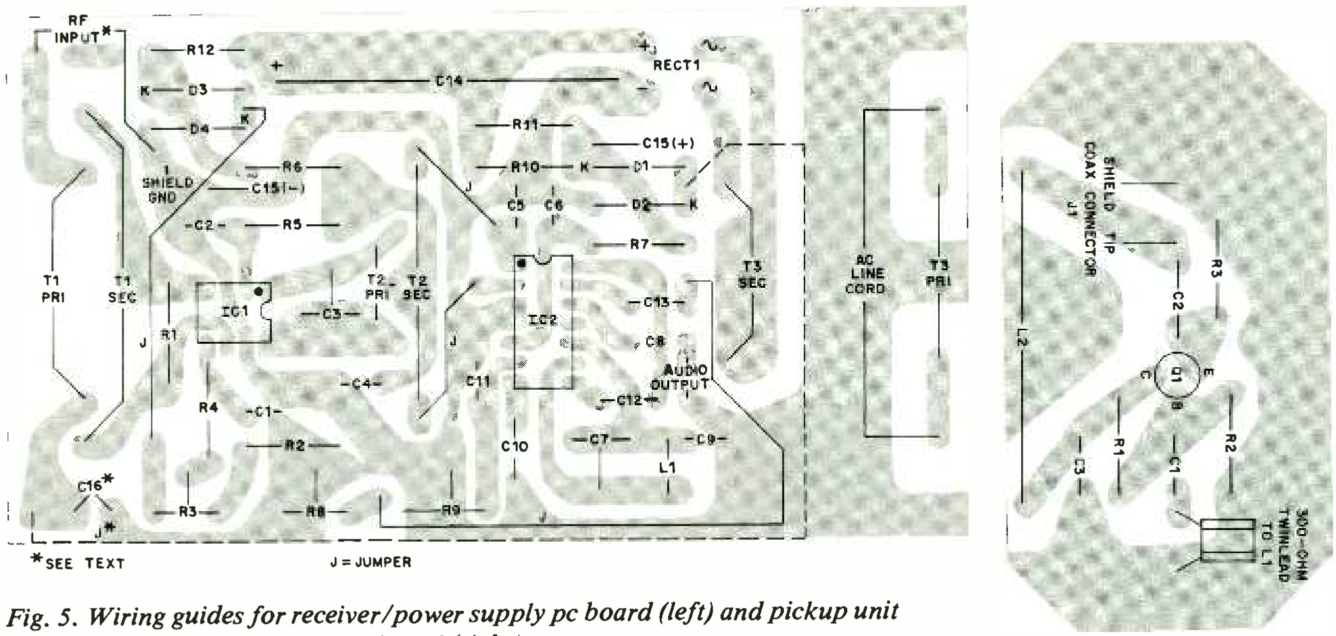


Fig. 5. Wiring guides for receiver/power supply pc board (left) and pickup unit board (right).

Although it may not be absolutely necessary, it's a good idea to enclose *T1* inside a shield. Make the shield from thin sheet aluminum stock that, when cut to size and bent to shape, forms an oblong box that fits over the entire transformer assembly. Include mounting tabs when cutting the aluminum stock. When mounting the shield over *T1*, use the tabs to hold it in place, and ground it via the solder lug attached to the wire coming from the board with machine hardware. Drill holes in the board for the tabs as needed. The shield secures to the board simply by bending the tabs. Make sure the tabs do not touch any part of the circuit except ground.

Loosely mount the circuit board assembly in the bottom half of the aluminum box, using ½″ spacers and machine hardware. Carefully mark the locations of the adjustment slots for the trimmer controls on the front panel and the holes for the line cord, *J1* and *J2* on the rear panel. Remove and set aside the circuit board assembly. Drill suitably sized holes in the marked locations. Deburr all holes. Then thoroughly clean all exterior surfaces with steel wool.

When the box is dry, use a dry-transfer lettering kit to label the *J1* and *J2* holes RF INPUT and AUDIO OUTPUT, respectively, and the holes in the front panel RF GAIN, TONE and AUDIO GAIN from left to right. You might also want to label the front panel with the identification of the project, such as 4.5-MHz FM RECEIVER. Then spray three *light* coats of clear acrylic on all exterior surfaces of this half of the box, allowing each coat to dry before spraying on the next, to protect the lettering. If you're using a tape labeler, spray the box first; when the acrylic has completely dried, apply the labels.

Line the ac cord hole with a small rubber grommet and mount *J1* and *J2* in their respective holes. Pass the line cord through the rubber grommet into the box and tie a knot in it 4″ from the inside end. Twist together the wires in each conductor and lightly tin with solder. Plug the conductors into the board holes labeled AC LINE CORD and solder.

Remove from both ends of a 4″ shielded audio cable ¾″ of outer plastic jacket, peel or separate the exposed shield back to the jacket, and trim ¼″ of insulation from the inner conductor. Twist together the wires at both ends of the shield and inner conductor and tin with solder. Plug one end of this cable into the holes labeled AUDIO OUTPUT (inner conductor to the pad that goes to *C8*) and solder into place.

Remove ¼″ of insulation from both ends of two 3″ hookup wires. Plug one end of these wires into the holes labeled RF INPUT and solder.

Mount the circuit board assembly in the box with the spacers and machine hardware. Locate the shielded audio cable and connect and solder the free inner conductor to the tip lug and the shield to the ground lug on *J2*. Then connect and solder the RF INPUT wire nearest the edge of the board to the tip lug and the other RF INPUT wire to the ground lug on *J1*. Affix rubber feet to the box.

Determine exactly where on the top half of the aluminum box to drill the access holes for *C3* and *C7*; drill ⁵⁄₃₂″ holes in both locations. Clean

CIRCLE NO. 180 ON FREE INFORMATION CARD

this box half with steel wool, dry thoroughly and spray three light coats of clear acrylic as you did for the bottom half. Temporarily set the receiver aside and proceed to the pickup unit if you're using it. Otherwise, proceed to checkout below.

Before wiring any components to the board of the pickup unit, drill two ⅛" mounting holes, spacing them ½" in from the long sides and centered between the short sides. Place the board, centered all around, on the metal lid of the box that's to house the pickup unit's circuitry and mark the locations of the mounting holes just drilled. Drill ⅛" holes at the marked locations. Then drill appropriately sized holes for the ground lug, coaxial connector, and twinlead entry and for access to the trimmer capacitor. Deburr the holes, install small rubber grommets in the two twinlead entry holes and mount the coaxial connector.

Trim ¼" of insulation from both ends of a 2" lightweight zip cord. Separate the cord's conductors about 1" at one end and ½" at the other end. Tightly twist together the wires in each conductor and tin with solder. Connect and solder a No. 6 solder lug to one conductor at the 1" separated end. Connect the other conductor at this end to the tip lug of the coaxial connector. Secure the solder lug to the front panel with 6-32 × ¼" machine hardware. Now remove 2" of the bridging plastic at both ends of a 36" length of 300-ohm twinlead cable and trim ¼" of insulation from all conductors. Twist together the wires in each conductor and tin with solder.

Wire the pickup unit as shown at the right in Fig. 5, observing proper basing for *Q1*. Then identify the conductor of the zip cord that goes to the ground lug near the coaxial connector and plug this into the ground hole for this connector on the board. Solder into place. Plug the other zip-cord conductor into the signal hole for the coaxial connector on the board and solder into place.

Plug one end of the 300-ohm twinlead into the rubber grommets in the front panel. Plug the conductors into the TWINLEAD holes and solder them into place. Mount the board to the front panel using ½" spacers and 4-40 machine hardware.

The inductance of the pickup coil for the pickup unit isn't critical, but it should be about 25 microhenries. The prototype coil consisted of 50 turns of 26-gauge enameled magnet wire wound on a ¾"-diameter air-core form, which yielded about 26 microhenries. If you wish to use a different size coilform, calculate the number of turns needed using the formula $N = \sqrt{26(9A + 10B)}/A$, where *A* is the radius of the coilform and *B* is winding length in inches.

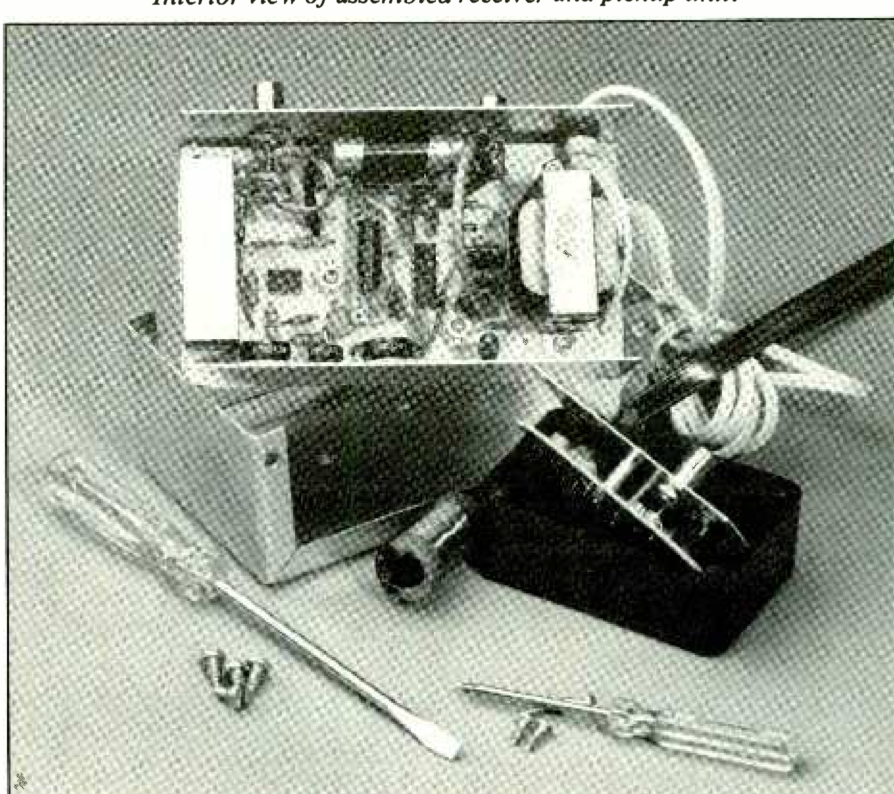
After winding the requisite number of turns on the coilform, secure the turns with a couple of layers of plastic tape. Scrape ¼" of enamel from both ends of the winding and connect and solder them to the free end of the 300-ohm twinlead cable. Use plastic tape to mechanically secure the connections to the coilform.

Checkout

Before installing the ICs in their sockets, plug the receiver's line cord into an ac outlet and use a multimeter to measure the dc voltages, referenced to circuit ground, at the cathodes of the zener diodes in the power-supply section. You should get readings of +24, +18, +12 and +9 volts at the cathodes of *D1, D3, D2* and *D4*, respectively (the first four entries in the "Voltage Checkout Table" elsewhere in this article). If you obtain these readings, power down the receiver and allow the capacitors in the power supply to discharge. Then install the ICs in their respective sockets, making certain you orient them as shown in Fig.5.

Plug the receiver's line cord into the ac outlet and perform all voltage

Interior view of assembled receiver and pickup unit.



measurements given in the Voltage Checkout Table. If everything appears to be okay, the receiver should be working as designed.

Temporarily connect the FM Receiver's output to the input of an audio power amplifier and set *R3* and *R9* to mid-rotation. You should hear the hissing sound that is typical of an FM receiver with no input signal. Adjust RF GAIN control *R3* until the hiss is at maximum. Then connect a short piece of hookup wire to the primary of *T1* at the point on the circuit board labeled RF INPUT (see Fig. 5). You should hear a mixture of extraneous signals being picked up by the short wire "antenna." Increasing r-f gain should increase the strength of the noise.

Now test the pickup unit, if you've decided to incorporate it into your project. When using this option, make sure *C16* and the optional jumper wire are installed on the receiver board. Connect the pickup unit to the receiver with a length of coaxial cable (terminated at both ends with suitable connectors), and check for + 12 volts with reference to circuit ground at the collector of *Q1* in the pickup unit.

