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APRIL 1989

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April 1989

Radio-Electronics
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BUILD THIS

TECHNOLOGY

CIRCUITS

DEPARTMENTS

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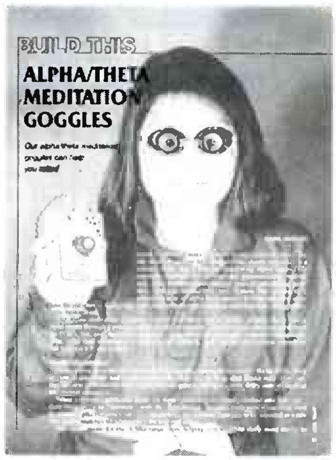

PAGE 53

AND MORE

ON THE COVER

Whether you live in a large city or a rural area crime has become a frightening fact of life. One reaction to the problem is the sometimes confusing proliferation of devices sold to protect your home, family, and possessions. How can you decide what kind of protection best suits your circumstances? In this issue, we sort out some of the home-security options that are available today. Turn to page 33 to read about how high-tech systems work and what features they offer. The devices pictured on the cover are representative of the two basic types of home-security systems—wired and wireless. Beginning on page 42, we describe how to install each kind of system. And, on page 47, there's a complete wireless home-security system that you can build yourself.

COMING NEXT MONTH

THE MAY ISSUE IS ON SALE APRIL 4.

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Advertising Sales Offices listed on page 104.

WHAT'S NEWS

Packet proposed for shuttle

WAYNE WILSON WB8TSO OF HEATH COMPANY (in jacket) presents Gil Carmen, president of the Johnson Space Center Amateur Radio Club, with the HK-21 Pocket Packet TNC, as club members look on.

Heath Company recently donated three *HK-21* pocket packet TNC's (*T*erminal *N*iode *C*ontroller) to the NASA Johnson Space Center Amateur Radio Club in Houston. As part of the *S*huttle *A*mateur *R*adio *EX*periment (SAREX), it is proposed that an HK-21 be used on a March 1990 shuttle flight.

Packet radio allows digitized information—voice, images, and data—to be transmitted over radio frequencies. In this experiment, amateur radio band frequencies will be used to transmit packetized data to and from the shuttle.

If the project is approved, one of the packet radios will be specially adapted for space travel. NASA will mount it into a protective SAREX casing unit and modifications will be made for use in zero gravity.

Computer controlled system uses water for cooling

Possibly the most common way of welding metals is to heat them with a mixture of oxygen and acetylene gas (oxyacetylene). That method has its weaknesses—acetylene is highly flammable and requires careful storing in metal containers. Welding must be done close to the acetylene source to keep pressure high.

As you may remember from high-school chemistry, water can easily be broken down into its components—oxygen and hydrogen—with an electric current. Those gases give out intense heat on reuniting.

Now a French system that uses complex computer controls appears to have put an end to the difficulties—such as producing large enough quantities of properly regulated gas at a workable pressure—of working with oxygen and hydrogen. The new method is safer than oxyacetylene because it produces only the amount of gas needed. The flame, which is hottest at the core, permits more precise work than oxyacetylene, which is hottest at the edges.

Despite the cheap fuel source, start-up expense may be a severe drawback, at least for the small operator. A complete system will cost at least $5000, as compared to less than $200 for an oxyacetylene system. Industrial users will find such costs insignificant in view of the lower operating costs. **R-E**

Oldest floppy disk

This floppy disk, unearthed at the site of the ancient Sumerian city of Lagash, extends the history of personal computing back to the third millennium B.C. The personal computer was previously thought to have been invented at about the time Columbus was busy discovering new lands, and only in widespread use since the gold-rush years made possible gold-plated connectors at a price affordable to even low-middle-income settlers. The inscription that appears on the protective clay sleeve reads, in part, "The program on this disk is protected by (illegible)...to the lions... beheaded...Copyright Microsoft Corp., 2900 B.C." **APR-1**

ALTHOUGH SOMEWHAT OUTDATED, this computer disk was once on the leading edge of technology.

HANDHELD DIGITAL IC COMPARATOR/TESTERS FEATURE 20 CHANNEL LOGIC MONITOR

B&K-PRECISION's Model 550 and 552 IC Comparator Tester/Logic Monitors test IC's by comparison to a known good reference in one simple operation. As logic monitors, they simultaneously indicate the logic states of up to 20 IC pins. They test most 14 to 20 pin, 54 and 74 Series TTL (Model 550) or 4000 and 74C Series CMOS (Model 552) devices. Both models are available from distributors at $425. Contact your local distributor or: B&K-PRECISION, Maxtec Int., 6460 W. Cortland St., Chicago, IL 60635. (312) 889-9087. **CIRCLE 251**

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

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

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NEW COMPARATOR ADDS IC/COMPONENT TESTING TO SCOPE

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

The new Model 540 component tester is an extremely cost effective, highly flexible trouble-shooting aid that can assist in rapidly locating faults on unpowered boards. Faults can be traced to the component level without specific circuit knowledge. Individual components can also be tested. Test results are displayed as a curve on a built-in CRT display. Curve tracing allows matching of components. Two channels allow production testing against known good boards. Ideal for field service or production testing. $995. Contact your local distributor or: B&K-PRECISION, Maxtec Int., 6460 W. Cortland St., Chicago, IL 60635. (312) 889-9087. **CIRCLE 253**

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VIDEO NEWS

DAVID LACHENBRUCH,
CONTRIBUTING EDITOR

• **Personal video.** Sony's compact *Video Walkman*, which combines an 8mm VCR and a TV set with a 3-inch LCD screen in a book-size package, seems to have opened a new product category called "personal video." Before the year is over, there probably will be at least a half-dozen competitors on the market. Most of them will sacrifice some compactness for versatility, though, using full-size VHS decks instead of 8mm. Casio already has a VHS combination with a 3.3-inch screen, and is expected to introduce new models with 4- and 5-inch pictures. Matsushita has a model with a compact Super VHS-C transport and will add one with full-size VHS, while Sharp has demonstrated a 4-inch combo and Hitachi has shown a 5-incher. Canon will join Sony in the 8mm field, but its model is reported to be even smaller and lighter than the original Sony *Video Walkman*.

• **Private Eye.** Consumer-electronics manufacturers are exploring possible personal-video uses of *Private Eye*, a tiny 2-ounce display device developed by Reflection Technology Inc., Cambridge, MA, that is expected to be used within a year for computer and calculator displays. Private Eye can be clipped to eyeglasses, a headphone, or a helmet so that one eye is looking through a viewing window that is less than 1-inch square. The eye sees the equivalent of a 12-inch display hanging in mid-air about 2 feet away. So far, it has been shown only as a monochrome display, but with high contrast and with resolution of 720 × 280 pixels. Its developers say that it is potentially very inexpensive and that a color-video version could be developed as "a realistic engineering activity, not a science activity." One major Japanese TV manufacturer reportedly has taken a license on the system, which could become the visual equivalent of earphones.

• **HDTV seen taking over.** HDTV will grow faster than either color TV or VCR's, according to a report by Robert R. Nathan Associates for the EIA. The report forecast that HDTV receivers would be in 25% of American households by the end of the century, and that 10% of American homes would have HDTV sets four years after high-definition broadcasting begins. Among other findings and assumptions in the report: Initially, HDTV will find its place in sets with screens 30 inches and larger, eventually dipping down to the 20-inch size. Transmission standards should be set in time for the first significant sales of HDTV sets to start in 1993. Large-screen HDTV sets will first be sold at an average retail price of about $2,500. Most large-screen HDTV sets will be made in the United States. HDTV sets will completely replace NTSC sets in the 30-inch-and-larger size group in the market within 6 years of adoption. Current NTSC sets won't be rendered obsolete by HDTV because the new broadcasts and cable-casts will be compatible with existing TV standards.

• **Still video.** Although video has taken over from film in consumer-movie making, it may have a much tougher road ahead before it can dispossess film in still-picture taking. At least eight manufacturers have now introduced still-video camera systems in Japan and/or the U.S.; all of those systems utilize the standard 2-inch magnetic "video floppy" that can store 50 single-field pictures or 25 full-frame images. Still video has already found a place in newspaper photography because of its immediacy and its ability to be transmitted over regular telephone wires. Its advantages in the home include that same capability of phone transport, along with the ability to view pictures over any TV set. However, its current disadvantages as a consumer product are topped by its high cost, its low definition as compared with film photography, and the high cost of making prints. In some ways, the history of consumer video and film photography have followed opposing paths: In film, still photography came first, followed much later by practical moving pictures. In video, however, just the opposite is true; motion was easy while economical still pictures pose a real problem to manufacturers. **R-E**

ASK R-E

RAM INCREASE

I have a Tandy 1000SX computer and would like to increase the amount of RAM in the circuit. I don't want to use a memory expansion board because I'd like to keep as many slots available as possible. Is it possible to add more RAM by piggy-backing memory IC's on top of the existing ones and tying in chip-select, address, and data lines at appropriate points on the bus?—B.M., Oakhurst, CA.

Judging by the mail, a lot of people seem to be interested in doing something like that. It's become a bit more expensive to experiment with RAM since the price of memory has multiplied by a factor of five in the last year or so, but I can't argue with the fact that more memory is a desirable thing.

In any event, while what you want to do is probably theoretically possible, from a practical point of view you're letting yourself in for a lot of potential brain damage. Since I don't have schematics on the Tandy 1000SX, it's impossible to tell how much of a job it is to add memory to the motherboard; but there are undoubtedly several major factors that you're overlooking.

First of all, it's a safe guess that you're talking about dynamic RAM and that brings up several ugly necessities, the chief of which is refresh. Dynamic RAM has to be refreshed periodically (usually every 2 milliseconds), or the stored data will fade away into hyperspace. A reliable refresh system is one of the major components in the design of the circuit and there's probably an upper limit to the amount of RAM it can handle. Adding memory to the board without knowing exactly how refresh is done is a risky business.

You also aren't paying any attention to how the control lines are handled. Tying the select lines to the new memory without paying any attention to how the memory is organized may lead to a situation where you're enabling two memory cells at the same bit location of the same address. At best that would be a waste of memory and at worst you'll damage some very expensive silicon.

The bottom line here is that it's not a good idea to monkey around with an existing design unless you understand the design; and that means having the paperwork. For what it's worth, I'd be willing to guess that the board isn't generating the proper control signals to deal with any additional memory. You'll have to check the circuit to see if that's true, and, if it is, your first job is to build decoding circuitry to handle the extra memory you want to add.

Remember, there's more on a memory expansion board than a bunch of RAM.

ADD A JACK

I'd like to add an earphone jack to my television set so that I can listen to it without disturbing anyone else. What's the easiest way to do that?—E. Juzumas, Seaford, NY.

Adding an earphone jack to a set is a straightforward operatio but there are a couple of twists th can make it more difficult. Le take a look at the simplest case a then talk about the problems th you might run across.

You can't deal with the audio u til the TV's front end has finish demodulating the RF and sep rates it into audio and baseba video, as shown in Fig. 1. On those two signals are available, t audio signal can be picked up a routed to an earphone jack. The are two places where you can that.

The first is at the volume cont and you have two options there well. You can take it from the en of the potentiometer, in whi case the TV set's volume cont won't have any effect on the le at the earphones, or you can ta

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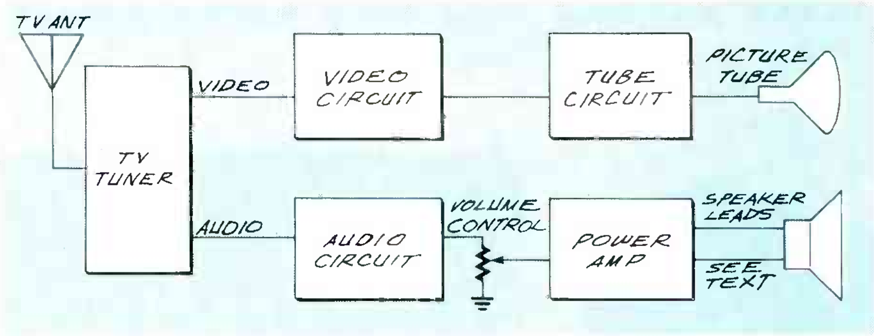

FIG. 1

the signal from the wiper of the potentiometer which will allow you to use the volume control to regulate the level at the earphones.

If you can't physically get at the volume control (or if it would require taking the entire set apart), you can also take the sound from the speaker connections. That would, of course, also allow you to set the volume with the TV set's volume control.

Most TV sets have an interlock on the power cord to make sure that the set is disconnected from the wall whenever the back is removed; but make sure that the plug is removed from the wall before you take the back off the set. Some of the voltages in a TV set are at lethal levels and, unless you know exactly what you're doing, playing around inside the cabinet with the power connected is a good way to risk getting fried.

When you decide to monkey around with a TV set, it's also a good idea to wait until the set's been off for an hour or so. There are some big capacitors inside and you want to make sure everything's been discharged before you go sticking your hands in there.

You can experiment with the three methods I've described and see which works best for you. Although it's probably easiest to take the sound from the speaker, be aware that some TV audio power amps don't have one side of their outputs tied to ground. You can check that by turning your TV off and testing for continuity between the chassis and the speaker leads.

If the amp in your set floats the outputs and the TV housing (on which you'll mount the earphone jack) is plastic, you can still pick the sound off the speaker leads. If, however, your TV is housed in a metal case and there's no continuity between one side of the speaker and ground, you'll have to take the sound from the volume control; that's because grounding one side of the speaker may damage the output stage of the TV audio amp.

Whichever method you choose, the wiring setup will be exactly the same. You'll have to break the connection in the TV set and wire the jack so that the sound is always routed through the contact switch in the jack. You'll need the capacitor and jack as shown in Fig. 2. You

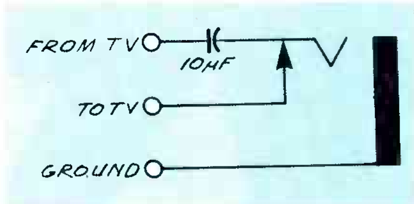

FIG. 2

can use any type of jack (it really depends on your earphone's plug), but make sure that you get the ones with a built-in switch.

That's really all there is to it. Drill a hole in the cabinet at a convenient location, mount the jack, and you'll be able to listen to the TV audio without bothering anyone else in the room. **R-E**


It's very realistic—it has a built-in 20-minute delay for takeoff.

LETTERS

THOSE DARN DIODES

We wish we had a dollar for every diode we put in backward—because we'd be $4 richer right now! In the article "High-Power Hi-Fi Audio Amp for Home or Car," (**Radio-Electronics**, March 1989) Fig. 5, the 12-volt power supply, on page 54 shows diodes D1 through D4 reversed. Figure 6, the photo on page 55, shows the correct orientation for those diodes. Sorry 'bout that.—*Editor*

CALIBRATION CLARIFICATION

The "TV-Derived Frequency Standard" (**Radio-Electronics**, April 1988) introduces three uncertainties that can be eliminated if the counter being calibrated has a 2.5-, 5-, or 10-MHz reference oscillator. The uncertainties are those in the transmitted 3.58-MHz color sub-carrier, the calibration of the standard itself, and the ±1 count error in the counter display. Those uncertainties are additive, and may amount to 3 ppm or so. (They could be much less than 3 ppm, but you can never really be certain of that; nor is it easy to ascertain what the value might be at any point in time.)

It's a waste of time to keep a frequency counter calibrated to an unnecessarily high degree of accuracy. If 2% is good enough for you in audio-frequency work, the line-voltage frequency is a handy calibration reference. Some work may require measurements to within 1 ppm or better.

A shortwave receiver is about all that's needed to calibrate a frequency counter with a 2.5-, 5-, or 10-MHz oscillator. Let the counter warm up and stabilize, and adjust its oscillator for zero beat with WWV. If the counter's radiated oscillator signal and the receiver's sensitivity are great enough, not even a dummy antenna will be needed to couple the signals and hear the beat frequency.

With no propagation path corrections, WWV carrier frequencies are accurate to ±0.03 ppm. The only other uncertainty introduced using this method is your ability to hear the beat, or difference frequency, and to adjust it to as close to zero as posssible. Difference frequencies as low as 0.1 Hz are easy to detect. If you can set the beat that low at 10 MHz, that's only 0.01 ppm. Adding the WWV tolerance gives 0.04 ppm, but don't expect any but the best Temperature-Controlled Crystal Oscillators (TCXO's) to remain steady at that value. Short- and long-term drift, ambient temperature, and line-voltage changes all play a role in increasing the uncertainty of the calibration, but that's a subject unto intself.

If the counter you have, or are thinking of getting, has a reference-oscillator frequency that won't beat audibly with WWV, then **Radio-Electronics**' "TV-Derived Frequency Standard" might be the next best thing to packing the unit off to the manufacturer for periodic recalibration.
DAN A. NIEMI
Gwinn, MI

SUMMER SCHOOL

The Massachusetts Institute of Technology's special Summer Session of professional seminars includes several programs that should interest the readers of **Radio-Electronics**. The following is a brief outline of selected seminars that are being offered:

June 1989

Program 6.01s: "Structure and Interpretation of Computer Programs"; June 26-12; Professor William M. Siebert.

Program 1.23s: "Knowledge-Based Expert Systems for Engineering"; June 26-30; Prof. Duvvuru Sriram.

July 1989

Program 6.84s: "Parallel Algorithms and Architecture"; July 17-21; Prof. F. Thomas Leighton.

Program 6.83s: "Parallel Computing: Dataflow Architecture and Languages"; July 24-28; Prof. Arvind.

Program 6.87s: "Robot Manipulators, Computer Vision and Artificial Intelligence"; July 24-28; Prof. Berthold K.P. Horn.

August 1989

One-Day Seminar: "Writing for the Computer Industry"; August 12; Prof. Edward Barrett.

Program 6.90s: Scientific Supercomputing with Dataflow"; August 14-18; Prof. Jack B. Dennis.

Program 6.64s: Computer-Aided Multivariable Control System Design"; August 21-25; Prof. Michael Athans.

Anyone who is interested in attending these seminars can receive descriptive brochures by contacting MIT Summer Session Office, Room E19-356, Cambridge, MA 02139; telephone 617-253-2101.
FREDERICK J. McGARRY
Director, Summer-Session Office of the Massachusetts Institute of Technology

CAPACITOR CONNECTIONS

In "Antique Radios" (**Radio-Electronics**, January 1989) you suggest connecting capacitors in series. Unless a voltage divider is implemented, the voltage will divide proportionally to the DC resistance of the capacitors. It is unlikely that they will be the same. If that distributed voltage exceeds the breakdown voltage of one of the capacitors, it will fail. Then the

continued on page 93

EQUIPMENT REPORTS

Sencore LC102 Capacitance/Inductance Meter

Check capacitors and inductors the fast and easy way!

CIRCLE 14 ON FREE INFORMATION CARD

IT SEEMS THAT AS CIRCUITS GET MORE and more complicated, testing components and troubleshooting in general get that much easier. For example, take the *LC102* "Auto-Z" meter from Sencore (3200 Sencore Drive, Sioux Falls, South Dakota 57107). It can give you a precise capacitance or inductance measurement displayed in common terms at the touch of a button, and even has an automatic test to tell you whether a capacitor or inductor is good or bad. Its capacitance range is from 0.1 pF to 19.99 F, and its inductance range is from 0.1 µH to 20 H, and both can be fully autoranged. It can also be operated on an IEEE 488 bus. Another good feature is that it can be powered from an optional rechargeable lead-acid battery, making the *LC102* well suited for field use.

Besides the obvious, such as checking a capacitor's value, the *LC102* can test for such things as leakage, ESR (*E*quivalent *S*eries *R*esistance), and dielectric absorption. ESR is the real resistive component of a capacitor's AC impedance. Dielectric absorption is the inability of a capacitor to fully discharge, and the *LC102* provides an automatic test for that. It also provides an accurate "true inductance" test, as well as a "ringing test" to check coils, deflection yokes, switching power supply transformers, and all other types of non-iron core inductors.

To determine a capacitor's value, the *LC102* measures one RC time constant while charging the capacitor under test to +5 volts. That basically means that the *LC102* measures the rate at which a capacitor charges under known conditions. An inductor's value is determined by applying a changing current to the inductor under test and measuring the produced EMF. In plain terms, an inductor has a tendency to resist changes in current, and the strength at which it resists those changes corresponds to the inductor's value.

The properties of an inductor are such that a current (or waveform) flowing through the inductor will continue to flow even after the current source is removed. The current continues to flow (or the waveform continuously repeats itself) until all of its energy is dissipated by the inductor in the form of heat (the waveform repeats itself as its magnitude gets increasingly smaller until the waveform "flattens," or dampens out completely—that is known as ringing). Therefore, the ringing test is done by applying a pulse to the inductor under test, and then counting the number of ring cycles before the pulse dampens to a preset point.

Good or bad?

One of the more interesting features of the *LC102* is that it can store a set of component parameters for either a capacitor or an inductor in memory, and then perform an automatic go/no-go test for any of those parameters. The test reading and "good" or "bad" will be displayed on the LCD when a test button is pressed. A large number of the same components can be quickly checked by connecting them one at a time to the test leads and selecting the desired test.

The go/no-go test is performed by first pressing the appropriate component-type button on the front panel of the *LC102*. The numerical value of the device is entered followed by a multiplier (pF, µF, mH, µH, etc.). The tolerance of the device is then entered as follows: A 1- to 3-digit number from 1 to 100 is entered, followed by pressing the "+%" button. Then a 1- or 2-digit number is entered, followed by pressing the "−%" button. The voltage rating, or working voltage (from 1 to 999.9) of the capacitor to be tested is entered, followed by pressing the "V" button. When the capacitor-leakage button is pressed, the working voltage is applied to the capacitor under test. Therefore, you do have to be careful **not** to touch the test -leads during that test.

For safety's sake, two red LED's on the front panel are there to warn you—one to indicate the presence of anything above 25 volts being applied to the test leads, and the other to indicate that the internal discharge circuit has failed. (When performing the leakage test, ultra-large capacitors may cause the test-lead fuse to blow, leaving the capacitor charged with a potentially dangerous voltage.)

Cable testing

Coaxial cables and transmission lines behave like a capacitor when open at both ends. The *LC102* can therefore be used to determine the length of a cable or the distance to an open. That is done by first measuring the capacitance of one foot of the cable under test, and then measuring the capacitance of the entire length. The entire capacitance is then divided by the capacitance per foot to find the distance to the break.

Likewise, coaxial cables behave like an inductor when shorted. So the *LC102* can be used to determine the approximate distance to a short. The inductance per foot of a sample cable is measured, and then the inductance of the suspected cable is measured. The total inductance is then divided by the inductance per foot to find the distance to the short.

Accessories

The *LC102* is supplied with an AC power adapter/recharger, and test leads and an adapter to connect to larger components. It also comes with a test-lead mounting clip and a test-button hold-down rod.

Optional accessories include a touch test probe, a field calibrator, a rechargeable lead-acid battery, an SCR/triac tester, a chip-component test lead, a bus interface for the IEEE 488 bus, and a 220-volt AC adapter/recharger. An easy-to-use component holder is also available that makes testing a lot quicker and, at the same time, frees up your hands for doing all sorts of other things.

We're sure that the *LC102* will feel at home in your repair shop or research and development center. Its advanced features will allow you to breeze through tests that used to take a lot more time. The *LC102* may end up paying for itself, by the amount of time saved. And, once you become familiar with its controls, you'll find the *LC102* is very easy—maybe even fun—to use. Of course, with a suggested retail price of $1895.00, the *LC102* is an investment for serious troubleshooting, not for fun. **R-E**

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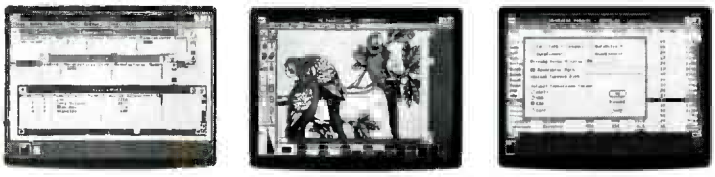

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NEW PRODUCTS

CIRCLE 10 ON FREE INFORMATION CARD

6-DISC CD-VIDEO PLAYER. video represents the merging of digital audio and laser video—two formats that *Philips* played a major role in developing. With CD-video gaining recognition and appreciation from both retailers and consumers, and an increase in the quantity and kinds of software being produced, Philips has introduced their model *CDV488* CD-video player. Compatible with 6 different types of discs, the *CDV488* can play virtually every type of software available today. It also offers advanced digital technology and features, a universal remote control, and such special effects as picture memory, mosaic picture effect, strobe, and freeze.

The unit plays the 3-inch CD single, the 5-inch CD, the 5-inch CD-V gold disc, and the 8- and 12-inch laser-video discs. It also plays the new 8-inch LD single—a thinner version of the standard 8-inch disc that provides 20 minutes of both audio and video.

The CD-V player offers favorite-track selection and 20 audio-track or video-chapter programming. It features Philips 16-bit, 4· oversampling digital filter, and dual 16-bit digital-to-analog converter. The *CDV488* also incorporates chrominance and luminance (Y/C) processing for superior picture quality. It features an "S"-type video output connector for compatibility with the growing number of high-performance monitors that use "S" inputs.

A universal remote control, which can control up to 10 different types of components, is included. Remote functions include jog for still-picture, step-picture, and slow-motion control. The shutter dial allows fast motion and high-speed scan; the angle and direction of its rotation determine the speed (2, 5, or 10 times normal speed) and the direction of the picture sequencing. Other remote functions include next and previous track/chapter, next and previous index, still/next-still and still/previous-still, select track/chapter, and on-screen display.

The *CDV488* has a suggested retail price of $1300.00.—**Philips Consumer Electronics Company**, One Philips Drive, P.O. Box 14810, Knoxville, TN 37914-1810.

COMPUTER WORKSTATION. *OPC's MACabinet Workstation* is specifically designed for *Apple Macintosh* computers, with special compartments that accommodate the monitor, printer, disk drive, hard disk, modem, and keyboard.

The workstation provides an efficient paper-management system that allows easy loading and restacks the printed paper on the bottom shelf. All computer components can be locked safely away behind a tambour door.

For quick access to cable connections, there is a rear service door; power cable exit slots are also provided on the back of the unit. A slide-out mouse tray can be used on either the right or the left side. The workstation sits on heavy-duty, dual-wheel, steel-bracketed casters so that it can be moved around easily.

CIRCLE 12 ON FREE INFORMATION CARD

The *MACabinet Workstation* has a suggested retail price of $649.00.—**OPC, Inc.**, 11828 Glenoaks Blvd., San Fernando, CA 91340.

DUST REMOVER. *Chemtronic's E-Series* line of chemicals for computer and electronic field service has been formulated to be environmentally sound, meeting EPA ozone safety standards. *E-Series Ultrajet* gas duster—a second generation EPA-exempt fluorocarbon that offers low toxicity, inertness, and non-flammability—has been designated as a substitute for regulated CFC's.

CIRCLE 13 ON FREE INFORMATION CARD

E-Series Ultrajet uses high-gauge pressure (120 psi) to deliver powerful jet blasts for dust removing and cleaning electronic systems. Because is is highly filtered, the product can be safely used on optical surfaces and precision mechanisms. *Ultrajet* is non-abrasive and leaves no residue.

It is packaged in 12-ounce cans. For high-volume users, a complete reusable system is also available.

E-Series Ultrajet costs $5.45 in individual cans; the complete system costs $24.50 (refills are $5.00).—**Chemtronics**, 681 Old Willets Path, Hauppauge, NY 11788.

FASTER ELECTRONS. *Electr-O-lube* is a spray-on liquid from *Zip-Tronix* which, its manufacturer claims, will reduce or eliminate the propagation-delay bottleneck in many of today's semiconductors. Applied in a thin film to the surface of a device or circuit board, the product penetrates to the interior through tiny cracks and crevices to lubricate the very paths traveled by the electrons within.

Speedups as great as 25% are promised, as well as a decrease in warmup times. Things also tend to turn off faster.

However, the manufacturer cautions, *Electr-O-Lube* is not intend-

CIRCLE 289 ON FREE INFORMATION CARD

ed for use in superconducting circuitry as it tends to get gummy at low temperatures and impede electron flow. For such situations, another Zip-Tronix product, *Kry-O-Flo*, is recommended. *Kry-O-Flo*, also available in spray cans, penetrates to cryogenic superconducting electron paths and imparts to them a soothing warmth that encourages normal electron flow to resume.—**A-Tronix Corp.**, 459-F Absolute Dr., Liberal, KS 76543. **R-E**

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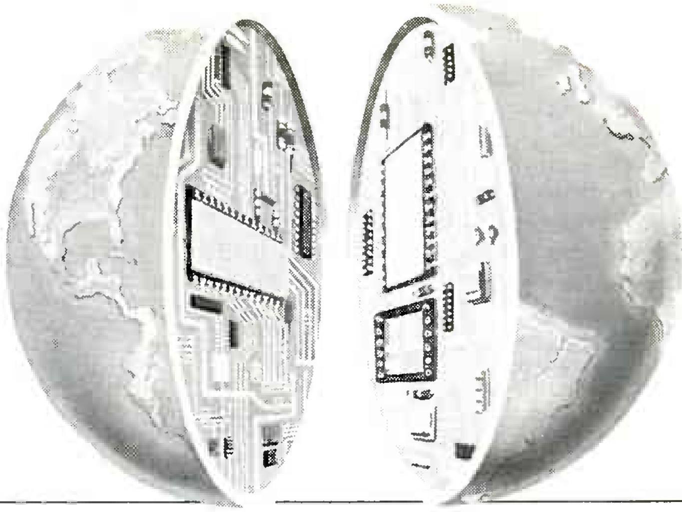

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Refilling SX toner cartridges

DON LANCASTER

BOY, THERE SURE HAS BEEN A LOT OF helpline response to the solid-state compass stuff we looked at two months ago. I guess I did mention that you can get fluxgate sensors off the shelf from *Radio Shack*. Meanwhile, the original "horse's mouth" paper about all that is *Earth's Field Magnetometry* by W.F. Stuart, appearing in *Reports on Progress in Physics*, 1972, vol. 35, pages 803–881. And you may also find *Recent Advances in Fluxgate Magnetometry* from the *IEEE Transactions on Magnetics*, MAG-8, no. 1, pages 76–82 of more than passing interest.

One helpline caller has asked why magnetoresistive sensors couldn't be used. Those are primarily to be used with very strong magnetic fields, and I don't think they are nearly sensitive enough for any compass use. Far and away the most off-the-wall winning entry in our fluxgate compass contest came from Dr. Dennis O'Leary who studies fish whose ears have built-in magnets. See his paper on "Magnets in guitarfish vestibular receptors", over in *Experientia*, v. 37 (1981), pages 86 and 87.

Several callers did give me some additional input in infrared filters. Apparently, unexposed 35-mm photo film works just fine. Years ago, I had a student learn that the hard way. He built a shaft encoder having the light transmission pattern exposed on a litho film disk. The trouble was that the infrared light whipped on through the black parts just as easily as it went through the clear portions.

Some infrared response curves on their various plastics is available in a "PEL-ette" known as "Infrared Transmittance of Plexiglas Colors that are Opaque in the Visible Portion of the Spectrum," available from the folks at *Rohm and Haas*.

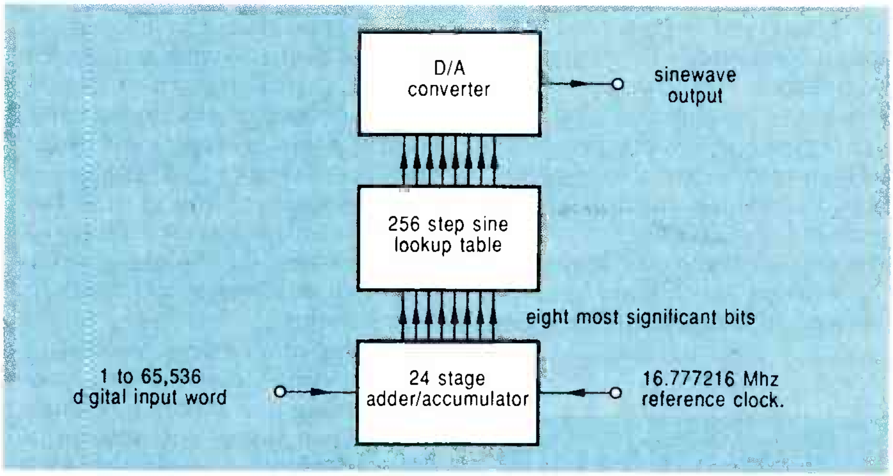

FIG. 1—DIGITAL SINE WAVES generated by phase addition. The input word sets how fast the waveform phase will advance, in turn deciding the directly synthesized output frequency. The values shown will generate 1 Hz to 65.536 kHz in 1-Hz steps.

Every once in a while a resource comes along which is absolutely and unquestionably in that "must have" category. That is certainly true of the *Signal* from the *Whole Earth Review* people. That is a master directory of virtually all communications resources, well done up in the style of the original *Whole Earth Catalog* and costing $16.95. No hacker can ignore that book. It is far too important.

NEED HELP?

Phone or write your **Hardware Hacker** questions directly to:
Don Lancaster
Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073

As per usual, this is your column and you can get technical help and off-the-wall networking per the *Need Help* box. As is customary, many of the products and services mentioned do appear in the *Names and Numbers* sidebar.

Let's start off with a loose end...

Digital sine waves

There was a surprising amount of interest in our recent digital sine wave stuff, and I apparently did forget to include one key technique. Thanks to Tim Green, another contest winner, for bringing that to my attention.

The idea is called *phase addition*, and its block diagram appears in Fig. 1. What you do is route a digital word to a D/A converter that is followed by a low-pass filter, just as we did before.

Only this time, your digital word consists of the top 8 bits of a 24-bit adder/accumulator. At a constant and high clock rate, a fixed phase increment is added to the accumulator. For instance a "1" input could advance the phase count so slowly that you'll get a 1-Hz sine wave, while a "2" would give you 2 Hz, on up to the much larger numbers which give you much higher frequencies.

Advantages of the method are that you are directly synthesizing the final frequency, which eliminates all the hunting and the noise bandwidth of phase-lock loops. Thus, your spectral purity can be extremely high. There is also no bad transient whenever you change frequency—just a smooth and unbroken transition.

For lower frequencies, a personal computer will work just fine, and it should be trivial to generate up to several kilohertz using an *Apple II*. You can do so in 1-Hz or even smaller resolution steps.

To work at any higher frequencies, speed limitations on those hardware adder-accumulators can get to be a problem. One extremely expensive source of ultrafast chips for that is *Stanford Telecommunications*, while slower and much lower-cost kits are obtainable from *A & A Engineering*. One source of additional details is the *Radio Amateur's Handbook*.

Minimum-order hassles

One of the biggest hacker helpline complaints concerns all of those steep minimum orders that many of the electronics distributors seem to be insisting upon. The problem is bad and it is getting much worse. How can you cope with it?

First, note that it just is simply not possible in this day and age for anyone to profitably offer the direct-mail sales of electronic hardware if their average mail order ends up less than $25. Those $15 or $25 minimums or any $5 to $8 below-minimum service charges from the "new-age" good-guy distributors are all necessary for their very survival.

On the other hand, several of the "old-line" distributors have gone as high as a $250 minimum order. Even worse yet, several of them now have an intolerable $100 per line item minimum. Which means if you want a two-cent part, you now have to buy 5000 identical ones at once, or else forget it.

The *Bell Electronics* people have just garnered a ZZZ rating and moved to the very summit of my *Synergetics* black list for their unacceptably high line minimums and all their outright arrogance. (All I wanted were a few jelly-bean regulators.) Unfortunately, those epsilon minuses are not alone.

The sad fact is that, if you are an individual hacker, the deck gets very much stacked against you. On the other hand, that just may end up as the only game in town.

So, how can you cope with steep minimum orders? Here are a baker's dozen partial solutions...

(1) Plan ahead. If you run in panic mode, you will almost always end up wasting money. Find the best dealer with the best source and the lowest minimums. Combine what you need with what you think you may need for other upcoming projects. Try to get everything from one or two suppliers, rather than a dozen.

(2) Try to always deal with a "new-age" distributor, such as *Mouser, Active, DigiKey*, or *Jameco*, instead of using those "old-line" houses such as *Schweber, Allied, Cramer, Newark, Bell*, or *Hamilton*.

(3) Fill out your minimum order with other goodies which you would someday like to play with.

(4) Rather than using a distributor, request free samples directly from Applications Engineering of the firm actually building the part. Use a laser-printed or other business letterhead. Request only as many parts as you need, and tell them exactly what you are going to do with them.

(5) Check into your local walk-in surplus stores. Often you might find reasonable substitutes at incredibly low prices, especially on unadvertised odd lots. The savings can even make a 100-mile drive worthwhile.

(6) Build up your own personal inventory of "in-stock" parts that you are likely to use in the future.