With *L1* connected to the pickup unit, you should hear the extraneous signals as before. If you aren't using *L1*, simply touch your finger to *C1* and note the excellent sensitivity of the receiver.

Using the Receiver

To use the 4.5-MHz FM Receiver to pick up sound from a TV receiver, you must locate the 4.5-MHz sound i-f section in the latter. If you find an exposed coil or transformer in the i-f section, slip *L1* over it and carefully adjust the RF GAIN control until you hear some of the picked-up sound. Adjust *C7* and then *C3* for best results. Readjust r-f gain after each tuning adjustment. With a strong enough signal, you will obtain good audio without noise. You may have to adjust the TV receiver's fine tuning to maximize results.

If your TV receiver doesn't have coils or transformers in the sound i-f section, try inserting a 100-microhenry choke in the core of the pickup coil and connect the choke to the output of the 4.5-MHz i-f amplifier in the TV receiver through a dc blocking capacitor.

If the above doesn't work, connect the twinlead directly to the signal source, ground to ground and signal to *C1*. If your TV receiver has a "hot" chassis, use two 0.001-microfarad capacitors rated at at least 200 volts. One capacitor goes between the grounds of the FM Receiver and the signal source, the other in place of *C1* in the pickup unit. For added safety, connect the FM Receiver's circuit ground to an earth ground.

If you aren't using the pickup unit, connect a jumper wire in place of *C16* and don't use the dashed jumper wire in Fig. 5. The extra pad at the top left of the board is provided for a blocking capacitor if your application requires one. Otherwise, connect the input lead to the pad immediately to the left of this and ignore the extra pad.

Connection of the 4.5-MHz FM Receiver to the Cable Communication System's receiver mentioned earlier requires another matching transformer and a blocking capacitor. A series-tuned primary will pass the 4.5-MHz signal and present a high impedance at other frequencies. This minimizes loading that would otherwise attenuate the video signal in your TV receiver.

Fabricate the required transformer on the core of a 10-microhenry choke by winding the primary as you did for *L1* in the 4.5-MHz FM Receiver. Then wind the secondary over this and use only half as many turns as in the primary. Use a 15-to-150-pF trimmer capacitor in *series* with the primary winding to block dc and to provide for tuning.

The signal source for the Cable Communication System's receiver can be any transmitter that is similar to the UM1285 vhf modulator. Personal computers and VCRs usually have such a transmitter with an r-f output that is switchable between TV channels 3 and 4. Align the Cable Communication System's receiver first according to the instructions provided in the original article. Then align the 4.5-MHz FM Receiver as detailed above. Tune the matching transformer for maximum signal and adjust the gain on the Cable Communication System receiver for best results. **ME**

A Full-Range Speaker System

Using an 8" dual-cone speaker and closed-box design, it's easy to build nice-sounding speaker systems in an afternoon's time while saving two thirds the cost of an equivalent commercial product

By William R. Hoffman

Working with electronic circuits can be a stimulating experience. Yet many of these circuits require electromechanical or electrical adjuncts. In the case of an audio amplifier, for example, you often need a speaker system (or two, if it's stereo).

It's not uncommon for someone to build a fairly capable audio amplifier for a modest sum only to discover that a speaker system to match its performance costs many times more than the electronic parts did. In other instances, you may want to add extension speakers to a fine stereo system, but the cheap ones sound pretty bad, acoustically. In either case, here's an opportunity to build a pair of nice-sounding speaker systems for $40 or less in materials that's equivalent in performance to systems selling for as much as three times the cost.

Our home-made system uses a high-quality dual-cone 8″ loudspeaker that can be driven well by a 10-watt power amplifier, while 30 watts (the driver's maximum continuous handling power) will fill any moderate-size room with good-quality, very high levels of acoustic output that will do justice to any rock or orchestral music. (The loudspeaker is available at most Radio Shack stores.)

The speaker system's midrange and treble are detailed and clear, while bass is natural and clean, with no apparent hangover or boom. In addition, owing to its simple design, the system is readily constructed with only simple tools, allowing it to be built in a single afternoon.

Technical Details

The speaker system's dual-cone 8″ loudspeaker has a rated resonant frequency of 57 Hz and a Q of 0.45. It's designed to be mounted in a 0.8-cubic-foot enclosure. In this project, you install it in a 0.43-cubic-foot enclosure, using 0.5 cu. ft. of fiberglass wool to effectively raise the loading on the speaker to 0.8 cu. ft. System resonance is then 95 Hz.

The speaker system's frequency response is shown in Fig. 1. This curve was obtained with a calibrated condenser microphone positioned on-axis in front of the speaker system at a distance of 1 meter. Though the system has the typical rising response on-axis at high frequencies, this is offset by a falling response off-axis. Hence, the system's average response is quite smooth.

While the response curve appears to be very irregular at the higher frequencies, it represents good performance for the simple and inexpensive speaker system described here.

Actually, our speaker system has a much better sound than would normally be obtained from low-end speaker systems costing twice what ours does to build.

Figure 1 shows that the speaker system has a fairly good bass response, down to about 100 Hz at −6 dB, for such a simple speaker system design. The midrange is solid and exhibits little "brightness" coloration. There is also plenty of treble to do justice to most music played through this speaker system.

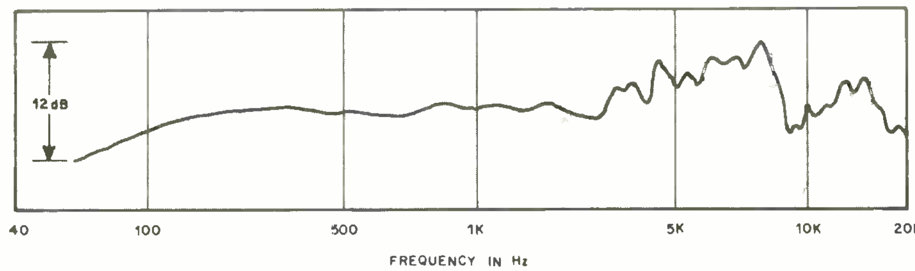


Fig. 1. The speaker system's frequency response extends from about 100 Hz to about 18 kHz for a fairly hefty bass and full-range sound. Irregularities in the midrange and treble are averaged out so that speaker system actually sounds much better than this curve implies.

Building It

No special tools or skills are needed to build this simple speaker system. All you really need are a hand saw and a hammer to assemble the enclosure with simple glued and nailed butt joints. If you have a power table saw and/or router, you can get as fancy as you like with mitered joints that are held together with wooden splines.

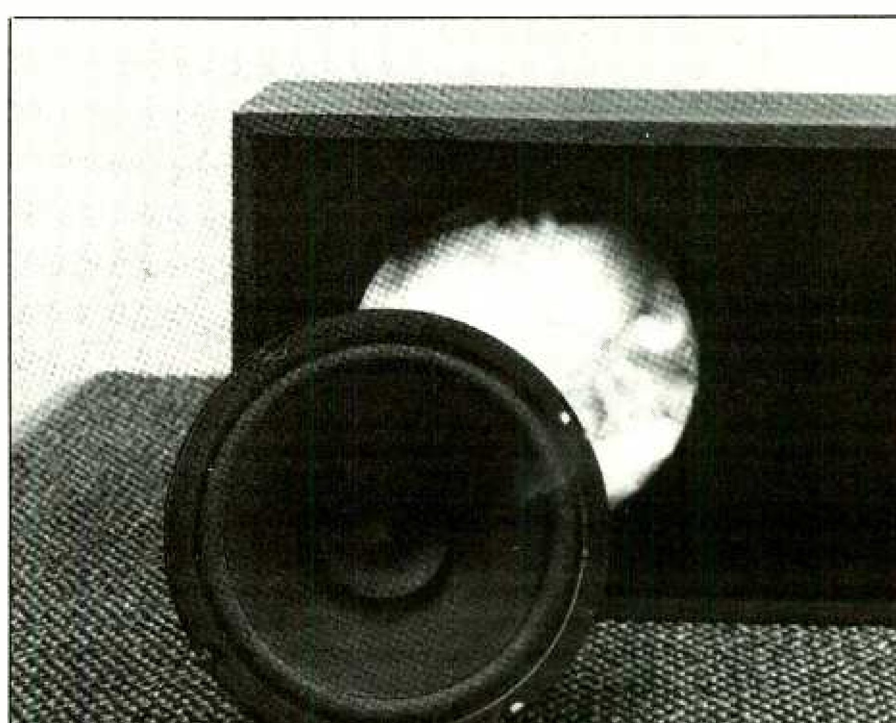
You can use solid lumber, plywood or particle board for the enclosure. This can be either ¾" or ½" thick with no changes in exterior dimensions of the enclosure. Though there will be a slight difference in internal volume, the fiberglass wool filling dominates the loading effect.

Construction details for the speaker system are given in Fig. 2. Notice that the enclosure is a sealed acoustic-suspension design and requires no internal bracing. The dimensioned drawing shows simple butt joints, which is reflected in the dimensions for the enclosure panels in the Bill of Materials. If you're assembling the enclosure with mitered joints, make the necessary adjustments in panel sizes. Whichever method of joinery you use, only gluing and nailing are required to hold together the cabinet panels. The speaker baffle and rear panel are inset within the enclosure walls.

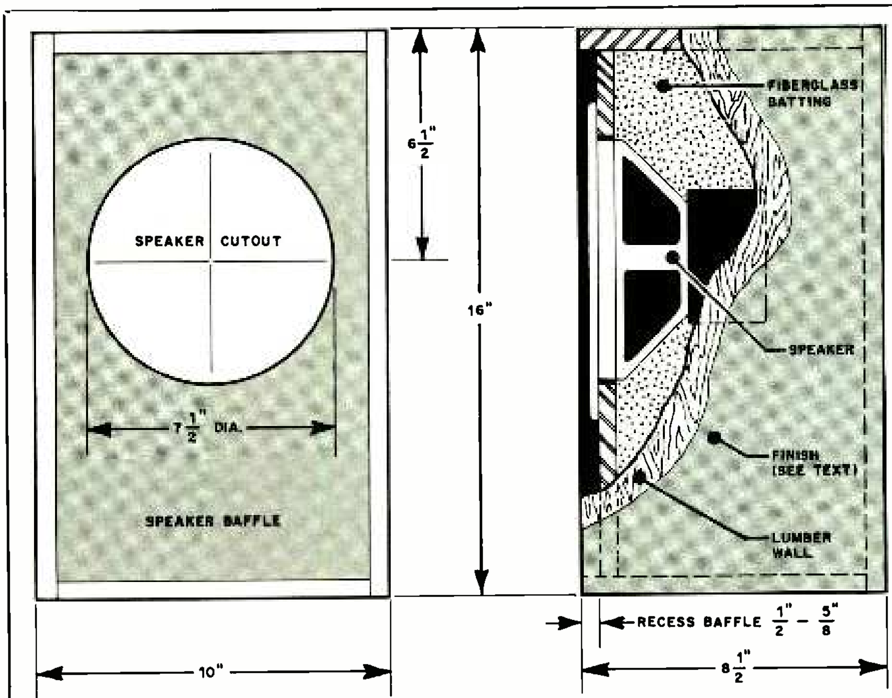
After cutting all enclosure panels to size, strike a pencil line down the center of the speaker baffle board. Place the top panel against the end of the baffle as it will be when the two are joined, measure 6½" down from the *top* of the top panel and strike a line squarely across the first to locate the center of the speaker cutout.

Handling it carefully to avoid damaging the cone, place the speaker over the crossed lines and position it so that the lines are centered in all four speaker mounting holes. Trace the outline of the speaker onto the baffle. Turn over the speaker and measure from the rim to where the basket flares out and mark this measurement (about ½") in from the previously drawn speaker outline.