(7) Network with friends in a ham or computer club, or with engineers or techs from an aerospace company or whatever. Be able to swap parts both ways. Become a resource for the other party.

(8) Move to Silicon Valley, where all of the 24-hour convenience grocery markets also carry all the other known types of chips. No minimum. Or, if you are too far away, always be sure to try *Radio Shack*.

(9) Naturally, we would hope you would always check out our **Radio-Electronics** advertisers first for any component part. That's why we put the bingo card in the magazine. But two other great source for oddball components are the unique *Nuts and Volts* bargain shopper and all the distress merchandisers found in that classified ad section of *Electronic News*. While the latter always will have steep minimum line charges, the prices are often so ridiculously low that it may not matter.

(10) Aggressively subscribe to all the electronics trade journals, such as *EDN, Electronic Design, E.E. Times, Electronic Products*, and/or the *Electronic Component*

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News. You'll find lots of free-sample offers in any of those, along with unique sources of supply. As usual, you get a complete list from *Uhlrichts Periodicals Dictionary* at your local library.

(11) Acquire an enormous junk box. Or better yet, a junk room or a junk building or two. Fill them with broken TV sets, dead VCR's, or whatever else trips your trigger. A dozen cubic yards or so should do for a bare-bones start.

(12) Hamfests, particularly the big regional ones, have outstanding parts bargains and zero minimum orders. Ask for full details at your local ham club, or, once again, do see *Nuts and Volts* for a listing.

(13) Combine your order with that of another hardware hacker. Or start your own "buying club."

Low-power regulators

The folks at *Maxim* have added yet two more low-power regulator chips to their line. The MAX644 steps up a single alkaline cell as weak as 0.9 volts up to a fixed and regulated 5.0 volts. The MAX645 gives the same treatment to a 2.4-volt lithium cell.

Figure 2 shows you the circuit. The secret is to have two switching regulators. The first regulator generates around 12 volts or so at a very low current for internal use. That high voltage gives enough *MOS* transistor base drive to allow for high efficiency.

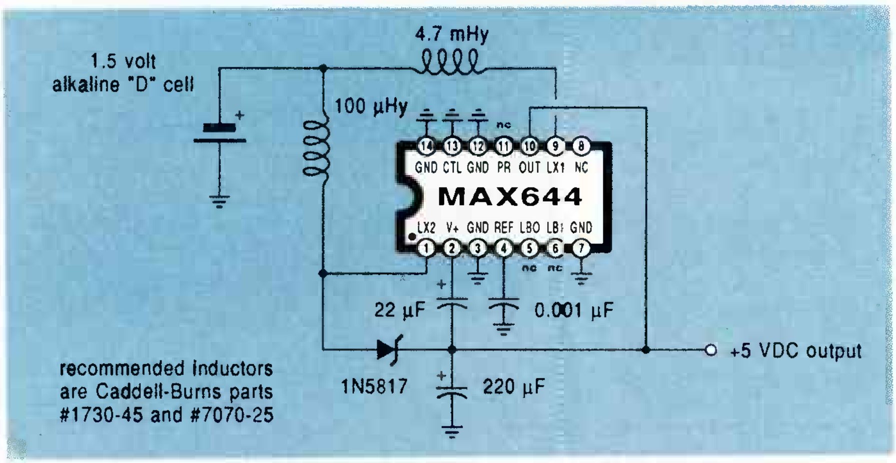

FIG. 2—THIS SIMPLE SWITCHING REGULATOR steps up a single alkaline cell to give you a fixed +5-volt output at 50 milliamps. An external pass transistor can be added for more output current.

While the circuit is quite simple, careful selection of the inductors and the Schottky diode are needed for maximum efficiency.

The typical efficiency is in the 75-percent range. Currents up to 59 mils are directly available, while an external pass transistor may be added for higher current needs.

For this month's contest, just tell me what you would do with a micro-power regulator that delivers +5 volts off a nearly dead single alkaline cell. We will have all the usual *Incredible Secret Money Machine* book prizes, along with an all-expense-paid (FOB Thatcher, AZ) tinaja quest for two for the best entry of all. Send all your written entries to me and not to **Radio-Electronics**.

Refilling SX cartridges

As we have seen in past columns, a profitable business can be built up centered around refilling toner cartridges for copiers and laser printers. Many recent hacker helpline requests have been for methods to refill those *Canon SX* cartridges as used in the *LaserJet II* and the *LaserWriter II*.

An affordable portable i

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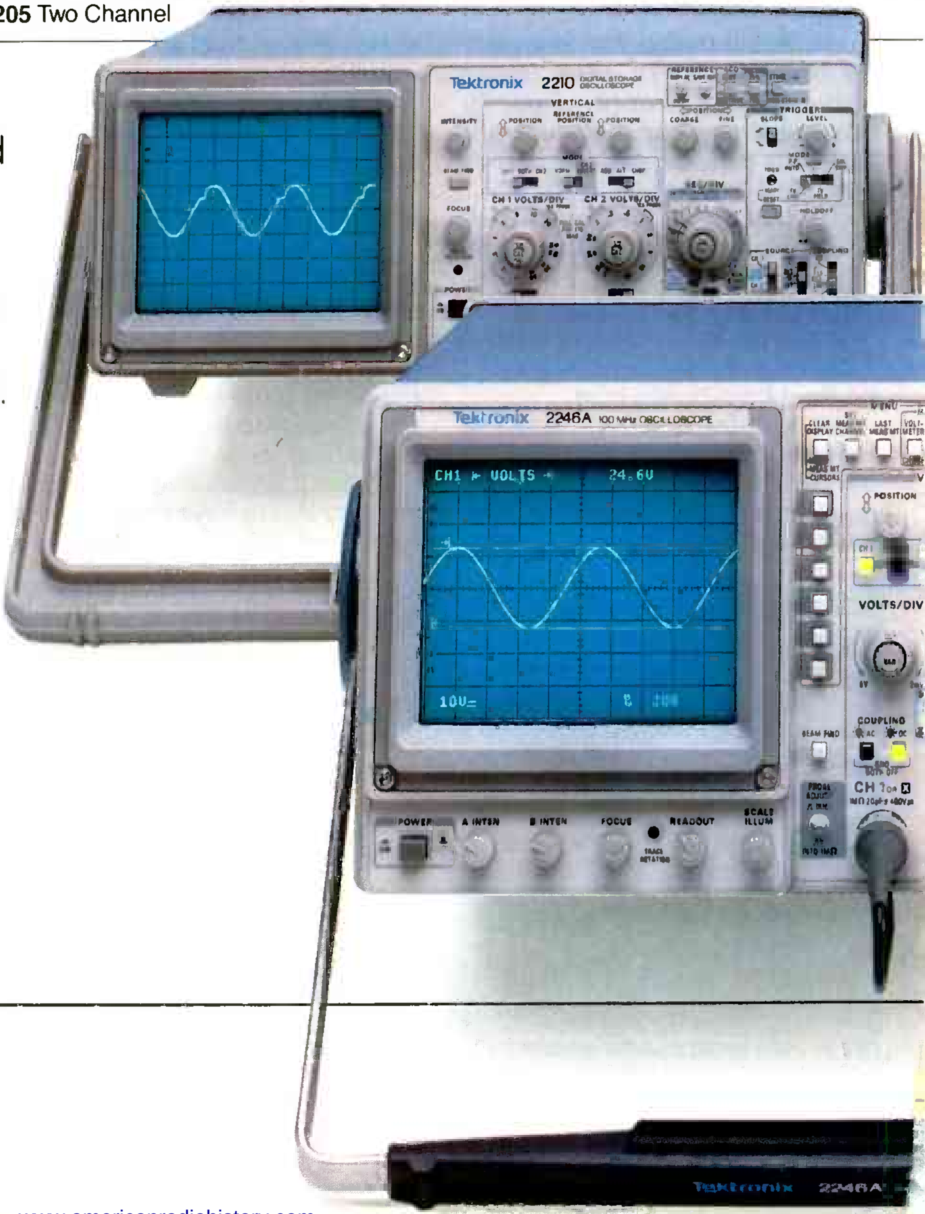
*Digital Storage Oscilloscope



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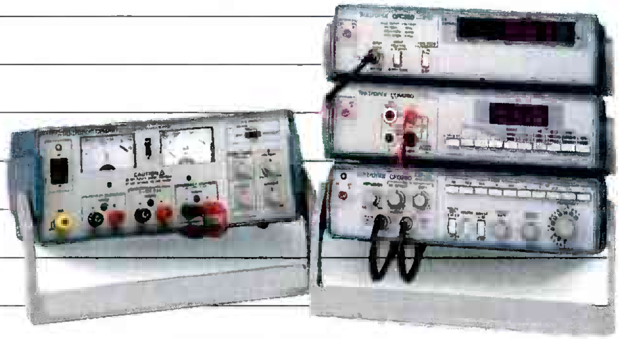

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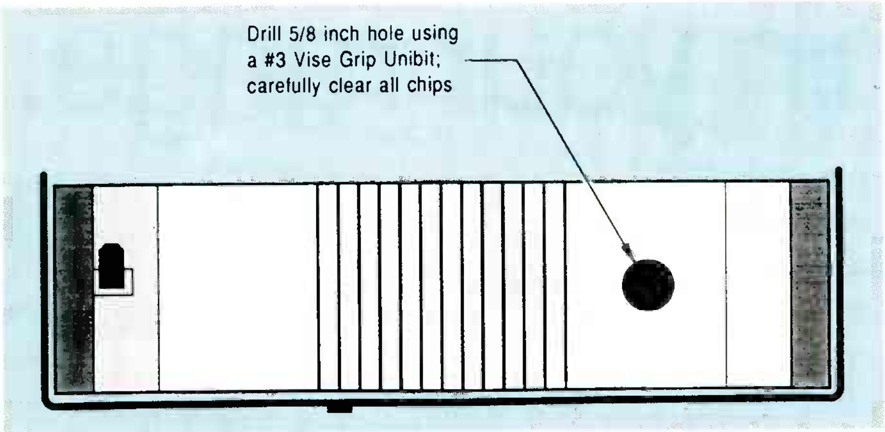

FIG. 3—ADDING A FRESH TONER filling hole to an SX cartridge. Use a no. 3 vise grip unibit and a very slow drilling speed.

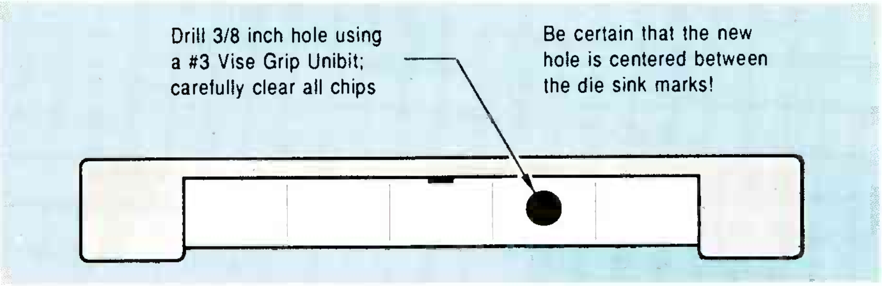

FIG. 4—ADDING THE SPENT-TONER emptying hole to a Canon SX cartridge.

Sadly, there is now as much as a 15:1 cost penalty in per-page toner costs when using those newer *Canon* SX laser printers over the older CX engines. On the older CX cartridges, you were able to buy cartridges for five bucks out of your Sunday paper and refill them up to seven times, bringing all your toner costs down into the 0.33-cents-a-page range that is cost competitive with jiffy offset printing services.

Unfortunately, those SX cartridges do use a highly abrasive toner, combined with drums that are intolerably scratch sensitive.

So, while you can in fact reload SX cartridges, at present, you just can not even remotely approach those CX cartridge economics. So, do consider this a progress report where I'll bring you up to date on what can and cannot be done at the present.

While it is difficult to even get a second SX reload, you can sometimes do so with the following ricks and techniques. First, you immediately remove the factory toner and give it to your friendly neighborhood diesel mechanic or use as a valve grinding compound. Replace it with a good quality third-party refill toner.

Second, be certain to use a drum lubricant, such as *Pixie Dust* or its equivalent. Do a very light dusting after every refill.

There are two refilling methods, the *Punch and Go* and the *Total Teardown*. I very much prefer punch and go, since that delivers far and away the lowest per-page toner cost to the end user. We charge $22 for local SX refills. Since this is a remote rural area, I can get away with such an outrageously high price. You can do the job by yourself for as little as $7.50 and three minutes time.

The SX cartridge needs to be modified before you can refill it. Using a Vise Grip no. 3 *Unibit* and a very slow drilling speed, you drill the two holes as shown in Figs. 3 and 4. Drill upside down and be very careful to remove the single chip that the unibit provides. The two holes are then capped with a nickel *Caplug* or else some very aggressive tape.

There are three major steps to the refilling process. You first open the holding-tank hole and carefully shake out the excess toner. Do this outside and avoid breathing any of the toner. You'll then reseal your holding-tank hole, open the fresh toner tank hole, and pour in a bottle of refill toner.

Finally, you remove the old fusion wiper wand and peel and stick a new wiper pad in place.

Another tip: keep the green toner dial advanced all the way to nine for any and all rough drafts and for all internal use documents. Note that the *higher* the number, the *less* toner you will use. Cartridge life can easily be doubled merely by using that simple technique.

I currently recommend using *Lazer Products* to supply toner, pixie dust, wiper pads, and drum recoating.

Mass teleportation

The rate at which science and technological fact is outpacing science fiction continues to utterly astound me. Nowhere is that more apparent than in the emerging field of mass teleportation.

The exciting center of all that has recently been happening is in that outstanding *International Journal of Teleportation and Mass Transfer*. In particular, do check out Barfoot and Gentry's tutorial material way back in Volume XVIII, pages 1146–1198, along with their extremely detailed bibliography.

continued on page 76

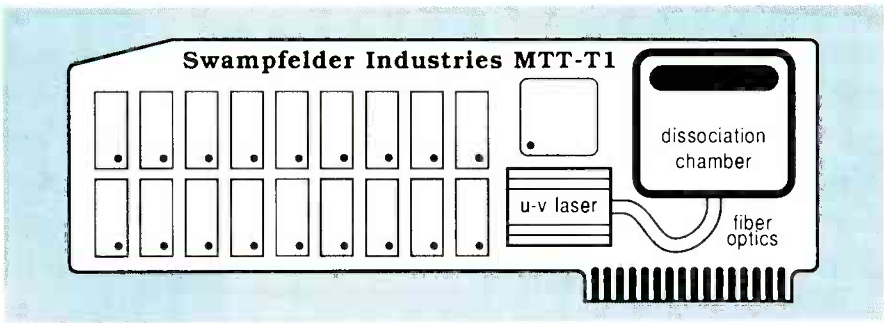

FIG. 5—PICTORIAL OF THE MTT-T1 mass-teleportation transmitter unit for the Apple II Plus. The solid-state 100 milliwatt ultra-violet laser chip is optical-fiber coupled to the dissociation chamber. The telephone connection is on the other side of the card.

HIGH-TECH HOME SECURITY

It takes more than a water-filled moat to protect your castle

HERB FRIEDMAN

EARLY MAN PROTECTED HIS HOME against marauding beasts and the things that go bump in the night by blocking the entrance to his cave with a large rock. As man's housing became more sophisticated, security was provided by a water-filled moat or a large dog. But as housing lots shrank in size there was no longer room for a moat, and a large enough dog eats too much; so security evolved into barbed wire, trip wires that rang bells, and even a flock of geese—because geese provide early warning by honking at strangers. Unfortunately, except for a mean dog, none of those security methods are very effective at protecting property when no one is around.

What was needed was an intruder alarm that could wake the dead, or, at the very least, alert a neighbor or the beat cop—the idea being that a potential intruder *knew for certain* that he was likely to be caught in the act. It was electric power—usually provided by batteries—that allowed us to use a very loud bell as an intruder alarm.

Of course, in time the miscreants learned how to defeat a simple electric-based alarm, so today we use high-technology electronic equipment to protect our castles: microprocessors, mainframe computers, electronic nightingale-floors, infrared motion detectors, microwave sensors, wireless signalling, automatic telephone dialers, subaudible telephone signals, cellular-telephone alarms, and most important, the *central station*.

The central station

Before we go any farther, let's take time out to look at the central station—also called a *central monitor* or *central station monitor*—because that is really what is behind the effective use almost all high-tech home-security equipment.

Before it became financially necessary for the majority of women to work, one could be reasonably certain that a neighbor would be home to hear an alarm bell, and the neighbor would notify the police if she heard clang-clang-clang. Also, in many areas, there were "beat cops," policemen who walked by your home several times a day. Today, however, many communities are deserted during working hours: If there is anyone around it's the postman or the UPS driver, and when they have moved on, the neighborhood is as deserted as Death Valley at high noon. As for the beat cop, he vanished long ago from residential areas—you're lucky if he passes by twice a day in a patrol car.

So an alarm bell can ring for hours and there will be no one to hear it; a fact that is well-known by both amateur and professional thieves. Because of that, the central station—which was formerly used primarily by business establishments—has become the front-line defense for the homeowner.

Basically, central-station monitoring works like this: When a home's alarm goes off it also triggers an automatic telephone dialer that calls a central monitoring facility. A computer at the central station tells the duty operator precisely what is wrong at the home: a fire, a burglary, a hold-up, an invalid needing medical attention, even freezing cold or a leaking water pipe. The central station's operator usually—not always—phones the house to find out what is wrong and to get a verbal all-clear password in the event that the alarm was accidental. If the operator does not get an *absolutely precise* password, he or she immediately notifies the proper authorities, such as the police or fire departments, an emergency rescue service, or a neighbor (if your alarm sends a "freezing temperature" or "water leak" signal).

Why an *absolutely precise* password? Well, assume that an intruder has forced you at gunpoint to silence the alarm, and then he listens in on an extension telephone—still pointing the gun—as you answer the central station's call. Assume that your password is the numbers 5678. You reply 8956. The operator will say "Thank you," and the intruder will feel safe. Meanwhile, the operator calls for the cops.

With a high-tech alarm there might be no call-back from the central station. A keypad code that is used to silence the alarm also tells the central station's computer that all is well. If an armed intruder forces you to turn off the alarm, entering an extra number tells the central station that you are being held at gunpoint. For example, if the code 5678 turns off the alarm and automatically sends an "all safe" signal to the central station, the code 56789 will turn off the alarm but send a signal to the central station that a hold-up is in progress.

Perimeter defense

The earliest home-security system was the "perimeter alarm," which in refined or "supervised" form is still the end result for many—usually the best—high-tech home alarms. Basically, it consists of a battery in series with a normally-open switch and an alarm bell. The switch might, for example, be a *mat switch*, the kind used by supermarkets to trigger a door-opening mechanism. Anything, or anyone causing the switch to close completes the electric circuit, which causes the alarm bell to sound.

As you can well figure out, there are two things wrong with that kind of alarm. First, the alarm stops when the switch is opened—when the person steps off the mat. But more important, it does not tell if the circuit is working. Suppose the switch becomes defective. How do you know that it's defective? An intruder can step on a defective mat-switch and the alarm will not sound.

It was to overcome those limitations that the latching alarm with a *supervised* loop was developed. Although initially designed to use commonly available relays, it remains the basic alarm circuit; we simply use high-tech components to do the same thing. Once you understand the supervised loop you can understand just about everything, including a wireless and a microprocessor-based alarm.

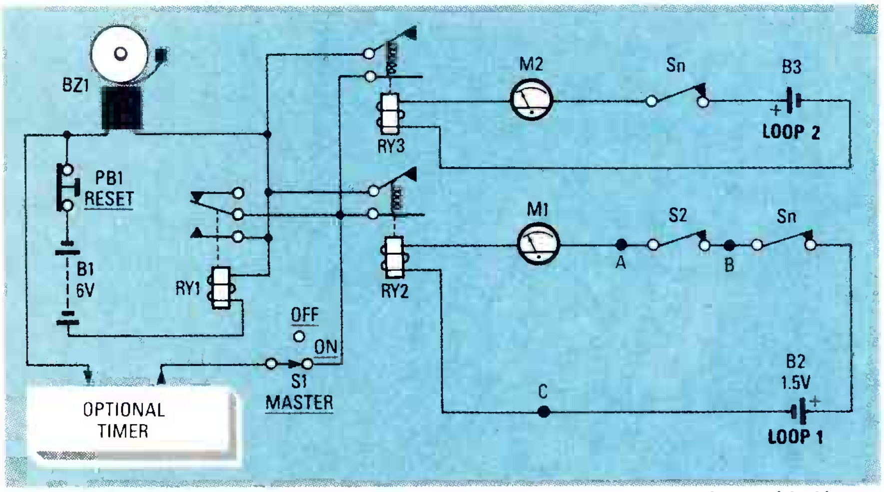

FIG. 1—IN A SIMPLE SUPERVISED SYSTEM the protective loop's power is provided by an end-of-line (EOL) battery. A meter indicates if the loop is closed.

Supervision

Figure 1 shows a simple latching supervised alarm. It was probably designed by Methuselah, although it is still in common use today because it is reliable, and it is absolutely free from electrical disturbances—which cannot be said of solid-state alarms.

The reason Fig. 1 is called a *supervised alarm* is because the user *knows for certain* that the protective devices—normally-closed switches—are not only working, but are properly set.

Trace the series-circuit labeled LOOP 1, which consists of relay RY2, battery B2, meter M1, switch S2, and switch Sn. Sn represents any number of series-connected switch devices: fine wires, spring switches, magnetic switches—any kind of device that will open a series circuit. Relay RY2 is an extremely sensitive device, requiring only 3–7 mA to pull in. The reason that the relay must be so sensitive is because it is powered by a 1.5-volt battery, B2. The battery is a special type known as a *No. 6 telephone*, *railroad*, or *protective alarm* cell. It is humongous, more than 6-inches high and 2⅝-inches in diameter. (You probably used one many years ago in your school's science class.) Since it supplies just a few milliamperes of current—and only when the loop circuit is closed—the battery could last for years—or at the very least, several months.

The battery is called an EOL (*E*nd *O*f *L*ine) power source because it is literally at the end of all the wiring in the loop, usually buried somewhere out of sight.

When all switches in the loop are closed, the current flowing in the loop causes a reading on meter M1. If the user sees a meter reading he knows that the circuit is "armed": All switches are closed and operating. If there is no meter reading the user knows that either a window, a door, or some other protected entrance is open, or a switch is defective, or the battery is pooped out. In short, the current flowing in the loop *supervises* the loop.

When the loop is armed, the current flowing in the loop causes RY2's spring-loaded contacts to be pulled open. If anything stops the current flow in the loop—we'll show shortly how it's done—RY1's contacts spring back, closing the series connection of battery B1, relay RY1, momentary switch PB1, etc. RY1's contacts self-latch RY1 so that the relay remains pulled in, even if RY2's contacts are opened. Since the alarm bell, BZ1, is connected across RY1's solenoid coil, it sounds off.

Because some towns and cities frown on alarms that sound for hours, an optional timer is often connected in series with the alarm circuit so that BZ1 is silenced after 10 or 15 minutes. Other than the timer drop-out, BZ1 can only be silenced by pressing RESET switch PB1, or by opening MASTER switch S1.

The loop's battery is placed at the end of the line to prevent easy bypassing of the system by an intruder. For example, if the intruder forces open a window that's protected by switch S1, the loop will be opened at points A and B. Current will cease flowing through RY2 and the alarm will sound. If the intruder should be able, somehow, to cut any part of the loop wiring, again the loop current ceases and the alarm will sound. Even if the intruder tries to maintain the series circuit by short-circuiting points A and C, the short will occur in front of the battery, so the current through RY2 will be interrupted and the alarm will sound. That is why EOL protection is provided in modern high-tech alarms even if a battery isn't used. We'll show later how it's done with resistors.

Notice that LOOP 2 is essentially identical to LOOP 1. In early systems, an entire house was protected by a single loop. Today, we usually use multiple loops, one reason being that it's easier to find an open switch. For example, if LOOP 1 is used to protect the basement windows while LOOP 2 is only for the front and rear doors, you don't have to run down to the basement to check all the window switches if the supervisory meter shows that LOOP 2 is open. Similarly, if the meter shows that LOOP 1 is open, you had better check the basement windows.

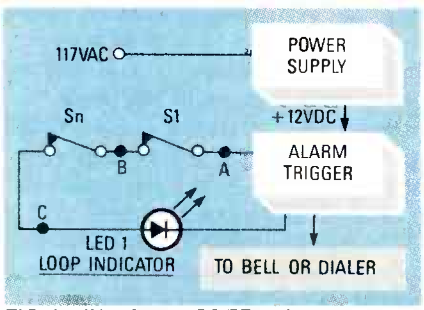

FIG. 2—IN MANY MODERN alarm systems the loop power comes from the center's power supply. An LED is used as the closed-loop indicator.

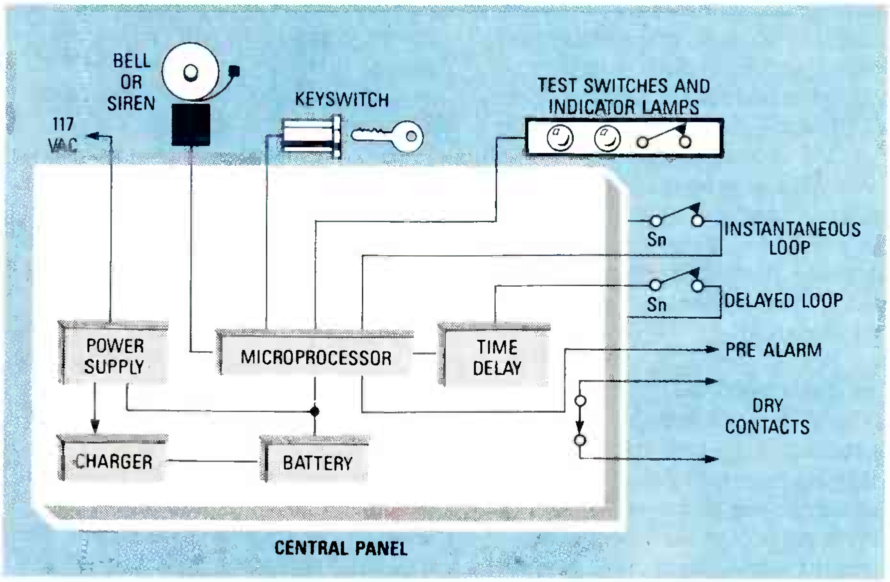

FIG. 3—A MICROPROCESSOR simplifies the operation of a basic control center that provides various time delays and signals.

Actually, with the relay-type system you know that something's wrong because an open loop will cause the bell to sound as soon as the alarm is turned on ("armed"). The modern computer-type system, however, can or will arm even if a loop is open; it simply bypasses the open loop. That means that if you have a multi-loop system, and say, for example, that a basement window has been left open, the alarm can/will automatically lock out the basement window loop. The lock-out allows you to set the alarm and leave, but your home is really unprotected against basement entry. It is precisely to avoid an unknown-lockout problem that all multi-loop alarms have individual indicators—either a meter or an LED—for each loop. And remember, each loop represents a separate protected circuit, and it doesn't matter how many protective devices are on the circuit; if they are all series-connected they are on the same supervised loop. (Take note that high-tech alarms now include normally-open switches in a loop. Although the N.O. switches are not supervised, they are considered loop switches because the term *loop* is now accepted to mean *all* the switches and detectors on the same control circuit.)

A final note before we move on to the high-tech stuff. To ensure minimum maintenance, battery B1 was replaced by a line-powered supply that automatically switched to a battery when the linepower failed—a not uncommon occurrence until recent years. Later still, the loop battery (B2, B3, etc.) was also replaced by power from the line-powered supply, which created a reliability problem that can plague even microprocessor-based alarms.

The problem is shown in Fig. 2, a simplified supervised loop that is powered by the main power supply. Light-emitting diode LED1 lights when switches S1 and Sn are closed—showing that the loop is armed. But what if an intruder can reach through a broken window, or had previously short-circuited points A and C? The loop indicator still shows a closed supervised loop, but S1 and Sn can be opened without triggering the alarm because they are located after the short-circuit.

Several early solid-state alarms used the loop powering shown in Fig. 2. Many "home-type" alarms still use the Fig. 2 loop powering, although they often have the option of EOL (End Of Line) resistor termination, which provides the same security as the EOL battery. We'll explain the EOL resistor termination later.

The control center

The control center—which is also called a control panel, a control box, an alarm control, or whatever—usually contains everything except for the alarm bell or siren, and the protective devices. Early solid-state control centers simply replaced the relays with transistors and/or SCR's. Most were disasters because an electric disturbance or RF radiation could trigger the solid-state devices, and a lightning hit anywhere in the neighborhood usually wiped out the control center. Fortunately, false-triggering is no longer a problem in the newer panels, provided that they are securely grounded to the main water pipe. But if you have one of the early centers that keep sending false alarms, you now know why. Also, grounding or not, some computerized control centers still get clobbered by a nearby lightning strike.

High-tech control

The difference between basic-solid-state and high-tech control centers is that the high-tech device contains a microprocessor that usually controls everything except the loop sensors.

For example, even the simplest high-tech panel provides for a 24-hour *panic* switch and two protective loops: an instantaneous loop for everything except the entry doors, and a delayed-entry loop. Instead of having to arm and disarm the door sensor by using a bypass keyswitch for the front door, the microprocessor allows the user a safe period of 0–45 seconds to get out of the house after the alarm is armed. Similarly, the user can take 0–45 seconds to turn off the alarm after entering through a door.

The microprocessor also provides a *delayed entry* warning so that you don't forget to turn off the alarm. The warning is usually a low-volume buzzer that will sound off as soon as the door is opened—so you don't forget to disable the alarm—or, it sounds off after 30 seconds as a warning that in another 30 seconds the main alarm siren or bell will sound off if not disabled.

The panic function is for emergencies that usually require a neighbor's attention rather than the police or fire departments. When an alarm system is connected to a central station, all alarm conditions except the panic loop are transmitted to the central station. Usually—not always—a *panic switch* sounds the alarm bell or siren to attract a neighbor: It might be used by an invalid. In both the simple and the most complex high-tech alarms, the panic loop will also arm the rest of the alarm.

Why panic-arm the alarm? Well, assume that you're home alone and you hear a noise in the yard. You don't know whether the sound is from an intruder or if you're just hearing things that go bump in the night. If your alarm sends a signal to a central station, you don't want to hit the *emergency* or *hold-up* switch because to do that will send an alarm to the central station, which might result in a false-alarm to the police. So you hit the *panic* switch, which causes the microprocessor to turn on the yard lights, sound the alarm siren so that your neighbor will peek out his window to see what's up, and *automatically* arm your alarm system if it had been *off*.

If the sound was actually made by an intruder, and if he attempts to enter your home, he triggers the alarm to the central station.

The panic loop is similar to the 24-hour, or perimeter, protective loops of some (usually more expensive) alarm systems. The primary difference is that a 24-hour loop provides full-time 24-hour protection even if you're home with most of the alarm system turned off. If the 24-hour loop is triggered, the control center sends an alarm to the central station and arms the rest of the alarm system. (You would normally keep the non-24-hour loops *off* so that you could move about freely, without having to worry about whether opening a closet or a door would trigger the alarm.)

Figure 3 is a generic block diagram of a low-cost microprocessor-controlled control center. Note that it does not contain a central-station dialer, although there is a set of "dry contacts" that can be used to activate an accessory dialer. (*Dry contacts* means switch contacts that have no resident voltage source.) Also note that there is no EOL power supply for the loops—the loops are powered from the center's power supply.

The more advanced high-tech control centers that are used in the home, such as those in Napco's *800* and *900* series, contain from six to nine protective circuits that can be set up as intruder loops, a panic alarm, fire pro-

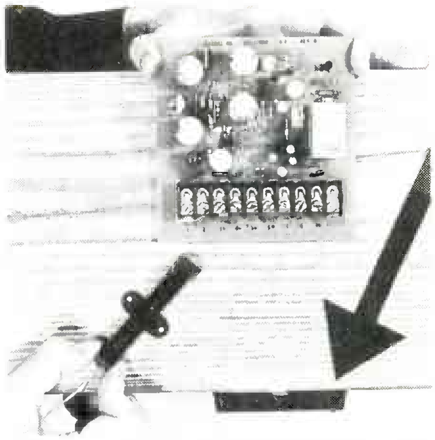

FIG. 6—A SMALL SILICON SENSOR and its control unit can distinguish between the footsteps of animals or humans.

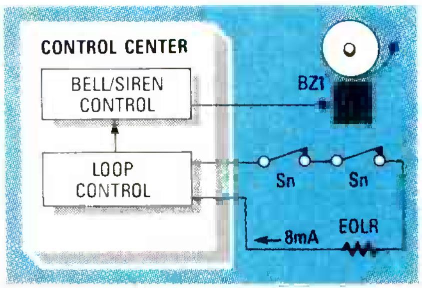

FIG. 4—AN END-OF-LINE-RESISTOR loop protects against anyone bypassing the loop by simply short-circuiting the wires.

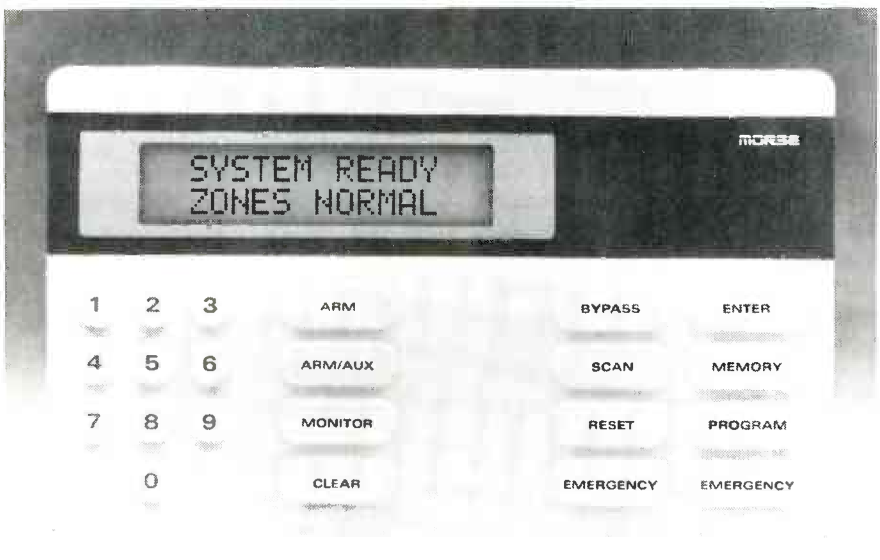

FIG. 5—THE MOST ADVANCED COMPUTERIZED home-alarm systems provide both user programming and an alpha display of all operating conditions and circuit problems.

tection, or medical supervision. Virtually every feature—including the function and operation of the loops as well as automatic battery testing—is under full-time microprocessor control. For example, the microprocessor controls a digital telephone dialer for central-station communications; a built-in two-tone/steady siren driver for intruder, panic, and fire protection; the time delay of the protective loops; and the time delays for the entry doors. It will even flash an outdoor strobe continuously after the alarm automatically resets to warn that an intrusion had been attempted, and that the intruders might well be inside the house even though the alarm bell/siren has timed-out. Typical of the control centers offering Napco's price/function level, the center can be controlled via one or more keypads, and the user-desired functions—even the dialer's telephone number(s)—are programmed in a PROM by the installer, or manufacturer.

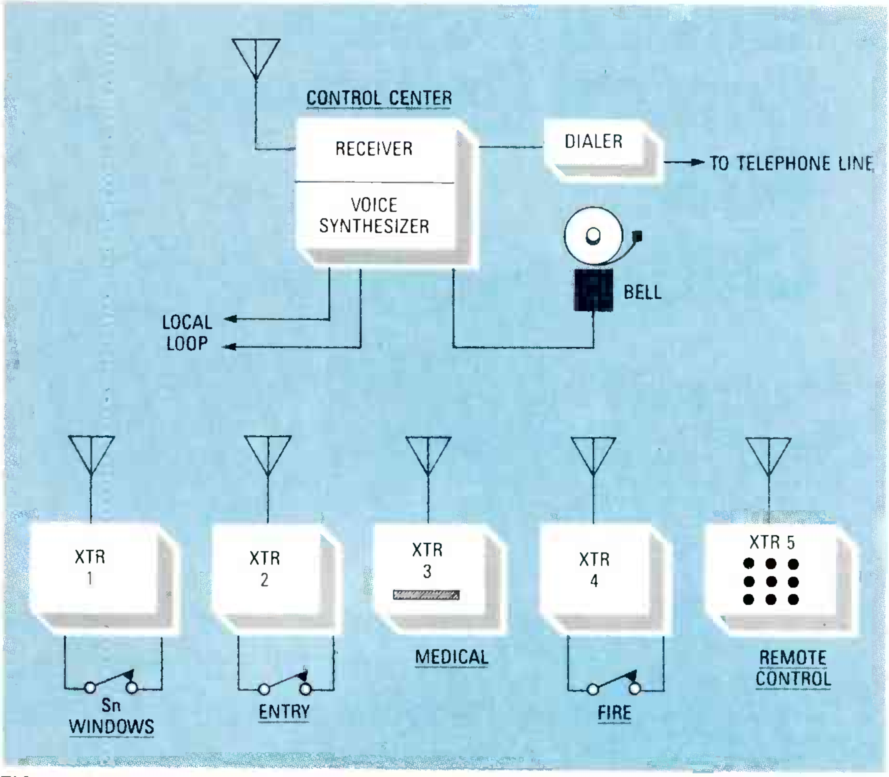

FIG. 7—IN A WIRELESS SECURITY SYSTEM the loop and emergency conditions are broadcast to a receiver in the control center. Once a day the control center automatically broadcasts a polling signal to each transmitter to check the condition of the transmitter's battery.

EOLR

The Napco *900* center, which is typical of the most recent PROM designs, provides EOL supervision through a resistor, which is called an EOLR for *E*nd *O*f *L*ine *R*esistor. Figure 4 shows the basic generic circuit of a supervised EOLR loop.

The loop control provides a voltage into the loop that results in about 8-mA of current flow when the EOLR resistor is connected to the end of the loop. The loop control is triggered by anything that causes the loop current to vary substantially above or below 8 mA. As you can see, if the loop is broken at any point, or if it is short-circuited in front of the EOLR, the loop control will trigger the bell/siren control, which causes the alarm bell or siren to sound.

Super-tech

The most advanced of the high-tech home systems—with an "advanced" price to match—is represented by the Morse *MDC-16* Control Communicator System, which includes the *MPC-32-D* Personal Control. Basically, the control center does everything that a PROM-type control center can do, only more so. There are more protective circuits, several arming modes, individual password codes for different protected areas and users, selectable transmission schemes for various central stations receivers, and zone trouble reports. There's even listen-in capability through a telephone, such as for a central station to check on a "medical" signal.

But most important, unlike less expensive high-tech panels that are programmed through a PROM "burn" by the installer or the manufacturer, the Morse panel uses non-volatile EEPROM *user programming* that allows any feature to be changed at any time from the personal control, which is shown in Fig. 5.

Notice that the personal control shown in Fig. 5 has a two-line alpha display, which provides cues for user programming or indicates various operating conditions. For example, Fig. 5 shows that all zones are normal and the system is ready for arming. If the loop that protects Pop's workshop is open, the condition will be alpha-displayed as "POP'S ROOM." The person attempting to arm the system would thereby know precisely which loop is open.

High-tech sensors

Of course, no panel will work unless there are sensors. While the most common sensors are some form of switch—even a foil strip is a normally-closed switch—we also use some high-tech witchcraft to avoid the use of hard-wired switches. For example, there are infrared, ultrasonic, and microwave devices that flood a wide area with unseen light, unheard sound, or radio waves. Any disturbance to the light, sound, or radio field triggers the alarm. Unfortunately, many of the "flood" devices can be triggered by household pets, curtains blowing, and the like.

Simply because it's relatively low in cost and easy to install, the high-tech sensor most commonly used in the home is the PIR detector—PIR meaning *P*assive *I*nfra*R*ed. A PIR detector, uses either a segmented front lens, or a combination segmented lens and mirror segments behind the lens to focus sensitivity on particular areas or angles of coverage. Optional lenses for many PIR's optimize sensitivity for many different conditions, such as long side hallways, alcoves, lofts, etc.

Nightingales sing

A somewhat unusual sensor for home use is the electronic *nightingale floor*. Back in antiquity, Sultans, Pashas, and other despots protected their harems and treasuries with a specially

continued on page 69

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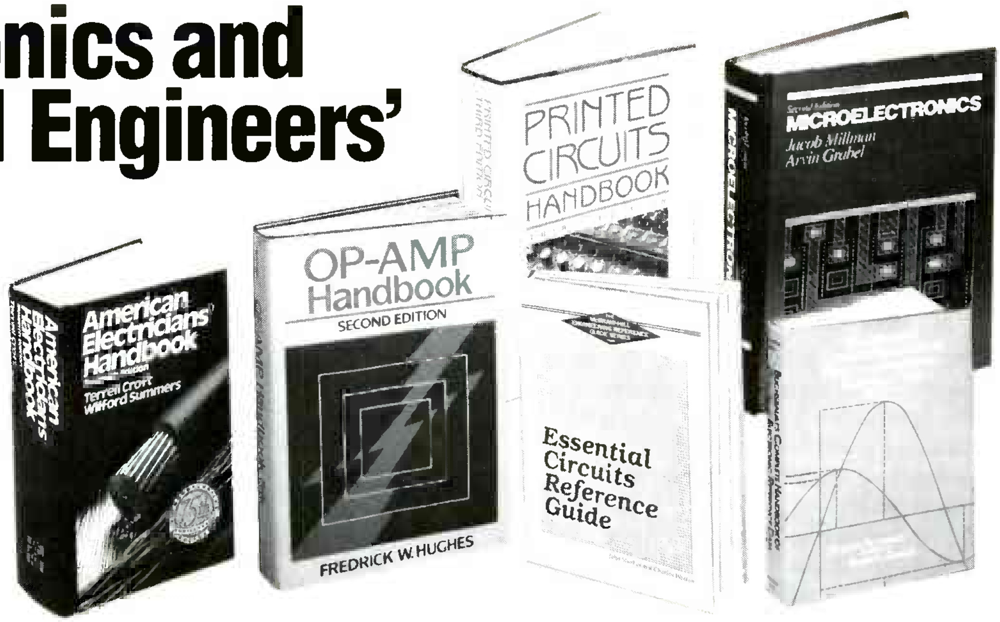

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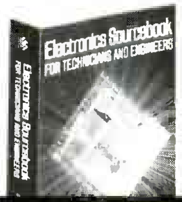

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HOW TO

INSTALL A HOME SECURITY SYSTEM

Do it yourself and save on the cost of a professional-quality home burglar alarm.

HERB FRIEDMAN and BRIAN C. FENTON

HOUSE BURGLARY IS NO LONGER A growth industry. Statistics show that for the past several years there has been a decline in the percentage of house burglaries. Is that because there are fewer thieves? No! There are fewer burglaries because there are more home alarm systems.

A burglar will move on to an unprotected house rather than take his chances with one that's obviously protected—unless he's certain that you've stashed away a fortune in cash or gems. Under those circumstances, *no* alarm system in the world will protect your valuables.

Unfortunately, if you've priced dealer-installed home protection you have most likely experienced "sticker shock," because in many localities there is a basic charge of several hundred dollars for the central control unit, plus $50 per opening—an *opening* being anything that has a sensor: a window, a door, a skylight, an interior closet, a valuable picture, etc. Fifty dollars an opening adds up quickly, so even a small burglar-alarm installation can cost well in excess of $1000, and even then you might not end up with every opening protected—you might get just door protection and some kind of area detector to cover the "important" parts of your home.

Do it yourself

But if you can spare from one to three days, you can install a professional-quality all-opening intruder system at a starting price of about $250. If you want to have more of the bells and whistles of a multi-zone pro system, you can still do it for significantly less than $1000. Here, we'll show you two basic alarm-system installations: first we'll look at a *wired* system, and second, a *wireless* system. But before we get into the nitty-gritty of drilling holes and connecting wires, a few words about the equipment used for this article.

For the wired system, we selected a Radio Shack *49-450* control center. Not because the Radio Shack control center is necessarily the best, but because it's good and it's easily available. A user can get service, and future Radio Shack accessories will probably work with all of their older equipment.

For the wireless system, we selected the *Dicon 9000* wireless security system from Dicon Systems, Inc. (631 Executive Drive, Willowbrok, IL 60521). We picked the *9000* because it gives us an excellent opportunity to point out how electronics has made super hi-tech features available on do-it-yourself home burglar-alarm systems.

Let's do it

Let's get on with installing our wired alarm. In addition to the usual hand tools—long-nose pliers, cutters, and screwdriver—you'll need an electric drill, an 18-inch long, ⅜-inch *feeler* or electrician's bit (it has a hole near the tip to help you pull wires through walls and floors), and an Arrow *T-25* staple gun. The T-25 shoots round staples, which are safe for stapling wires to moldings—the round staple doesn't cut into the wire. (The T-25 staple gun can usually be rented for a day or so.)

The Radio Shack model *49-450* control center is powered by 117 volts AC or a rechargeable battery that automatically cuts in if the AC power fails. The control center provides three protective circuits that are called *loops*. There is an instantaneous loop that sounds the alarm as soon as one of its switches is opened; a door loop that provides up to 45 seconds to get out of the house after the alarm is armed (turned on), and up to 45 seconds to turn off the alarm after you enter; and a panic circuit that allows you to sound the alarm—even if the system isn't armed—by pressing a panic or an emergency switch within the house. Most important, the Radio Shack control center can be used with a $22 *Touch-Tone*-type digital keyswitch (we'll explain its importance later). So-called *pro* control centers require almost $200 in extra hardware to provide digital keyswitch control. The control center has LED indicators that show the protective loops are set (sensors closed), that the system is armed, that the AC power is on, and also shows the condition of the backup battery.

There are front-panel switches for testing the battery and the alarm siren or bell. In our system we choose to use a 2-tone siren—a "wailer"—because it is supplied in a low-cost "package" deal, and because in certain localities the houses and apartments must have a fire alarm that sounds a bell. While a bell can be either a fire or a burglar alarm, a wailing siren is always recognized as a burglar alarm, or a panic or a medical-transmitter call for assistance.

Take note that there are two versions of the control center, and both use the *49-450* stock number. The older version's battery backup is individual alkaline or Ni-Cd cells. The new version's backup battery is two series-connected 6-volt rechargeable gel-cells that mount in the bottom of the control center. The new version also comes with an absolutely superb operating and alarm-installation manual. You want the new version.

Mounting the center

The control center has only two knockouts in the back of the cabinet, and they are going to end up packed with wires. If a knockout is blocked by a stud within the wall you are going to have a miserable time fishing all the necessary wires through the one remaining knockout, so make certain that the center is mounted to the wall between two studs. It is easy to use an electronic stud finder to determine the position of the studs in the wall. While stud finders are available at Radio Shack, similar devices are available at Sears for under $10—half the price of the Radio Shack model.

When you mount the control center be sure that the test switches can be used, and the LED indicators can be seen by the shortest person who will use the alarm system; but keep the control center high enough so that its switches are beyond the reach of small children.

No matter what you decide to use as the main control center, and no matter where you will place it, install a keyswitch in the control center's front-panel knockout as shown in Fig. 1. (A keyswitch is supplied in the "package kit.") That way, if everything else crashes the system can be disarmed.

FIG. 1—REGARDLESS OF WHAT YOU use for the regular arming switch, there should be a control keyswitch on the front of the central control box.

FIG. 2—TO LEAVE A WINDOW OPEN while the alarm is armed, mount a second magnet a few inches below the magnetic sensor's main magnet. Simply raise the window until the second magnet is opposite the switch.

FIG. 3—A PULL-APART will allow you to leave the top part of an up-down or a slider window open.

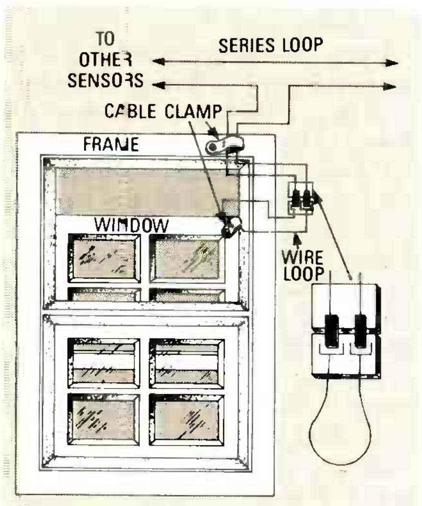


FIG. 4—THIS IS HOW A PULL-APART is connected to the loop.

The sensors

Next, install the various sensors—called *bugs*—on the windows and doors. The easiest window *bug* to install is the magnetic switch. If you want to be able to leave the bottom open for ventilation, install a second magnet about halfway down, as shown in Fig. 2. You can then raise the window until the extra magnet is opposite the switch.

If you want to be able to open the top of the window, use the *pull-apart* shown in Fig. 3. If someone attempts to lower the window, the pull-apart literally pulls apart and triggers the alarm. A pull-apart is really a 300-ohm TV-line coupler whose contacts are gold-plated. If you can't get an "alarm-type" pull-apart, use standard TV connectors. Either type is wired as shown in Fig. 4.

As shown in Fig. 5, difficult-to-protect basement windows can be *bugged* with wire lacing made from No. 24 or No. 26 enamel-insulated solid wire. Anyone attempting to push out the window will break the wire lacing and trigger the alarm. The wires themselves are held in place with round *T-25* staples.

Basement windows with removable screens and storms can be protected by using the ball-type *pull-trap* shown in Fig. 6 and Fig. 7. Normally, when the metal separator between the balls is pulled out the ball contacts don't touch and the alarm is triggered. But by using the connection shown in Fig. 7, anyone forcing the window, or trying to cut the metal pull wire, interrupts the series loop and thus triggers the alarm.

Cool it

Basement air conditioners are a favorite spot for breaking in because they are often left unconnected to the alarm. As shown in Fig. 8, you can wire the A/C into the system by placing a magnetic switch on the window frame above the A/C, and its magnet on the top of the A/C's frame. Use *Barge* adhesive or double-sided foam tape to secure the magnet to the air conditioner's frame.

Every splice should be soldered for

FIG. 5—WIRE LACING WILL PROTECT a screened basement window or a crawl-space opening.

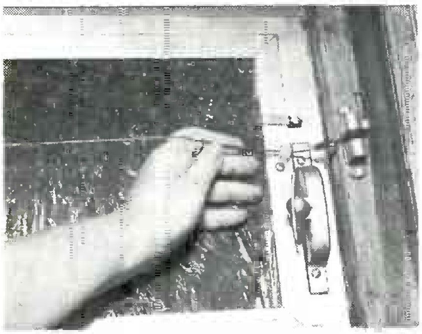


FIG. 6—IF A WINDOW SCREEN must be removed and lacing will get in the way, use a pull-trap to loop through a removable trip-wire lace. Cutting the trip wire will trigger the alarm. Trying to move the trip wire will open the pull-trap.

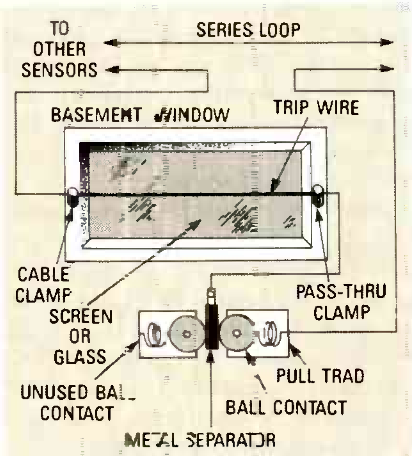


FIG. 7—THIS IS HOW the pull-trap is connected to the protective loop.

FIG. 8—AN AIR CONDITIONER can be *bugged* with a conventional magnetic switch.

at least a ½-inch, wrapped with tape, and then stapled to a beam or other wood support—even floor molding—as shown in Fig. 9. There must be no connections that are simply twisted and taped, because they can oxidize and cause false alarms.

If you use foil to *bug* window glass, you must cover the foil with clear varnish or thinned, clear nail-polish. Without the protective covering, the foil will peel off the glass on the first humid day. You can really make a mess of the job, so use a ⅜-inch artist's brush, span the brush across only one edge of the foil and try to "paint" each side of the tape in a single pass. Try not to go over the same foil twice except at the corners, which should get at least two, preferably three coats.

Across the hinge

If you use foil on an entry door's window—and every entry door having a window through which someone can reach should be *bugged* with foil—as shown in Fig. 10, you span across the hinge with a *door cord*. The door cord shown is an *Ademco*, purchased in an electrical-supply store. It is preferred to the Radio Shack door cord because of the position of the terminal screws. The screws on a Radio Shack cord are arranged so that they are almost impossible to access if the door has its hinges immediately adjacent to a wall. (When you see the cord you'll understand the problem.) Take note that a door's window foil is connected to the instantaneous protective loop, not the delayed door loop; you want the alarm to go off the instant someone smashes through the window, not 45 seconds later.

If you can manage to install it without hacking the wall, one of the best entry-door switches is the roller type shown in Fig. 11. Mounted in the top of the jamb it is almost weatherproof; and, as shown, it does not interfere with the old-time (meaning high-quality) interlocking weatherstripping. It's particularly useful when the door has sagged on its hinges, leaving a somewhat large gap between the top of the door and the frame. The roller switch is basically a plunger switch that pushes in as the door squeezes the roller wheel upward. It's a hard switch to locate, but worth the effort to search out if needed.

If you can't manage to install a

FIG. 9—SOLDER ALL SPLICES, and then staple the taped splice to a wood support—a beam, molding, etc.

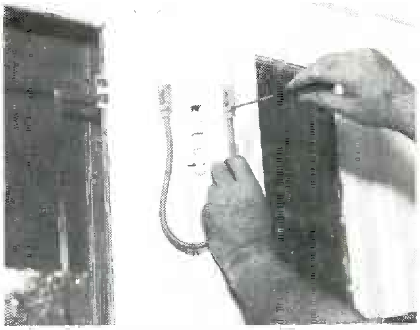


FIG. 10—USE A DOOR CORD to bridge a flexible connection across a door hinge.

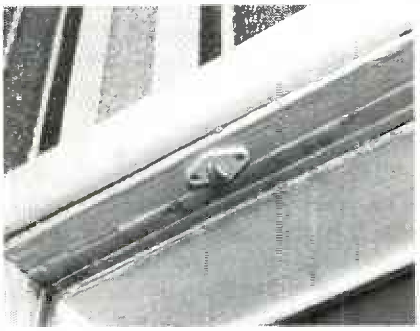


FIG. 11—A ROLLER SWITCH is among the best of the entry-door "bugs," but installation takes quite a bit of skill. If you don't think you can do it, don't.

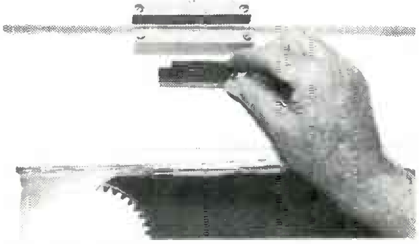


FIG. 12—A WIDE GAP between the door and its frame or molding requires an oversize magnetic switch. The standard-size magnetic switch held in the hand is for comparison.

concealed roller switch (or a plunger switch) for the entrance door, use a magnetic switch. The problem is that the most common switch, the one shown being held in Fig. 12, must be within ¼ to ½ inch of its magnet. In an older house with a thick door trim, or if the door has sagged, there might be no way to locate the switch and its magnet within their working separation distance. In that case, use the long magnetic switch shown. Although it's almost twice the cost of the smaller conventional switch, it can work within five inches of its magnet. The one from Radio Shack is supplied with several thick spacers that can resolve just about any mounting problem you may come across.

If you have included any interior doors such as closets in the alarm loop, you might want some way to bypass one or more so that you can move around the house freely, yet still have the alarm turned on. Or you might want to bypass the back door, yet keep the rest of the house protected. Either way, it's done with switch assembly which is wired as shown in Fig. 13. Just remember that the switch's *on* position means that the bypass is what's on.

A tiny 12-volt buzzer can be wired near the door as a pre-alarm to remind anyone entering that the alarm is on and must be turned off before the time-out elapses (up to 45 seconds). It is a decided asset, because it helps avoid waking the neighborhood if you come home late at night too tired to remember to turn off the alarm.

Keypad entry

As shown in Fig. 14, the pre-alarm buzzer can be mounted with two-sided foam tape directly below a Radio Shack keypad entry switch; and you should certainly consider using a keypad switch that is located adjacent to the entry door. The switch has LED's that indicate when the loop is ready (green), and when the system is armed (red). The user selects and can change the code at any time. If something goes wrong with the switch or the system, unlike other keypad switches that lock out—leaving the user franticaliy searching for the control center's key that will turn off the alarm—the Radio Shack unit defaults to a factory code. The combination of the * and # keys is also a panic switch.

Unfortunately, Radio Shack does not sell a surface-mounting box for the keyswitch. Their mounting box requires that you chop a relatively large mounting hole in the wall; wiring inside the wall might prove difficult, and the landlord might not be

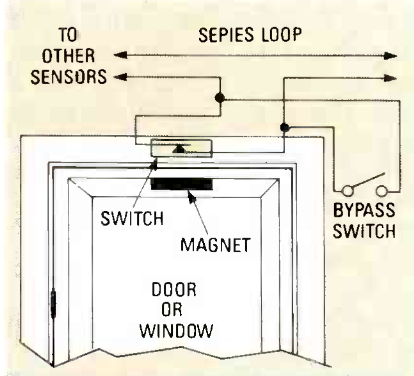


FIG. 13—THIS IS HOW a bypass switch is connected to a door "bug."

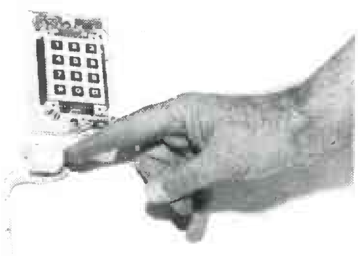


FIG. 14—IF YOU USE A KEYPAD entry switch, you can tape the pre-alarm buzzer to the bottom of the switch's surface-mounting box.

FIG. 15—A STROBE LIGHT mounted on the front of the house instantly tells the neighbors and the police that it's your alarm that's wailing.

FIG. 16—THE LAST STEP is to install the backup battery and connect the AC power. If all went well, the green loop light will turn on and the siren will sound when you press the test switch.

thrilled at the prospect of your moving and leaving a gaping hole behind. Use a surface-mounting box instead, such as a plastic or a metal *Wiremold* box from your local electrical-parts store.

When your keypad switch is completed, you can simply enter your code, then take up to 45 seconds to get out the door. The system arms long after you have safely passed through the door. Same thing on entry. You enter, hear the buzzer, and get up to 45 seconds to punch in the code that turns off the alarm. Any attempt to tamper with the keypad triggers an internal switch that sets off the alarm.

Figure 15 shows a strobe light that is mounted on the front of the house. It answers the question "Whose alarm is ringing?" by flashing when the siren (or bell) goes off—so anyone within earshot knows instantly whose home is under attack. Put the strobe light out in the open, as conspicuous as is possible. Make certain that it's not screened by one or more tall or leafy trees.

Finally, as shown in Fig. 16, connect the AC power and install the backup batteries. If all went well, the siren should sound, and the strobe should flash when you press the TEST switch.

A wireless system

Installing a wireless system isn't all that different from a wired system, with one major exception: You don't have to drill holes for fishing wires through walls and ceilings. Because of that, installation is usually much quicker. However, the considerations for mounting sensors and the like remain very much the same.

The basic *Dicon 9000* package that we chose for our sample installation (Fig. 17) consists of a base unit, two remote door/window sensors with transmitters, and an emergency speaker/siren. The sugested retail price for the system is under $700. Available accessories include emergency pendants, smoke detectors, temperature sensors, flood sensors, remote keypads, and motion detectors.

The *9000* is a sophisticated system with up to four security zones; it can dial up to eight telephone numbers to report an emergency, and it can dial them in any order depending on the emergency. For example, in a medical emergency, you would want your doctor to be called before the fire department, yet during a fire emergency, your doctor is the last person you'd want to call—unless he lives next door. Along with a voice-synthesized response of "Security emergency!," "Fire emergency!," or "Medical emergency!" you can record a 15-second message in digital memory.)

While we're on the subject of dialers, we should point out that, especially in larger towns and cities, a fire or police department will not respond to a recorded message. You should have the unit call a neighbor, or a central monitoring system. Dicon has set up a central monitoring system to accept emergency responses. While the price for the service is fairly standard, it's not cheap: about $15 per month. However, the people at the central station are trained and therefore can conceivably get help to you quicker—and they're always home. Perhaps more important, they receive the necessary information in digital form for speedier responses.

Setting up the system

The basic *Dicon 9000* is meant to cover two doors or windows. One of its most obvious features is that it is very easy to set up. A voice synthesizer guides you through the process. The first setup task is to install batteries in the remote transmitters and to plug the base unit in. As soon as power is supplied to the base unit, it will ask you to select a 3-digit security code using its very intelligible voice synthesizer. After you enter your selected code, it will repeat the code, and will then ask you to connect the first module.

Each remote transmitter is assigned a unique code by the base unit. To program the code, a module is removed from the transmitter and plugged into the base unit. Once the base programs the module with a code, it asks for the second module to be plugged in. Since each module code is unique, any alarm can be tracked down to the exact module and reported. The *9000* can support up to 30 individual modules.

The *Dicon 9000*'s voice synthesizer guides you through the entering of emergency telephone numbers and the recording of your personal message. Once you complete that task, you're ready to test the system. Assuming everything passes the tests, you can permanently install the sensors. (See Figs. 18–20).

The *9000* features 4 security zones. Zone 1, usually for your entry doors, can be selected for immediate or delayed alarm. Zones 2–4 are always immediate. Any individual sensor can be turned off or bypassed, and any zone can be on or off.

While most people contemplating their first alarm don't see the need for multiple security zones, we'll give a simple example to show why they are necessary. If you are home alone and would like your alarm on, you don't want to be made a captive of one room. If all of your motion detectors are on one zone, you can secure the premises with a perimeter zone, yet be free to move around inside. If you are expecting someone else to come home, the entry door on one zone can be left on delay, yet opening any windows—which are on another zone—will immediately trigger the alarm. At all times, sensors such as smoke detectors and medical pendants will cause an alarm when triggered, even if the system is not armed.

continued on page 68

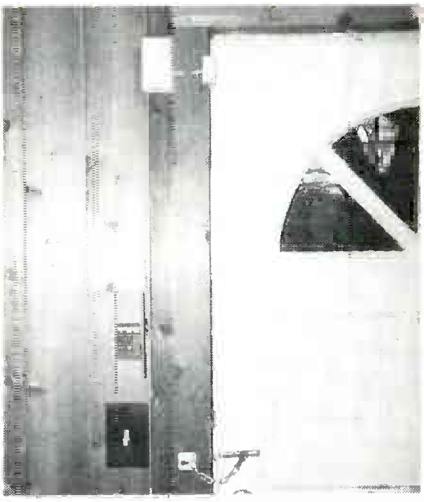


FIG. 18—THE REMOTE KEYPAD is easily installed by an exit door. Note the magnetic reed switch with transmitter at the top left of the door. Such sensors should always be installed on the outer edge, not the hinge side, of a door.

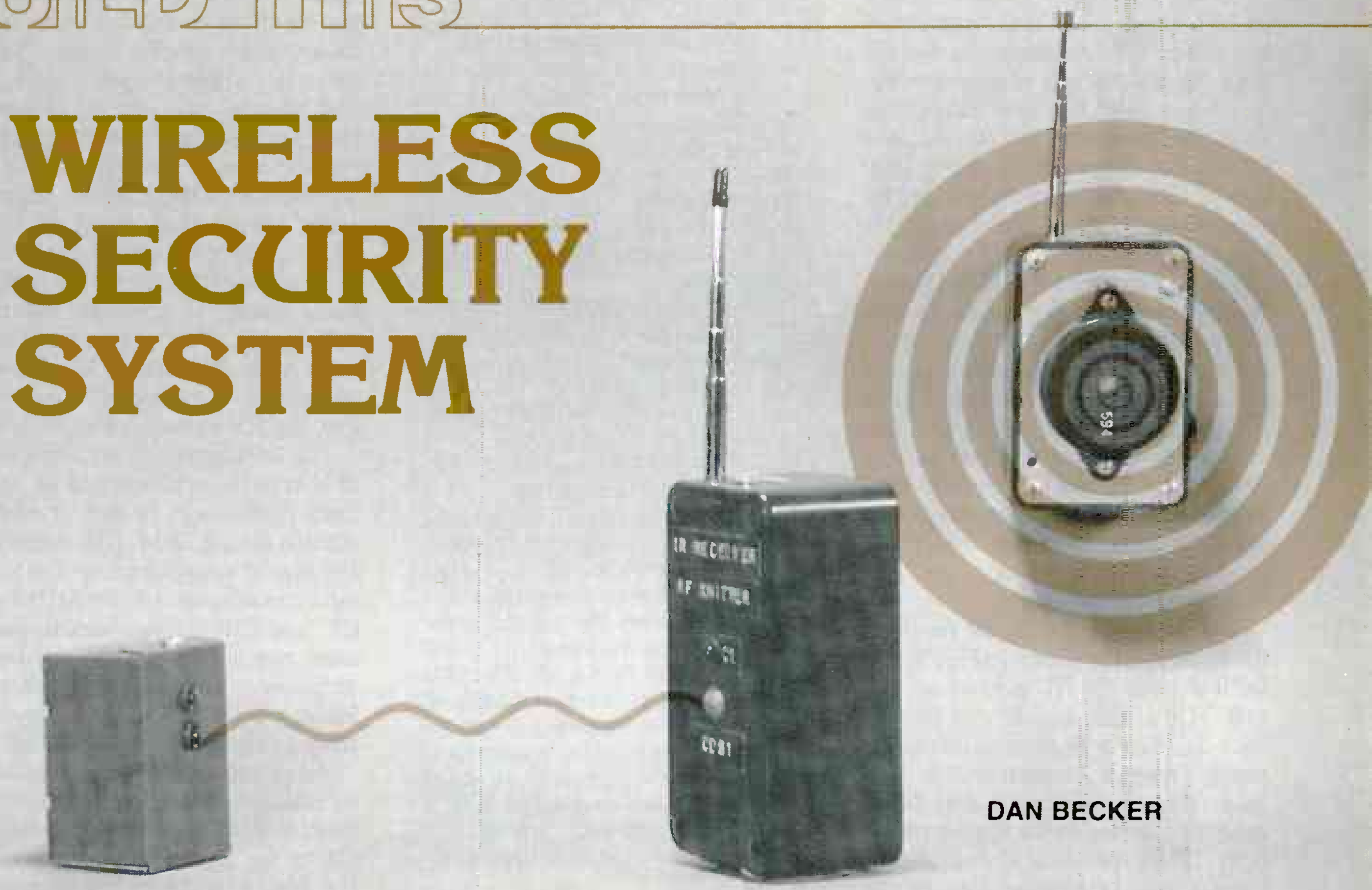
FIG. 19—THE REMOTE TRANSMITTERS can be easily be concealed behind curtains or drapes.

FIG. 20—AN INFRARED SENSOR can view a whole room if it is mounted in a corner. Be sure that it doesn't "see" windows, or radiators that can change temperature rapidly. Also, be sure that such sensors are on zones that can be easily turned off, so that you don't become a prisoner in your own home.

FIG. 17—THE DICON 9000 SYSTEM. Shown are the emergency speaker/siren, two magnetic switches with remote transmitters, the base unit, and the optional fire alarm, infrared sensor, and remote keypad.

BUILD THIS

WIRELESS SECURITY SYSTEM



DAN BECKER

Build a wireless security system that monitors an area using an invisible infrared beam and beeps a hand-held buzzer unit when a problem is detected.

EACH YEAR THE NEED FOR A SECURITY alarm in the home increases. Fortunately, security-system technology increases, too, as does the ease of installation. Our system is a good example—it uses an unseen infrared beam which, when interrupted, activates an RF transmitter that broadcasts a signal to a hand-held beeper-like device. By making the system wireless, installation is simplified and one or more remote locations can be monitored.

How it works

Figure 1 shows a block diagram of the system, which contains an IR transmitter, an IR receiver/RF transmitter, and an RF receiver/alert beeper.

Two IR-LED's in the transmitter transmit a pulsed beam of invisible infrared light to the receiver, which contains an IR phototransistor. The phototransistor detects and amplifies the pulse-modulated IR beam. If the receiver section senses that the IR beam is momentarily interrupted by an object blocking the beam's path, it triggers the transmitter whose output is a 49.890-MHz carrier that is amplitude modulated by a 490-Hz tone.

Upon receiving the 490-Hz amplitude-modulated carrier, the RF receiver/beeper unit sounds an alarm that alerts the user to the intrusion.

The system is not limited to just one RF transmitter. A single RF receiver/beeper can be used to monitor any number of RF transmitters (or locations). However, the receiver/beeper unit can not discriminate between different transmitter sites in multiple-transmitter systems.

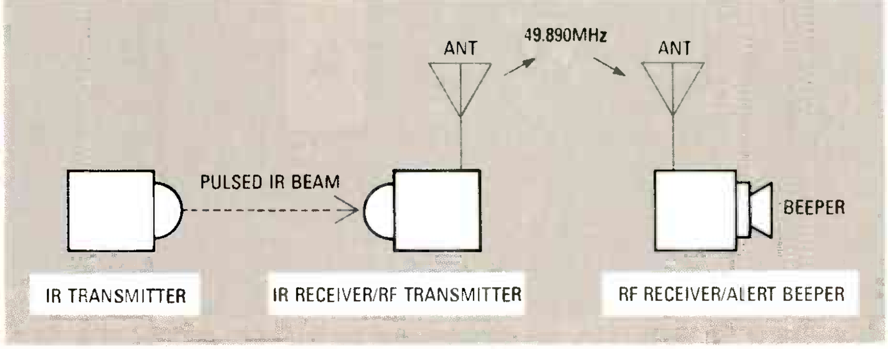


FIG. 1—BLOCK DIAGRAM of the wireless infrared security system.

IR transmitter

As shown in Fig. 2, current through IR-LED1 and IR-LED2 is switched on and off by Q2. Resistors R6 and R7 limit the peak current to approximately 1.4 amperes. IC1 is configured as an astable oscillator, and R1, R2, and C1 set the frequency to about 1500 Hz. In the astable configuration, R1 controls the length of time that pin 3 is low—approximately 43 microseconds. During that low, Q1 and Q2 are switched on, allowing current to flow through both IR-LED's. By limiting the *on* time to 43 microseconds, the power dissipation in the two IR-LED's is approximately 128 milliwatts. Resistors R3–R5 limit the base current of Q1 and Q2, and C2 provides low-impedance bypassing of the power supply.

Receiver/transmitter

The schematic for the IR receiver/RF transmitter is shown in Fig. 3, and we'll discuss the IR receiver section first. IC1-a, Q2, and R1, in parallel with LDR1, a light-dependent resistor, create a current source. Because phototransistor Q1 and LDR1 are both exposed to the same ambient light, LDR1 automatically adjusts the current that is feeding into Q1, in order to maximize the sensitivity of the photodetector circuit.

When Q1 faces the pulsing infrared beam from the transmitter, Q1's emitter-collector voltage fluctuates in step with the pulses. Capacitor C14 couples Q1's output to op-amp IC1-b. R4 and R5 set IC1-b's gain to about 51 dB. Resistors R2, R3, R17, R18, and capacitor C13 establish a DC voltage-offset that is approximately two-thirds

PARTS LIST

INFRARED TRANSMITTER

All resistors are ¼-watt, 5%, unless otherwise noted.
R1—3300 ohms
R2—82,000 ohms
R3—33,000 ohms
R4—1300 ohms
R5—10,000 ohms
R6, R7—2.2 ohms, ½ watt

Capacitors
C1—0.01 µF, metalized film, 16 volts
C2—100 µF, 16 volts, electrolytic

Semiconductors
IC1—7555 CMOS timer
IR-LED1, IR-LED2—VT1261 Vactec infrared light-emitting diode
Q1—2N4403 PNP transistor
Q2—TIP110 NPN transistor

Miscellaneous: SPST switch, PC board, LED mounting rings, hook-up wire, enclosure, etc.

Note: The following items are available from the source mentioned in the Sources Box. A PC board (TS5.1), $3.95; IR-LED1 and IR-LED2 (kit IR5-1), $7.95; All components including semiconductors, resistors, capacitors, optoelectronic devices, IC socket, LED mounting rings, and a PC board (IR5-2 kit), $17.95.

of the power-supply voltage, V_{CC}, or about 8 volts. That allows the amplifier to operate from a single-ended power supply.

The AC signal and the 8-volt DC offset are fed to pin 2 of IC2. As long as the voltage on pin 2 is greater than two-thirds V_{CC}, IC2 operates as a monostable multivibrator whose time delay is determined by R6 and C2. IC2 and Q3 function as a missing-pulse detector. As long as pin 2 is held above 8 volts, Q3 is biased *off*, and has no effect on the operation of the monostable's circuit. Once a timing cycle is completed, pin 3 goes to—and remains at—ground potential. However, with an infrared signal present, the base of Q3 and pin 2 of IC2 are repeatedly triggered by negative-going pulses from pin 7 of IC1-b. Consequently, the timing cycle of IC2 is continuously interrupted before it has a chance to complete one time-delay cycle. That causes pin 3 to remain high. With pin 3 high, the RF transmitter is turned off; with pin 3 low, the RF transmitter is turned on.