With a compass or string and nail, draw a circle from the crossed center lines of the cutout area to the last measurement mark. If you have a power router, cut a channel as wide as the limits between the two drawn circles and about ³⁄₁₆" deep to inset the speaker into the baffle. If you don't have a router, simply mount



After finishing the speaker system's enclosure, including painting the speaker baffle flat back, loosely fill the interior with fiberglass wool.



BILL OF MATERIALS

8" full-range loudspeaker (Radio Shack Cat. No. 40-1286C)
4—16" × 8½" panels of ½" or ¾" plywood, particle board or solid wood shelving for sides, back panel and speaker baffle
1—14½" × 8½" × ¼" plywood or Masonite panel for grille
2—8½" × 8½" panels of ½" or ¾" plywood, particle board or solid wood shelving for enclosure top and bottom panels

Miscellaneous—2-lug screw-type terminal strip; 0.5 cu. ft. fiberlgass wool; wood glue; caulking or silicone sealer; zip cord; sheetmetal screws; grille cloth; flat black paint; finishing materials; 2" finishing nails; solder; etc.

Fig. 2. Dimension and assembly details of the speaker system. You have a choice of materials and thicknesses for the enclosure walls.

the speaker on the front of the baffle. You can rout the channel either before or after removing with a jigsaw or keyhole saw the lumber within the smaller drawn circle. Test fit the speaker in the cutout and trim the baffle if necessary to obtain a perfect fit.

Centered in the rear panel, make the cutout for the 2-lug screw-type terminal strip. Set the enclosure's top, bottom and side panels inside-surface up. Measure ½" to ⅝" in from the front edges and strike a line this distance in from and parallel to the edges to use as positioning guides for the speaker baffle when assembling the enclosure.

Turn over the panels. If you're using ¾"-thick lumber, measure ⅜" in from the rear edge of each panel and ⅞" or 1" in from the front edge, depending on how far back you plan to set the speaker baffle. Strike lines at the marked locations parallel to the indicated edges. If you're using ½"-thick lumber, reduce the above measurements by ⅛".

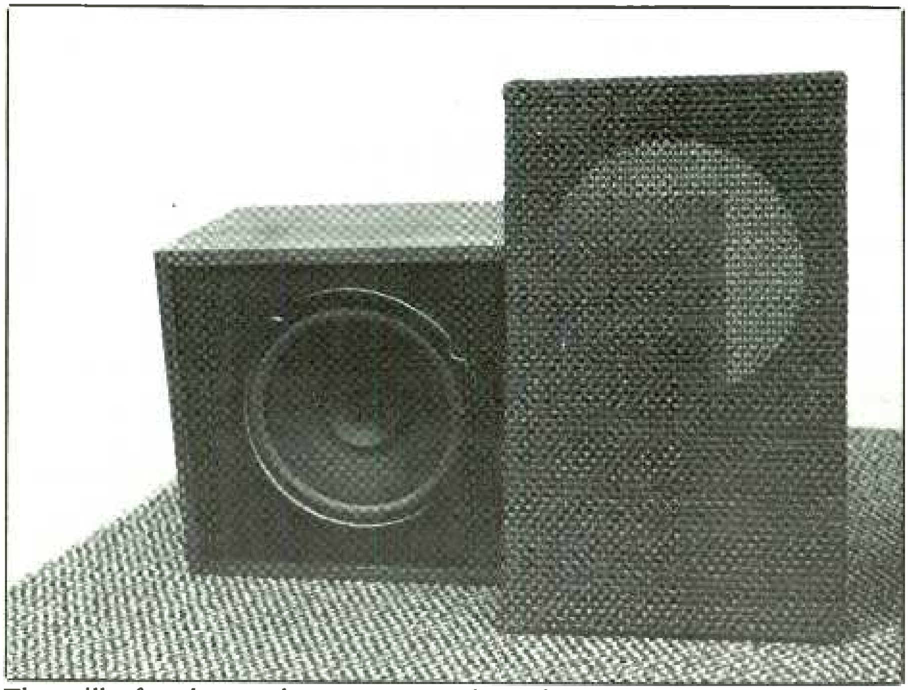
Sand smooth all exterior surfaces of all panels, including the speaker baffle. Don't forget the front and rear edges of the top, bottom and side panels. Wipe the panels completely clean of sawdust. Then strip ⅜" of insulation from the conductors at both ends of a 12" to 15" length of two-conductor zip cord. Tightly twist together the fine wires and tin them with solder. Connect and solder the conductors at one end to the lugs on the screw-type terminal strip. Pass the free end of othe zip cord through the hole in the rear panel and mount the terminal strip in place. With the screws of the terminal strip screwed fully in, fill all around the inside of the terminal strip with caulking or silicone adhesive, taking care to avoid fouling the screws, to create an air seal.

Drive a 2" finishing nail every 3" or so along the lines struck on the exterior surfaces near the rear and front edges of the top or bottom and one side of the enclosure. Drive the nails only 3/16" in. Liberally coat the edge of the smaller panel with wood glue and nail it to the rear panel, making the latter flush with the rear edge of the former. Do the same for the selected wall, squaring the panels as you work. Run a bead of wood glue along the mating edges of the speaker baffle, align the baffle with the setback lines on the interior surfaces of the panels and nail the two panels together.

Drive finishing nails partially into the remaining panels of the enclosure along the guide lines. Coat with glue the remaining edges of the speaker baffle, rear panel and the mating panel edges. Nail the panels to the enclosure's rear panel and speaker baffle. Then tightly clamp or weight the enclosure for 24 hours.

When the glue has set, run a thick bead of caulking or silicone adhesive along all interior joints, including those for the speaker baffle, to air-seal the enclosure. Then mask off the front edges of the enclosure and paint the speaker baffle and interior surfaces of the walls in front of it with flat black paint.

You can finish the enclosure as



The grille for the speaker system consists of an open-weave cloth that is stretched on a ¼"-thick frame and is held in place by friction.

you wish—paint it, cover it with self-stick sheet plastic "veneer" or, for a really professional appearance, apply a colorful plastic laminate or a wood veneer stained and finished as desired. If you're painting or applying self-stick plastic to the enclosure, prefinish the exterior walls with a good sanding and a thin coat of DAP to fill the grain and any gouges. When the Dap has completely dried, sand it to a smooth, even finish and apply a coat of sealer.

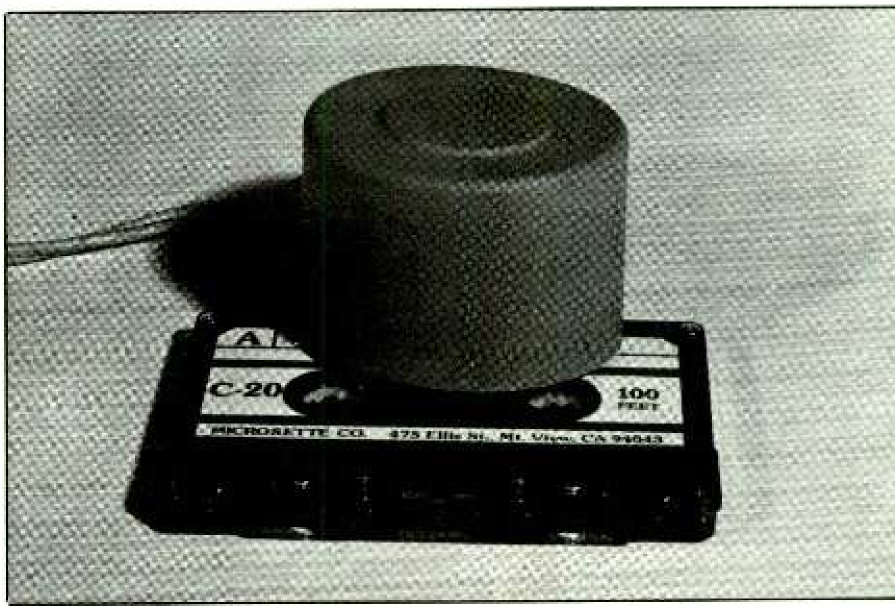
Cut to size an open-weave grille cloth and mount it on a ¼"-thick plywood or Masonite frame. Paint the frame flat black before stretching the grille cloth over it, and use spots of glue to hold the cloth in place. Make the frame large enough to hold the grille in place without hardware.

Pull the free end of the zip cord through the speaker cutout and loosely fill the enclosure with 0.5 cu. ft. of fiberglass wool. Connect and solder the free end of the zip cord to the speaker's lugs. Run a bead of caulking around the perimeter of the speaker cutout (in the recessed area if you routed it, or on the front surface at the edge of the cutout if you didn't). Lower the speaker into the cutout and press it into the caulking to assure a good air seal. Secure the speaker to the baffle with panhead sheet metal screws.

While observing the speaker cone, momentarily connect a 1.5-volt C or D cell across the speaker via the screw hookups on the rear panel. If the cone moves outward, the screw to which the cell's positive (+) terminal is connected is the "hot" or signal line. If cone travel is inward, the cell's negative (−) terminal identifies the signal line. Use a label, paint or nail enamel to permanently identify the signal terminal.

Install the grille, connect it to your amplifier and your speaker system(s) is now ready to use. You'll need much costlier multi-speaker systems to get extended frequency range, wider treble dispersion and deep, clean bass reproduction, but for nicely balanced, clean sound at very low cost, this speaker system design will serve many people very well. ME

A Bulk Eraser For Cassettes & Diskettes



Erasing an audio or computer cassette by running it through a tape deck is time-consuming. And deleting all files on a floppy disk doesn't wipe the slate clean (it just changes the first bit). A bulk eraser, like the miniature one described here, will improve these operations by wiping out anything recorded on tape or diskette in just a few seconds. Therefore you gain erasing speed for tape and data security for disks.

You can build the ac-line-operated bulk eraser for nothing if you have a well-stocked spare parts box, or for just a few dollars if you don't.

Commercial line-operated bulk erasers consist of an electromagnet that delivers a powerful ac field that wipes out anything recorded on magnetic media. Our mini-eraser uses the same principle, using a laminated iron-core filter choke salvaged from an old vacuum-type TV receiver.

A 1-Henry, 350-milliampere filter choke is the main component. The choke I used measured 2¼ " by 1¾ " square. You can use any similar unit. Any choke that has 0.5 to 4 Henrys of inductance, 30 to 100 ohms of dc resistance and a current rating of 400 to 250 milliamperes is suitable for the mini bulk eraser. The choke is typically made up of E and I laminations with the former holding the coil and a fish-paper separator.

To make the bulk eraser, remove the frame that holds together the E and I laminations. Discard the frame and I laminations. Figure 1 shows the choke as it appears stripped of its mounting frame and ready for installation in a plastic container. The coil is usually firmly stuck to the E laminations. However, if it's loose, insert cardboard shims and fill the voids with epoxy cement to make a solid structure. Then wire the bulk eraser as shown in Fig. 2.

The choke I used fitted snugly inside the cap of a spray paint can. Since this left no room for the switch and fuse, I used an Amphenol fused plug and installed *S1* in the line cord. A better approach might have been to house the entire circuit inside a suitably sized oblong plastic box.

Once you've prepared the choke as described, temporarily connect to it a line cord. Plug the line cord into an ac outlet and, after 10 seconds, pull the plug. The choke should be barely warm. If it feels very hot, do *not* use this particular choke; if you do it will quickly burn up.

Install the choke in the plastic box with the open end of the E laminations pointing toward and flush with the opening of the box. Apply a strip of plastic tape to the exposed metal of the choke. A word of caution: Don't try to economize by omitting the switch because *L1* will burn out if left energized continuously.

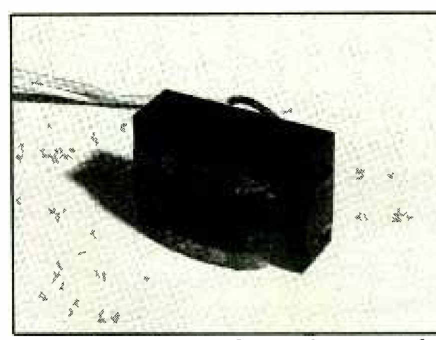


Fig. 1. Modified filter choke ready for installation in plastic box.

In use, *never* operate the bulk eraser near audio, videocassette or computer tapes and disks. Do your erasing at least 10 feet away from magnetic media and preferably in another

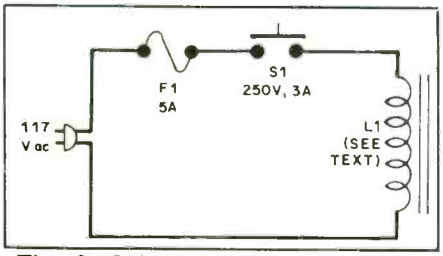


Fig. 2. Schematic diagram of cassette/diskette mini bulk eraser.

room. Also, avoid using the eraser when your computer is running because if you do a program running in the computer is likely to crash.

Press and hold *S1* as you slowly pass the eraser in a circular motion for five seconds over a cassette to erase it. Release *S1* only after moving the eraser about 3 feet away from the cassette. As the eraser is operating, you may hear a buzz or rattle; this is normal and does no damage to magnetic media.

To erase a floppy diskette, place it in the middle of a magazine about the thickness of *Modern Electronics* and move the eraser in a widening spiral over the diskette. Flip over the magazine and erase the other side of the diskette in the same manner. Again, move the eraser at least 3 feet away from the diskette before releasing *S1*. The whole operation should take no more than 10 seconds. If you have more than one diskette to erase, do each about 5 minutes apart to avoid overheating the eraser.

I tried erasing cassettes at various ac voltages, powering the eraser through a powerstat. For my particular choke, erasures were satisfactory down to about 65 volts. This means that it's possible to install a suitable power resistor in series with *L1* to reduce coil voltage and current.

I did not attempt to use the project to erase videocassettes. I suspect, though, that these may require a larger electromagnet and a more powerful magnetic field to assure complete erasure.

—*Adolph A. Mangieri*

Understanding strain gauges; video art A/D conversion; transducer information; robotics parts

By Don Lancaster

If you want to start your own hi-tech venture, check into my *Incredible Secret Money Machine* book that's chock full of ideas for your own technical or craft venture. I just happen to have several autographed copies on hand here that I'll be happy to lay on you.

Uh, it seems there were some problems with last month's *Omnicrom* phone numbers. Try using (617) 881-4100 or (800) 447-2326 instead.

And now, onward with this month's goodies.

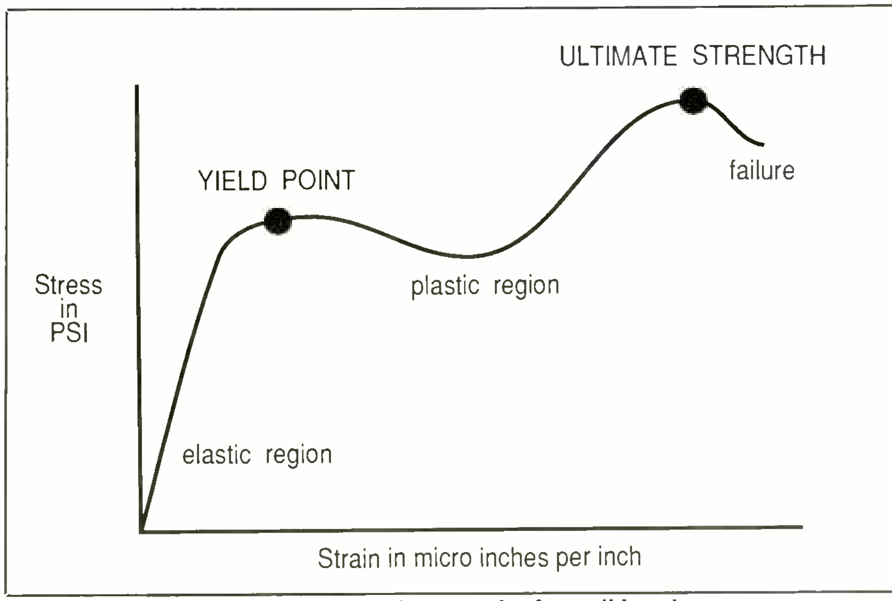


Fig. 1. Stress-versus-strain curve plot for mild steel.

What is a strain gauge?

A strain gauge is a sensor that can measure very small changes in physical size. Strain gauges are extremely useful for electronic weighing and scales; load cells; materials testing; accelerometers; electronic-music keyboards; pressure and force measurement; stress analysis; robotics, traffic sensors; unique game input devices; and much more.

Despite costs starting at $4 and their simple use, strain gauges remain virtually unknown as hacker components. Yet the opportunities here are mind-boggling.

Let's start at the beginning. Say you had a piece of steel and started pulling on it. If you try this, you will generate the classic stress-strain curve shown in Fig. 1. If you pull on the steel only moderately, it will spring back to its original shape. If you pull harder, it will stretch like taffy. Pull too hard, and the steel will fail by snaping in two.

The stress you apply to the steel will be determined by the force you use and the cross-sectional area over which that force is applied. Stress is often measured in psi, or pounds per square inch. If you are pulling on the steel, you place it in tension, much the same as the cables of a suspension bridge. If you are pushing on the steel instead, you put it in compression, similar to the loading on the concrete pylons of a highway bridge.

As the steel is stressed, it will get longer. This lengthening is called strain, and is normally measured in microinches per inch. Under normal loading, strain values usually range from a few hundredths to a few tenths of a percent. This, of course, varies widely with the material and the applied load.

For fairly low stress values, the steel will stretch linearly with the applied load. It will also return completely back to its original size when the stress is released. This is called "elasticity." By this definition, steel is much more elastic than rubber, and ceramic materials are even more elastic than steel.

You could build an electronic scale by measuring the linear elastic strain on a piece of steel as you add weight to it.

As you increase the stress further, you stay elastic, but you are no longer linear, picking up added strain with added load. But, you will still return to the original size when the stress is released.

Eventually you will get to the yield point. The stress here is so high that the steel cannot return to its original state. Instead a process of plastic deformation occurs. Release the stress, and the steel ends up longer than it was originally.

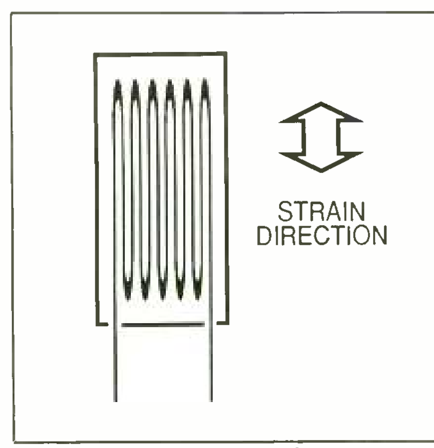


Fig. 2. A resistive strain gauge.

Many metal forming processes, particularly deep drawing and bending, work by forcing the material into its elastic deformation state.

The reason that the curve tends downward past the ultimate strength point is that the cross-sectional area is getting progressively reduced, through a process called "necking down."

Other materials have different stress-strain curves. Ceramics are almost entire-

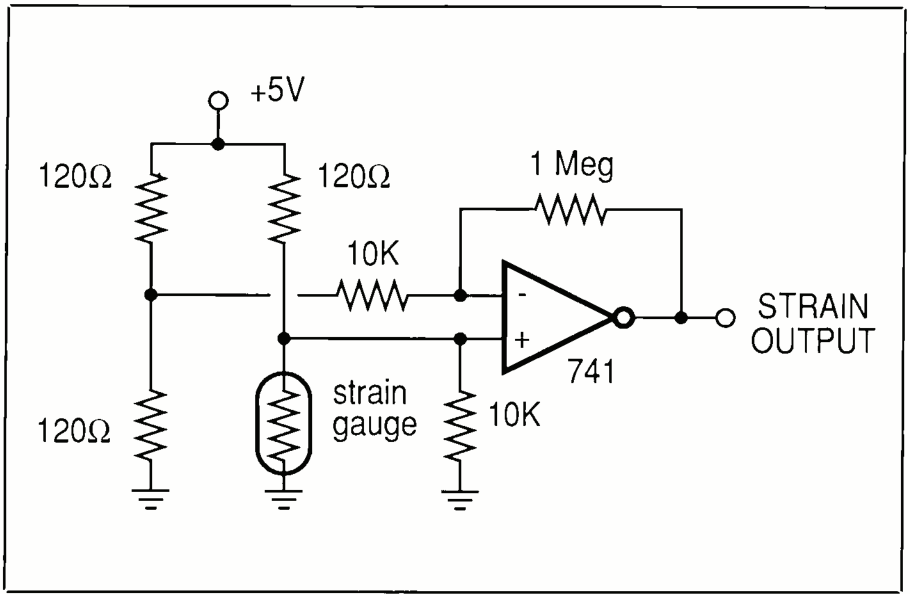


Fig. 3. A typical strain gauge bridge and amplifier.

ly linear, with no plastic deformation at all. Such materials are said to be brittle. A brittle material is elastic up to its ultimate strength, and then fails without much in the way of deformation.

More details on all of this appear in most any college-level text on strength of materials.

What we are interested in here is how to measure strain. While there are many types of strain gauges, the typical resistive type is shown in Fig. 2. What you have here is a foil pattern on an insulating carrier. As you slightly stretch the pattern, the resistance of the foil changes.

In use, the strain gauge is carefully cemented to the material to be stressed. The strain gauge, the material, and the adhesive to be used must be carefully matched to each other, particularly if temperature effects are to be compensated.

As you stress the material, the strain gauge will slightly change its resistance. Nominal resistance values range from 120 ohms upwards. Such low values are used to minimize noise pickup.

The "gauge factor" of a strain gauge is a ratio of how much the resistance changes when length changes. A gauge factor of 2 is typical. Thus, the resistance change will be double the length change.

Figure 3 shows a typical strain gauge circuit. Because of the small changes in resistance involved, you normally use a bridge circuit followed by an operational amplifier. While you can use a 741 op amp for experiments, premium devices with lower offsets and lower temperature coefficients are often better.

You would normally bond the strain gauge to some material that will change its length under stress, using a recommended adhesive. You then use the output of the op amp to measure the resultant strain. The circuit shown has a gain of 200, since the gauge factor is 2 and op amp gain has been set externally to 100. This means that output voltage will change 200 times more than input strain movement.

A zero control can be added by placing a small potentiometer in the middle of the left bridge arm. The actual materials used and the op amp's gain will depend on your particular application.

The *Omega* HBM 6/120 LY 13 is a good choice of strain gauge for hacking. Details on this device and many others appear in the company's free *Pressure, Strain, and Force Measuring Handbook*, along with much more technical details and applications information.

How are strain gauges related to the pressure transducers we looked at in earlier columns? Well, pressure transducers are really nothing but strain gauges that have been factory built on a silicon diaphram. By measuring the strain on the diaphram, you can, in turn, measure gauge, absolute, or differential pressures. You normally would use a pressure transducer to measure pressure in a liquid or a gas, while you would typically use a strain gauge to measure deformation in a solid.

Where can I get robotics parts?

Try *Small Parts*. These people stock all sorts of metals, plastics, hardware, fasteners, and whatever—all reasonably priced. Very small quantities are a specialty here.

They will also custom cut small pieces of steel, stainless, plastic, brass, copper, or aluminum to size. Most importantly, they have the parts the average hardware store never heard of—timing belts, hitch pins, plastic balls, spring assortments, wire clips, perforated metal, and bunches more. Check them out.

How can I find more out about transducers and sensors?

First, check into the excellent free handbook series available from *Omega Engineering* that covers many types of temperature, flow, humidity, pressure, strain, force, and pH measurement.

Second, look into the many specialized magazines that cover this field. Important examples are *Measurements and Data, Control Engineering, Instruments and Apparatus News*, and *Pollution Control News*.

Third, contact the individual companies that specialize in interface electronics, such as *Motorola* and *Microswitch* for pressure transducers, and various application notes from *Analog Devices* and *Burr Brown* on transducer interfacing.