The RF-transmitter section consists of a crystal oscillator and an audio-tone modulator. In the crystal-oscillator circuit, R14–R16 establish a DC bias of approximately 7 mA. The circuit is tuned to 49.890 MHz by L1, C9, and C10. T1 provides an impedance match between the oscillator's output and the antenna. The antenna-loading coil, L2, tunes a one-meter whip to resonance at 49.890 MHz.

Amplitude modulation is achieved by connecting R16 to pin 3 of astable-timer IC3. Components R11–R13 and C6 set the astable's frequency to 490 Hz. Pin 3 of IC3 goes low once during each 490-Hz cycle, which turns on Q5, allowing it to generate and transmit an RF signal. When pin 3 of IC3 is high, Q5 is *off*, and RF oscillation stops. Because IC3 is set to oscillate at the audio rate of 490 Hz, a 490-Hz amplitude-modulated RF carrier is generated by the Q5 circuit.

Figure 4 shows the envelope of the transmitted RF signal as seen on a spectrum analyzer. The bandwidth is less than ±10 kHz, as required by Part 15 of the FCC's Rules and Regulations.

The RF transmitter is turned on or off by Q4 and its associated components (see Fig. 3). To do that, Q4 turns the modulator, IC3, on or off. Q4's drain is connected through L4, a radio-frequency choke, to pins 2 and 6 of IC3. When Q4 is on, pins 2 and 6 are held below four volts (one-third of V_{CC}), causing pin 3 to go high; that stops the RF oscillation because Q5 is turned off. When Q4 is off, pins 2 and 6 of IC3 are unaffected by Q4's very high off-state impedance. Consequently, RF transmission occurs.

Transistor Q4 is switched on and off by pin 3 of IC2. C4 charges through R7 when pin 3 goes high. The

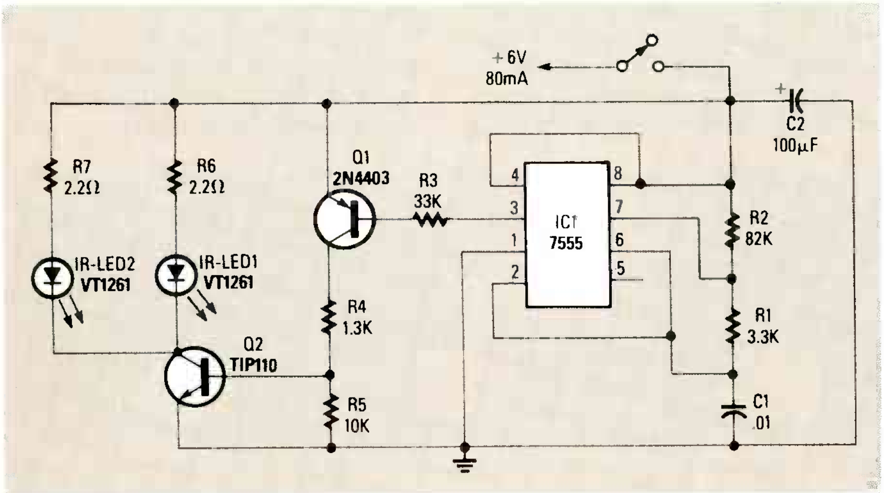


FIG. 2—THE IR TRANSMITTER, one component of the three-part system, transmits a continuous beam of infrared light to the IR receiver/RF transmitter.

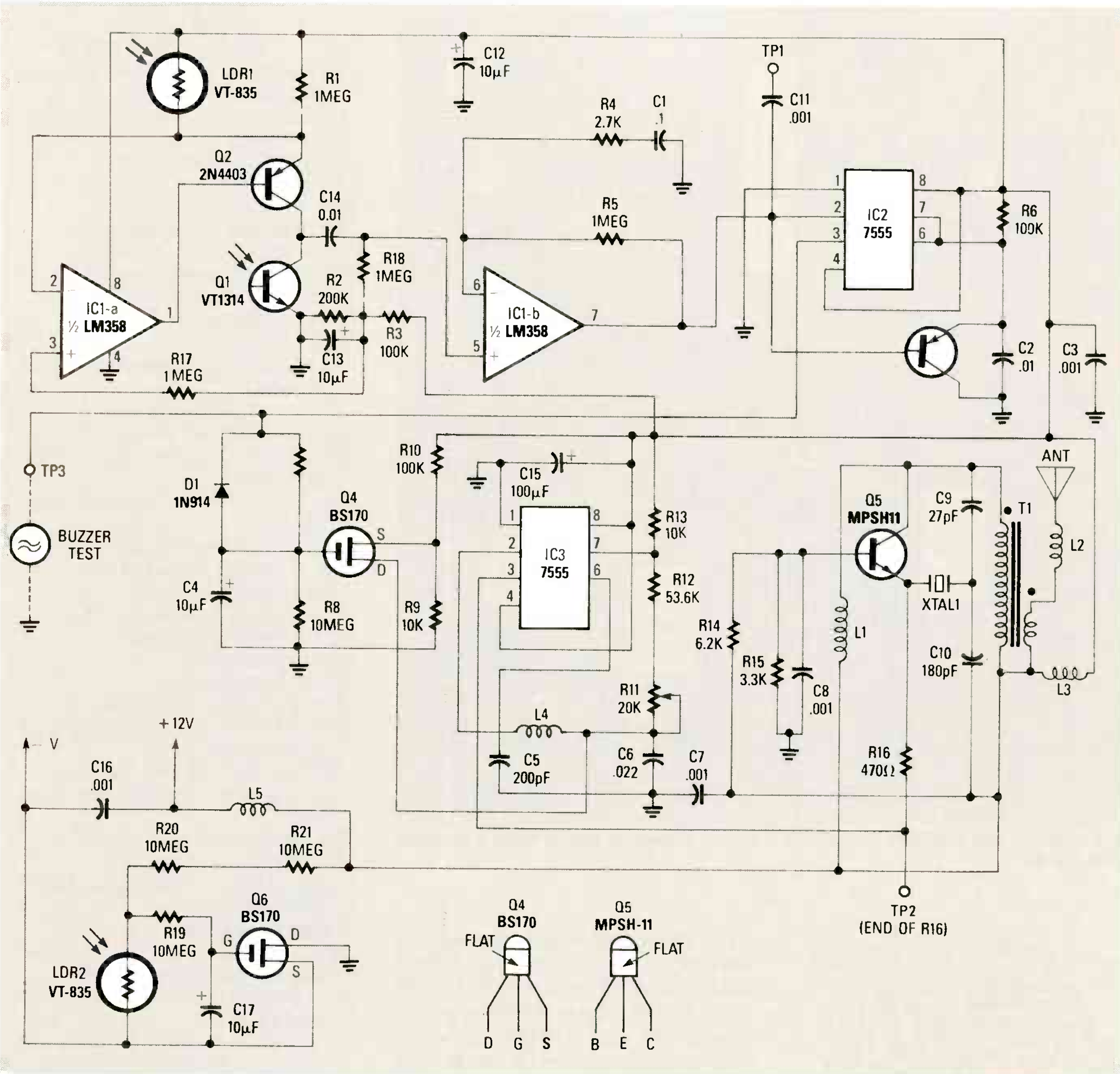


FIG. 3—THE IR RECEIVER/RF TRANSMITTER receives the IR beam and transmits an RF warning signal when the beam is interrupted.

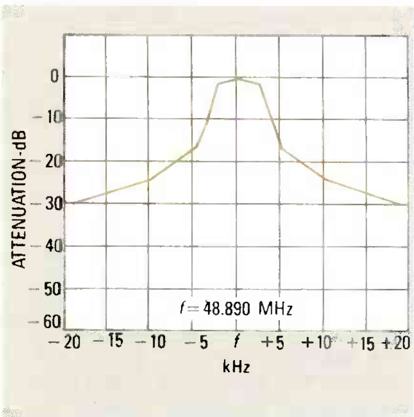


FIG. 4—THE BANDWIDTH of the transmitted RF signal.

voltage across C4 and between Q4's source and gate biases Q4 on when it reaches approximately three volts. When pin 3 goes low (to ground), C4 quickly discharges through D1, thereby biasing Q4 off.

Voltage-divider R9 and R10 bias Q4's source terminal to approximately 0.7 volts. That voltage, in conjunction with R8, provide a delay of several seconds between when Q4 turns on and when it turns off (it turns off when C4 charges to 3 volts or more). The RC time-constant circuit activates the RF transmitter for several seconds, even if pin 3 of IC2 goes low for only a fraction of a second.

Transistor Q6 and its associated components function as an on-off switch that is controlled by the intensity of the ambient light. LDR2's resistance is low when the device is exposed to light, thereby forcing Q6's V_{GS} (gate-source voltage) below the turn-on threshold. Capacitor C17 charges through resistors R19–R21 when LDR2 is not illuminated. Q6 turns on when the voltage across C17 reaches approximately 2.5 volts. With transistor Q6 on, the negative terminal of the power supply is connected to the circuit ground, thereby applying power to the IR receiver/RF transmitter.

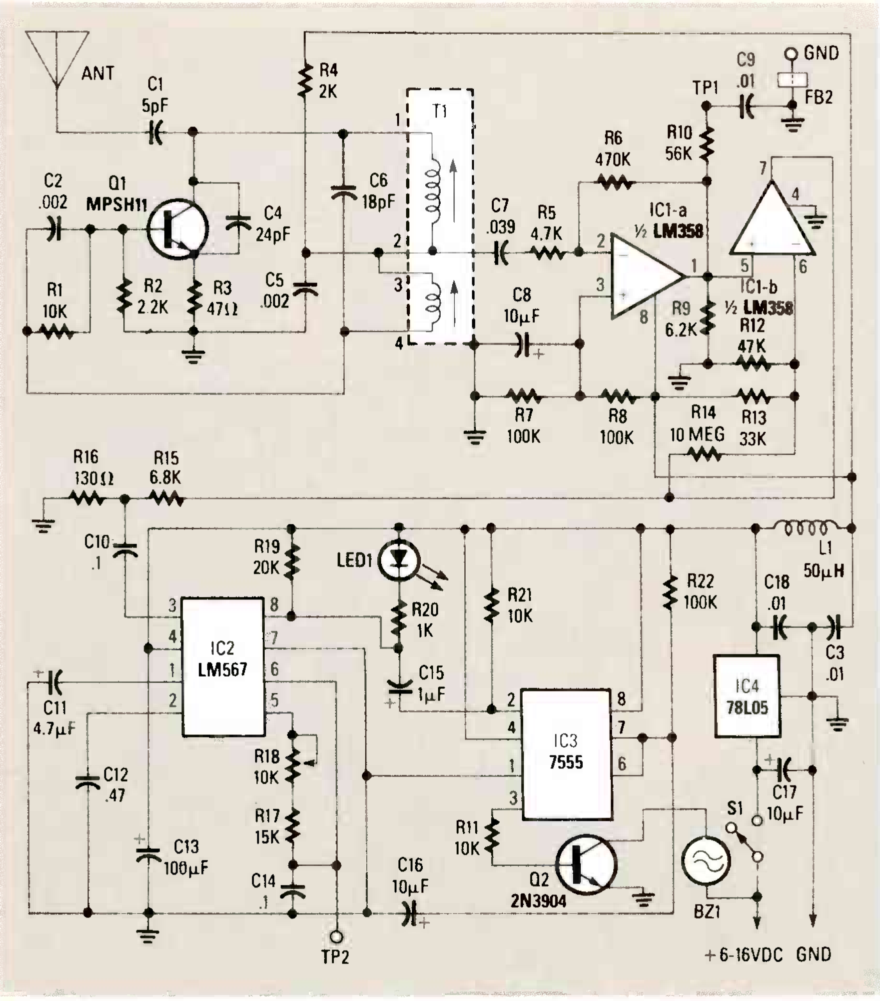


FIG. 5—THE RF RECEIVER/ALERT BEEPER sounds a warning buzzer when it receives the RF signal.

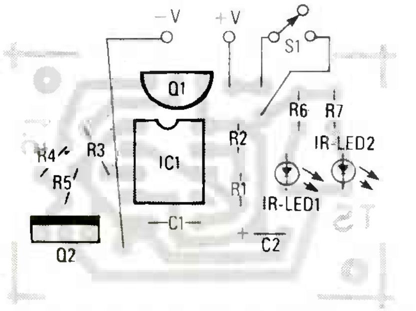


FIG. 6—PARTS PLACEMENT for the IR transmitter.

RF receiver/beeper

The RF receiver/alert beeper is shown in Fig. 5; the receiver circuit is a superregenerative receiver. An amplitude-modulated RF carrier is coupled from the antenna, through C1, into T1, and then to Q1's base. Resistors R1–R4 bias Q1 for an emitter current of approximately 1 mA. Capacitor C5 bypasses the RF signal, but not audio signals, to ground. The value of C2 is selected to cause self-oscillation, or motorboating, which is a requirement of a superregenerative detector. In that configuration, Q1 oscillates at an RF frequency of 49.890 MHz, at a repetition rate of approximately 450 kHz. During each 450-kHz cycle, just before Q1 breaks into RF oscillation, the circuit functions as a very-high-gain RF amplifier.

Transistor Q1's average DC emitter current increases and decreases according to the amplitude of the RF signal. Because the RF signal is amplitude-modulated by a 490-Hz tone, a 490-Hz voltage appears at the junction of Q1's collector and R4. C7 couples the 490-Hz signal from the receiver to op-amp IC1-a, which provides 10-dB gain. IC1-b further amplifies and clips the signal, shaping it into square pulses. Resistors R7–R9, R12, and R13 allow IC1 to be powered by a single-ended power supply.

The square-wave pulses from IC1-b are fed to tone-decoder IC2 through R15 and C10. The decoder's input-signal voltage is reduced by R16,

PARTS LIST
IR RECEIVER/
RF TRANSMITTER

All resistors are ¼-watt, 5%, unless otherwise noted.
R1, R5, R7, R17, R18—1 megohm
R2—200,000 ohms
R3, R6, R10—100,000 ohms
R4—2700 ohms
R9, R13—10,000 ohms
R8, R19–R21—10 megohms
R11—20,000 ohms, trimmer
R12—53,600 ohms, ¼-watt, 1%
R14—6200 ohms
R15—3300 ohms
R16—470 ohms
All capacitors are rated for at least 16 volts.
C1—0.1 μF, metalized film
C2, C14—0.01 μF, metalized film
C3, C7, C8, C11, C16—0.001 μF, ceramic disc
C4, C12, C13, C17—10 μF, electrolytic
C5—200 pF, ceramic disc
C6—0.022 μF, metalized film
C9—27 pF, ceramic disc
C10—180 pF, ceramic disc
C15—100 μF, electrolytic
Semiconductors
IC1—LM358 op-amp
IC2, IC3—7555 CMOS timer
Q1—VT1314 Vactec NPN infrared phototransistor
Q2, Q3—2N4403 PNP transistor
Q4, Q6—BS170 MOS power transistor
Q5—MPSH11 NPN transistor
D1—1N914 switching diode
LDR1, LDR2—VT-835 Vactec photoconductive cell
Other components
ANT—1-meter whip, or a 1-meter length of No. 22 hookup wire
L1—0.47-μH RF inductor (TOKO 7KM series)
L2—0.6-μH antenna loading coil (Time Space Scientific TS500-34-24)
L3–L5—50-μH miniature RF choke
T1—RF transformer (Time Space Scientific TS2343-18-5)
XTAL1—49.890-MHz series-resonant crystal
Miscellaneous: SPST switch (optional), PC board, IC sockets, etc.
Note: The following items are available from the source mentioned in the Sources Box. T1 and L1–L5 (kit TR3-1), $10.95; PC board (TS3.3), $9.95; LDR1, LDR2, and Q1 (kit TR3-3), $9.95; XTAL1 (49.890 MHz), $5.35; All components including semiconductors, resistors, capacitors, dip sockets, and a PC board (kit TR3-4), $45.95. (None of the kits include an antenna, switch, or enclosure.)

PARTS LIST
RF RECEIVER/ALERT BEEPER

All resistors are ¼-watt, 5%, unless otherwise noted.
R1, R11, R21—10,000 ohms
R2—2200 ohms
R3—47 ohms
R4—2000 ohms
R5—4700 ohms
R6—470,000 ohms
R7, R8, R22—100,000 ohms
R9—6200 ohms
R10—56,000 ohms
R12—47,000 ohms
R13—33,000 ohms
R14—10 megohms
R15—6800 ohms
R16—130 ohms
R17—15,000 ohms
R18—10,000 ohms, 20-turn trimmer potentiometer
R19—20,000 ohms
R20—1000 ohms

All capacitors are rated for at least 16 volts.
C1—5 pF, ceramic disc
C2, C5—0.002 µF, ceramic disc
C4—24 pF, ceramic disc
C6—18 pF, ceramic disc
C7—0.039 µF, metalized film
C8, C16, C17—10 µF, electrolytic
C3, C9, C18—0.01 µF, ceramic disc
C10, C14—0.1 µF, metalized film
C11—4.7 µF, tantalum
C12—0.47 µF, tantalum
C13—100 µF, electrolytic
C15—1 µF, electrolytic

Semiconductors
IC1—LM358 op-amp
IC2—LM567 tone decoder
IC3—7555 CMOS timer
IC4—78L05 5-volt regulator
LED1—Red light-emitting diode
Q1—MPSH11 NPN transistor
Q2—2N3904 NPN transistor

Other components
ANT—Telescopic antenna or two feet of No. 22 hookup wire
BZ1—Piezo buzzer
S1—SPST switch
L1—50-µH RF choke
T1—RF transformer, primary is 18 turns of no. 28 magnet wire, secondary is 5 turns of no. 24 magnet wire, on 0.23-inch diameter, no. 43 ferrite core

Miscellaneous: dip sockets, plastic enclosure, SPST switch (optional), wire, etc.

Note: The following items are available from the source mentioned in the Sources Box. A PC board (TS2.2), $9.35; T1 (TS3310), $7.95; All components including semiconductors, resistors, capacitors, ferrite beads, L1, T1, antenna wire, dip sockets, and a PC board (kit RC2-1), $29.95.

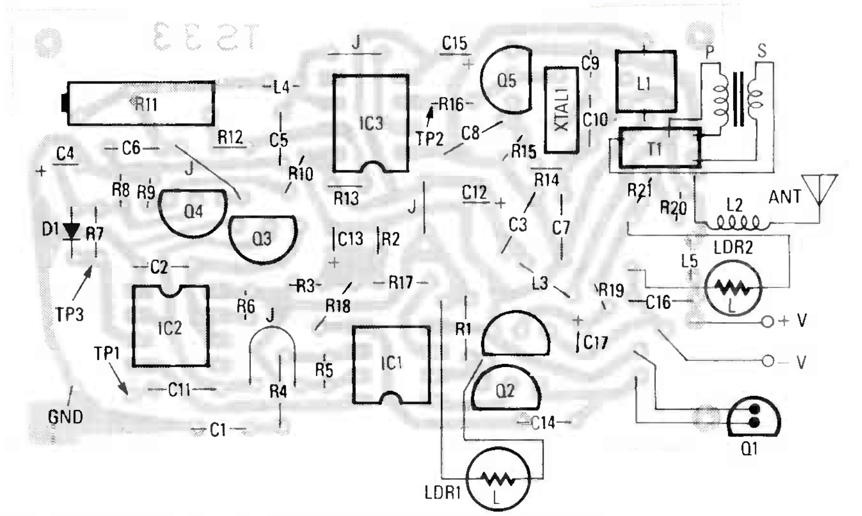


FIG. 7—PARTS PLACEMENT for the IR receiver/RF transmitter.

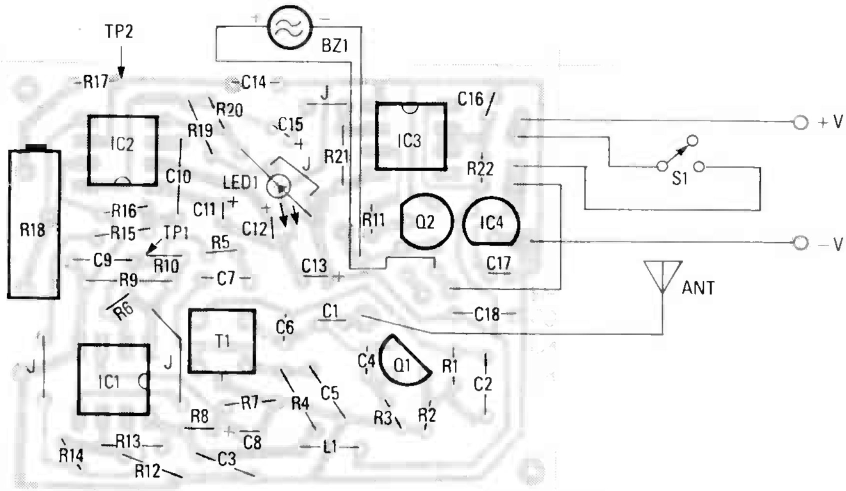


FIG. 8—PARTS PLACEMENT for the RF receiver/alert beeper.

thereby increasing the decoder's immunity to false triggering caused by other signals present in the 49-MHz band. Therefore, R16 is optional and, if installed, it will reduce the maximum range of the RF system. Capacitors C11 and C12 set the decoder's bandwidth, and R17, R18, and C14 set the frequency to which IC2 will respond (490 Hz). Pin 8 of IC2 goes low when a 490-Hz tone is applied to pin 3. At all other times, pull-up resistor R19 keeps pin 8 high. A high-to-low pulse transition at pin 8 is coupled to IC3's trigger input (pin 2) through C15. Pull-up resistor R21 keeps pin 2 high at all other times. Once triggered, IC3's output (pin 3) goes high, biasing Q2 *on*. (Q2 functions as a current sink for BZ1.) R22 and C16 determine the length of time that BZ1 sounds.

Construction

Each of the three circuits is assembled on its own PC board and mounted in its own enclosure. Templates for the boards are provided in PC Service. Alternatively, etched and drilled boards can be purchased from the source given in the Parts List. Use a suitable enclosure for each circuit. If you intend to use rechargeable batteries as the power supply, be sure that the enclosure is large enough for both the PC board and the batteries. If you use an AC adapter for the power supply, you can use a smaller enclosure.

Before mounting components on the PC boards, use the boards as templates for any holes that have to be drilled in the enclosures. All 555 timer IC's are CMOS, so we suggest that you use dip sockets, and wear a grounded wrist strap when handling the IC's. If you don't use IC sockets, use a grounded (3-wire) soldering iron.

Figures 6, 7, and 8 show the Parts Placement diagrams for the IR transmitter, the IR receiver/RF transmitter, and the RF receiver/alert beeper, respectively. All resistors are installed vertically. Capacitors mount flush against the board with *minimum* lead lengths—that is especially important in the RF and tone-decoder circuits. Install XTAL1 after C9 and C10 are installed. All transistor leads are approximately ¼-inch long. If you decide to control the IR receiver/RF transmitter manually, rather than use the automatic daytime-off circuit, omit Q6's circuit and install an SPST switch between the solder pads that were intended for Q6's source and drain.

Test points

For the RF receiver/alert beeper, make TP1 (test point 1) by placing a ferrite bead over one end of R10, and then solder the resistor onto the PC board so that it stands vertically, with the ferrite bead and the ring on top. Also, be sure that there is an easily accessible ground test point. TP2 is located at the junction of R17 and C14.

The IR receiver/RF transmitter board has three test points. TP1 is located on the free end of C11. Just temporarily solder a piece of red wire to the TP1 pad, and a piece of black wire to ground (both should be about 4 inches long). In the alignment procedure that follows, those two wires temporarily attach to an external audio amplifier/speaker. TP2 is the point where R16 and IC3 pin 3 meet, and TP3 is between R7 and the cathode of D1.

If you find that the test points are picking up interference, you may have to install a ferrite bead over the test point as was previously described.

FIG. 9—THE PROTOTYPE SYSTEM. The unit on the left is the IR transmitter, the one in the center is the IR receiver/RF transmitter, and the one on the right is the RF receiver/alert beeper.

SOURCES

All of the parts or parts kits mentioned in the Parts List are available from Time Space Scientific, 101 Highland Dr., Chapel Hill, NC 27514. Be sure to add $4.50 to any total order for shipping and handling. For technical information, write to Time Space Scientific, and please include a self-addressed stamped envelope.

The completed system units are shown in Fig. 9.

Optics

Mount the optical components in their respective enclosures as follows: For the IR Transmitter, drill two ¼-inch holes in the cover of the case with their centers ½-inch apart. Install IR-LED1 and IR-LED2 in the holes using LED mounting rings. If necessary, connect a pair of wire leads between the PC board and the IR-LED's, but keep the leads reasonably short.

Install phototransistor Q1 into the enclosure of the IR receiver/RF transmitter, the same way you installed the IR-LED's. Also, mount LDR1 adjacent to Q1 so that both are exposed to the same intensity of ambient light. Mount LDR2 in a location that will ensure maximum exposure to ambient light.

Alignment

For test purposes, each of the three circuits can be powered from a 9-volt battery, but for continuous operation, rechargeable batteries or AC adapters are recommended. The IR transmitter, and the RF receiver/alert beeper work well from a 6-volt gel-cell battery, but a 12-volt DC supply is required for the IR receiver/RF transmitter. And, if the connecting wires to the 12-volt supply are longer than two feet, install a 50-μH RF choke in series with the negative supply lead at the PC board.

The alignment requires a frequency counter that is capable of measuring audio frequencies, and an audio amplifier/speaker that has either an auxiliary- or a microphone-input jack (a portable cassette player with a microphone-input jack can be used). All test points are referenced to the circuit ground.

Cover LDR2 with black tape or plastic to shield it from ambient light. Attach a power supply to the IR receiver/RF transmitter circuit and allow one minute for C17 to charge. Then, using a small screwdriver, turn L1's core counterclockwise until it protrudes approximately 1/32 inch. Attach a frequency counter to TP2 and adjust R11 for a reading of 490 Hz. Disconnect the frequency counter and, using the appropriate connectors, attach the audio amplifier/speaker (the portable cassette recorder) to TP1: A 490-Hz tone should be heard.

Apply power to the IR transmitter.

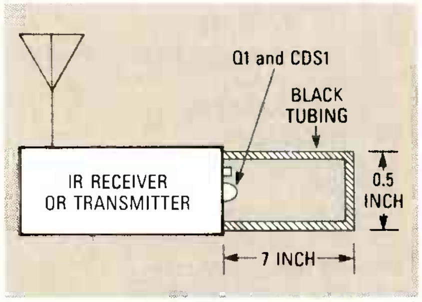


FIG. 10—A LIGHT SHIELD may be needed depending on the ambient light levels (see text).

While listening to the audio signal at TP1, place the IR transmitter in front of phototransistor Q1; a higher-pitched tone of approximately 1500 Hz should also be heard. After a few seconds, the 490-Hz tone should stop, leaving only the 1500-Hz tone. Momentarily interrupt the IR beam; the 490-Hz tone should again be heard.

Expose LDR2 to light. After a few seconds the audio tone(s) should stop, indicating that Q6 has shut off the circuit. Cover LDR2 so that the IR receiver/RF transmitter operates. Turn off the IR transmitter.

Apply power to the RF receiver/beeper (BZ1 may sound momentarily). Connect a frequency counter to TP2, and adjust R18 so that the counter measures 490 Hz. Next, connect the audio amplifier/speaker to TP1. Adjust T1's core until the top of the core is level with the top of the RF transformer. A rushing noise—and possibly the 490-Hz audio tone from the RF transmitter—should be heard. Adjust both T1 and L1 (in the receiver and the transmitter) for the loudest 490-Hz tone. Momentarily turn off the RF receiver/beeper and remove IC2. Collapse the antenna on the RF transmitter and place it about 30 feet from the receiver. Then, turn on the RF receiver and fine-tune T1 (on the

continued on page 58

BUILD THIS

ALPHA/THETA MEDITATION GOGGLES

Our alpha/theta meditation goggles can help you relax!

MARK WORLEY

MOST OF US NEED TO LEARN HOW TO RELAX FROM THE EVERY day stress of modern life. Research has shown that while in a relaxed state, our brains are generating alpha waves. For example, practitioners of yoga and transcendental meditation, after months and sometimes years of painstaking practice, can put themselves into a state that produces a preponderance of alpha brain-waves. But because few of us have the patience to learn yoga, a far simpler technique to achieve relaxation is by using alpha-wave biofeedback.

The *Alpha/Meditation Goggles* (A/MG) will allow you to readily produce those restful alpha waves through a process called photic stimulation. That technique has been used since the 1930's, but, until recently, it required a darkened room with bulky, expensive equipment. Now, solid-state electronics provides an inexpensive, safe, pocket-sized photic stimulator that runs on a 9-volt battery.

Photic stimulation

Alpha waves are a normal rhythm of brain signals, ranging from about 7 Hz to 14 Hz. They are low in amplitude and occur infrequently while you're in an alert awake state. However, they become pronounced when you close your eyes and fall into a cozy, drifty state of physical and mental relaxation.

When a person's particular alpha (or theta) frequency is visually flashed into their eyes, their brain tends to "resonate" with the light flashes. Because each person has their own dominant alpha frequency (or theta frequency), the flashing light has to be adjusted to a rate that nearly matches that frequency for any real effect.

The applications for the A/MG range from helping you to get to sleep more easily, to meditate, or for self-hypnosis training. You'll find that the alpha waves occur while you're in a state of relaxed awareness, which is often called an *alpha state*.

Circuit description

As Fig. 1 shows, a 555 astable oscillator (IC1), and transistor driver (Q2) are used to flash the series-connected LED's over an adjustable range of about 6.5 pps to 14.5 pps (pulses per second), or, optionally, 3.5 pps to 7 pps.

IC1 is configured as a conventional astable oscillator having an output pulse that goes low for 10 ms at the rate set by potentiometer R1. Resistors R4, R5, and R6 allow the oscillator to be fine tuned to correct for ±20% tolerance error in C2 and R1. You can use a frequency counter on pin 3 of IC1 to set R1's range, so that it has about the same overlap at each end of the 7- to 14-Hz band.

Note: Resistors R4–R6 can be omitted from the project, because it may not be necessary to trim the flash rate of your instrument so precisely. If you like, R5 can be a panel-mounted potentiometer for fine-adjusting R1.

Transistor Q1 is normally kept off by R8; Q1, in turn, keeps Q3 off. A low-going pulse from IC1 turns on Q1 for 10 ms, and pulses Q2 to momentarily flash the LED's. Resistor R10 will develop 650 mV across it at 54 mA. That 650 mV will turn on Q3 and limit Q2's current to 54 mA. Having that limiter, a constant current passes through the LED's with each pulse, independent of the supply voltage.

Most LED's are rated for about 20 mA of continuous current, but at a 15% duty-cycle, they can handle over 50 mA without harm. The LED brightness is significantly increased, yet the battery drain is still kept quite low. If you find that the LED's are uncomfortably bright, increase R10 to between 15 and 27 ohms.

The specified LED's are high-efficiency versions that emit a surprisingly intense beam of 30-mcd (millicandles are a measure of light intensity) at 20 mA. Standard LED's frequently have an intensity of 1 to 5 mcd, and a scattered, diffused beam. For the best effect, use the specified LED's because they have lightly tinted lenses, higher output, and a narrow beam.

Commonly, red LED's have a forward voltage drop (V_F) of about 1.7

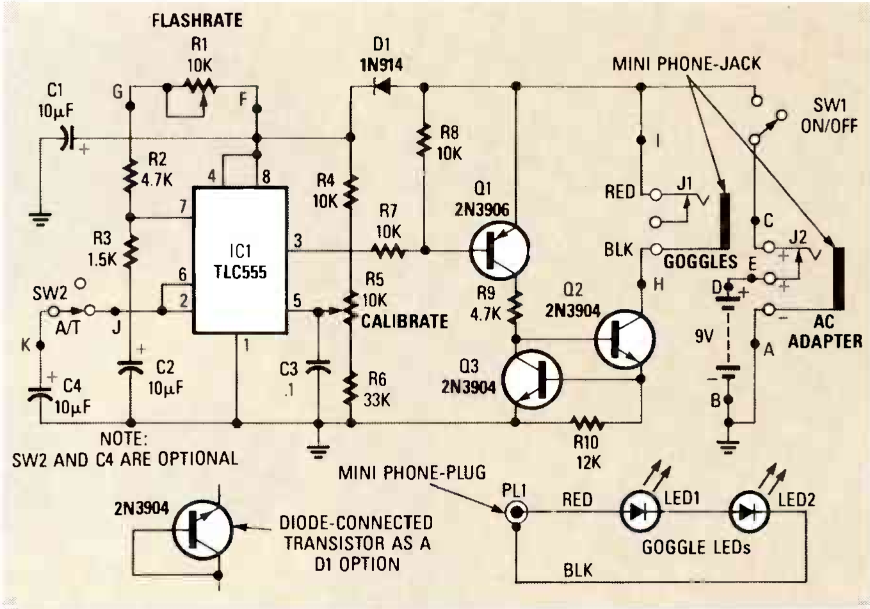


FIG. 1—THE HEART OF THE ALPHA MEDITATION circuit is a simple 555 timer whose pulse frequency is controlled by potentiometer R1. The pulse rate sets the visual flashing rate of the LED's in the goggles.

volts at 20 mA, whereas the brighter ones typically have a V_F of over 2 volts.

Therefore, up to four standard LED's can be used in the circuit. However, the V_F of the brighter LED's prevents using four of them with a 9-volt supply.

Diode D1 and capacitor C1 provide better power-supply filtering and isolation for IC1 than a conventional R/C filter. However, a 100-ohm resistor can be substituted for D1 if you desire. For a very-low voltage loss across D1, you could try using a Schottky diode or a diode-connected transistor, such as a 2N2222 or 2N3904 (see Fig 1.). That isn't really necessary, but it may keep some purists happier. Without the filter, the high-current pulses through the LED's can adversely affect the 555's operation, particularly with a weakening battery.

A mini phone-jack, J1, provides a convenient way to disconnect the goggles from the control box for storage. Another jack, J2, allows you to power the A/MG from an AC adapter having a 6- to 12-volt DC output. Make sure that the adapter has the proper polarity (a DC output, not AC), and a rating of 50 mA or more. Remember that a 12-volt adapter will not make the LED's any brighter than a 9-volt battery because of the current limiting.

PC-board assembly

The control circuitry does not need special care in assembly or layout, so perfboard should work just as well as the author's PC-board; the Parts Placement is shown in Fig. 2. For ease of discussion, we'll assume you're using the PC board. Note that the PC board supplied by the author is silk screened with all parts labeled, and solder-pads A through K are identified. All the holes have been drilled to their proper size. The inside of the control box is shown in Fig. 3, while the control box exterior assembly is shown in Fig. 4.

1. To keep the board oriented properly, lay the board on your work surface with the copper side down and S1's mounting holes to your right. Identify the locations of all the component mounting holes, and the mounting pads. Keep IC1 in its anti-static foam until you're ready to install it.

2. Insert the switch into its mounting holes and solder the three leads. The mounting tabs can be soldered to the board, too, but you will have to scrape the black finish from those tabs in order to do that.

3. Install C1, C2, and D1. Those parts are polarized and must be installed as indicated. (C4 should also be installed if it is going to be used.)

4. Install all resistors except R1, and also install C3. There are two ground pads for C3 to accommodate a variety of capacitor styles and sizes.

5. Use a piece of capacitor or resistor lead to jumper the two pads on the 555 (pins 4 and 8). Install the jumper flat

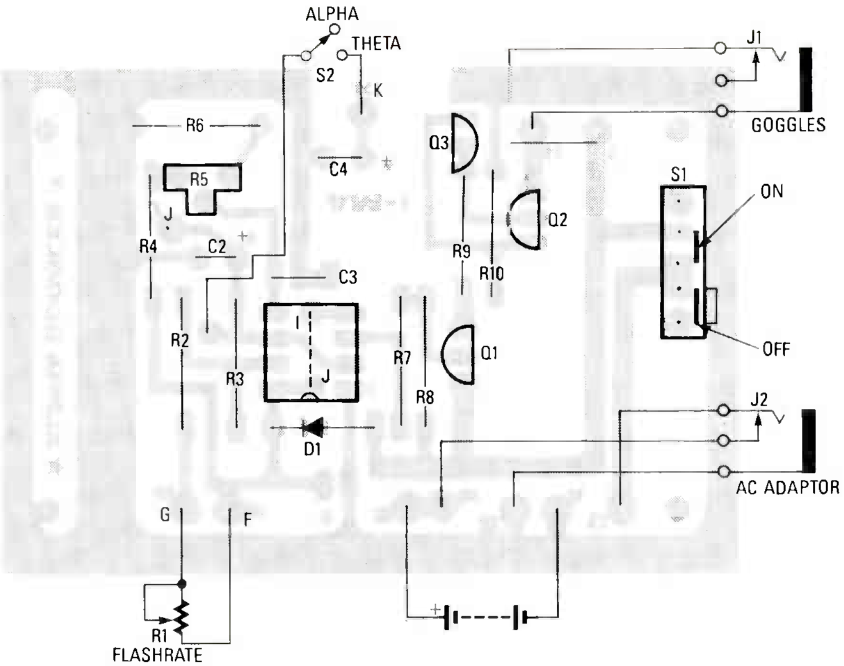


FIG. 2—THE PARTS PLACEMENT for the A/MG PC-board shows switch S1 soldered directly on the board. Notice transistor orientation, and the polarity of capacitors and diode D1.