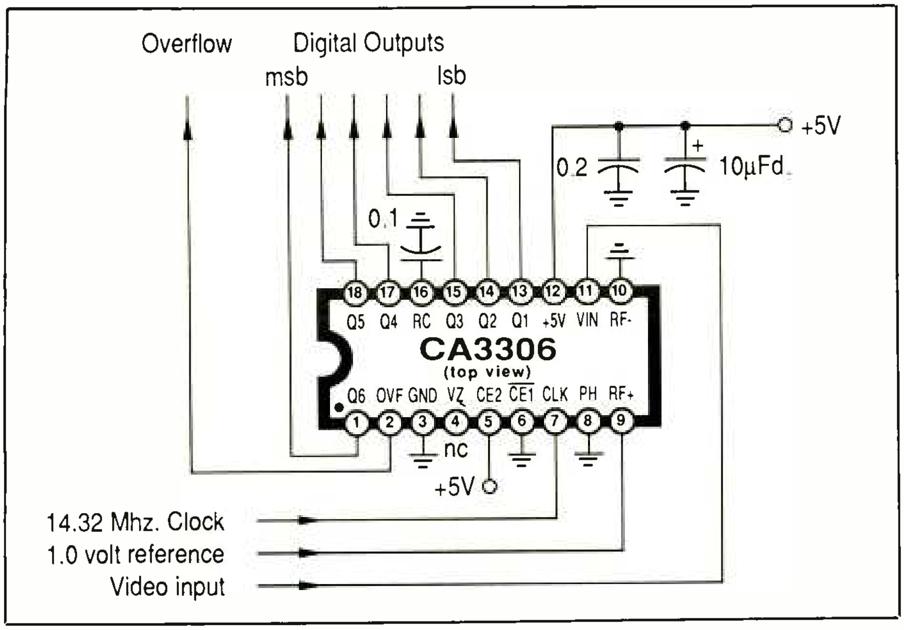


Fig. 4. A 6-bit, 64-level RCA video A/D converter.

There are lots of opportunities out there for new and creative use of sensors, particularly strain gauges, pressure transducers, humidity sensors, and such. Let us know what hacker projects or applications you come up with.

Show me a video A/D converter.

Analog-to-digital (A/D) conversion at video speeds has traditionally been a real hassle. Yet, there is lots of hacker potential here, particularly for such things as capturing images for personal computers, in desktop publishing, and for doing digital TV signal processing.

Video-rate A/D conversion has to be done much faster than can be handled by most traditional circuits. Instead a brute force method has to be used, in which the input analog video is simultaneously routed to 64 or 256 individual comparators. The result of each comparison is then converted into a 6-bit (64 level) or 8-bit (256 level) digital code.

One very popular sampling frequency for video conversion is 14.32 MHz, which is four times the standard NTSC color subcarrier frequency of 3.58 MHz.

Capturing and storing digital data at this rate is not trivial, since you get a new word every 70 nanoseconds or so, and since there will be almost a quarter of a million bytes per frame. If you are planning on processing this image with a personal computer, some sort of a high-speed buffer will be needed between the computer and your A/D converter.

If you are interested only in digitizing to 256 by 256, then a smaller buffer of 64K can be used, combined with a lower clock frequency. There are some exciting new fast memory chips available called dual-port RAMs that are particularly attractive for this sort of thing. Fortunately, single integrated circuits are now available that will do most of the brute force conversion for you. Let's look at two examples.

Figure 4 is a 6-bit, 64-level converter that uses the *RCA* CA3306. As you can see, there is a video input and a reference input. The reference input is usually a precise and fairly high-current source of 1.0 volt. This reference sets the full-scale value of the input video.

You also have to input on pin 7 a reference clock equal to the sampling rate you want. It is extremely important that the highest video frequency you are sampling is less than one-half this value. Thus, some sort of input low-pass filtering or other bandwidth limiting must be done before doing the actual A/D conversion.

Sometimes, you may want to vary the clock rate. In many applications, there is no point in sampling the sync and blanking times.

Finally, you have six data outputs, one for each bit of the 6-bit digitized video, and a seventh overflow line. While we have shown the chip-select on pin 6 grounded here, for most uses, you will want to use this to tri-state control the digital outputs.

A newer *Motorola* 8-bit video A/D converter circuit is shown in Fig. 5. Unfortunately, this chip is larger and needs a negative 5-volt supply besides the usual positive 5-volt supply. It is also faster, which means that it may be noisier for most hacker uses. Cost of these chips is

NAMES AND NUMBERS

Analog Devices 2 Technology Way Norwood, MA 02062 (617) 329-4700	**Motorola Semiconductor** Box 20912 Phoenix, AZ 85036 (602) 244-6900	**RCA Solid State** Route 202 Somerville, NJ 08876 (201) 685-6000
Burr-Brown Box 11400 Tucson, AZ 85734 (602) 746-1111	**Omega Engineering** Box 4047 Stamford, CT 06907 (203) 359-1660	**Small Parts** 6901 NE Third Avenue Miami, FL 33238 (305) 751-0856

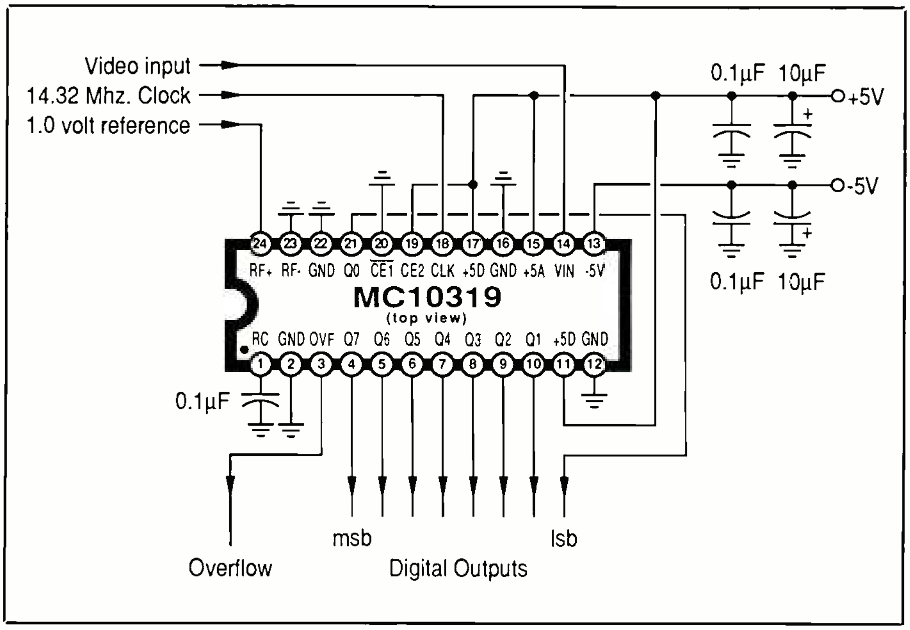


Fig. 5. An 8-bit, 256-level Motorola video A/D converter.

currently in the $20 to $35 range, but lower-priced plastic versions should shortly be available.

Before you throw these two circuits together, note that these are strictly advanced hacker components. A decent oscilloscope is almost essential, as is a very carefully done printed-circuit board layout. It is extremely important to use low-noise power supplies, possibly even to the point of using a separate regulator for the converter itself.

The supply lines must be thoroughly bypassed directly at the converter pins using very-high-quality capacitors. Tantalum capacitors are almost essential, since many electrolytics have uselessly high impedances at video frequencies.

The input video must come from a low-impedance source, preferably from an on-bolard input buffer. The RCA CA3450 is a good choice for this.

There are really two reference voltages needed, one for the top and one for the bottom of a resistor chain that forms the reference for each of the 64 or 256 comparators. While I've shown the bottom end grounded, you can move this up or down a volt or so as needed. One use would be for automatically stripping sync.

It is very important that your reference voltages be low-noise and low-impedance. In a real circuit, you will probably want to drive these from the output of an op-amp setup as a unity gain voltage buffer, driven from a suitable stable source.

Careful control of grounds is also important. The input analog ground return must be direct and must not share any common-mode digital ground noise.

If you digitize a 1-volt video waveform to 255 levels, that is something like 4 millivolts per level. It is trivially easy to get digital ground noise that is hundreds of times higher. **ME**

NEED HELP?

Phone or write your **Hardware Hacker** questions directly to:

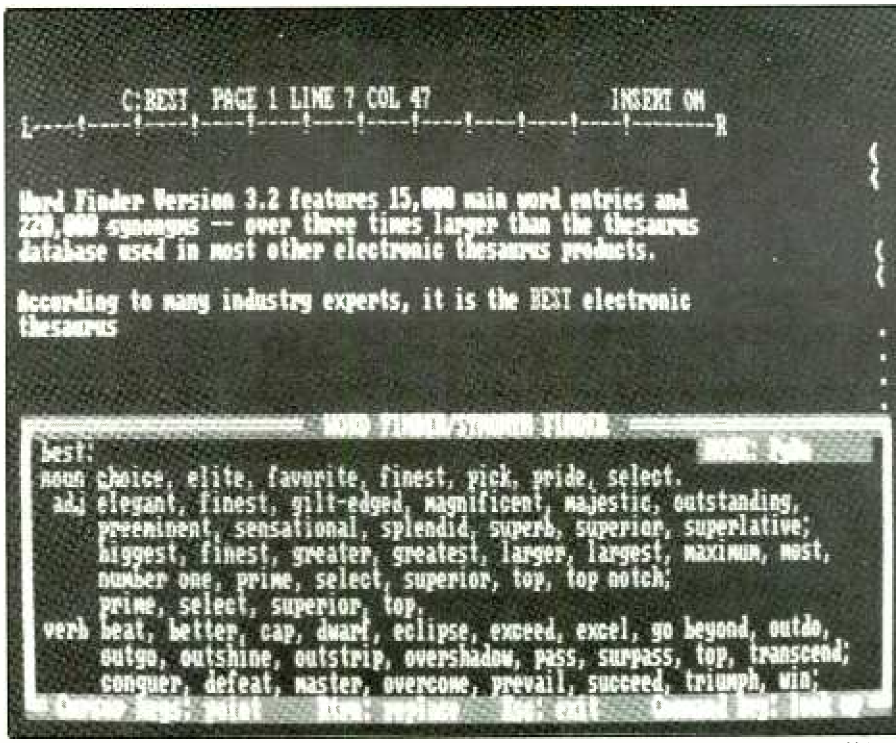
Don Lancaster
Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073

Word Finder—A Giant Synonym Finder

By Art Salsberg

Microlytics' (300 Main St., East Rochester, NY 14445) newest Word Finder thesaurus, Version 3.22, has become a giant, with 220,000 synonyms for IBM PC/XT/AT and compatible computers. The previous version had "only" 90,000 synonyms, which itself was very competitive with other on-line thesaurus's such as Webster's (over 100,000) and Turbo Lightning's (50,000 in its spelling-checker/thesaurus program).

Word Finder works with most word-processor programs, such as WordStar, Microsoft Word, Easy, Multimate, Word Perfect, XyWrite III, Framework, etc., as well as a host of utilities such as Sidekick, Prokey, and so on. It takes up less than 30K of memory and is ultra-simple to use. The program comes on two disks, one of which is a synonym database that gives you a choice of 220,000 synonyms and a smaller 90,000 one for users with limited disk space. Suggested selling price is $79.95.



Using Word Finder's "Synonym Finder" to call up synonyms for the word "BEST" in a text file.

Evaluation

Does an electronic thesaurus with the most look-up words we know of automatically make it the very best one in town? Yes and no. Aside from size, key factors to consider are: speed, ease of use, flexibility, and clarity.

In the speed category, Word Finder performs like lightning (sorry, Borland). In this respect, it's a smidgen faster than Webster's New World On-Line Thesaurus in replacing a word in matter you've typed with a word processor.