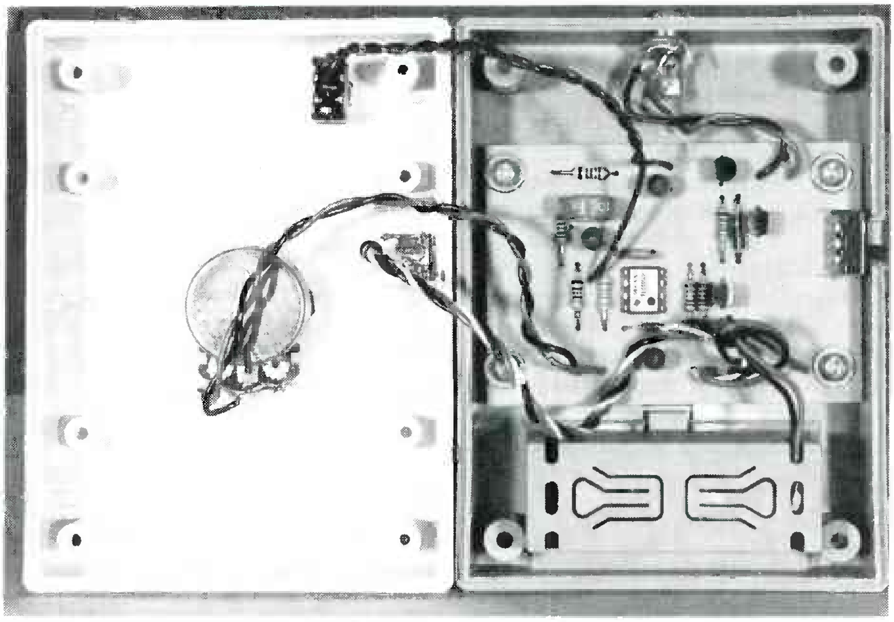


FIG. 3—THE INSIDE VIEW OF THE A/MG control box. Notice the clean layout. A 9-volt-battery compartment is just below PC board.

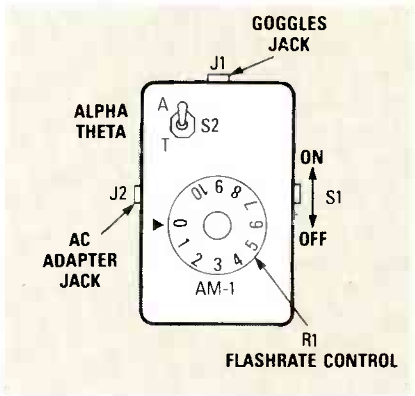


FIG. 4—EXTERIOR DIAGRAM OF THE A/MG control box showing the position of the flashrate control knob, and various jacks and switches.

on the component side of the board. The 555 will be installed on top of that wire.

6. Identify the three transistors, Q1–Q3. Install them with their flat side facing the proper direction, according to the Parts-Placement diagram in Fig. 2.

7. Install IC1 with pin 1 in the lower-right corner near D1. (Pin 1 is also identified on the copper foil.) Be sure the jumper wire has been installed under IC1 before you install IC1 or a socket. We'll continue with the remaining wires later.

8. Temporarily mount the board loosely in the bottom half of the box on top of the mounting bosses, and mark the hole for the on/off switch. Be sure to slide the switch between its two positions when marking the cutout. The plastic is easy to cut, so a small, flat file is all that's required. The switch has a low profile, so the top half of the case does not have to be notched.

9. In the bottom half of the case, mount a mini phone-jack (J1) for the goggles. Also, mount a jack for the AC adapter (J2) on the top half of the case. Make sure the jack clears any internal obstructions.

10. Insert the battery-clip leads from inside the battery holder through the slot on the right side. Tie a large knot in the leads to keep them from pulling back through the slot, while leaving 1¼ inch of lead length to solder to the PC board.

11. Solder the black battery-lead to solder pad "A" and the red lead in pad "D." (If you aren't installing an AC-adapter jack at this time, solder the red battery lead to pad "C," and the black lead to pad "A.")

12. Solder a red wire to pad "C" and a black wire to pad "B," then route them to the AC-adapter jack and solder them in place. Make sure that the polarity of the adapter matches the red (+) and black (−) wires. Also, connect a white wire between pad "E" and the switched terminal on the same jack. (That way, the battery will be disconnected when the AC adapter is plugged in.)

13. Solder a black wire between pad "H" and the outer ring terminal of the jack for the goggles, then solder a red wire between pad "I" and the "tip" terminal of the same jack.

14. Drill a hole in the center of the box's cover for the flash-rate potentiometer, R1.

15. If the theta-range option is used, connect a pair of lightly twisted 3-inch wires from pads "J" and "K" and S2, which should be mounted on the instrument's cover. Either wire can go to either pad. When S2 is closed, the A/MG will be operating in

PARTS LIST

All resistors are ¼-watt, 5%.

R1—10,000 potentiometer
R2, R9—4700 ohms
R3—1500 ohms
R4, R7, R8—10,000 ohms
R5—10,000 trimmer potentiometer
R6—33,000 ohms
R10—12 ohms

Capacitors

C1—10µF, 15 volts, electrolytic
C2, C4—10µF, 20 volts, 10%, tantalum
C3—0.1µF ceramic disk

Semiconductors

IC1—Texas Instruments, TLC555CP oscillator
Q1—2N3906 transistor
Q2, Q3—2N3904, 2N2222, or equivalent transistor
D1—1N4148, 1N914, or equivalent diode
LED1, LED2—Dialight #521-9247, red LED

Other components

S1—slide switch, Mouser #10SP018
J1, J2—mini phone-jack, 2 conductor, closed circuit
PL1, PL2—mini phone-plugs, 2 conductor

Miscellaneous: 9-volt battery clip, Amerex box No. 171, ⅜-inch No. 4 screws, No. 4 washers, knob, PC board, pair of goggles, 1-inch diameter black-vinyl caps for goggles, 4 foot of 22-gauge wire (red and black).

Note: The following is available from Mark C. Worley, PO Box 261113, San Diego, CA 92126. Kit No. 1 has all the listed parts for alpha frequency only, including wire for the interconnecting cable and internal wiring, instructions, diagrams, and schematic: $40. Kit No. 2 contains all the parts of kit No. 1 plus S2 and C4 for theta frequency: $43. A silk-screened PC board with parts placement sheet is available for $5, plus $0.50 postage. An AC adapter suitable to power the A/MG is available for $5 plus $1 postage. Please include $3 shipping charge per kit order. California residents must add 7% tax. Payment in U.S. funds only. Shipment will be made within 30 days of receipt of order. Please include a SASE when inquiring about individual parts or technical questions.

the theta mode, otherwise the A/MG will be in the alpha mode. (The unmarked pad between R2 and R3 can be used in place of pad "J" if you find it more convenient.)

16. Mount the PC board with four No. 4 screws and four No. 4 washers, so that S1 is fixed solidly against the inside edge of the box.

Goggle assembly

As shown in Fig. 5, the goggles are built from modified swimming goggles, which can be bought from a variety of department and sporting-goods stores for $5 or less. Choose darkly colored goggles if you have a choice.

1. Carefully identify the center of the lenses; that's where the LED's will be mounted. That way you'll get the maximum exposure from the LED's.

2. Some goggles are made from a plastic that can shatter quite easily when drilled, so use sharp drill bits and operate your drill at the lowest practical speed possible.

3. Drill the LED mounting holes 0.2-inch in diameter, or better yet, measure your LED's with calipers and drill the holes slightly undersized. With care, you'll get a good press fit. If the hole is too large, a little epoxy or *Super glue* will fix that. Don't worry about a little glue mess because it will be covered later.

4. Drill a series of 5 holes (1/16-inch in diameter) across the top of the goggles (not the lenses) to allow them to "breathe." Remember, they are watertight, so we'll need to let any perspiration escape.

5. Use minimum heat and a heatsink when soldering wires to the LED's because they are easily destroyed by excessive heat. Solder the following wires about ¼-inch up from the base of the LED, then clip the LED leads just above the solder point. Tightly twist a pair of red and black 22-gauge wires to form a flexible cable about 3-feet long to connect the goggles and the control box. Solder a 3-inch wire between the cathode of LED1 to the anode of LED2; solder the red wire of the 3-foot twisted pair to the anode of LED1, then solder the black wire of the twisted pair to the cathode of LED2.

6. Finally, attach a mini phone plug to the end of the cable that matches J1, on the control box.

7. After verifying that the LED's flash properly when plugged into the control box, use epoxy, hot glue, or RTV to glue two plastic bottle caps over the exposed lead ends of the two LED's, and then anchor the twisted-pair cable to the side of the goggles to prevent straining the LED solder connections. The caps can be medicine-vial caps, bottle caps, or anything similar that's about 1 inch in diameter.

8. Complete any final assembly work, attach the two halves of the instrument case, and apply power.

Using the goggles

Seat yourself comfortably where you'll have minimal distractions. Put the goggles on and adjust the straps for a comfortable fit. Place the control box where you can easily adjust the flashrate with minimal arm movement. Now close your eyes and turn the A/MG on. Play with the flashrate control for awhile to get a feel for the instrument. At the two extreme ends of the control's rotation, you should

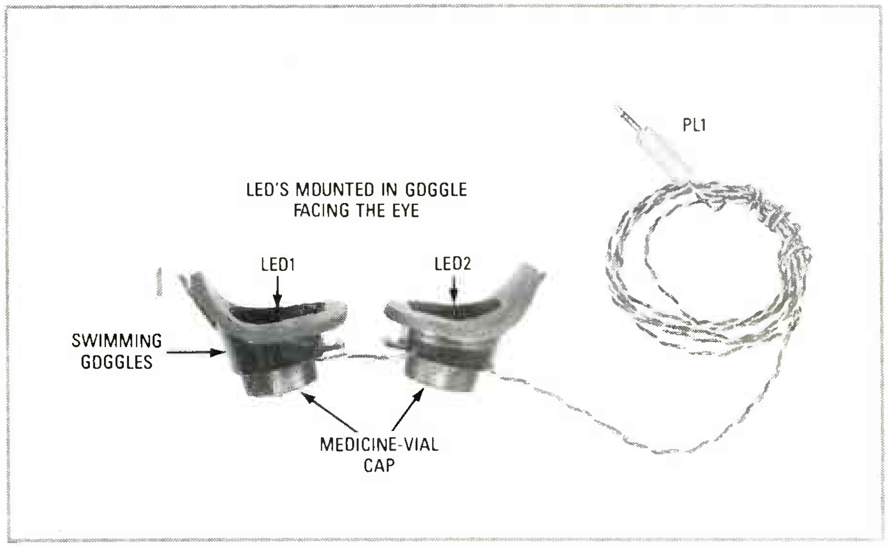


FIG. 5—THE ALPHA-MEDITATION GOGGLES are really common swimming goggles having LED's mounted inside each eye goggle. The LED's are electrically connected in series, and synchronously flash on and off.

feel that the flashrate somehow feels too fast and too slow. Somewhere in between those two extremes is a flashrate that's just right for you.

You should find that even with your eyes closed, there's still a noticeable flashing from the goggles. The LED's aren't bright enough to hurt your eyes, but the best effects are accomplished with your eyes closed. Continue to adjust the control slowly back and forth as you search for your own, personal alpha frequency.

At the correct frequency, you may find that your eyelids tend to flutter slightly in time with the flashes, or the intensity of the LED's may seem to be greater. Also, somehow, the flashrate will feel more comfortable and in tune with you. Don't force the process or worry too much about whether or not the A/MG is working at your frequency. Pick a rate that seems comfortable and try to relax under its effects.

After about 10 minutes, turn the A/MG off. You will almost assuredly find that you are feeling quite relaxed, almost languid, and that the feeling will begin to dissipate with the instrument turned off. That means that you've found the right flashrate for yourself. Make a note of the dial position for future reference. Each person that uses the A/MG will likely have a different setting.

Theta waves

For those wanting to experiment with the theta band, add a switch on the front panel, S2, that will connect a 10μF capacitor (C4) in parallel with C2, for the lower frequency range. (Refer to step No. 15 in the PC-board assembly instructions.) There's a space on the PC board for C4 just below the legend "AM-1." Watch the polarity of the new capacitor. Because the timing capacitance is doubled with C4 added, the pulse width of each flash has also doubled, but the duty cycle is the same because the pulse period has also doubled.

Here is a list of the more commonly documented brain frequencies, and when they usually occur. That is not to imply that these frequencies occur only during these states, or that all authorities on brain functions agree to the exact frequencies specified for each band.

- **Beta:** 14–30 Hz, predominant frequencies while awake.
- **Alpha:** 7–14 Hz, predominant when sitting or lying down quietly with eyes closed and the mind is at ease.
- **Theta:** 3.5–7 Hz, present during problem solving, also present during sleep or deep trance.
- **Delta:** 0.5–3.5 Hz, present during sleep and, sometimes, illness.

Questions & answers

When do alpha brain waves appear? Alpha waves change under differing conditions and may disappear completely. They are most prominent when the subject is sitting or lying down quietly with the eyes closed and the mind at ease. Considerable mental effort tends to depress alpha waves, such as concentration or emotional excitement can cause their complete disappearance.

What are Alpha goggles? The meditation goggles are photic stimulators that synchronize the brain's natural alpha frequency to that of the goggles. When a close match of the flashing rate and the subject's alpha rate is accomplished, the brain naturally begins to "get in step" with the goggles and increases the amplitude of the alpha waves. Simply put, the flash rate forces the brain to generate alpha waves, resulting in relaxation.

How do you adjust for the proper flash rate? That is a difficult and subjective thing to describe. For the most part, you will notice that as you adjust the rate, it will seem too slow at one point and too fast at another. Somewhere in between those points is a frequency that feels right, somehow. Also, at that rate, you may notice that the flashing lights seem brighter and that your eyelids or other related muscles begin to twitch slightly with the rhythm of the lights. The rate does not have to be set precisely.

How do you know that it's working? Again, that is quite subjective, but easily proved. Lie back, set the rate for what seems right, and relax for a few minutes under the influence of the goggles. Now, leave the goggles on, but turn the switch off, using a minimum of body movement to do so. There will be a noticeable "coming down" feeling as you lose the high state of alpha that was induced by the goggles. You'll also feel quite lethargic and at ease, something you might not have noticed while the goggles were flashing. You're still producing a good level of alpha waves and are still in a meditative state with the goggles turned off, so why not continue your meditation at that time?

What dangers are there? With one exception, epilepsy, none that we know of. Photic stimulation is not a new idea. What is new is the application of solid-state circuitry and sensory-reducing goggles. The lights are low-powered solid-state devices called LED's, virtually the same as used in many digital clocks and appliances. There are no dangerous, eye-damaging light levels used.

If you are a known epileptic, do not use this instrument. Lights flashing at the alpha rate can cause a seizure: see medical alert side box. If you have undiagnosed epilepsy, you may perceive an odd smell, or other unusual effect immediately prior to a seizure. If that happens, remove the goggles immediately!

What about hypnosis? The goggles are also a useful aid in hypnosis when the subject is overly analytical, or critical of the hypnotic techniques used. Likewise, self-hypnosis is more easily achieved through the relaxation the goggles provide.

Will I lose control of myself? An emphatic NO. Except as noted about epilepsy, the goggles cannot control your mind; they are only a tool. You are always in control. The state that the goggles help induce is usually of heightened awareness, so you're more aware of your surroundings, but, because you're relaxed, they aren't as distracting.

Of course, there is the chance that you'll become so relaxed you'll fall asleep and miss your favorite TV program, or maybe you'll be late for supper—but those usually aren't classified as harmful side effects. **R-E**

MEDICAL ALERT

If you are an epileptic, do not not use the A/MG goggles. Persons suffering from epilepsy can experience a seizure when exposed to alpha-rhythm photic stimulation. For example, one commonplace photic stimulation is the "picket fence effect," which gives the sunlight a strobing effect when viewed through trees from a moving vehicle—such photic stimulation is also caused by the A/MG goggles. If you are not known to be an epileptic, but begin to perceive an odd odor, sound, or other unexpected phenomenon while using the A/MG goggles, shut it off immediately and seek professional advice from your physician.

Radio-Electronics mini-ADS

SECURITY SYSTEM

continued from page 52

receiver) for the best reception. Finally, disconnect all the test probes and reinsert IC2.

If necessary, fine-tune L1 (on the RF transmitter) to minimize the transmission of a second harmonic, which may be heard on an FM radio tuned to approximately 100 MHz.

Installation and operation

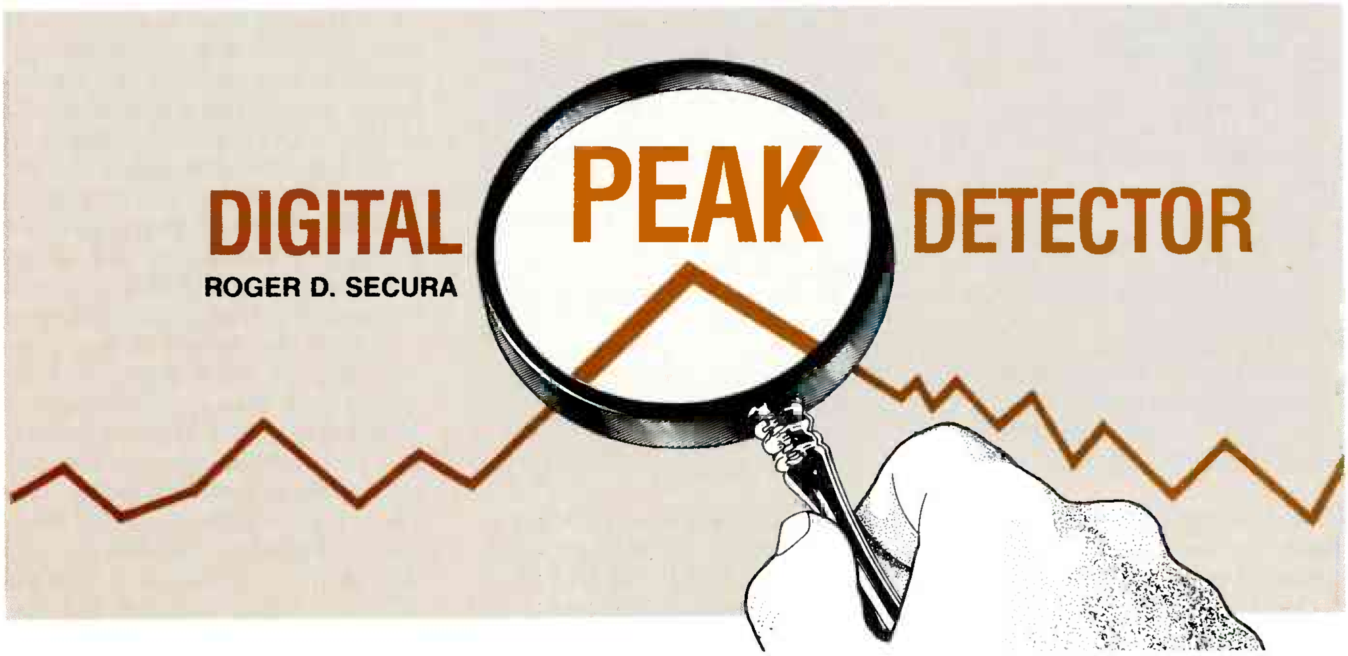
The range of the IR beam is inversely proportional to the intensity of the ambient light, and is typically a maximum of 18 feet. The system is designed to operate under low-intensity lighting. Although strong fluorescent lighting has little effect on the system, bright daylight and bright incandescent lighting will reduce the maximum range of the IR beam. For operation under modest amounts of daylight and/or incandescent lighting, a simple light shield can be constructed from black tubing installed over over phototransistor Q1 and LDR1, as shown in Fig. 10

Keeping in mind the effects of external light sources, mount the IR receiver/RF transmitter on a wall or a pole across from the intended location of the IR transmitter. With the IR receiver securely mounted, attach the audio amplifier/speaker to TP1. Apply power to both the IR receiver/RF transmitter and the IR transmitter. Holding the IR transmitter approximately where you intend to mount it, align the two devices while listening to the 1500-Hz tone from the amplifier. The IR beam is correctly aligned when the 1500-Hz tone sounds the loudest, and the IR transmitter is within range when the 490-Hz tone dies out.

An alternative alignment method is to connect a piezo buzzer to TP3. The buzzer will continuously sound until the IR transmitter and the IR receiver are properly aligned and within range, at which time the buzzer abruptly stops.

Next, decide on a location for the RF receiver. The range of the RF transmitter is approximately 100 feet. You may keep the receiver portable.

You may want to consider additional locations to be monitored, such as a driveway, a garage, or the entrance to a swimming pool. The system is adaptable to many interesting projects. **R-E**



DIGITAL PEAK DETECTOR

ROGER D. SECURA

When you need to know the hottest, the fastest, the highest, or the absolute most, you need to build our peak detector.

WHAT'S THE TOP WIND SPEED DURING A hurricane? What about that jumbo jet on final approach, flying 1000-feet over your home: Is the noise pollution higher than that allowed by law? How hot does beach-sand get under a blazing summer sun?

To answer those questions, you have to measure the relevant physical parameter, store the maximum event, and then display the result. To sense the relevant parameter, you need a *transducer*. To track and hold the maximum event, you need a *peak detector*. And to record the result, you need a *digital display*. Such a peak-detecting device should continuously track, hold, and display the maximum level of any physical parameter; for example, speed, loudness, temperature, pressure, position, flow rate, force, light intensity, and so on—you name it.

Transducers

Getting the world of electronics to communicate with the physical world is like trying to mix oil with water—an almost impossible task, unless you have the right emulsifier. We know that emulsifiers work with oil and water, but what works with physical quantities and electronics? You can't shake them up in a bottle. To get them to mix you need a transducer. And their are literally hundreds of different types of transducers; each type mixing a specific physical parameter with electricity.

A transducer outputs an electrical signal that is proportional to the magnitude of the physical event it's detecting; an output can be a series of digital pulses, an analog voltage, a varying frequency, or a change in current or resistance.

An example of a practical transducer is a *L*ight *D*ependent *R*esistor or LDR, which is a resistor whose resistance changes in proportion to the amount of light striking its surface. (Cadmium-sulfide photocells are the most common LDR's.) But our peak detector can sense only voltage within the 0 to 5-volt range; it can't sense resistance at all! What's needed is a method to convert the LDR's resistance to an equivalent voltage. A typical LDR might have a light-to-dark resistance range of 100 ohms to 500,000 ohms. A circuit must be designed that transforms that resistance range into a voltage range between 0 to 5 volts. That conversion process is called signal conditioning.

As shown in Fig. 1, to condition the

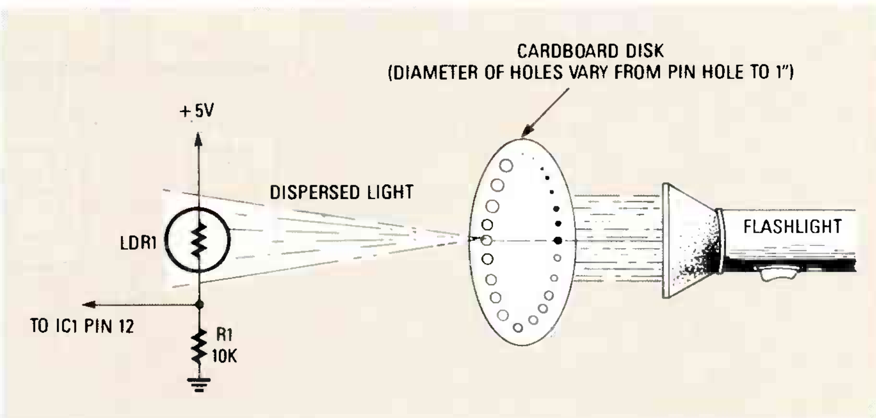


FIG. 1—THE *L*IGHT *D*EPENDENT *R*ESISTOR (LDR1) IS A TRANSDUCER whose resistance changes in proportion to amount of light falling on its surface.

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted)
R1, R7—1000 ohms
R2—100 ohms
R8, R9, R42—10,000 ohms
R3–R6, R10–R19—10,000 ohms, 1%
R20–R40—330 ohms
R41—250,000-ohm potentiometer

Capacitors
C1—22µF, 16 volts, electrolytic
C2—10µF, 16 volts, electrolytic
C3—.01µF, 50 volts, ceramic disc

Semiconductors
D1, D2—1N914 Diode
DISP1–DISP3—7 Segment LED Display (common anode)
Q1—2N3906, PNP Transistor
Q2—2N3904, NPN Transistor
IC1—LM324, Quad Op-amp
IC2—555, Timer
IC3—4066, Quad Bilateral Switch
IC4, IC5—74193, 4-bit up-down counter
IC6–IC8—74190, 4-bit up-down counter
IC9–IC11—7446, BCD-to-Seven-Segment Decoder/Driver

Other components
S1, S2—Normally-open momentary-on push button
S3—6 position rotary switch
LDR1—cadmium-sulfide (CdS) photocell

LDR, a voltage divider is formed by connecting the LDR in series with resistor R1 and a 5-volt source. When the light source is maximum, the LDR appears as a low resistance, allowing almost the entire 5 volts to be developed across R1. When the light source is minimum (dark), the LDR has its highest resistance, so almost all the voltage is developed across it, and practically no voltage is developed across R1. So far, we've taken a light-intensity transducer, the LDR, and conditioned its changing resistance to be compatible with the our peak detector's input requirement of 0 to 5-volts. Shortly, we'll see how to calibrate our transducer.

How it works

Figure 2 shows a block diagram of our digital-readout peak-detector. The purpose of the peak detector is to track and hold (using the charge-storing ability of a capacitor) the highest output voltage from a transducer. An op-amp with a high input-impedance is used as a buffer to ensure that the stored charge on the capacitor doesn't leak off. Another op-amp is used as a comparator that has the task of enabling/disabling the *B*inary *C*oded *D*ecimal (BCD) and binary counters.

Initially, the voltage on the inverting input of the comparator is at ground level. As a small voltage (0–5 volts) is captured by the peak detector and presented to the comparator's non-inverting input, the output will swing high, which asserts the bilateral switch; clock pulses now pass through the switch to clock both the BCD and binary counters. The outputs of the binary counters are connected to a R2R ladder network, which functions as a digital-to-analog converter. As the binary count increases, the R2R ladder voltage also

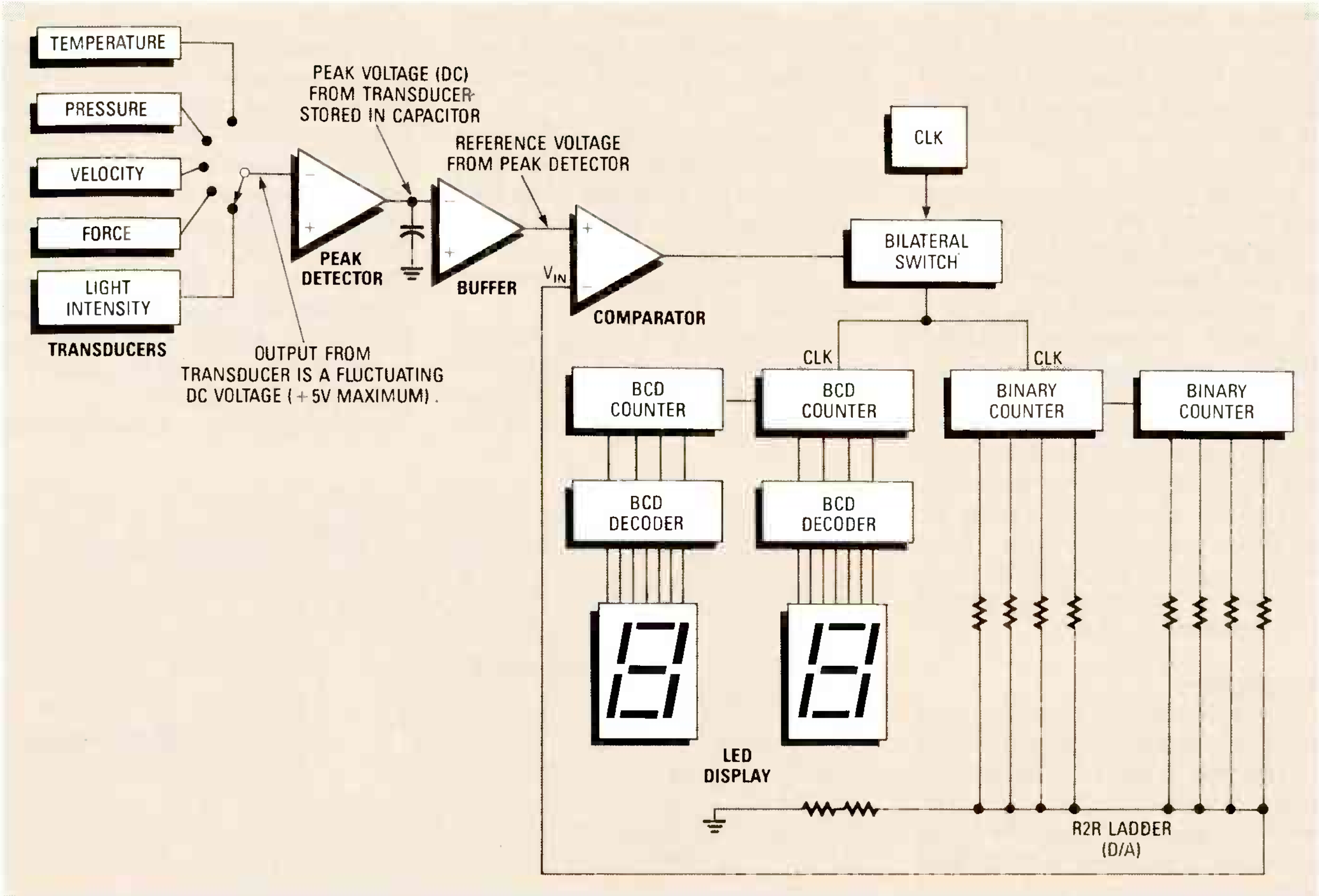


FIG. 2—THE TRANSDUCER, PEAK DETECTOR, AND DISPLAY are the main components of a digital-readout peak-detector.

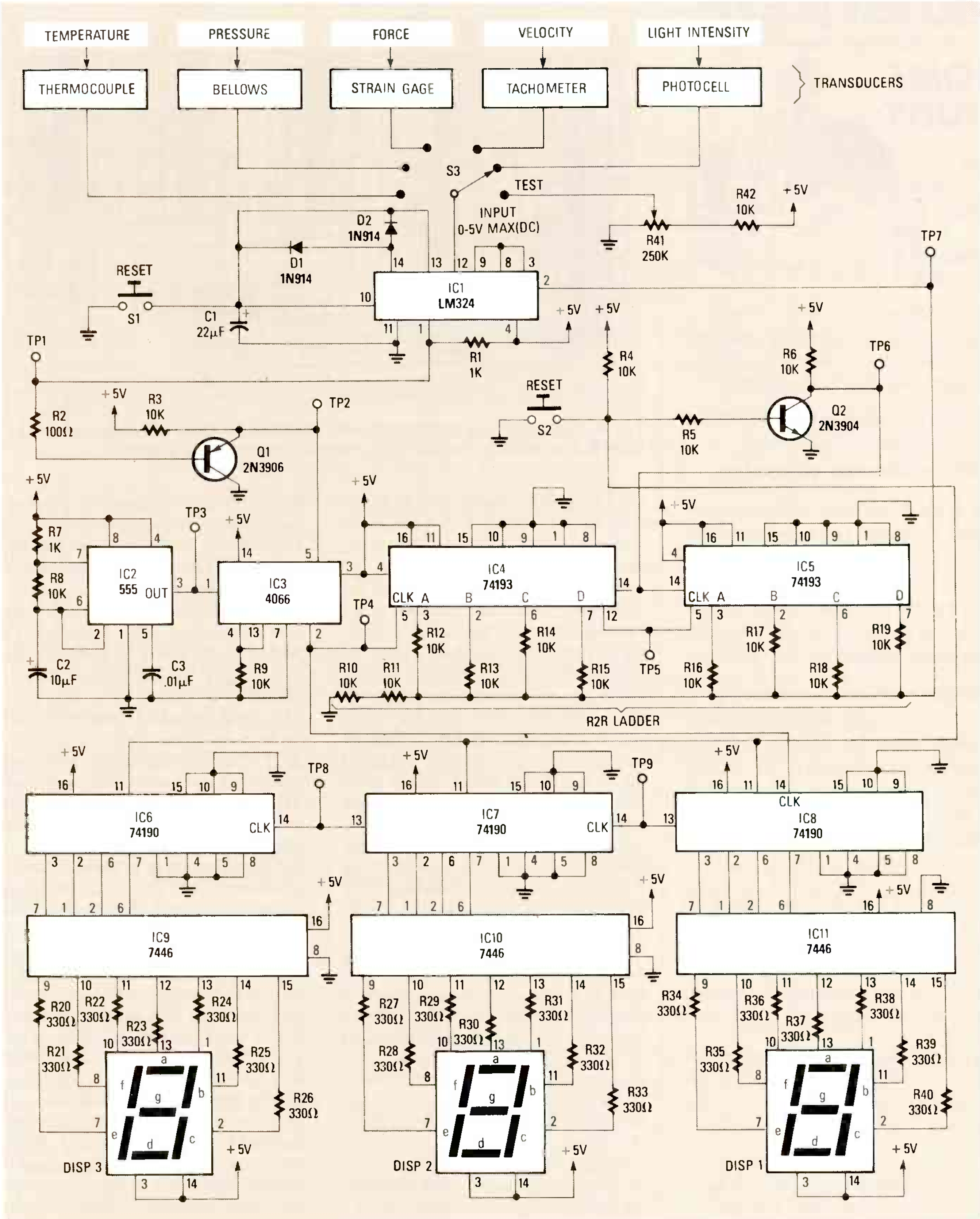


FIG. 3—THE CIRCUITRY CONSISTS OF COMMON TTL, CMOS, AND OP-AMP IC'S. When switch S3 is in the test position, varying R41 simulates a transducer's voltage output.

increases until it reaches a point slightly above the voltage of the peak detector; at that instant, the comparator output swings low, which disables the bilateral switch and stops the counters.

If everything functions properly, the number displayed on the 7-segment LED's will represent a value equivalent to the transducer's output. Note that the display's reading is not an actual voltage reading, but simply

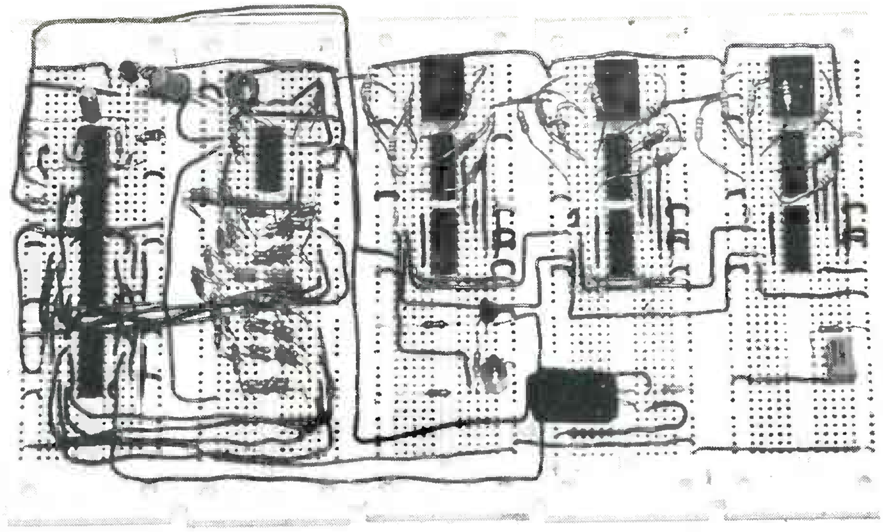


FIG. 4—THE AUTHOR'S PROTOTYPE WAS ASSEMBLED ON A SOLDERLESS BREADBOARD. Use insulated hookup wire to minimize the possibility of shorts.

the BCD count from IC9 and IC10. Any further increase in transducer voltage will be tracked, displayed, and maintained.

Of course, the transducer is not yet calibrated. Calibration implies comparison with a known standard. Getting into the mathematics of footcandles can be pretty complicated, so we'll develop our own standard—albeit crude for our light sensor. As shown in Fig. 1, simply punch holes of increasing diameter into a cardboard disk to allow extra light to pass through each successive hole; then chart the light intensity falling on the LDR, for each punched hole, by measuring the voltage across R1 and the display's reading. The more light that falls on the LDR, the lower its resistance and, consequently, the greater the voltage drop across R1. Although that method is far from scientific, it should give you a rough scale with which to compare lilght levels. The same technique can be used with other transducers, such as temperature-dependent resistor's. Using a thermometer for comparison can give a more meaningful calibration curve.