For ease of use, we can't think of a less-complicated operation than Word Finder's. Just place the cursor on the word you want synonyms for, press Control-Function-Key 6 together, and the list of similar-meaning words magically appears. Then move the cursor to the new word you want, press enter, and it'll immediately be substituted for the old word. But one does give up some flexibility for this simplicity. Webster, for example, also has a Type-In feature that enables a user to simply type in the word he wishes to explore with ones that have similar meanings. Webster also uses a function key for *Whoops* to correct a mistake and get you back to the original. Obviously, the more operating choices you have, the more complex it all becomes, though Webster's is certainly easy enough to work with (it also has a Help key to list what different function keys will do).

Nonetheless, Word Finder is sufficiently flexible and so easy to use that it makes up for all this, with the exception of a Type-In function that is so very useful to have.

Clarity. How quickly can you find the right new word for you to replace the one you typed? This isn't measurable, of course, but it's easily sensed. In this area, Word Finder's strength is also a weakness. It pops up a listing of so many words to choose from that the very selection of the one you want slows the process down.

For a synonym list when the cursor was on the word "begin," for example, Word Finder quickly listed 41 words. Each word could be explored further by placing the cursor under it and pressing the return key, which cuts down on the number of words to choose from and focuses more tightly on its meaning.

Webster's Thesaurus, a main competitor with less than half the synonyms available, listed 24 synonyms for the selected word, which is 17 choices less than Word Finder provided. But it listed them in two sections, numbered 1 and 2, with a maximum line character count of 34, excluding the numbers. Word Finder lists words in a much wider window that extends each line to as much as 68 characters. It does group words with closest meanings in alphabetical order, starting a new grouping without issuing any indentation, number, or any other division that would make it easier to read.

In another instance, with the word "word," 81 synonyms were listed by Word Finder, while Webster had only 10. Webster, however, also prefaced three of its synonyms with "see," indicating that there are other alternates to see in another window if you select one of these words for further exploration. Doing this on the three words, which meant moving the highlight bar and using three separate key strokes to get each grouping (shown one at a time). This brought up 43 more words. And these had seven words prefaced by "see," which enables you to pop up many more words. More words can be brought up from Word Finder's 81-word listing, too, in truth.

So what we have here is the Word Finder thesaurus with a full listing to view at one time (if the listing is too long, it continues when pressing a Page Down key) that's a bit trying to read and digest, and another synonym finder that lists only a fraction of what Word Finder shows in one gulp, but can show additional alternate words by positioning a highlight bar over the word prefaced by "see" and pressing a function key. Here, function Key 2 flips control to the new window if you want to extend words with any synonym shown in the new list that's also prefaced by "see." Even then, you won't gather as many choices in many instances as Word Finder gives you in one shot.

In addition, contrasting the two fine programs, I feel that Webster's highlight bar is easier to work with than Word Finder's speedy cursor. Furthermore, Webster requires a second, confirmation function-key press when automatically substituting a word in your text, which may be preferred by some people who habitually make such initial mistakes.

In conclusion, I'm very impressed by the new version of Word Finder. Lots more synonyms are *very* welcome. If the makers would revise its synonym display so that each group of closest meanings was easier to sight, perhaps prefacing them with numbers, I'd make it my number-one choice, even giving up the type-in facility I love. As it stands, I think Webster wins by a nose for me. Others, who want the most synonyms available by far, however, might choose Word Finder. That's horse racing for you!

P.S. For computer owners with CP/M operating systems, there's a Word Finder version available for you, too with 120,000 synonyms (up from 90,000). **ME**

Free Product Information

Readers can obtain free information on products advertised by certain companies, as well as for some editorially mentioned products. Simply circle the appropriate number printed below an advertisement onto the Modern Electronics "Free Information Service" card bound into this issue. After filling in your name and address, just mail the postpaid card. Your request will be forwarded directly to the advertiser with a mailing label prepared by our reader-service department to ensure speedy response.

The Sams Hookup Book: Do-it-Yourself Connections for Your VCR. (Howard W. Sams. Soft cover. 92 pages. $4.95.)

Hookup arrangements shown in the manuals that accompany videocassette recorders rarely address the needs of the owner who wants to use two or more program sources with his VCR. If he has an outside antenna and a cable feed or any of the many program sources popularly used with VCRs, this book can help him put together a properly integrated system. More than half of the book is devoted to perspective drawings and text that detail each step in the connection procedures and the various ways to operate each of the 17 configurations covered. The "by the numbers" text gives the reader a checklist of every step and can be followed even by someone who has no technical background in video.

Hookups covered are basically simple arrangements that use only couplers, splitters, A/B switches and cables. They range from the simplest antenna/VCR/TV receiver setup to an arrangement that integrates a cable-TV line, cable-TV decoder and satellite-TV block converter in which all remote controllers are operational. Though fairly comprehensive, the detailed arrangements do not take into account switching multiple program sources directly to the TV receiver or monitor, nor do they cover integration of more than three sources into a system. All hookup arrangements are based on a single VCR in the system. However, the arrangements provided should suit the vast majority of current needs, and a technically knowledgeable reader can easily tailor them to his needs.

Troubleshooting and Repairing Solid-State TVs by Homer L. Davidson. (Tab Books. Soft cover. 450 pages. $24.95.)

Good troubleshooting books for solid-state TV receivers are a rarity. This book is one of them, written by an author who brings to its pages almost 40 years of experience on a wide variety of TV chassis. His experience pays off for the professional reader because what the author covers—and just as importantly, how he covers it—in this thick volume has the mark of a professional who knows his job well. Geared toward the needs of the TV service technician, it starts with a chapter on common-sense servicing tips. Then, chapter by chapter, it details troubleshooting various circuits common to all solid-state color TV receivers, including a chapter on remote controllers, concluding with servicing the black-and-white chassis.

Troubleshooting tips for particular problems and actual case histories of five different chassis problems are given in each chapter. Each case history details how to localize the problem to the particular faculty component. Though not every possible problem that can occur in a given circuit can be covered in any book of this nature, this book makes a creditable effort to present the broadest possible picture, including "tough-dog" problems that can frustrate even the most dedicated technician. We would not hesitate to recommend this book to any TV repair technician who wishes to sharpen his servicing skills.

Satellites Today, 2nd Edition by Frank Baylin. (Universal Electronics, Inc., 4555 Groves Rd., Suite 3, Columbus, OH 43232. Soft Cover. 167 pages. $12.95.)

This nontechnical book is a primer on the current situation for people who have an interest in satellite television. Basically the story of the technology behind satellite TV, it begins with a brief history of satellite communications in general. Then the remaining seven chapters quickly bring the focus to satellite TV, with each chapter devoted to a specific topic. Chapters 2 through 5, for example, deal with the uplink, the satelites themselves, earth stations and the kind of programming available on the satellite channels. Chapter 6 discusses the current legality of private receive-only (TVRO) stations that more and more people are installing to expand their viewing horizons. The two closing chapters look into the future and discuss career opportunities in the satellite-TV field.

Supporting the text are drawings, photos (some of current satellite receiving equipment for the home) and tables. The text itself is informative and well-written, handling the topic in a relatively nontechnical manner.

Complete Guide to Telephone Equipment Troubleshooting and Repair by John D. Lenk. (Prentice-Hall. Hard cover. 237 pages. $29.95.)

This book concentrates on a basic troubleshooting approach that can be applied to both current and future telephone equipment. By avoiding equipment-specific troubleshooting procedures, the material presented will remain current as new technology is incorporated into future telephone equipment. Since the secret to effective troubleshooting and repair of anything relies heavily upon the technician's knowledge of the faulty equipment, this book concentrates heavily on theory of operation. The textbook-style text is supported by more than 150 photos and illustrations, the great majority of which are schematics.

Full coverage is provided not only by presenting the theory of telephones and networks, but also in informing the reader about specialized telephone test equipment and tools needed and detailing safety procedures that should be practiced. Troubleshooting procedures for specific types of telephone equipment are covered in related chapters. This is an unusually complete guide for troubleshooting both wired and cordless telephones.

NEW LITERATURE

Holiday Specials Catalog. The Heath Company's Christmas Catalog offers a number of holiday specials on selected items in its more-than-350-item line of electronic kits and products running the gamut from audio to video equipment and just about everything electronic in between. New in this catalog are PC AT-compatible desk-top and PC XT-compatible laptop computers, a removable hard-disk system, a computer touch tablet, a data line protector, a data director, a Loran receiver for boaters, benchtop/portable and shirt-pocket DMMs, and Fischer-technik construction toys, among others. Full descriptions of each product include technical details, price and photo. Items on holiday special are clearly indicated. For a free copy, write to: Heath Co., Dept. 150-815 ME, Benton Harbor, MI 49022.

I/O Connector System Catalog. Molex is offering an 8-page catalog that fully describes its SEMICONN shielded electromagnetic compatible connector system designed to terminate round and flat shielded cable for high-speed busing. Included are drawings, photos, specifications applications and terminating tooling. For a free copy, write to: Molex Inc., 2222 Wellington Ct., Lisle, IL 60532.

Ribbon Blues

• On your article on "Rejuvenating Printer Ribbons" (*Modern Electronics*, October 1986), WD-40 does a printhead *no* good! Secondly, a procedure taking over 24 hours is not worth the $3.00 to $5.00 replacement cost. The proper way to rejuvenate a ribbon is to use aerosol print ribbon ink (Ebonize from UPWEGO Computer Supply Inc. in Chicago, IL) at about $8.00 for 3 ozs.

When a ribbon gets "thin" printing, I open the can and spray the ribbon. I then set it aside and use ribbon #2, which I had previously rejuvenated.

Rejuvenated ribbons are far blacker than any new ribbon, and they last longer between treatments.

Two ribbons + Ebonize = less than $20.00. Each ribbon can be treated 10 to 20 times with one can, saving over $100.00.

John Topham
Prospect Heights, IL

• I just received my October edition and as always it is filled with useful information . . . with one exception: The article on "How to Rejuvenate Printer Ribbons." You've got to be kidding!! Is there really anyone so poor that he cannot afford to buy a new ribbon for his printer?? I, for one, have a few thousand dollars invested in my computer system and there's no way I would even consider "rejuvenating" the ribbon to save a few bucks. The last time I bought a ribbon for my Epson MX-80 it was $6.00. That was about a year ago. Yes, it is starting to get a little dim, but I'll somehow find the $6.00 and buy another. I know that ribbons for some printers cost more, but I really feel that no matter what the cost, this is a false economy.

Keep up the (overall) great publication.

Bob Hill
Burbank, CA

Lots of people feel differently about this than you do. There are computer ribbons that cost as much as $40, you know. One for a NEC Pinwriter P/5 series costs more than $20. Further, there are many ribbon types that are not readily available, even for popular printers. And many times a ribbon is bought that has "dead spots." This combination has generated a ready market for ribbon rejuvenation that is filled by commercial products. Computer Friends (6415 SW Canyon Ct., Portland, OR 97221), which specializes in re-inkers, for example, claims 50,000 MAC INKERS are in the field.—Ed.

Skipping Around

• As a new subscriber to your magazine, (first issue July 1986) I would like to say you have some fine articles and useful projects. But not having consecutive page numbers (July and August issues) is somewhat annoying. Perhaps there is a yearly "special" issue that contains all the missing pages and parts of articles and projects?