Figure 3 is the complete schematic of the digital-readout peak-detector. As shown in Fig. 4, the author used a proto-board for assembly, but you may just as easily use a prototype PC-board and wire-wrap all connections.

Testing

If your circuit fails to respond after construction, use the following troubleshooting procedures to pinpoint the problem (refer to Fig. 3):

1. Switch S1 to the test position, and adjust the potentiometer R41 for an output of 2.5 volts.

2. Check TP3 for a 30-Hz clock signal. No clock on TP4 means there's a problem with either IC2 or IC3. The clock signal at TP5 should have a frequency of about 1 Hz. Test Point TP8 sould output less than one clock cycle every 16 seconds.

3. If all checks out so far, press and release the reset button (S2) and see if TP6 goes from a low to a high, and then back to low. If there's a problem, check Q2 and associated circuitry.

4. Check the output of the R2R ladder network at TP7. To do that, press and release S2 to reset the counters, and watch TP7 (using an oscilloscope or meter) for a slow rising DC voltage (+5-volts maximum). Any deviation from the normal ascension indicates a problem in the R2R ladder network or binary counters IC4 and IC5. Note: The resistors in the R2R ladder, R10-R19, should be within 1% tolerance.

5. The final test is to simultaneously press and release S1 and S2, then wait for the LED's to stop counting. When they stop, the display will register a number equivalent to the 2.5 volts on R41 potentiometer. (Don't worry about the actual displayed number.) Repeat that procedure a few times. The same number should re-appear on each test. Next, turn the test potentiometer R41 up to three volts. The LED's should start counting up to some number and then stop. **R-E**

WORKING WITH COUNTERS

Count on counter circuits to keep counting.

RAY MARSTON

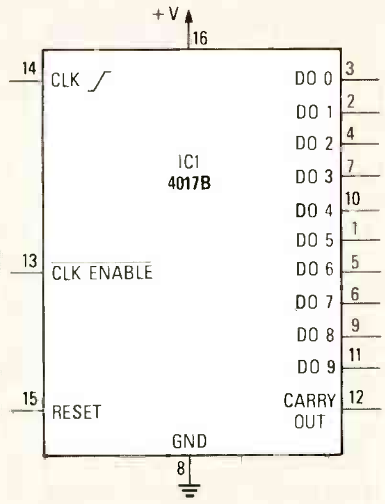


FIG. 1—THE 4017B DECADE COUNTER has 10 DECODED OUTPUTS, a CARRY OUT bit, and is triggered on the clock's rising-edge.

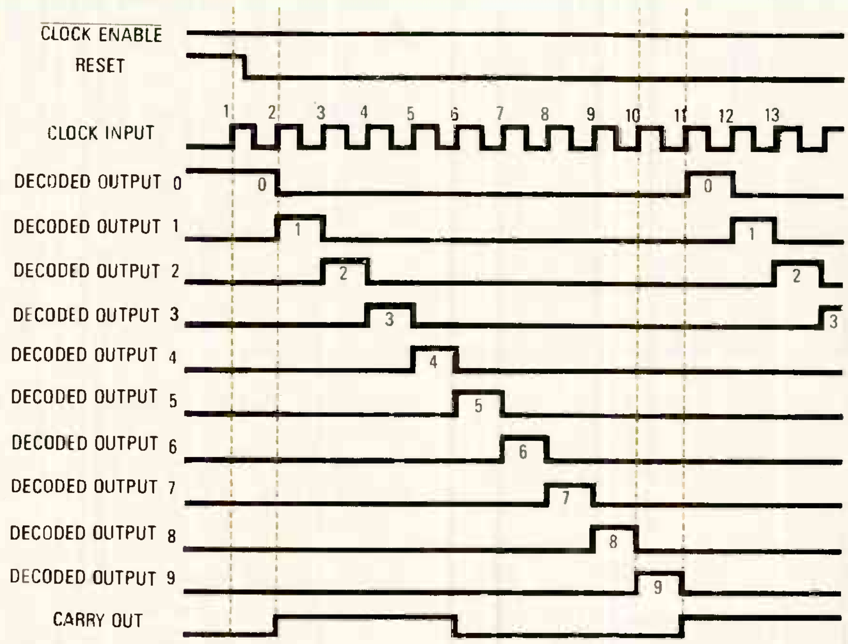


FIG. 2—TIMING DIAGRAM OF THE 4017B. Only one DECODED OUTPUT is high at any given moment.

CMOS D AND JK FLIP-FLOPS ARE THE BUILDing blocks for all counter/dividers. Constructing your own counter/divider is fine—especially when only one or two flip-flops are required. However, for a complicated design requiring 10 or more flip-flops, it's best to use a counter/divider IC already developed in a single *D*ual *I*n-line *P*ackage (DIP): options include binary, decade, or hexadecimal counters, up/down counting, resets, presets, LED driver outputs, and a carry-out line for cascading IC's. Let's start by examining one of the best know CMOS up-counters, the 4017B.

Decade counter

Figure 1 shows the 4017B IC pin-out; that IC is one of the best known CMOS up-counters, having a synchronous decade-counter and 10-decoded outputs. Synchronous means that all flip-flops are triggered at the same time (no ripple through clocking), and all DECODED OUTPUTS 0-9 will change states simultaneously. The 4017B works quite simply: When asserted, a single high bit is latched into the counter at DECODED OUTPUT 0. That bit will then travel to the next DECODED OUTPUT on the rising edge of each new clock pulse. (Only one of the ten DECODED OUTPUTS will be high at any given moment.) The DECODED OUTPUTS 0-9 thereby represent a decimal (1-10) equivalent of the total number of clock cycles.

Timing diagrams

The timing diagram for any counter IC is like a road map—without it you will be lost. If you intend to do any serious design work using counter IC's, then by all means get a copy of National Semiconductor's CMOS logic data book.

Figure 2 shows the 4017B timing diagram. By placing a high on the RESET (pin 15) and holding the CLOCK ENABLE (pin 13) low, the chip is asserted and a high bit is automatically entered into DECODED OUTPUT 0 (pin 9). To initialize the IC, the RESET line should be brought low just after the rising-edge of the first clock pulse. On the rising edge of the second clock pulse, the high bit will then advance to DECODED OUTPUT 1 (pin 2). Then, after the rising edge of the third clock pulse, the high bit will advance to DECODED OUTPUT 2 (pin 4), and so forth. At any given moment, nine of the ten DECODED OUTPUTS will be low, with the remaining DECODED OUTPUT high. The counting cycle can be stopped by setting the CLOCK ENABLE (pin 13) high. Furthermore, the IC has a built-in Schmitt trigger on its CLOCK ENABLE line, and is therefore not bothered by a trigger signal with a slow rise time. An additional CARRY OUT signal (pin 12) completes one cycle for every ten clock cycles and, as we'll see, can be used to clock additional 4017B's in a multi-decade ripple counter.

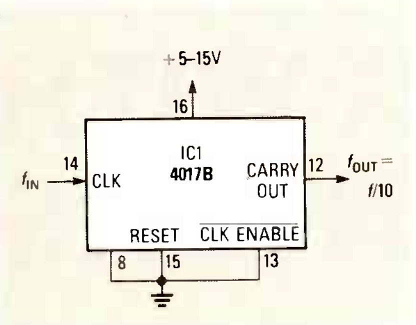


FIG. 3—A 4017B CONNECTED as a decade counter/divider.

Decade circuits

Figure 3 shows the 4017B connected as a decade divider, where the output frequency is 1/10th the input frequency. The IC is always asserted because RESET and CLOCK ENABLE are grounded. The output is taken from the CARRY OUT, while the DECODED OUTPUTS are ignored.

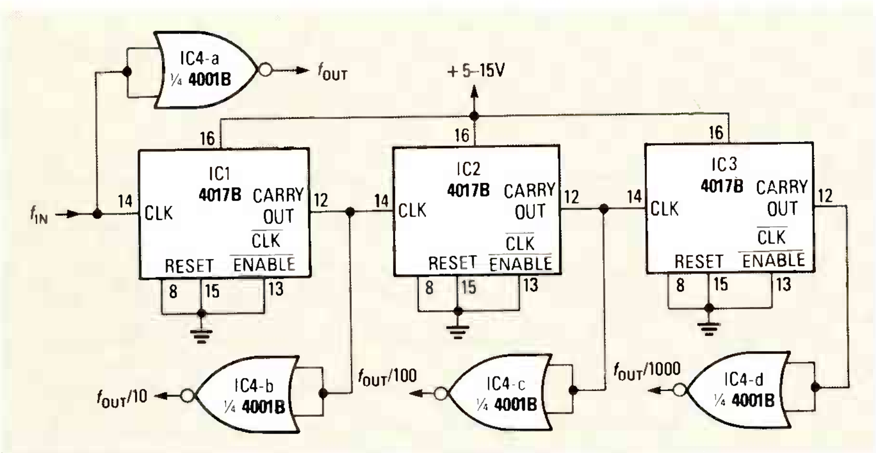


FIG. 4—ANY NUMBER OF 4017B's can be cascaded to make a multi-decade divider. Outputs should be buffered using a 4001B CMOS INVERTER gate.

Figure 4 shows how to cascade 4017B counters to divide the f_{IN} clock frequency by 10, 100, and 1000. The CARRY OUT of each counter is used as the clock input to the following IC. Notice that all $f_{OUTPUTS}$ are buffered via simple CMOS inverters (made from 4001B NOR gates); that ensures that output loading does not degrade the pulse's rise time. For example, using a 1-MHz crystal oscillator as a clock, then a 100 kHz, 10 kHz, and 1-kHz frequency can be generated.

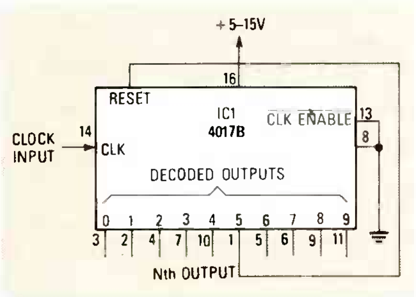


FIG. 5—THE 4017B AS A DIVIDE-BY-N COUNTER. This circuit is set for divide-by-5 operation.

Figure 5 shows how to connect the 4017B as a divide-by-N counter (where N = any integer from 2 to 9). A divide-by-N counter (or Mod-N counter) has its "Nth" DECODED OUTPUT hard-wired back to the RESET. The counter is then cleared to its zero count (a high on pin DECODE OUTPUT 0) on the arrival of the "Nth" clock pulse.

What could happen if the divide-by-5 counter, in Fig. 5, used a clock signal having an extremely slow rise-time? The RESET could be triggered high and then low (by the DECODED OUTPUT 5) while the slowly rising clock is still rising. The DECODED OUTPUT 0 is reset high, but is then immediately clocked again by the remaining positive edge of the rising clock—causing the DECODED OUTPUT to shift to the next position. Now let's design a circuit to avoid that problem.

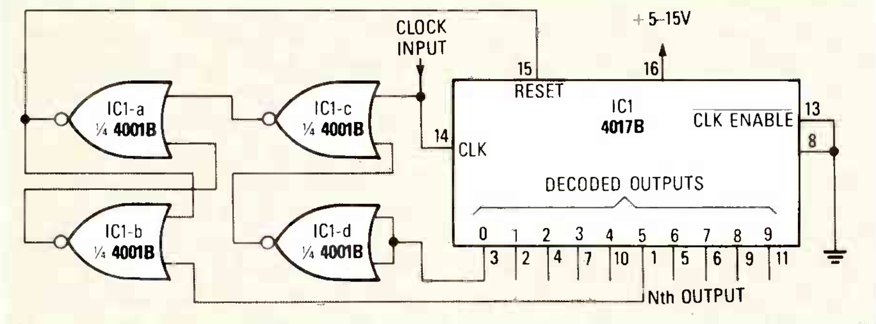


FIG. 6—A DIVIDE-BY-N COUNTER USING A 4017B. The extra logic gates ensure a minimum reset pulse-width.

Figure 6 shows a slightly more reliable version of the divide-by-N counter. Logic gates control the RESET operation via IC1-a to IC1-d, (IC1-a and IC1-b form a NOR flip-flop). Here the RESET command is latched high on the arrival of the "Nth" clock pulse, only while the clock pulse remains high, but is removed automatically when the clock pulse goes low again. Those extra gates ensures a minimum RESET pulse width (for a given clock rise time), which stabilizes counter operation.

The 4017B is particularly useful for a whole range of "sequencer" applications, where the DECODED OUTPUTS can drive LED displays, relays, or sound generators.

Sometimes it's desirable to count up to a predetermined number and then stop. Figure 7 shows a 4017B wired for that type of operation. The counter will stop when its CLOCK ENABLE pin is driven high by DECODED OUTPUT 9; moreover, the counter can

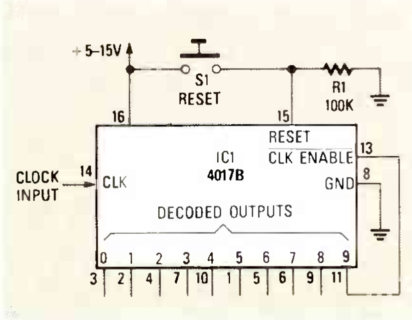


FIG. 7—THE 4017B CONNECTED for sequence-and-stop action.

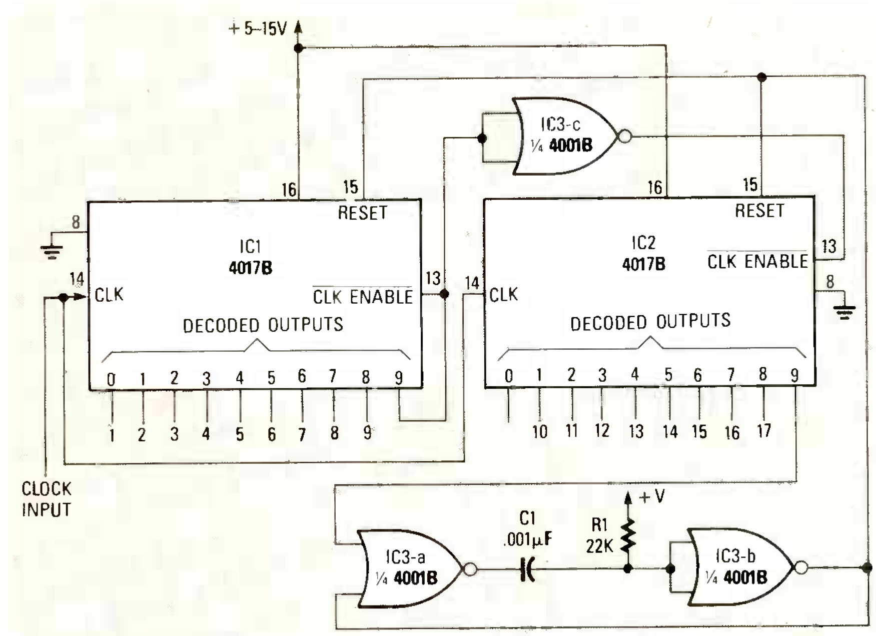


FIG. 8—THE 4017B CONNECTED for divide-by-17 operation.

be negated via any one of the 4017B's DECODED OUTPUTS. The count sequence is then re-started by pressing reset button S1.

Figure 8 shows how to connect a pair of 4017B's to provide 17 stages of fully decoded outputs. The clock signal is simultaneously fed to both IC's; however, when the count is below 10, the DECODED OUTPUT 9 of IC1 is low, which forces the CLOCK ENABLE of IC2 to be set high by INVERTER gate IC3-c. So IC2 is negated, meaning it's not influenced by the clock signals. When the 10th clock pulse arrives, the DECODED OUTPUT 9 of IC1 goes high, which negates IC1; simultaneously, the CLOCK ENABLE of IC2 is driven low by IC3-c, thereby asserting IC2; the high that is already in DECODED OUTPUT 0 is immediately toggled into DECODED OUTPUT 1 by the same 10th clock pulse. Eventually, the 17th clock pulse arrives, causing the DECODED OUTPUT 9 of IC2 to go high. That triggers the 15µs monostable made from IC3-a and IC3-b, which clears both counters to their high DECODED OUTPUT 0 states. The counting sequence then repeats itself.

Note that the DECODED OUTPUT 9 of IC1, and the DECODED OUTPUTS 0 and 9 of IC2 are lost in the counting action, so the circuit gives a maximum of 17 usable counting states. Any number of counts within the range from 10 to 17 can be designed by connecting the input of IC3-a to the appropriate DECODED OUTPUT of IC2.

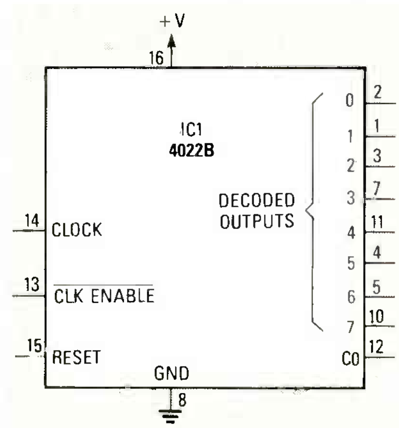


FIG. 9—PINOUT DIAGRAM OF THE 4022B Octal counter.

Counters in computers

Counters can be used in simple applications where it's necessary to merely count a number of input pulses, or divide them by a fixed ratio. Those are some of the relatively common applications. But what about more complex timing applications? For example, dividers are very often used in all kinds of computer timing circuits. A master clock first generates an overall synchronizing signal. Dividers are then used to derive other clock speeds needed in slower sections of the computer—yet still need to be synchronized with the master clock. For example, if the master clock runs at 1 MHz, then a 4017B decade counter could be used to generate a synchronous 100-kHz signal.

Octal counter

The 4022B is a synchronous octal counter (divide-by-8) having eight DECODED OUTPUTS (0 TO 7) that sequentially go high as the IC is clocked. Fig. 9 shows the 4022B pinout diagram. For normal octal counting, the RESET and CLOCK ENABLE pins are tied low, which asserts the IC for counting. The high bit advances to the next DECODED OUTPUT on the rising edge of the clocking pulse. The CARRY OUT signal completes 1 cycle for every 8-clock cycles. Lastly, the IC has a built-in Schmitt trigger on its CLOCK ENABLE line, which renders it insensitive to clock signal rise and fall times.

Synchronous up-counters

The 4026B and 4033B are both synchronous up-counters that have circuitry for decoding and driving a 7-segment common-cathode LED display. The output drive currents, however, are limited to only a few mA.

Figure 10 shows the pinout diagram of the 4026B. A special feature of that IC is the DISPLAY ENABLE IN and DISPLAY ENABLE OUT pins. If the DISPLAY ENABLE IN pin is held high, the display will function normally. When the pin is pulled low, the display will be

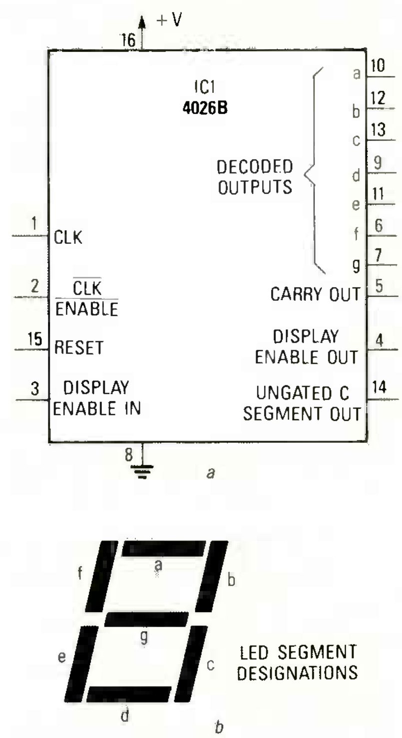


FIG. 10—PINOUT DIAGRAM OF THE 4026B decade counter with 7-segment display driver having DISPLAY ENABLE control *(a)*, and LED-segment designations *(b)*.

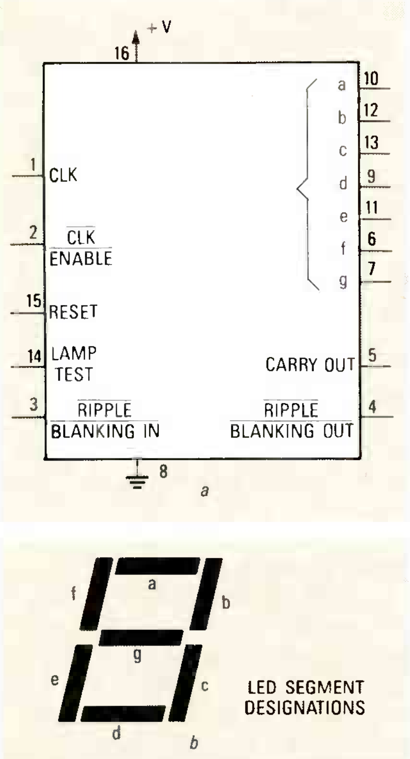


FIG. 11—PINOUT DIAGRAM OF THE 4033B decade counter with 7-segment display driver having RIPPLE BLANKING facility *(a)*, and LED-segment designations *(b)*.

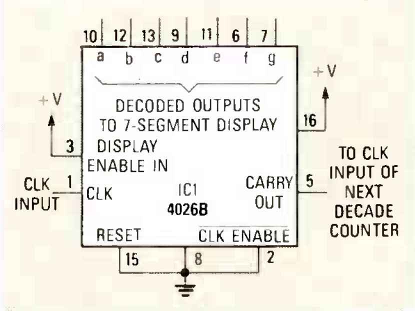


FIG. 12—THE 4026B CONNECTED for decade dividing and 7-segment display operation; DISPLAY ENABLE input must be tied high for display illumination.

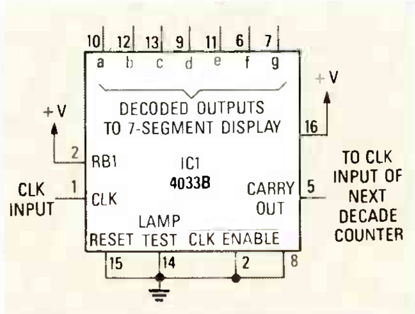


FIG. 13—THE 4033B CONNECTED for decade dividing and 7-segment display operation; RBI (ripple blanking input) must be tied high for normal display operation, or low for zero-digit suppression.

blanked, although the counter IC continues to count. The IC also has an UNGATED C SEGMENT OUTPUT pin, which can be used in conjunction with external logic to control the display segments individually.

Figure 11 shows the pinout diagram of the 4033B. That IC features RIPPLE BLANKING input and output pin, which can be used to blank the leading and trailing zeros in multi-decade applications. The "O" display blanks automatically when the RIPPLE BLANKING INPUT pin is held low. Additionally, the IC features a LAMP TEST pin; that if pulled high, will drive all display decoded outputs high, illuminating all 7-segments of the display.

Figures 12 and 13 show how to connect the 4026B and 4033B, for decade 7-segment display operation. For each positive edge of the clock, the counter will illuminate the proper LED segments to display the decimal numbers from 0 to 9. When using the 4026B, the DISPLAY ENABLE INPUT pin must be tied high if the display is to be illuminated. When using the 4033B, the RBI INPUT (ripple-blanking input) must be tied high if the display is to operate normally, or tied low to give zero-digit suppression. Notice that in both circuits if multi-decade counting is used, the CARRY OUT of one stage becomes the clock input to the next stage.

Figure 14 shows how to interconnect several 4033B's for multi-decade counting; additionally, to give automatic suppression of leading and trailing zeros so that, for example, the count 009.90 will actually be displayed as 9.9. To get leading zero suppression on the integer side, the RBI INPUT of the *M*ost *S*ignificant *B*it' (MSB) IC must be tied low; its RBO (ripple blanking output) must be connected to the RBI of the next MSB IC, and so on down the line. To get trailing zero suppression on the fraction side of the display, the RBI pin of the

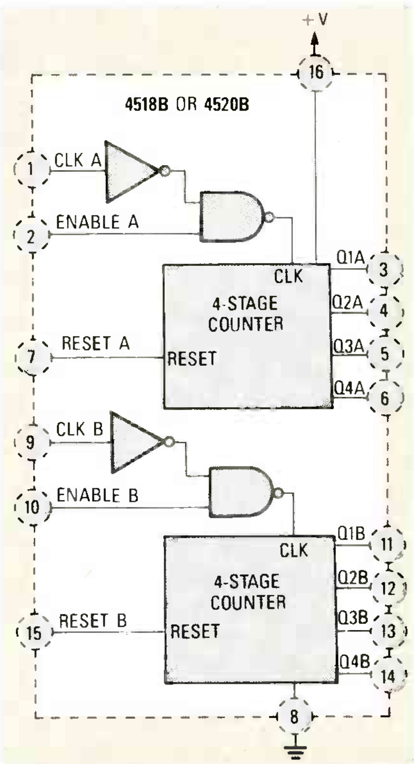


FIG. 15—PINOUT DIAGRAM OF THE 4518B dual decade-counter, and 4520B dual binary-counter.

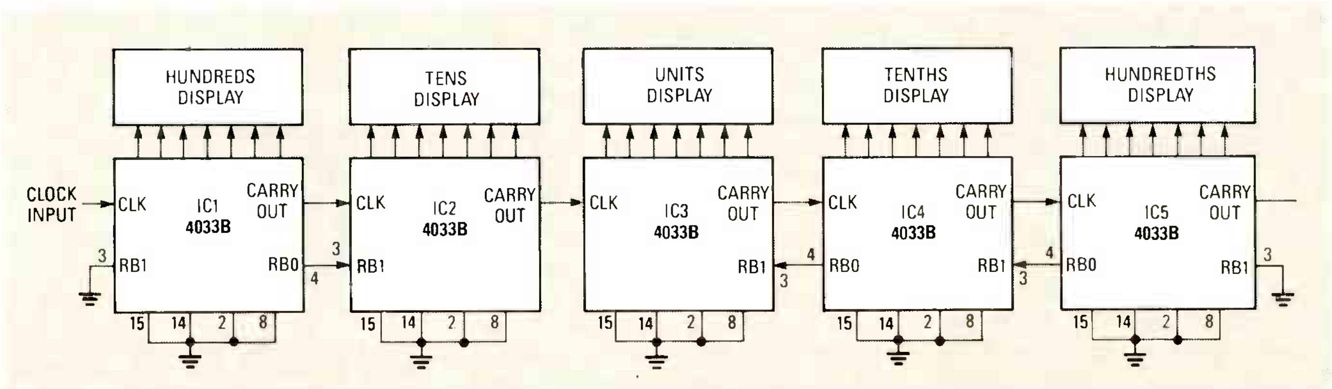


FIG. 14—THE 4033B CONNECTED so that RBI and RBO give leading and trailing zero suppression in a multi-decade display.

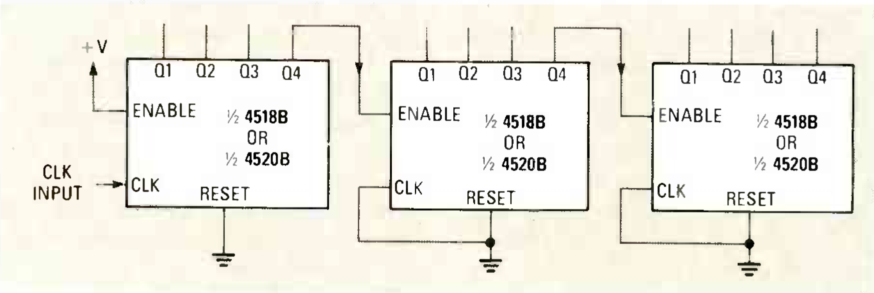


FIG. 16—THE 4518B OR 4520B counters cascaded for ripple operation.

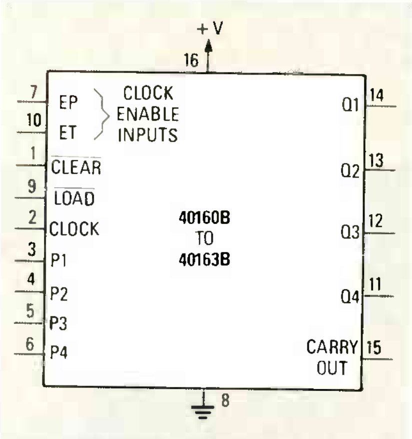


FIG. 17—PINOUT DIAGRAM OF THE 40160B TO 40163B range of programmable 4-bit counters.

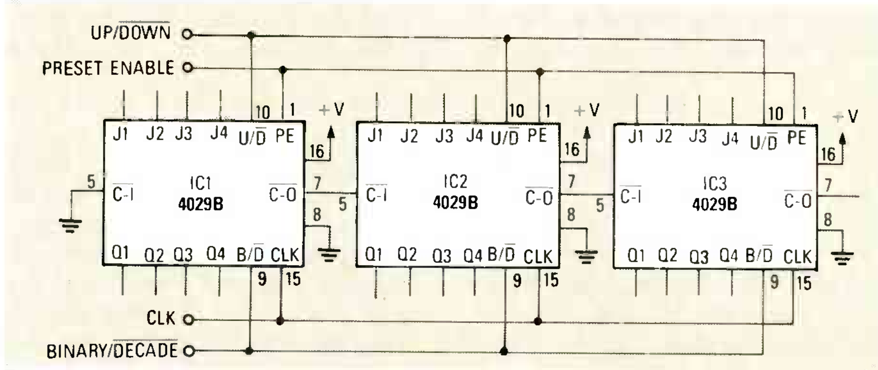


FIG. 20—HERE'S HOW TO CASCADE 4029B's for synchronous parallel-clocking.

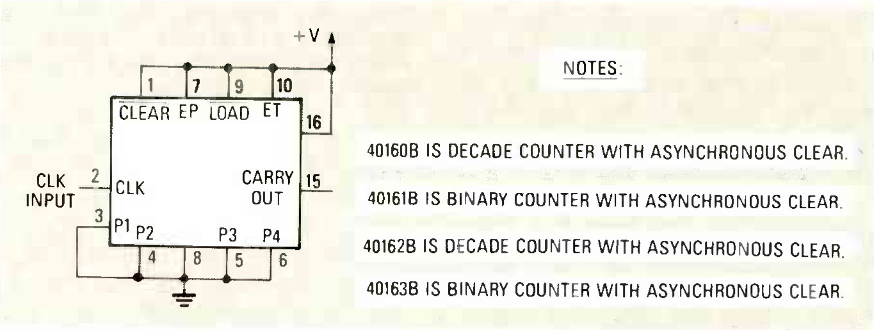


FIG. 18—THE 40160B TO 40163B connected for normal counter operation.

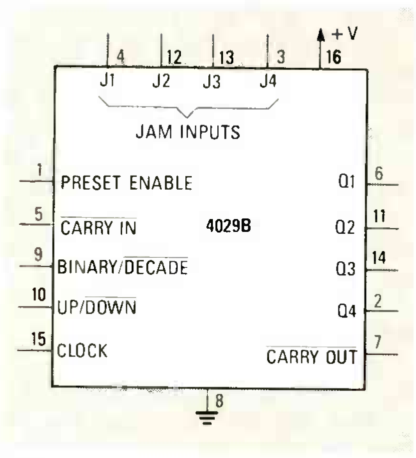


FIG. 19—PINOUT DIAGRAM OF THE 4029B presettable up/down counter.

*L*east *S*ignificant *B*it' (LSB) must be tied low, and its RBO must be taken to the RBI of the next LSB counter, and so on, to the first counter in the fractions chain.

Keep in mind that neither the 4026B nor the 4033B have data latches. That basically means that the displays tend to blur while the IC's are going through a counting cycle. It is, however, no tremendous problem.

Dual up-counters

The 4518B and 4520B are IC's that house two counters in a single 16-pin package. The 4518B is a dual decade counter with BCD outputs; the 4520B is a dual hexadecimal (divide-by-16) counter with a 4-bit binary output. Figure 15 shows the identical pinout diagram of the 4518B and 4520B.

Those counters can be clocked using either positive- or negative-edge triggering. For positive-edge triggering, feed the clock to the CLOCK pin and tie the ENABLE pin high. For negative-edge triggering, the feed the clock to the ENABLE pin and tie the CLOCK pin low. Each counter can be asynchronously cleared by a high level on the RESET pin. The outputs of both dual IC's must be decoded externally to drive a 7-segment display.

Notice that those counters don't have a CARRY OUTPUT. In order to cascade stages, triggering on the negative-edge of the clock is required. As shown in figure 16, the Q4 OUTPUT of each counter is fed to the ENABLE INPUT of the following stage, which must also have its CLOCK pin tied low.

Counters that preset

As shown in Fig. 17, the 40160B to 40163B series of presettable up-counters have identical pinouts. By presettable we mean that the DECODED OUTPUTS Q1-Q4 can be preset to start counting from any number that is fed into the four PRESET P1-P4 input pins—sometimes called JAM inputs. The presetting function is not limited only to start-up, but can also be used during the counting sequence; the decoded outputs can thus be cleared back to the original preset inputs at any time.

The 40160B and 40162B are decade dividers, while the 40161B and 40163B are binary dividers. Also, the clear function for the 40162B and 40163B is synchronous with the clock. That means a low on the CLEAR sets all outputs low on the rising edge of the next clock pulse. On the other hand, the clear function for the 40160B and 40161B is asynchronous. A low level on that CLEAR sets all outputs low regardless of the clocks state.

Figure 18 shows how to connect any of the 40160 to 40163 IC's as a normal counter. All counters in that series have two clock-enable pins, EP and ET, which must be tied high for normal counting operation. Those pins facilitate an internal carry look-ahead feature that is useful in fast counting applications.

Synchronous up/down counters

Synchronous up/down counters are devices that can count in either direction. Counting direction is controlled by either of two methods. The first by using a single clock in conjunction with an UP/$\overline{\text{DOWN}}$ control pin. The second by using two separate clock signals, with one controlling the up-count and the other controlling the down-count.

All CMOS up/down counters are presettable types that output a 4-bit binary word, or BCD number, with either synchronous or asynchronous clearing functions. Because the up/down counters are presettable, the outputs can be forced to agree with the 4-JAM pins, otherwise called PRESET pins.

Figure 19 shows the 4029B counter. That device uses a single clock with count direction controlled via an UP/$\overline{\text{DOWN}}$ pin. The IC can act as either a decade (BCD output) counter, or as a binary (4-bit) counter, depending on the logic setting of a BINARY/$\overline{\text{DECADE}}$ pin. The actions of the $\overline{\text{CARRY OUT}}$ pin facilitate fully synchronous action in multi-decade counting applications, as shown in Fig. 20. Here, all IC's are clocked in parallel, and the $\overline{\text{CARRY OUT}}$ pin of each counter is used to enable the following one.

Several 4029B's can also be cascaded and clocked in an asynchronous ripple mode but that's a subject for another article. **R-E**

SECURITY

continued from page 46

You don't need a module for each door or window: you can connect a complete, normally closed loop to each transmitter module. (The manual for the system makes no mention of that potentially valuable feature.) Although you might feel that wiring such loops defeat the whole purpose of a wireless system, it really doesn't—you still can get away without having to drill any holes to fish wires through. If you really object to having any wires visible, you can install a transmitter at each window and door. Although the Dicon unit comes with reed-type sensors, you are free to include any passive, normally closed sensors within the loop.

Mounting the base unit and emergency speaker/siren are two important considerations. The base unit, of course, must be mounted near a telephone line. It doesn't have to be mounted near an exit door, and indeed, it is preferable *not* to mount it there for two reasons. First, since the heart of the system is a telephone dialer, the last thing you want a burglar to do is to unplug the *9000* from the telephone line. Since the obvious place for the control center to be mounted is by the front door, it's the first place the burglar will look, and therefore the worst place to mount it. The second reason that makes it unnecessary to mount the unit by the exit is that remote keypads are available. The remote can be mounted by any exit door, or can be left handheld. A burglar can do very little with the remote—unless he knows your security code.

The emergency speaker/siren not only is an attention-getter in times of emergencies, it also is used to give information to the user. For example, when you arm the system, the base unit gives a report of troubles with any of the modules. If you arm the alarm using the remote keypad, you still want to hear any of those reports. And you can, thanks to the speaker. If an intruder breaks in he will hear the report of "Security emergency!" followed by your recorded message. If that doesn't chase him off, he may use the speaker to guide him to the base unit and disconnect it from the phone line. To protect against such brazen burglars, it might be wise to conceal the speaker and base unit—or perhaps use a cellular telephone.

Anyone who has ever armed an alarm only to find himself rushing around to get out before the time delay expires will like the *9000*'s non-delay feature. Instead of giving you a specified time to get out the door, the *9000* looks at the door's status. Once you give your command to arm the system, it waits for you to close the door before actually arming itself.

Some professional alarm installers insist that a wireless system is not as reliable or secure as a wired system. (What if the batteries die? What about false alarms? etc.) To be honest, we had the same reservations. However, it doesn't have to be true about a wireless system. In the *Dicon 9000*, battery status is constantly monitored. All sensors report to the base unit regularly. When a battery goes low (meaning that it has about a month of life remaining), the TROUBLE LED lights, and pressing a special key gives a verbal report of the trouble. Every time the alarm is set, the trouble report is given again so that it's difficult to forget. (Any modules that

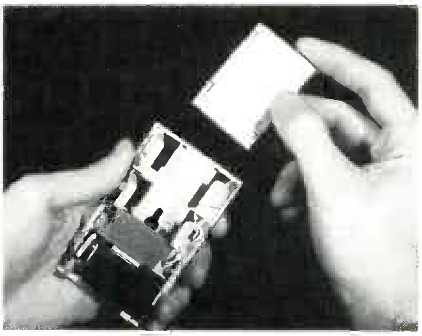


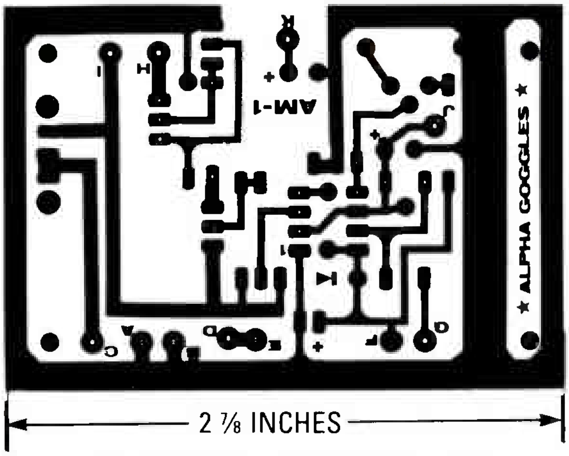
FIG. 21—THE HEART OF a Dicon remote transmitter is a small, removable module. The module is programmed by the base unit with a unique code. Therefore any emergency condition can be tracked down to the exact module.

have been turned off are also reported.) Signal strength is always monitored for level. The signal range for the system is 200 feet. That increases to 500 feet with the addition of a small whip antenna. Since the RF signals are in the 300-MHz range, you must be sure not to mount the base unit in, or too close to, such things as metal file cabinets.

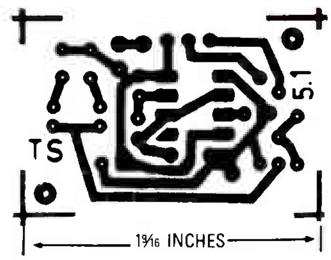
To eliminate false alarms, the transmitter modules send a 16-bit digital message, which is repeated 32 times within 2 seconds. Three of four consecutive messages must be identical, or they will be considered false. Although not a scientific test, in six months of actual use, our test system never falsed.

Which system is best?

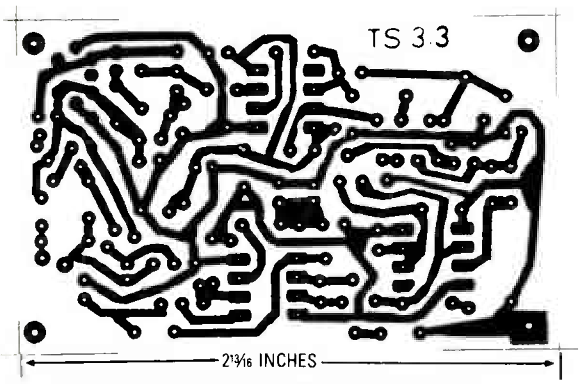
Both wired and wireless systems, as you've seen, have their advantages. Neither one can be considered the best for all instances. But we hope that this article has given you an idea of what features can be found in home-alarm systems, and has helped you make a decision as to which type is best for your home. **R-E**



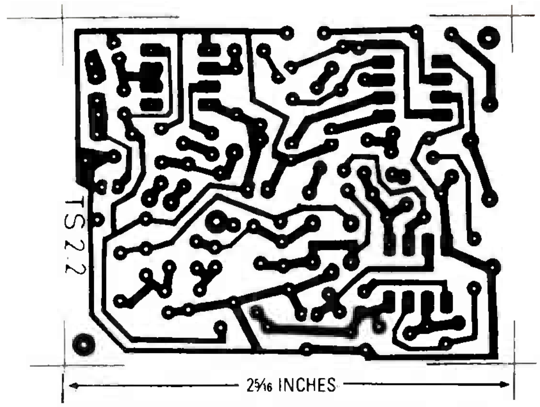
ALPHA MEDITATION GOGGLES foil pattern.



THEIR TRANSMITTER foil pattern.



IR RECEIVER/RF TRANSMITTER foil pattern.



RF RECEIVER/ALERT BEEPER foil pattern.

HOME SECURITY

continued from page 37

built floor—the nightingale floor—that creaked loudly when walked on. A shrill *sque-e-e-k* in the middle of the night was certain to bring on the Sultan's personal bodyguards.

The modern *nightingale floor* is the Teiresias, Inc.'s *Pulsor Volumetric Stress Detector*, shown in Fig. 6. The sensing device is an encapsulated silicon bar that is epoxy-cemented to a floor beam. Any deformation of the beam, no matter how slight, is detected by the sensor, whose processing amplifier can tell the difference between the stresses caused by structural shifts, the patter of the multi-legged feet of household pets (or rodents), or the strides of a human. When the processor senses the stresses caused by humans, it trips a conventional alarm's protective loop.

Wireless protection

Wireless detectors and control centers are the latest development in high-tech home security. As shown in Fig. 7, a generic representation of a full-feature wireless system such as the one offered by Dicon Systems, Inc., the control center consists of a radio receiver, a super-sophisticated computerized control system, and a voice synthesizer that can give user instructions and voice alarms. The center drives an internal digital dialer for a central station and one or more other numbers and announcements, a local alarm bell or siren, and it can be hard-wired to a local loop or detector. Its real sensing power, however, lies in individual transmitters, each having its own digital code so that the control center knows where the alarm is coming from. Although Fig. 9 shows only five transmitters, the center can accommodate more. For example, there might be two or more transmitters for the windows; one for upstairs, one for downstairs, and possibly one for the basement. (It saves wiring through floors and ceilings.) Similarly, there might be separate transmitters for the front and back doors, or multiple transmitters for fire detectors and medical or panic transmitters (pendant transmitters worn on a necklace). Best of all, the system can be controlled from one or more remote-control transmitters.

The transmitters are battery powered. They are *supervised* in that their battery levels and signal strengths are checked regularly. If the center determines that a battery is getting weak, it announces—by voice, beeper, or display—that the transmitter's battery should be replaced soon.

The operating frequency for wireless systems is usually in the 300-MHz band, so that the antenna can fit in the small transmitter cases. Where there are reception problems, the equipment might operate on 40.8 MHz, because the lower frequency passes through brick and steel doors and walls with less attenuation.

An important point to keep in mind when considering a home-security system is that many installation services are familiar only with the equipment that they are authorized to sell, or the stuff they are used to using. (Try asking a dealer if he knows of a *nightingale floor* sensor.) If you think you need a particular kind of protection, do not accept that it doesn't exist. In this era of high-tech devices, somewhere out there someone has exactly what you want. **R-E**

AUDIO UPDATE

The importance of amplifier output current.

LARRY KLEIN,
AUDIO EDITOR

MANY YEARS AGO, I WAS INVITED TO attend a record company's press conference, given to introduce a new "blockbuster" four-channel classical recording. To ensure that there would be adequate sound-pressure level in the very large recording studio where the record was being demonstrated, the engineer in charge had set up four Acoustic Research *LST* speaker systems facing inward from the corners of an imaginary 25- by 25-foot square in the middle of the studio floor. Those speakers were to be driven by a pair of Phase Linear *700* amplifiers, thus providing 350 watts per speaker channel. The engineer in charge of the setup was an old friend of mine and he invited me to come early to help balance the system.

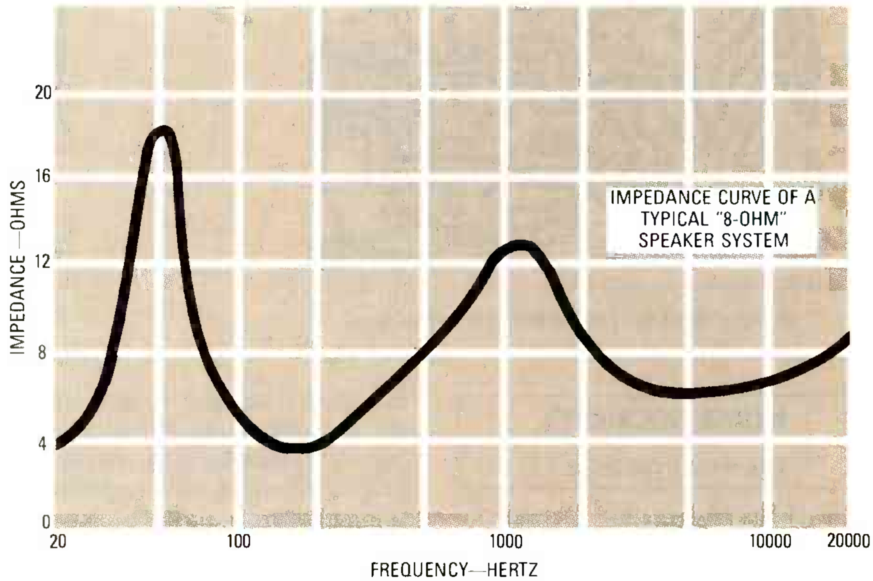


FIG. 1

When I arrived, my engineer friend was cursing to himself because the amplifiers, for some reason, were distorting badly on musical peaks. I was mystified, because, in my experience, the pair of *LST's* I happened to have at home certainly didn't seem to be so low in efficiency as to cause clipping in a 350-watt amplifier. My friend subsequently solved the problem by replacing the power amps with another brand (I think they were Crowns) borrowed from a local dealer—and the press conference went on as scheduled without further technical hitches.

I forget whether I didn't get a chance to ask about the amplifier problem, or whether I simply didn't understand my friend's answer. In any case, I filed the matter away in my head in the "unsolved audio mystery" category—where it remained until many years later. It was during a discussion about the strange reactive loads presented by some speaker systems that everything suddenly fell into place. As I mentally reconstructed the problem, it wasn't that the original amplifiers weren't capable of putting out their rated power into standard 8-ohm loads; they just couldn't deliver their power into the very low impedance reactive load characteristics of the AR *LST* speaker system. (As I recall, the *LST* system had both a tapped inductor and a very large capacitor at its input terminals). As the curve in Fig. 1 shows, the impedance of a typical "8-ohm" speaker system can vary widely with frequency.

Speaker impedance and power

The best of today's better solid-state amplifiers approximate a constant-voltage source. That means that for a given input signal, the amplifier will, within reason, put out a constant voltage across the speaker terminals—*whatever the load.* If, for example, there are 20 volts at the amplifier's speaker terminals, the relevant part of Ohm's Law (watts = volts^2/speaker impedance) tells us that there are 50 watts being fed to an 8-ohm speaker. Theoretically, if a 4-ohm speaker were connected, the same 20 volts across it would produce 100 watts.

However, very few amplifiers double their maximum output power when switched from an 8-ohm to a 4-ohm load. Most amplifiers will deliver only about 50% more power into 4 ohms than 8 ohms, due to power-supply current limitations or the intervention of their protective circuits. Each time the load resistance is halved (causing the power output to be doubled), the amplifier's power supply is called upon to deliver *twice as much* current to the output devices at a given input signal. Obviously, that can create problems. Under conditions of excessive current drain, the power supply's voltage level sags. As the power-supply voltage falls, so does the maximum output-power capability of the amplifier. Any attempt to drive the amplifier beyond its lowered power-output capability will result in clipping distortion.

To recapitulate, the sequence goes this way: A very low value speaker impedance causes excessive current to be drawn—via the output transistors—from the amplifier's power-supply. The excessive drain, in turn, causes the power-supply voltage to fall. The drop in power-supply voltage reduces the signal level that can be handled by the amplifier. When that limit is exceeded, waveform clipping results. The audibility of clipping depends both on its severity and its duration. If only the tips of the highest peak waveforms are truncated, then the clipping may pass unnoticed. However, insofar as the music waveforms begin to resemble square waves, the problem becomes very audible.

Overloads such as I've described are likely to have additional consequences. The amplifier may run hot enough to trigger its thermal-protection circuit, it may blow fuses, or—worst case—it may burn out its output transistors or the tweeters in the connected speaker systems. Some of the early circuits that were designed to protect the output devices from excessive current tended to be complex and unreliable and, worst of all, would sometimes audibly misbehave. However, with today's improved output devices, simpler and more reliable protection circuits (sometimes consisting only of speaker-line or power-supply fuses) provide the required protection.

Current thinking

Given all the above, it's easy to see why many amplifier manufacturers have recently begun to feature "current reserve" as an important specification. Even conventional 8-ohm-rated speaker systems can fall as low as 2 to 3 ohms at some test frequencies, or on musical material containing those frequencies. If the current reserves of an amplifier are not sufficient to sustain its wattage output into low impedances, the amplifier momentarily runs out of power—and frequently right at the time when it is musically needed the most!

I'm not too embarrassed that it took me so many years to appreciate the importance of high-current capability in amplifiers; most of the Japanese manufacturers had no more insight into the matter than I did. The reason, I suspect, had to do with the impedance characteristics of Japanese speakers. In the 1970's, you still found Japanese amplifiers that overheated or shut off if you tried to drive American-made 4-ohm speakers with them. And it was only five or six years ago, if memory serves, that an engineer from a major Japanese manufacturer asked me for reference material that explained dynamic headroom and current capability.

One final note: If you check the current EIA amplifier-test standard you will find no mention of output-current capability in either the primary or secondary ratings. At the time we were working on the standard, none of us thought about output current as an important factor. Today, there still does not appear to be a universally agreed-upon method of rating amplifier-current capability. I therefore assume that output-current ratings such as 20, 30 or 50 amperes usually refer to an amplifier's short-term capability, not to its continuous rating. But in any case, I'm encouraged by the fact that output-current ratings continue to be played up in press releases and spec sheets. I believe that a large output-current capability can make a significant contribution to sound quality, given today's speakers and the way they are designed and used. R-E

SHORTWAVE RADIO

STANLEY LEINWOLL

International Frequency Coordinating Committee

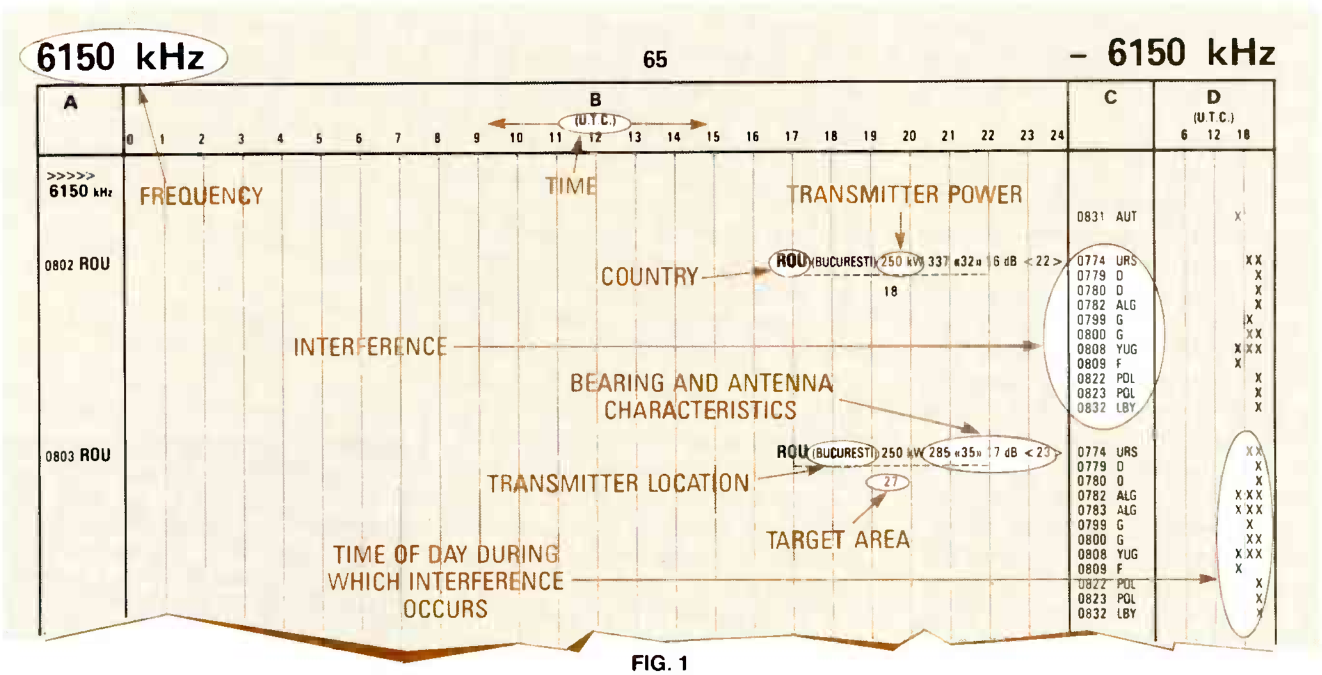


FIG. 1

ONE OF THE MOST IMPORTANT, INFLUENtial, yet little-known organizations in the field of shortwave broadcasting is the *I*nternational *F*requency *C*oordinating *C*ommittee (IFCC), which is also known as "The Club."

The IFCC is made up of high-level technical representatives of the *V*oice of *A*merica (VOA), *R*adio *F*ree *E*urope (RFE) and *R*adio *L*iberty (RL), the *B*ritish *B*roadcasting *C*orp. (BBC), Radio Germany (Deutsche Welle), Radio Canada International, Radio Nederland, and the *F*ederal *C*ommunications *C*ommission (FCC), which represents some sixteen private U.S. broadcasting organizations, such as WYFR, KGEI, KTWR, WINB, and others. The IFCC meets six times yearly to coordinate their shortwave-broadcast schedules.

IFCC history

Roger Legge was the father of Article 17 of the *I*nternational *T*elecommunication *U*nion (ITU) Radio Regulations; that was a revolutionary coordination procedure, under which all shortwave broadcasting organizations submitted their schedules six months in advance of implementation to the *I*nternational *F*requency *R*egistration *B*oard (IFRB). In force since 1960, Article 17 has had a major impact on shortwave broadcasting, enabling broadcasters to resolve conflicts before a tentative frequency schedule was implemented.

At that time, Legge noted that U.S. broadcasters were submitting schedules that were in conflict with each other. He suggested that U.S. broadcasters, VOA, RFE, RL, and the FCC meet periodically to resolve their conflicts before submitting schedules to the IFRB. The U.S. broadcasters accepted the proposal and, in 1963, at the suggestion of Roger Legge, then frequency manager of VOA, the IFCC was born.

Tentative Schedule

The early IFCC meetings were very difficult, sometimes acrimonious; when a conflict arose, a change had to be made to resolve it. One of the broadcasters must either move to another frequency, or change characteristics such as antenna bearing or transmitter location, in order to make interference-producing conflicts technically compatible. That was not always easy, or even possible. Conflicts over a single frequency sometimes lasted a full day. However, even from the start, the group worked together to resolve its differences, and the number of solutions to problems far outweighed those that could not be resolved immediately.

The IFRB publishes the submitted information in a book called the *Tentative Schedule*. Continuing conflicts, such as two or more broadcasters operating on the same frequency to the same target area can easily be identified, and it's then up to the broadcasters concerned to solve their problems. In some cases, the IFRB makes recommendations for resolving conflicts, but acceptance of the recommendations is not mandatory; IFRB is a part of the ITU. Figure 1 shows an annotated page from a recent *Tentative Schedule*.

It was not long before other broadcast organizations became aware of the IFCC, and requested membership. Radio Canada, Radio Nederland, and the BBC joined during the first several years, and the Deutsche Welle entered the group in 1966.

Other broadcasters soon learned of the IFCC's activities and wanted to join. One representative from a Far Eastern broadcaster traveled 6,000 miles to attend a meeting as an observer, then appealed to the group to allow his organization to participate in the meetings. By that time, however, with about 400 transmitters represented at the meetings, and conflicts becoming more and more difficult to resolve, the IFCC decided that additional participation would prejudice the effectiveness of the group.

Still other broadcasters continued trying to gain admittance to the IFCC and were also turned down. It was then that one of the European rejectees referred to the group as "The Club."

How the Club Works

The Article 17 coordination procedure divides the broadcasting year into four seasons:

- Spring: The first Sunday in March to the first Sunday in May.
- Summer: The first Sunday in May to the first Sunday in September.
- Fall: The first Sunday in September to the first Sunday in November.
- Winter: The first Sunday in November to the first Sunday in March of the following year.

Approximately six months before the start of a season, IFCC members send their schedules to a designated host, who records the schedules in a booklet, which, when complete, contains the combined schedules of all the participants. Technical representatives of the member broadcasters travel to the host city, and with all the representatives sitting around a conference table, the host then reads through all frequencies, from 5,955 kHz to 26,095 kHz. Should a conflict arise, the reading stops until a satisfactory solution can be found. A total of 375 frequencies are coordinated.

Each schedule is coordinated twice. The first reading is made six months in advance of implementation of the schedule. The final reading is about two months before a schedule is due to go into effect; that takes into account any modifications to the schedule that must be made because of programming or propagation changes, or because of unexpected interference problems that have arisen since the original submission of the tentative schedules.

IFCC meeting schedule

With the exception of the FCC, participating organizations take turns hosting meetings. The annual meeting schedule, indicating when each schedule is coordinated, is as follows:

- January: The final Spring schedule is coordinated.
- March: The final Summer schedule, plus the preliminary Fall schedule.
- May: Preliminary Winter schedule.
- July: Final Fall schedule.
- September: Final Winter schedule, plus preliminary Spring schedule for the following year.
- November: Preliminary Summer schedule for the following year.

The IFCC is unique in the annals of shortwave broadcasting. It has met for over 25 years, and in spite of the fact that the shortwave bands are overcrowded by a factor of more than two, and that all participants are in competition for the same scarce natural re-

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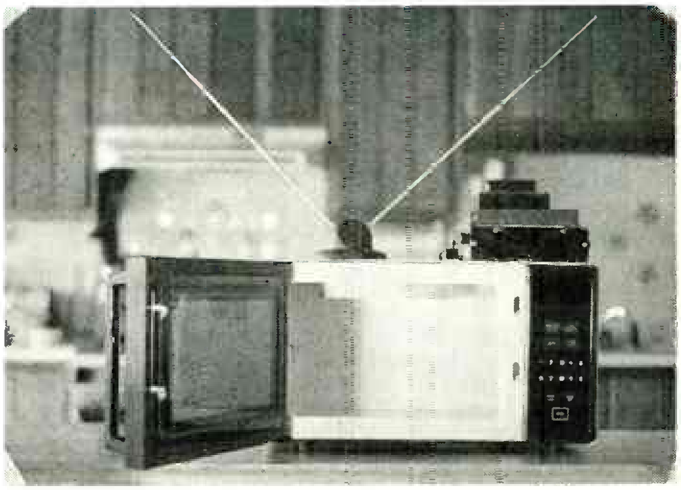
MACROWAVE OVEN



The big chill: Build a macrowave oven.

LAURENCE HAKEMACHI

ONE OF THIS GENERATION'S MOST SIGNIFIcant electronics accomplishments, ranking alongside the solid-state whoopie cushion and the CD-player-in-a-boom-box as indicators of our society's grasp and appreciation of technology, is the microwave oven. A microwave oven liberates you from much of the tedium of food preparation and frees valuable time for such worthwhile pursuits as watching TV, staring into space, or partying.

However, there are times when what you need is not a way to heat things up faster, but a way to cool them down faster. Maybe you have leftovers to put in the freezer but don't want to wait up half the night for them to get cold enough so they won't defrost everything else in there. Or what if you need more ice cubes right away, or want to cool down a case of beer fast? Maybe you're just in a hurry to freeze-dry a cat! What you need is what will be the up-and-coming electronic glamour-gadget of the '90's—the macrowave oven!

How it works

It has long been known, although never referred to in polite company, that just as short-wavelength microwaves can generate heat in many materials, much longer electromagnetic wavelengths known as *macrowaves* can have the opposite effect. Macrowaves remove heat from objects by causing infrared radiation to be radiated faster than it can be generated, thus producing a cooling effect. Because of their great penetrating power, macrowaves cause immediate internal as well as surface heat loss, resulting in an efficiency much greater than that of convection-type cooling devices such as refrigerators.

Oven modification

Until quite recently, the construction of a macrowave oven would have been a difficult and time-consuming affair, well beyond the abilities and budgets of most home experimenters. However, the availability of a device called a krystron, which takes the place of the magnetron found in microwave ovens, has changed all that. For the sake of this project, a ready-to-install krystron is available by mail.

(The etymology of the word "krystron," incidentally, is uncertain. Some claim that it is derived from the Greek kryo, meaning "cold." Others believe it comes from the Japanese word for a microwave-generating device.)

FIG. 1—MACROWAVE OVEN replaces standard magnetron with krystron. Type 18-OZ device is shown here.

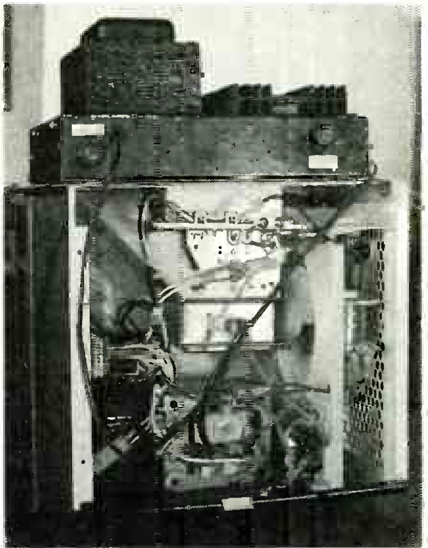


FIG. 2—THERE'S NO SUCH THING as too much power when it comes to generating macrowaves.

It is not necessary to start from scratch. An ordinary microwave oven of the kind you may already own will do. The modifications required are threefold. First, the existing magnetron must be replaced with a krystron (Fig. 1). Depending on the size of your unit, you will need a krystron designated 8-OZ, 18-OZ or 24-OZ. A 500-watt oven will be converted nicely with an 8-OZ unit; a 1000-watt or greater one will work best with a 24-OZ krystron. All that is necessary is to remove the existing magnetron (which you have probably already

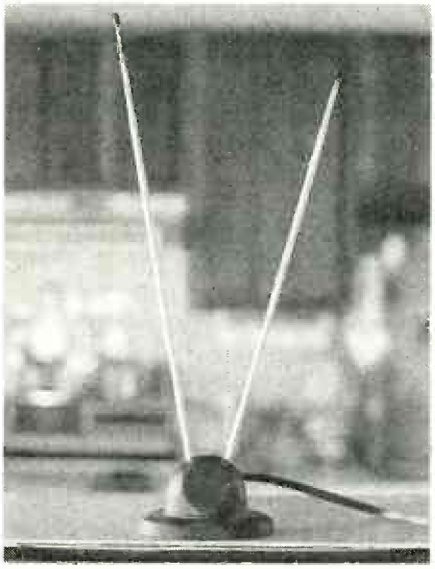


FIG. 3—HEAT REMOVED from items being cooled is down-converted to RF and harmlessly re-radiated by a high-precision dissipation device.

done, see box on this page) and replace it with the plug-compatible krystron. Make sure it is seated securely in its socket, and that all waveguides, if any, are secure.

The second step involves the power supply. Krystrons require a lot of power, so the bigger the power supply the better your macrowave oven will perform. The exact voltage and current available are unimportant—what matters is that more is better! Figure 2 shows the author's prototype, which has been successful in inducing hypothermia in houseflies. The supply can be mounted anywhere you can fit it where it won't slide off.

The final component called an RF dissipator, shown in Fig. 3, reradiates the up-converted infrared radiation (heat) removed from the item being processed in the form of harmless radio-frequency waves which will be of little bother to anyone. DO NOT ATTEMPT TO CONSTRUCT THE DISSIPATOR YOURSELF! It is extremely complex with very critical dimensional tolerances. If you do not purchase the already assembled unit, there is no guarantee that your macrowave oven will work.

And that's all there is to it. Just put on your mittens and immerse the completed macrowave oven, with the stuff you want to cool inside, in a large Dewar flask containing enough liquid nitrogen or helium to cover everything. The efficiency of the device is largely determined by the amount of coolant used.

If we forgot to mention earlier that the krystron is a superconducting device and will not operate at ordinary temperatures, we're sorry and we apologize. Anyway, before you can say, "April Fool," your macrowave oven will be doing its job. **R-E**

You can save a lot of work by having your magnetron converted to a krystron. Remove it carefully from its socket, wrap it well, and mail it to:
Laurence Hakemachi
Utilities Closet
Chaco Laboratories
Josephson Junction, NM 87500

The cost for the simple conversion is as follows:

- Type 8-OZ—$3000.85
- Type 18-OZ—$3001.65
- Type 24-OZ—$3002.05

Also available is the precision RF-dissipation device, type RS-15-958, mentioned in the text. Price is $399.00. Shipping is additional, and will be billed separately. All checks should be made payable to the *C*haco *A*dvanced *S*uperconducting *H*eadquarters, or simply "CASH."

HARDWARE HACKER

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Next, for plenty of the hands-on construction details, check out Chediski, Colcord, and Elden's medium-budget project on pages 1245–1277 of the same issue.

It sure is refreshing to see a very scholarly journal that always remains simple, practical, and yet quite easily understood by lay people. It looks like the technology you should be watching is the *quark-muon* dissociation and regeneration process.

So, I guess I was not too overly surprised when Marcia Swampfelder shipped me her latest two peripheral cards for the old Apple II Plus, her MTT-T1 mass-transference transmitter, along with her MTT-R1 mass-transference receiver. Marcia is a tad on the conservative side, so she insisted on using the illegal monitor entry points that precludes the use of those cards on newer Apples or other personal computers.

The pricing is rather attractive at $68.50 for the MTT-T1 and a mere $43.50 for the separate MTT-R1. You can order direct from Marcia.

Anyway, you first plug your transmitter card into one Apple II Plus and as many as four receiver cards into four receiving Apple II Plus computers. Any object that gets placed in the transmitter's dissociation chamber then will appear reconstructed in the receiver's regeneration chamber.

The effective range does depend on the telephone line in use, but for your average quality voice grade line, you can teleport objects as far as 500 miles using one receiver, 200 miles using two receivers, 100 with three, and 50 miles with four receivers. The poorly understood methodology of *conjugate phase decongruence* does prevent you from reliably using more than four receivers, regardless of the distance. Even on local loops.

The Apple power-supply and baud-rate considerations both limit the size of the teleportation chambers. Those chambers found on the MTT-T1 and the MTT-R1 are slightly larger than a quarter. In the usual demo of the cards you insert a quarter into the chamber on the MTT-T1 card, and it will reappear intact approximately 12 minutes later on the MTT-R1.

For a real "Golly Gee Mr. Science" demo, you permit four regeneration cards to serve each dissociation card. The single quarter you placed in the dissociation chamber will simultaneously reappear in all four of the receiving cards, again in the twelve minute dissociation-regeneration interval. Put another way, the quad demo returns a dollar in change for every quarter that is invested.

Figure 5 shows you the MTT-T1 transmitter card. The teleportation chamber is optical fiber coupled to an *Atascotia Industries* 100-milliwatt tunable ultra-violet solid-state laser. I don't know whether the $2.75 price or the 67-percent optical efficiency is the most outstanding feature of that new component. The rest of the card consists of RAM, ROM, CPU, and I/O stuff, all done up in Marcia's highly conservative style.

Marcia reports that virtually all of her current production is going to all the importers of specialty herbs and spices. Her new teleportation system eliminates all of those long delays at customs, besides allowing her users to set all of their own international currency exchange rates.

New tech literature

A new *Microelectronic Data Book* just arrived today from *Mitel*. It is chock full of telecommunications chips, and includes bunches of useful ap-notes. Two other recent arrivals are the *Linear Circuits Applications* from *Texas Instruments*, and that *MOS Products Catalog*, from *Gould*, who recently bought out *AMI* and all the chips described in the book.

Some interesting new strain-gauge products are now available from *BLH Electronics*. In particular, their SR-4 should be useful for weighing scales or whatever. And *Sharp* has a new *LCD Units* booklet on liquid-crystal displays and their drivers.

Tektronix has a new *TEK Direct* catalog and several free videotapes out. Their oscilloscope prices do start at under $700, and are much better than those of any other manufacturer.

Unusual and quite high-quality audio kits are available from the *Old Colony Sound Lab*. As a caver who exclusively uses carbide for light, I guess I've disqualified myself from commenting on the apparent stupidity of still continuing to use vacuum tubes in this day and age. Oh well.

ColorEase is an unusual and quite messy process that lets you create your own full color "real ink" instant transfers that may be applied to virtually any surface.

Two interesting new trade journals include *ID Systems* on bar codes and such, along with *Sensors*, for the robotics crowd.

Turning to my own products, if you are at all into designing active electronic filters, check out my *Active Filter Cookbook*. If you are into high-quality text or graphics of any style, be sure to look at all my PostScript stuff, especially the *PostScript Show and Tell*. Finally, remember that we now have fully updated and edited *Hardware Hacker* bound reprints available. Let's hear from you. **R-E**

COMPUTERDIGEST

A PC run circles around a Cray?

TJ BYERS

Despite advances in microprocessor technology, the single-CPU architecture of the personal computer limits the maximum rate at which data can be processed. There is just so much data you can cram through a processor in a given amount of time.

While faster clock rates provide some relief, all other things being equal, performance only increases linearly with clock speed. A 16-MHz system, for example, would be twice as fast as an 8-MHz system. However, we are fast approaching the speed limit of our present technology.

Wider data buses provide another avenue for improvement. During the past decade, the data buses of common PC's have doubled in width twice, from the 8-bit buses of the Z80 and the 8088, to the 16-bit buses of the 80286 and 68020, to the 32-bit buses of the 80386 and the 68030. However, those wide new buses are straining conventional hardware and software techniques to the limit.

The point is that we're reaching the attainable limit of performance improvement by increasing raw CPU speed. Fortunately, however, there is hope. To increase performance, savvy PC users are adding dedicated coprocessors and general-purpose parallel processors to their systems—processors that are designed to increase performance by assuming at least partial responsibility for the processing workload.

In fact, given enough processing help, there is no limit to what a PC can do. For about the price of a workstation, a single PC can run circles around a mighty Cray 1S supercomputer.

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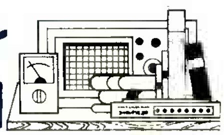
EDITOR'S WORKBENCH



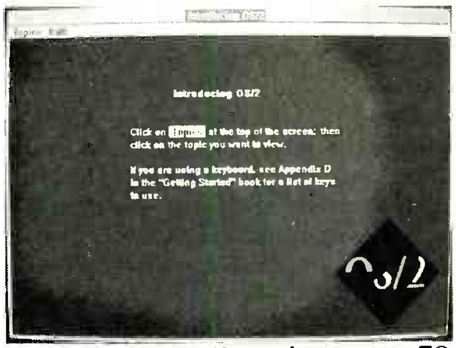
JEFF HOLTZMAN

Presentation Manager

OS/2 Standard Edition Version 1.1 (Presentation Manager, or PM for short) was released on Halloween, 1988. It's not something you want to rush out and buy, because there's not much you can do with it. But it is something you want to get a hands-on look at, because it's a harbinger of the future.

The long-awaited graphical interface for OS/2 is:

- Big (8MB of hard disk space is required)
- Hungry (3MB RAM minimum)
- Slow on anything but a fast 286 or 386



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Build an intelligent cable tester for only $25!

JIM BARBARELLO

A single fault in a printer or modem cable can disable the device just when you need it most. A cable fault is not a problem if you're a cable manufacturer, because you can use your sophisticated (and expensive) cable tester to troubleshoot the cable. The problem is that most of us can't afford that type of equipment. There is, however, a simple and inexpensive alternative. If you own a PC and have about $25 in spare change, you can build your own multi-line cable tester.

Our tester connects to your PC's printer port and allows you to test any cable with as many as 24 active lines. The tester works by performing a continuity check on the 576 possible interconnections; a complete test takes only about ten seconds. The tester uses inexpensive, readily available components, is built on a solderless breadboard (so no PC board is required), and is controlled by a simple BASIC program, which you're free to modify or enhance.

Multiplexing

To understand how the cable tester works, let's review the concept of multiplexing. Consider the circuit shown in Fig. 1. The two rotary switches are ganged, so both sections change simultaneously. In each position a different device glows: LED1, LED2, or LMP1. However, if we rotate the

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Of course there's no software for it now, but Microsoft, Aldus (PageMaker), and Micrografx (Designer) are working feverishly to get new versions of their products out the door. Interestingly, however, it appears that Borland will beat them with a PM version of SideKick Plus.