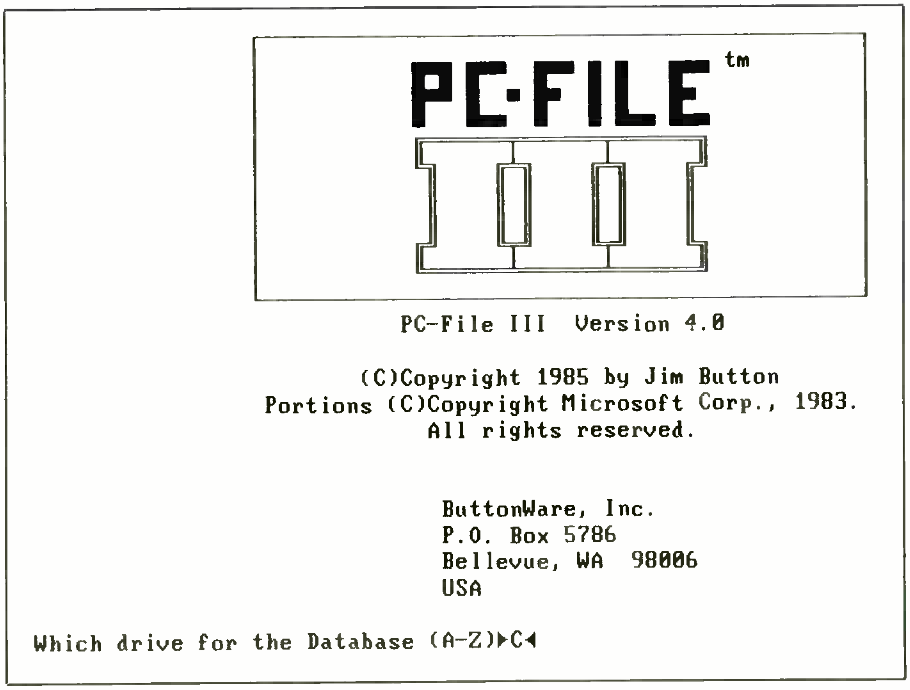
Keep up the good work!

Hans Kneip
Victoria, Canada

Pages appear to be skipped due to postal regulations when there are insert cards, which have to carry assumed page numbers, though they're not printed as such. So you'll see two apparently skipped ones in a few spots in each issue.

First Impressions: Open Access II; a Big Kiss; No-Risk Trials

By Eric Grevstad



The best $65 database around: a shining example of shareware.

Every so often, people tell me I'm behind the times, sticking with low-cost software and affordable 8088 systems instead of lining up for the new 80386 supermicros—I'm going to the Comdex/Fall trade show in a few weeks and expect to see two dozen 386 boxes following Compaq's lead, becoming commodity items almost before IBM releases its own. Lately, when folks urge me to scrap my aging XT clone and join the frenzy, I silent ly hand them a clipping from *InfoWorld*.

The quote is from a Microsoft marketing manager, and concerns DOS 5.0 or Advanced DOS or whatever they'll call the multi-tasking, colossal-memory-addressing system that's been the center of attention and anticipation since mid-1984: "We've had 27 people working on [the new DOS] for two and a half years. It's a significant multi-tasking system, very complex, and you can expect 25 to 30 substantial bugs when it finally comes out."

While people gasp and sputter at this confession, I go home to play with my XT clone and other less than optimal technologies. My favorite product this month is a bunch of software I bought for $6 per disk.

The Honest Approach

Long before big-name software publishers grudgingly removed copy protection, enthusiasts responded to the idea of "shareware" or "user-supported software"—programs which you're encouraged to pass along to friends via users' groups or bulletin boards. Instead of assuming you're a dishonest pirate, user-supported software relies on your honesty—if you try a program and find yourself liking and using it, you're asked to become a registered owner, entitled to support, upgrades, and usually a real manual to replace the skimpy hints on disk.

It's a fine concept, which I just endorsed by paying $20 for a year's membership in one of a half-dozen leading shareware houses, PC-SIG of Sunnyvale, California. (Actually, I got the $39 special of membership plus five disks, normally $6 each; with $4 shipping, my bill came to $43.) Having tried my first selections and scanned the PC-SIG catalog, I'm pleased. If I used Turbo Pascal—I never realized there are so many Turbo hackers' utilities out there—I'd probably be ecstatic.

Many user-supported programs are great choices for someone who doesn't already have, say, a communications package or checkbook balancer, if rarely enough to make you abandom the commercial packages you've used for years. PC-Write from Quicksoft's Bob Wallace (registered price $89) has the heart of a primitive word processor (separate editing and printing programs), but so many tweaks, tailfins, bells, and whistles it can keep up with almost any medium-range program.

ProComm ($25) offers a spectacular variety of communications options and protocols. DOSamatic ($39) is a glorious idea—a combination of a 1Dir- or Le Menu-style file manager and a switcher that lets you keep multiple programs in memory—though it prefers PC-DOS 2.10 to my hard disk's MS-DOS 3.1, eats memory fast, and lacks the cut-and-paste ability of my favorite switcher, Awesome Technology's Multiple Choice.

Finally, though I'm far from the first to do so, I must salute the shareware king, Jim Button. His PC-Calc spreadsheet ($64.95) is limited to 64 columns by 256 rows and lacks Lotus' fancy financial functions (though it can calculate loan interest and payments), but it's a first-class worksheet for moderate jobs. PC-File III ($64.95), among the most popular user-supported programs, is a sensational (if not relational) database, with fast, flexible searches, macros, calculations, password encryption, and import/export formats galore. Try a shareware copy and I'll bet you'll want to register—if only because the disk-based manual reads rather like *Hamlet* with all of Hamlet's speeches replaced by "This section has been deleted from your evaluation copy."

Not Quite Integrated

It's unfortunate that, while I was testing Software Products International's Open

Access II ($595), Ashton-Tate abandoned copy protection so I could stop boycotting my favorite integrated package, Framework II. Three of Open Access II's modules are superior to those of other all-in-one programs—there's a strong relational database, a slick 3-D graphics function, and communications that supports Xmodem and Kermit protocols and lets companies set up a small bulletin board or electronic mail system. But others are disappointing, awkward, or both, and Open Access II isn't truly integrated in terms of having multiple files open at once. As its demo disk says, it's "a collection of powerful separate programs," sharing a windowing interface but meant to be used one at a time.

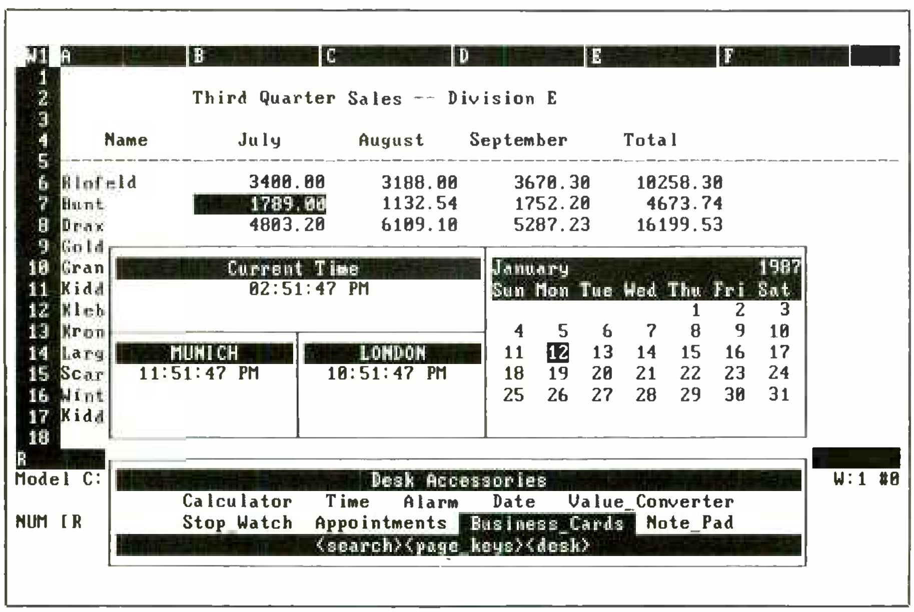
While Open Access comes in a vinyl box big enough to be Barbie's Dream House, there's no function-key template to help you decipher the constant references <do>, <change>, <line del>, <macro>, and similar keys; you'll need the reference card or the ample on-screen help. There's no tutorial for the program as a whole, but chapters in the module manuals.

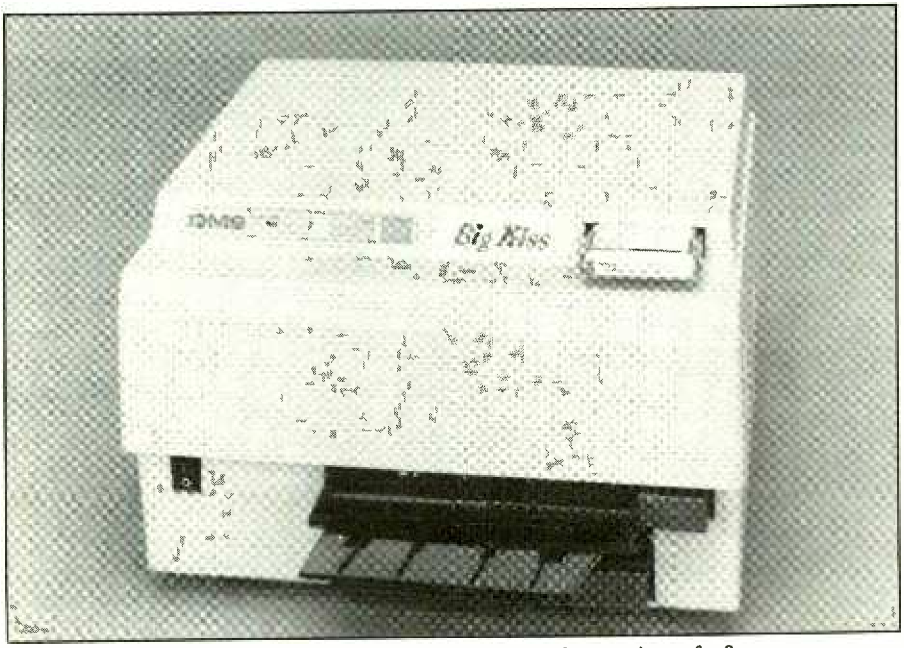
The general layout is appealing—F2 always calls a menu of functions executed by typing one or two letters, and F8 summons built-in desk accessories including a calendar, calculator, alarm clock, stopwatch, and business card file. The modules have highs (the database) and lows (a dreadful word processor, whose overwrite mode lets you type infinitely long lines—the Enter key aligns the margins, but won't start a new paragraph).

The spreadsheet is a good middle example: adequate size (3,000 rows by 216 columns), twice the speed of Framework II (though half that of 1-2-3), a helpful goal-seeking or reverse what-if function that lets you enter a result to find a variable, and financial functions for not only dollar format but mark, franc, pound, yen, peseta, lira, krona, guilder, drachma, and shilling format as well. With such sophistication, you wonder why it requires manual recalculation and sets format attributes through a bizarre syntax of changing, say, the value represented by the fifth in a row of eight question marks.

Open Access II has some strong abilities, but it's something of a renegade among integrated packages. Others are composed of various disk overlays, but

You can't use two applications at once, but you can always call Open Access II's desk accessories.





QMS' Big Kiss: What do you want a laser printer for?

let you switch among files on a desktop; the SPI program creates one whopping (1.1-MB) hard disk file, but makes you close and save your spreadsheet before work on a word-processing file.

Lasers in the Annex

Besides setting up a consulting business to occupy his semiretirement, my dad has bought so much hardware and software since outgrowing his Apple IIe that my parents' house has become the PC Papers Annex. I was there last weekend to check out his latest purchase, a QMS Big Kill laser printer. I was envious, but Dad was unhappily muttering, "I should have bought a Hewlett-Packard LaserJet Plus."

The difference comes down to the two tasks of laser printers. One is to act as a fast daisy-wheel or letter-quality device, spitting out sharp text in near silence at irresistible speed. The Big Kiss ($2,995) does that job to a nicety, emulating a Diablo 630 or Qume Sprint while offering 14 built-in fonts (up to 64 with a plug-in cartridge, plus downloadable fonts), an ample print buffer, and the power to glide through a long ASCII text dump (30,000 characters, eight single-spaced pages) in a minute and 20 seconds or the 110-page PC-File manual in 20 minutes. Speaking as someone who produces text files for a living, I could live with a QMS.

But Dad dreams of desktop publishing and fancy graphics, where the Big Kiss suffers compared to the industry-standard Hewlett-Packard and all the software available for it. While the QMS can emulate an Epson FX-80 well enough to produce Framework II or Clickart Personal Publisher graphics, they have the fuzzy dot-matrix appearance (only darker) of, well, FX-80 graphics. It refused to right-justify text when I tried my word processor, NewWord, and its FX-80 driver, and did so only in draft mode of Microsoft Word 3.0, ignoring the latter's ability to change Epson character size. [*Editors note: The NewWord product line, which is functionally similar to WordStar, has been acquired by Micropro, WordStar's parent.*]

The local dealer supplied a memory-resident utility called PopSet, designed to save QMS owners the complex chore of programming font and emulation modes from the printer's keypad; it clashed with Word, and QMS' tech support line confessed that it was meant for the slower $1,995 Kiss, not its big brother. Meanwhile, Dad tells everyone he meets, "If all you need is text printing, there are lots of good lasers to choose from. But if you're lured by pictures of gorgeous reports and page layouts, get the LaserJet!" Such conversation attracts attention on the streets of Sunapee, N.H. **ME**

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QMS Inc.
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ware performs resistance, decibels, VSWR ratio, resonance and other calculations. It also has menu selections for circuit designs for transistor amplifiers, Schmitt-trigger transistor circuits, passive and active filters using op amps, attenuators, among others. In addition to designing circuits, CompDes serves as an educational tool.

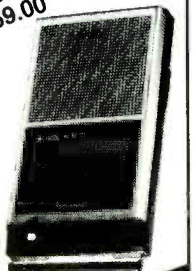
CompDes runs under MS-DOS 2.0 or up in any IBM PC/XT/AT/jr or compatible computer with either a color or a monochrome monitor. $49.95.

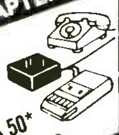
CIRCLE 19 ON FREE INFORMATION CARD

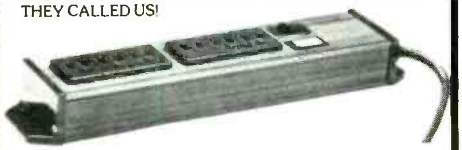
Digital AM/FM Receiver

Sherwood's new 55-watt/channel Model S-2750CP digital stereo receiver offers surround-sound and synthetic-stereo circuitry, a 5-band graphic equalizer and video and CD inputs. Surround-sound is used with stereo sources and requires four speaker systems, while synthetic stereo simulates two-channel sound from monaural source material. Features include: PLL synthesized tuning with 16 station presets, automatic scan tuning and fine-tuning indi-

(Continued on page 92)







A $20 Drum Synthesizer *(from page 48)*

project, use an ohmmeter to check for short circuiting between either contact of its jack and circuit ground and the chassis box. Repeat for the other contact. If you note any reading other than infinity, correct the problem before proceeding. When the voltages check out okay, wire the jack to the touch-pad circuit. Then wire the power supply into the system.

For the touch-pad, I've tried using the conductive foam carriers that protect CMOS ICs as the pressure sensor (R_a in Fig. 3) with disappointing results. Their linearity and response leave much to be desired. Therefore, the better approach would be to use commercially made touch sensors.

Setup and Use

It's time to check out the Drum Synthesizer. Before you do this, temporarily (or permanently, if you wish), connect a normally-open, momentary-action spst pushbutton switch between pin 15 of *IC1* and *J1*'s tip lug. Then connect the AUDIO OUTPUT from the Drum Synthesizer to your audio amplifier and power up the system. (Make sure your amplifier is off and its volume control is turned *all* the way down before making the connection.) If when you press and release the pushbutton switch you don't hear anything from the Drum Synthesizer, do the following. Check at pin 13 of *IC1* for the presence of an audio signal. For this, you can use any audio amplifier, but be sure to place a 0.1- to 10-microfarad capacitor in series with the signal line to keep unwanted offset voltages out of the amplifier. (An inexpensive amplifier designed for audio troubleshooting was presented in the October 1985 issue of *Modern Electronics*.)

If an audio signal is present at pin 13 of *IC1*, the complex signal generator is eliminated as the source of the problem. Hence, either the envelope generator or the vca portion of the circuit must be at fault. Should this be the case, power down the project and remove *IC2* from its socket. Temporarily connect a jumper wire between pins 2 and 14 of the empty socket and power up the project. The jumper wire rigs the circuit so that the envelope is turned on continuously.

If you now obtain an audio output from pin 6 of *IC4*, the problem lies in

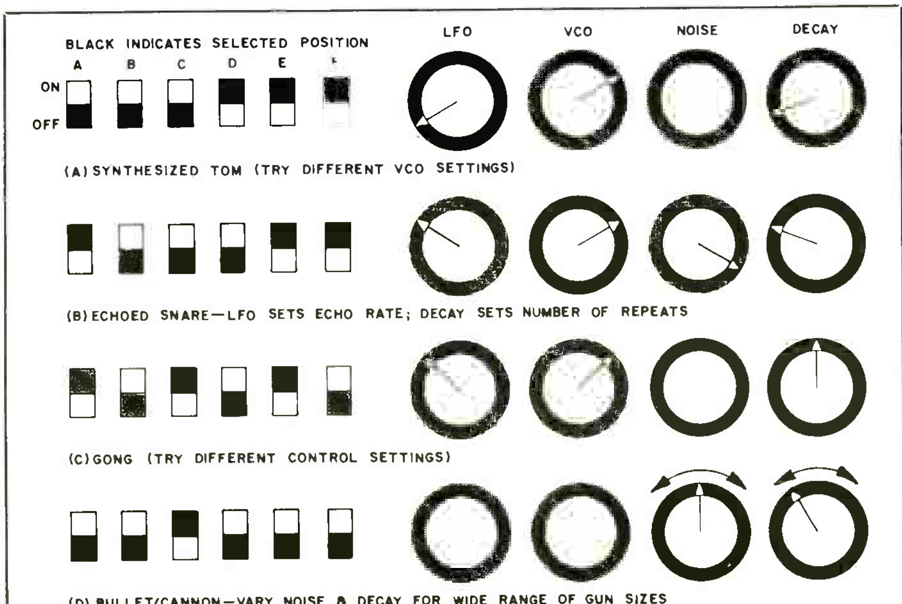


Fig. 7. Switch/control settings for generating a range of different sounds.

the *IC2* circuit. Remove the jumper wire, rectify the problem and then install a CD4001B in the socket. Return the Drum Synthesizer to service.

When everything is working properly, try generating some sounds with the Drum Synthesizer. Switch and control settings for a good sound for initial testing of the Drum Synthesizer are shown in Fig. 6. Both the noise generator and the lfo-controlled vco are used so that you can tell if all three sources are operating properly.

At this point, the best way to learn how to "play" the synthesizer is to experiment with the various switch and control settings. Settings for a few of this author's favorites are illustrated in Fig. 7. Of course, there are an almost infinite variety of control and switch settings you can try. Also try using external effects sources, plugged into the TRIGGER INPUT, to enhance the sound.

If you've built more than one Drum Synthesizer circuit into the project box, try setting each to a radically different sound and trigger all of them from a single source. It's amazing to hear how many cheap instruments have been used in recent musical recordings and equally surprising to hear how a "cheesy" synthetic tom can improve the sound of an expensive professional percussion synthesizer.

We've deliberately kept our Drum Synthesizer simple to make it accessible to as many people as possible. Even so, there are a number of refinements you can incorporate to make the instrument much more flexible. For example, you can experiment with different values for *C3* or/and *C5*, perhaps having a range of values that can be individually selected with a rotary switch. There are a number of other changes you can make to the basic circuit, referring to the 76477's data sheet. A very interesting prospect would be to use an external vco to drive the noise generator to obtain dramatic flanged noise effects that would otherwise tie up a lot of hardware.

One of the most interesting possibilities is the use of a microprocessor to memorize and control the sounds for a fully programmable project. The potentiometer controls could then be replaced with MOSFETs or optical isolators. With the proper software, the microprocessor could play back the sounds on command as well as vary the timbre for some really unusual effects. I haven't attempted to do this myself, but the subject has been covered in books like Hal Chamberlain's excellent *Musical Applications of Microprocessors* (Hayden Press).

Our Drum Synthesizer is hardly the last word in percussion synthesizing circuitry. However, it does show that it is possible to obtain a musically useful instrument without spending a fortune. **ME**

How To Design Ultra-Long-Delay Timers

(from page 36)

used for *C4* until the timer's accuracy approaches the rated 0.5-percent basic tolerance of the XR-2240 timer chip itself.

The three remaining ranges of 15 minutes each included in the Timer Beeper are obtained by switching 1-megohm resistors *R6, R7* and *R8* into the RC timing network in series with the 4-megohm composite value of *R5*. All resistors must have 1-percent tolerances. For other applications requiring other delays, a linear potentiometer with a dial (preferably a multi-turn pot with a vernier dial) could be substituted for *R5* through *R8*. Bear in mind that if you use a pot, no matter how precise its dial settings are claimed to be, the accuracy of the delays selected will be less than you would obtain if you used precision resistors instead. **ME**

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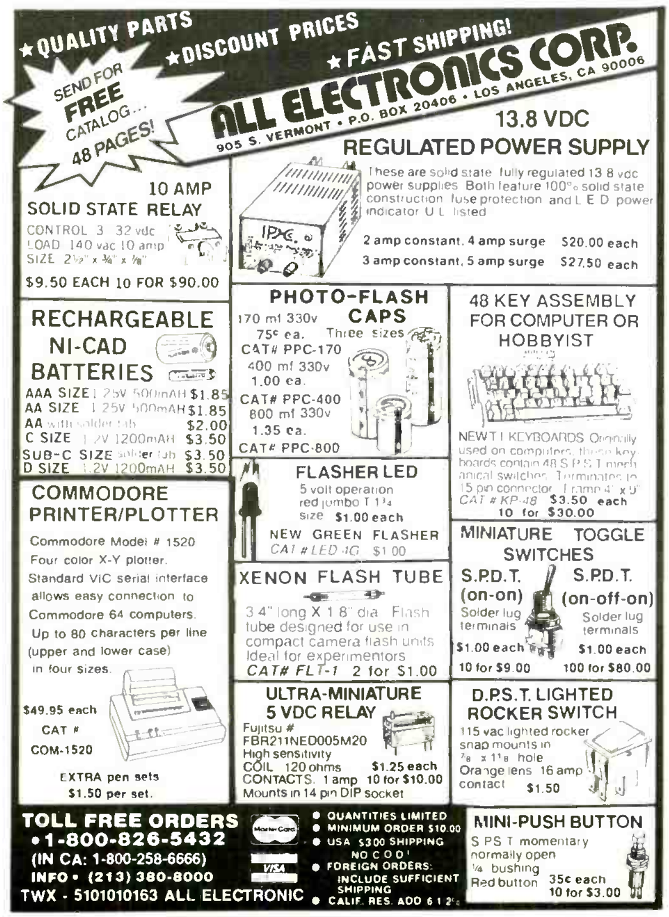

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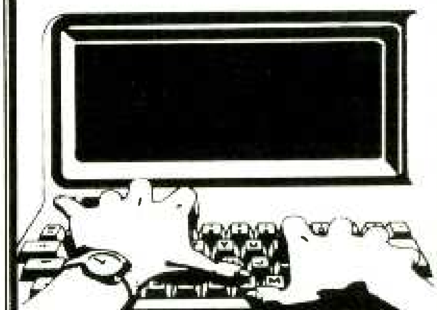

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97	98	99	100	101	102	103	104	105	106	107	108
109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132
133	134	135	136	137	138	139	140	141	142	143	144
145	146	147	148	149	150	151	152	153	154	155	156
157	158	159	160	161	162	163	164	165	166	167	168
169	170	171	172	173	174	175	176	177	178	179	180

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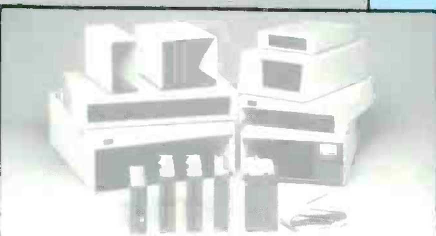

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