In addition, like the character-based version of OS/2, special features of the 386 go sadly unused. That means there's still support for only one DOS session, and that it won't run in a window.

Hardware support is also limited. Few printers and fewer display adapters are supported (although IBM will release more drivers shortly), and PM itself is much more selective about the hardware it will run on. In fact, most of the non-IBM AT compatibles I had in the office wasn't able to get through the installation process. My AST Premium/286, which runs IBM's version of OS/2 1.0 fine, couldn't even get through the PM installation program without rebooting, and I had to trick the install program to complete installation on a Dell System 300.

In spite of those gripes, there's something about PM that's highly appealing. For one, it's like a grown-up version of Windows. It's got a new screen-oriented file manager that makes copying, moving, creating, and deleting files and subdirectories easy—better than the typical DOS shell, in fact.

For purposes of testing, I installed PM on Compaq's new SLT/286, a battery-powered 12-MHz AT-compatible that has the first VGA-compatible screen in a laptop. The machine had a 40MB hard disk and 2.6MB of RAM. I drove an NEC MultiSync monitor through the SLT/286's external VGA port.

PM comes on five 1.44MB floppy disks. You boot from one; it copies a minimal system to your hard disk. Then you boot from the hard disk; an automatic process prompts you to insert the remaining floppies one by one as it copies each to the hard disk.

After installation, PM comes up with a Start Programs menu in

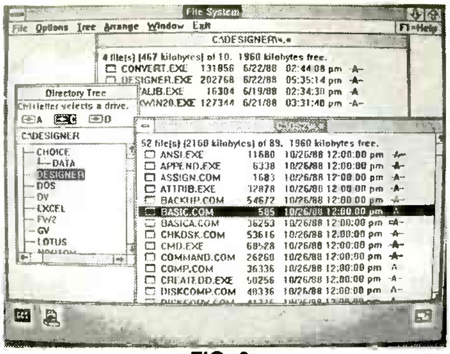


FIG. 2

the center of the screen, and three icons along the bottom. Those icons allow access to DOS, a print spooler, and PM's task manager. You make the process represented by an icon the active one by double-clicking on the icon.

As its name suggests, the Start Programs menu allows you to run a program. Programs are organized in groups; PM comes with two groups: Main and Utility. The Main group includes File System (the file manager), a tutorial called Introducing OS/2, a full-screen OS/2 command-line prompt, and a windowed OS/2 prompt. The Utility group includes the Control Panel (for setting time, date, and mouse preferences), CHKDSK, FORMAT, and the OS/2 System Editor. (Yes! OS/2 now includes a protected-mode editor! It's a full-screen editor that's better than EDLIN, but that's the best you can say about it.) Of course, you can add your own groups and programs to the Start Programs menu.

The task manager allows you to switch among active processes. In the default configuration, that allows you to switch among the DOS command prompt, the Start Programs menu, and the print spooler manager. Of course, as you start more programs, their names are added to the Task Manager's list. You can call the Task up at any time by pressing Ctrl-Esc.

The Task Manager also adds one item sorely missing from Windows: the ability to arrange the currently active processes on screen, in either cascade (overlapping) or tiled (non-overlapping) form. With Windows, by contrast, you have to size and place each window manually.

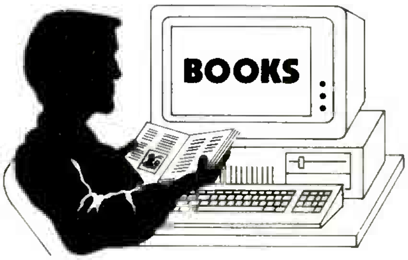
PM also includes an extensive on-line help system that does a good job of teaching you about and reminding you of the basics of using the system.

The File System displays a graphic representation of your hard disk's structure. To log into a particular subdirectory, just click on it with the mouse. A window opens that shows each file in that directory. You can list all files, programs (BAT, COM, EXE) only, or data files only; you can further qualify the list by file attribute; you can sort the list by name, extension, date and time, or by size; you can display just file names, or complete file info (size, time and date of last modification, and file attributes).

PM provides several ways of selecting one or more files or complete subdirectories; after selecting, you can copy, move, or delete any one of them with a few quick mouse motions.

What good is it?

Right now, not much. But neither was MS-DOS 1.0 in 1981. It's going to take some time, maybe even longer than it took DOS to overtake CP/M; but it will, eventually. For now, however, because of high RAM prices and lack of applications, PM is the most expensive DOS shell available. ◆CD◆



A Pair From Prentice Hall

Books that provide a balance of detailed hardware and software information are hard to come by; Jeffrey P. Royer's *Handbook of Software and Hardware Interfacing for IBM PCs* attempts to bridge the gap. The *Handbook* is well written and clearly illustrated; it includes more information on PC hardware and less on BIOS and DOS than Peter Norton's guide.

The first half of the book introduces software basics: dealing with the keyboard, disk files, COM and EXE files, etc. A strong point is the chapter on device drivers. Several short yet useful utility programs are provided as examples. One is a simple program for toggling the attribute bits of a directory entry; another lengthens the keyboard buffer from 16 to 40 bytes. A sample device driver provides screen output using normal BIOS calls; it can be used as a model for a more elaborate driver.

Later sections of the book describe fundamental microprocessor operation, and the meaning and use of the I/O bus control signals. A number of practical circuits are shown in enough detail that a moderately knowledgeable technician or engineer could build them without problem. For example, one circuit provides an 8-bit input port (for reading pushbutton switches) and a latched 8-bit output port (for driving LED's).

Later, the book provides a good introduction to wait states, ready-signal generation, and DMA operation. All topics are thoroughly covered. A sample circuit and program shows how to connect and operate an 8-bit A/D converter.

An appendix outlines construction of a "Pedagogical Board" that contains a parallel interface, a timer IC, an A/D converter, an interrupt controller, an audio amplifier, a stepper-motor driver, LED's, and a keypad. The author sells the board as well as the example programs for modest fees.

The *Handbook* is not aimed at beginners; it assumes passing familiarity with microprocessors, DMA controllers, etc., and similar familiarity with BIOS and DOS. Experts won't find much new here, but for those aspiring to expert status, the book is a good place to start. Its circuits and discussions are limited to the 8-bit PC and XT systems, but the principles developed are applicable to 16-bit AT systems.

CIRCLE 29 ON FREE INFORMATION CARD

Troubleshooting guide

Byron W. Putnam's *Microcomputer Hardware Operation, and Troubleshooting with IBM PC Applications* starts at a more basic level. The first third of the book discusses the elements of a computer system in elementary terms. Things pick up in Chapter 5, which discusses the LSI devices on the system board (parallel port, timer, interrupt, DMA, and video controllers, etc.). Chapter 6 continues with an overview of DRAM systems and touches briefly on the expansion slot signals.

A strong point is the discussion of floppy-disk drive operation and maintenance in Chapter 8. Several good diagrams show how the complicated electrical and mechanical systems interact with one another as a system; the book also provides detailed information on how to align floppy-disk drives.

All in all, the book provides a well-written introduction to computer systems in general and the IBM PC in particular. You'll need to understand the principles developed here (along with some digital electronics) to know what's going on in Royer's book. The chapter on disk drives is a little out of place in a book that is otherwise so basic, but the information presented is solid and a little hard to come by. ◆CD◆

CIRCLE 30 ON FREE INFORMATION CARD

CABLE TESTER

continued from page 77

switches quickly, all three devices will appear to be on at the same time.

That process is called *multiplexing*; it lets each device share the common transmission line part of the time. Multiplexing is the basis of modern phone transmission; that's how hundreds of calls are sent over a single pair of wires.

Our cable tester reverses the standard multiplexing scheme to allow testing many wires with just a single input and a single output. The principle is shown in Fig. 2; note that the rotary switches there are not ganged.

If we place both switches in position 1, LED1 will light, indicating continuity. But if we leave S1 in position 1 and move S2 to position 2, the LED should go out. If it doesn't, there must be a connection—intentional or otherwise—between lines 1 and 2.

We accomplish that type of switching with a 4051 multiplexer/demultiplexer, shown in Fig. 3. As shown in Table 1, depending on the binary code present at inputs A, B, and C of the 4051, we can connect the common line to any of the eight transmission lines. Note that if we apply a high level to the Inhibit line, all connections are broken between the common and transmission lines, regardless of the state of the A, B, and C inputs. Like the rotary switches in Figures 1 and 2, the 4051 can accommodate AC and DC signals in both directions.

The circuit

If the PC had a standard interface with 24 input and 24 output lines, multiplexing would be unnecessary. It doesn't, so the cable tester uses the 11 output lines of the PC's parallel port to control six 4051 IC's, and one of the port's five input lines to sense transmission status. The complete circuit is shown in Fig. 4.

To select IC1, we must bring its Inhibit line low while keeping the Inhibit lines of IC2 and IC3 high. Then, depending on what we apply to the A, B, and C inputs, we can select any of the eight transmission lines. The Common line (pin 3) is connected to +V, so +5 volts will be transmitted through the selected transmission line to the cable under test via J1.

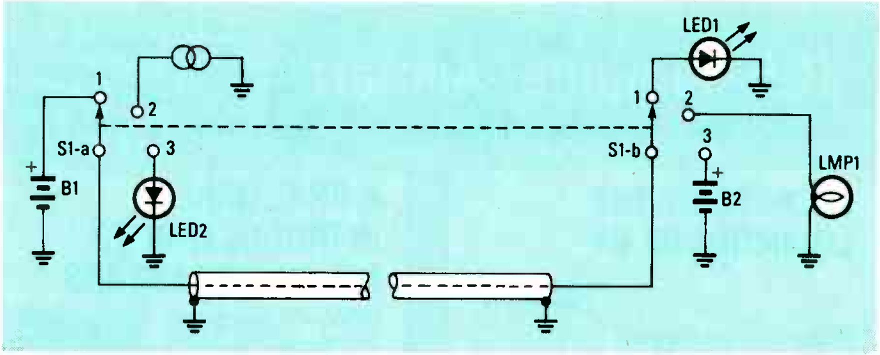


Fig. 1. *A MULTIPLEXED CIRCUIT allows a single cable to carry several different circuits.*

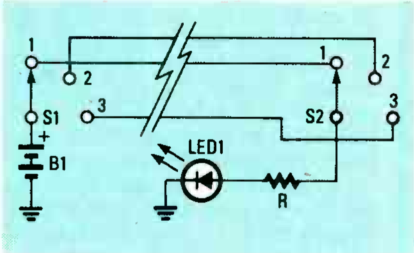


Fig. 2. *BY DECOUPLING the switches and driving (B1) and sensing (LED1) the common lines, it's possible to test various combinations of connections.*

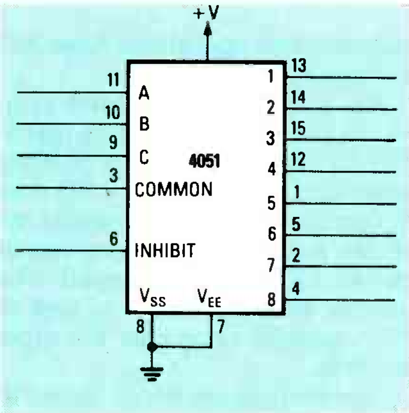


Fig. 3. *THE CMOS 4051 allows a single common line to connect to one of eight input/output lines when the inhibit line is low.*

The other end of the cable is connected to J2. There, a line is selected by similar use of the Inhibit and A, B, and C lines of IC4, IC5 and IC6. The Common output line is sensed by pin 11 of the printer port. Resistor R1 serves as a pull-down to prevent false readings.

Think of the combination of IC1, IC2, and IC3 as a 24-position electronically controlled rotary switch. Similarly, the combination of IC4, IC5, and IC6 acts like a second rotary switch. Each "switch" is independently adjustable. For example, line 1 can be selected as the input to the cable, while any of lines 1 through 24 can be sensed at the output of the cable. That independent selection allows checking of all possible combinations of input and output lines. Power is provided by three 1½-volt AA batteries.

Addressing the 4051's

On the input side, lines A, B, and C are connected to printer-port pins 4, 3, and 2, respectively. Those pins correspond to the three lowest bits (D2, D1, and D0) of the 8-bit parallel data. To select transmission line 1, we connect the A, B, and C lines to ground; to select transmission line 8, we connect A, B, and C to +V.

Note that all three IC's (IC1–IC3) are addressed; we avoid contention by releasing the Inhibit line of only one IC at a time. The Inhibit line for IC1 is pin 1 ($\overline{\text{STROBE}}$). For IC2, it is pin 14 ($\overline{\text{AUTOFD}}$), and for IC3 it is pin 16 ($\overline{\text{INIT}}$). To select IC1, send a decimal 5 to port 890 (OUT 890,5). A decimal 6 selects IC2, and decimal 0 selects IC3.

Addressing the output side is more complicated. Bits D7 and D6 (pins 9 and 8, respectively) are used to generate the A, B, and C signals through IC7 and IC8. To select IC4, set D7 = 1 and D6 = 1. Select IC5 with D7 = 1 and D6 = 0. Finally, select IC6 with D7 = 0 and D6 = 1. The A, B, and C lines are driven by D5, D4, and D3 (pins 7, 6, and 5, respectively). So, to select transmission line "5" in IC5, we would make D7 = 1, D6 = 0, D5 = 1, D4 = 0 and D3 = 0.

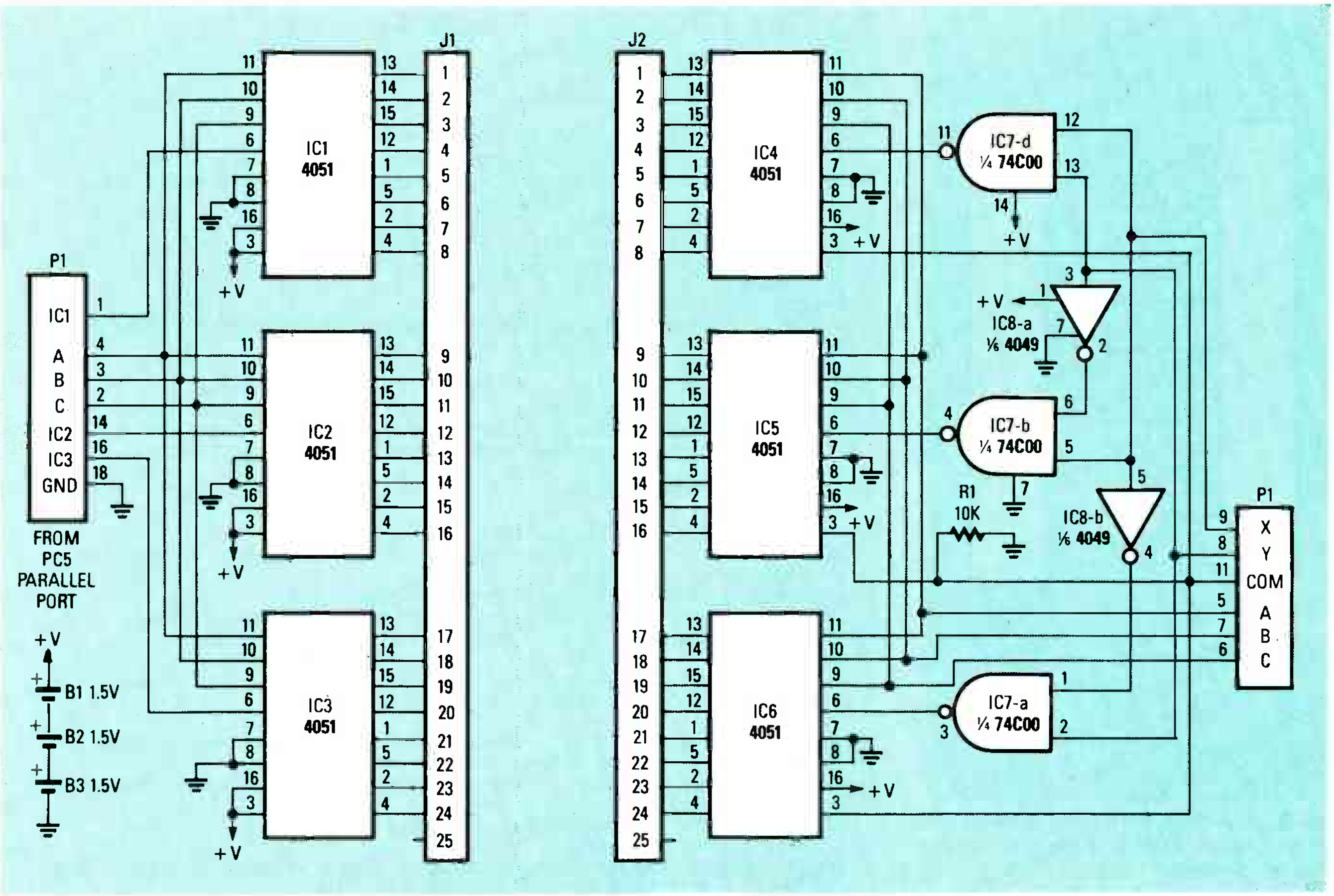


Fig. 4. *COMPLETE SCHEMATIC DIAGRAM of the cable tester. The circuitry to the left of J1 is the input side; to the right is the output. Plug P1 connects to the PC's parallel port.*

However, we must be careful not to disturb bits D2, D1, and D0, which were previously set. We do that by reading the status of port 888 and masking off the higher bits with the function INP(888) AND 7. That gives us a decimal value indicating the status of bits D2–D0. We can now add the decimal value from bits D7–D3 to that number and send it back out. To continue the previous example, we had D7 = 1, D6 = 0, D5 = 1, D4 = 0, and D3 = 0, or 10100XXX (with the X's meaning we don't care what those bits are). The decimal number for that pattern is 128 × 1 + 64 × 0 + 32 × 1 + 16 × 0 + 8 × 0, or 160.

If D2 = 1, D1 = 1, and D0 = 0, that pattern's decimal equivalent is 6. Add that to 160 and we get 166. So to select input line 15 and output line 13, we OUT 890,6 (to select IC2), and OUT 888,166 (to select transmission line 7 in IC2 and transmission line 5 in IC5).

Although the calculations seem somewhat involved, the computer program accomplishes them quickly; in Listing 1, see lines 110 and 120 for the input side and 250–290 for the output side of the PC Cable Tester.

Construction

It's certainly possible to design a PC board for the tester, but we chose to build it on a standard 6 ½-inch solderless breadboard, which provides just enough room for the circuit's eight IC's. Use short lengths of no. 22 solid wire to make the breadboard interconnections.

Next, obtain a four-foot length of 15-conductor cable; that cable connects to the PC's printer port. On the end that will attach to the

TABLE 1—4051 TRUTH TABLE

Inhibit	A	B	C	Line Selected
0	0	0	0	1
0	0	0	1	2
0	0	1	0	3
0	0	1	1	4
0	1	0	0	5
0	1	0	1	6
0	1	1	0	7
0	1	1	1	8
1	X	X	X	NONE

PARTS LIST

IC1–IC6—4051, 8-channel CMOS mux/demux
IC7—74C00, quad CMOS NAND gate
IC8—4049, quad CMOS hex inverter
R1—10,000 ohms, ¼ watt, 5%
P1—25-pin D Plug and hood
J1, J2—25-pin D socket and hood
6½-inch × 2⅛-inch solderless breadboard
5 feet of 15-conductor, 24 AWG unshielded cable
22 AWG solid wire
2-inch × 6-inch aluminum panel
AA battery holder (3 cells)
5-inch × 9-inch × ½-inch plywood base
3 AA batteries

NOTE: An enhanced version of the test program, along with a detailed description of operation is available on a 5¼-inch disk for $7.00 from J. J. Barbarello, RD #3, Box 241H, Tennent Road, Manalapan, NJ 07726. Both BASIC source and a compiled version of the program are included.

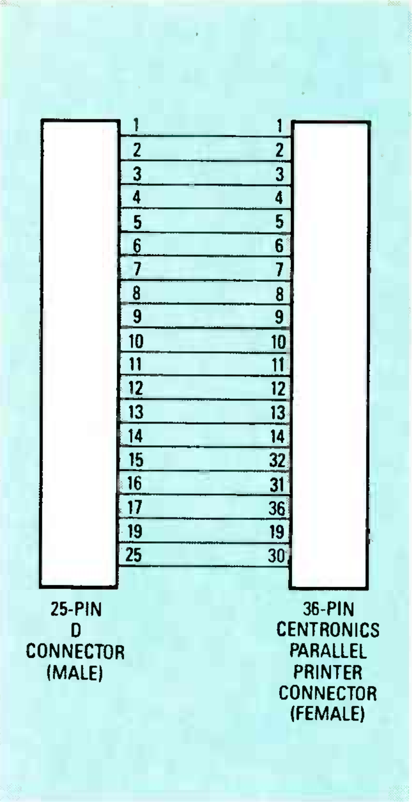


Fig. 5. *ADAPTER for testing a standard printer cable with a male Centronics plug on one end.*

LISTING 1

```
1 REM**  PC Cable Tester Program
2 REM**  Name: PCCABLE
3 REM**  (c) 1987 J.J. Barbarello
4 REM**  V871017
10 DEF SEG=64:KEY OFF:DEFINT I,O:DIM I(576),O(576)
20 CLS:CNT=1:PRINT TAB(30);"P.C. CABLE TESTER":PRINT STRING$(79,223)
30 LOCATE 4,15:PRINT STRING$(50,32):LOCATE 4,15:LINE INPUT"How many wires in
   the cable (1-24)?... ";NL$:NL=VAL(NL$)
40 IF NL<1 OR NL>24 THEN 20
50 N1=INT(NL/8):N2=NL MOD 8:IF N2=0 THEN N2=7 ELSE N2=N2-1
60 LOCATE 6,18,0:PRINT"Checking for Connections on Line:"
90 T=TIMER
100 FOR I=1 TO NL
110 IF I=1 THEN OUT 890,5 ELSE IF I=9 THEN OUT 890,6 ELSE IF I=17 THEN OUT 890,0
120 OUT 888,(I-1) AND 7:LOCATE 6,52:PRINT USING"##";I
130 GOSUB 250:NEXT I
140 CLS:PRINT TAB(30);"P.C. CABLE TESTER":PRINT STRING$(79,223)
150 LOCATE 3,22,1:PRINT USING"Test Completed in ###.## seconds.";TIMER-T
160 IF CNT=1 THEN LOCATE 5,28:PRINT"NO CONNECTIONS FOUND.":GOTO 190
170 LOCATE 5,1:PRINT"CONNECTION FOUND BETWEEN THE FOLLOWING INPUT AND OUTPUT
LINES (IN/OUT):"
180 FOR I=0 TO CNT-2:LOCATE (I MOD 10)+7,INT(I/10)*10+1:PRINT USING"##/##";
    I(I+1);O(I+1);:NEXT I
190 LOCATE 18,27:PRINT"Another Test (Y/N)?... ;
200 W$=INPUT$(1):W$=CHR$(ASC(W$) AND 223):IF W$<>"Y" AND W$<>"N" THEN 200
210 PRINT W$:IF W$="Y" THEN 20
220 LOCATE 18,27:PRINT"PC CABLE TESTER OFF LINE.
230 OUT 888,0:OUT 890,238:END:REM* TURN EVERYTHING OFF BEFORE ENDING
240 REM** SUBROUTINE TO CHECK EACH INPUT LINE
250 L1=7:IF NL<8 THEN L1=N2
260 MASK=192:C=1:FOR L=0 TO L1:OUT 888,(MASK+L*8+(INP(888) AND 7)):GOSUB 310:
    NEXT L:IF NL<9 THEN RETURN
270 L1=7:IF NL<16 THEN L1=N2
280 MASK=128:C=9:FOR L=0 TO L1:OUT 888,(MASK+L*8+(INP(888) AND 7)):GOSUB 310:
    NEXT L:IF NL<17 THEN RETURN
290 MASK=64:C=17:FOR L=0 TO N2:OUT 888,(MASK+L*8+(INP(888) AND 7)):GOSUB 310:
    NEXT L:RETURN
300 REM** SUBROUTINE TO CHECK FOR CONTINUITY
310 IF (INP(889) AND 128)=128 THEN RETURN
320 IF (INP(889) AND 128)<>0 THEN LOCATE 10,1:PRINT"** ERROR **":STOP
330 I(CNT)=I:O(CNT)=L+C:CNT=CNT+1:RETURN
```

connector, strip back the outer cable jacket about 1½ inches, exposing the 15 wires. Then strip ⅛ inch of insulation from 13 of the wires, and cut off the remaining two wires. Tin each of the exposed ends. Repeat the process for the other end of the cable, but strip 4 inches of outer jacket and ⅜ of an inch of insulation from each wire. The wires on the connector end are soldered to the 13 pins of P1 as shown in Fig. 4. The wires on the other end are inserted into the appropriate points on the breadboard.

Cut forty-eight 4-inch lengths of no. 22 solid wire, stripping ⅛ of an inch of insulation from one end and ⅜ of an inch of insulation from the other. Solder the ⅛-inch stripped end of a wire to pin 1 of J1. Repeat that process for pins 2–24 of J1 and pins 1–24 of J2 (J1 and J2 are standard 25-pin "D" connectors). Make a bracket out of a piece of aluminum and then mount J1 and J2 on the bracket. Finally, insert the free end of each of the forty eight wires into the appropriate points on the breadboard.

The three AA batteries are housed in a standard battery holder. You can use a power switch, but it's just as easy to insert or remove the +V battery wire to the breadboard. The breadboard, batteries and bracket can be mounted on a plywood base.

To test a cable without 25-pin D connectors, make a suitable adapter. One end of the adapter will be a 25 pin "D" plug. The other end will have a mating connector for the cable to be tested. These two connectors are then attached. An adapter for a 36-pin Centronics connector is shown in Fig. 5.

Operation

Type in and save the BASIC program shown in Listing 1 (or download PCCABLE. BAS from the RE-BBS—516-293-3000). Attach the cable tester to your PC's printer port and then run the program. Connect the cable to be tested to the input and output jacks of the tester. When the program asks *How many wires in the cable (1–24)?*, enter the appropriate number; if you're not sure, enter 24. The program will then check all possible combinations of lines and give you a list of connections found.

Each item in the list is of the form 1/1, meaning that pin 1 of the connector that is attached to the tester's input is connected to pin 1 of the other connector at the tester's output. On a standard 4.77-MHz PC, it takes about 10 seconds to test all 24 lines in all 576 combinations; testing fewer lines decreases the test time. Compiling the program reduces test time considerably. ◆CD◆

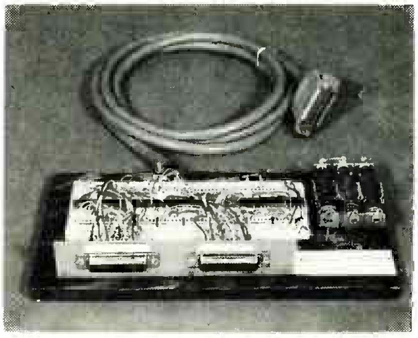


Fig. 6. *The completed cable tester. Construction is not critical, and a prototyping board should give good results.*

TRANSPUTER

continued from page 77

Divide and conquer

The idea is to divide and conquer; let's illustrate with an analogy. If, for example, you find that your secretary is not getting her work done because of constant telephone interruptions, you hire a receptionist and divide the workload between the two, thereby improving productivity.

In a similar manner, a computer can divide and distribute its workload by offloading portions of it to other processors. Whereas dedicated hardware—disk controllers and video adapters, for example—improve system performance by doing some of the CPU's work, those types of controllers typically differ from general-purpose processors in that they require step-by-step instructions from the CPU about how to operate.

By contrast, a processor gets its orders directly from the software application without involving the CPU at all. That leaves the CPU free to do other things, and thereby increases overall productivity. In addition, a general-purpose processor can be adapted to a number of tasks, whereas the typical hardware controller can only do one thing, albeit very well.

Basically, there are two different types of processors: coprocessors and parallel processors, although the distinction between them is at times hazy. Strictly speaking, a coprocessor is a processor dedicated to one task and one task alone—like the receptionist in the example. Parallel processors, on the other hand, can function in different situations.

In what follows, we'll discuss several parallel and coprocessing products for the IBM family. Keep in mind, however, that comparable products for the Apple and other systems are available.

Number crunching

The most popular and best known coprocessors are the math coprocessors from Intel: the 8087, 80287, and the 80387. Those IC's work in conjunction with the 8088/86, 80286, and 80386 CPU's, respectively, and usually plug directly into a socket on the PC's motherboard.

As the name suggests, a math coprocessor does nothing but mathematical calculations—a task that a general-purpose microprocessor is very slow at. The chip doesn't do windows and it can't read a disk—but it can multiply two numbers as much as 100 times faster than a CPU by itself.

To give you an idea of how a math coprocessor can improve performance, consider the math-intensive CAD program, AutoCAD. Without a math coprocessor, even simple AutoCAD drawings can take several minutes to compute for display using just the CPU as a number cruncher.

However, when a math coprocessor is installed, AutoCAD recognizes its presence and diverts all math routines to it rather than forcing them through the CPU. Then, while the coprocessor is busy munching mantissas, the CPU is analyzing the results and placing them on the screen. The outcome of that partnership is a tenfold increase in speed.

You want to do windows?

If it's screen performance you want, there are coprocessors for that, too. Popular IC's include Texas Instruments' 34010, Intel's 82786, and others from Hitachi, National Semiconductor, and others. Like the math coprocessors discussed above, video coprocessors are optimized for a single task: manipulating graphics on a video screen. They can't access a disk drive or read a keyboard, but they sure can move pixels around!

Unlike the simple interface between the microprocessor and the math coprocessor, video coprocessors usually require a good deal of support circuitry. Commercial products include the *Pepper 1600* from Number Nine Computer and the *Ultra 2000* CAD from INI Computer Systems.

Unlike typical IBM-style video controllers (Hercules, EGA, etc.), those video adapters use video coprocessor IC's that receive display instructions directly from applications software. In that situation, the CPU is relegated simply to coordinating screen operations with keyboard input, disk access, and other housekeeping system functions.

Parallel processors

Parallel processors are more versatile than dedicated coprocessors because they can be programmed to do more than one thing, be it number crunching, video graphics, or just plain system routines.

Like a coprocessor, a parallel processor works alongside the main CPU and receives its instructions from the software application rather than from the CPU. Generally, each parallel processor is an island unto itself. It is assigned a specific task, it does it, and then it waits for another assignment.

A crude analogy to parallel processing is a local-area network (LAN), in which information is accessed by an individual node from a shared data bank, and is then processed according to the user's needs. Then the results are returned to the data bank so that others may make use of it.

Parallel processors handle things on a more basic level. Whereas the LAN may have more than one application running on the network, with each user using a different piece of software, the parallel processor is driven by one all-encompassing application that takes total control of each processor.

The transputer

An increasingly popular parallel processor for PC applications is called a *transputer*, an acronym derived from TRANSistor comPUTER. The term was coined by INMOS Corp. of Bristol, England, (the same company that makes the DAC used in most VGA adapters); it basically means a computer on a chip.

In fact, INMOS makes two transputers: the T414 and the T800. As shown in Fig. 1, the T414 is a 32-bit CPU with 2K of

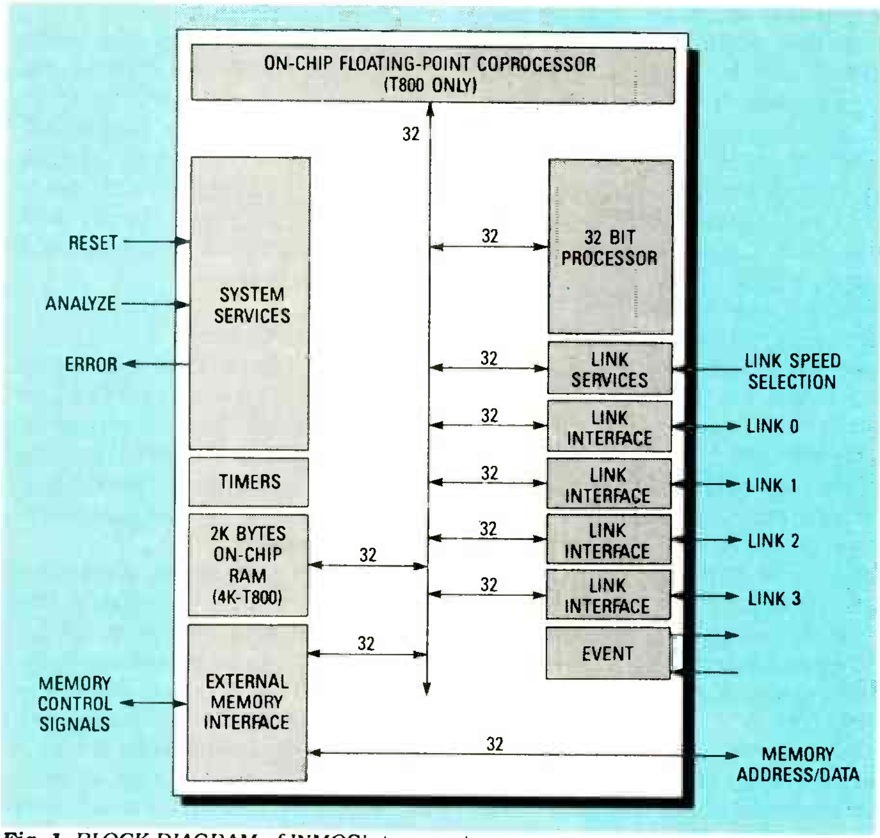


***Fig. 1.** BLOCK DIAGRAM of INMOS's transputers.*

cache memory; the T800 is electrically equivalent, but with a built-in numeric coprocessor and 4K of cache memory.

Currently, three companies are actively involved in making transputers for PC use: MicroWay, Computer System Architects (CSA), and Definicon. Each has a family of transputer boards built around as many as four INMOS transputer IC's on a single card. MicroWay sells the *Monoputer, Biputer,* and *Quadputer*; CSA sells the PARallel Transputer Series (PARTS); and Definicon sells the T4 series. In addition to the transputer and support logic, each card contains on-board RAM; the amount of memory varies from board to board.

Although transputer-board prices often reach into the tens of thousands of dollars, you can do a lot for under $2000. For example, the $1995 MicroWay *Monoputer* with a single 20-MHz T800 transputer and 2MB of RAM can provide the PC with the numeric processing power of a VAX 8600—DEC's largest miniframe system. The $1990 Definicon T4-1/800, with one 20-MHz T800 and 1MB of RAM has the same processing speed as the Monoputer, but less RAM. If those are beyond your budget, CSA's PARTS.2 Evaluation/Starter Kit, shown in Fig. 2, consists of a single 20-MHz T414 transputer, 256K of RAM, and C compiler. That kit puts PC-based parallel processing power in the hands of the experimenter for well under $1000.

By itself, the INMOS transputer is nothing special. It is only slightly faster than a 16-MHz 80386; both have 32-bit buses, and both can access up to four gigabits of virtual memory. In fact, 80386 CPU's have successfully been used by Intel Scientific Computers (a division of Intel Corporation) in parallel processing supercomputers.

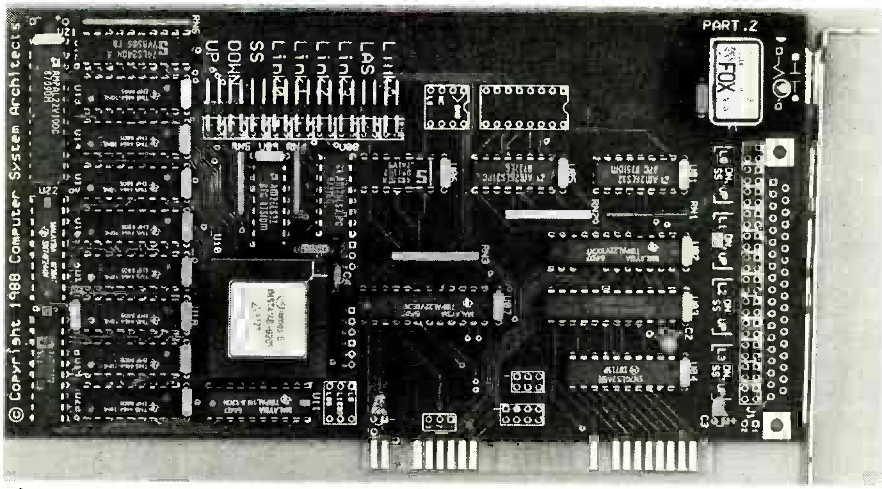


***Fig. 2.** THE CSA EVALUATION/STARTER KIT contains a 20-MHz T414 INMOS transputer, 256K of RAM, and C compiler, and sells for less than $1000.*

What sets the transputer apart from a typical microprocessor is its four high-speed serial communication links—links that can interconnect several transputers in a network or array of processors using simple hardware jumpers. In essence, a transputer serves as a building block for a system of arbitrary size and complexity. For example, it's possible to build a system that exceeds the processing power of a mighty Cray 1S supercomputer using only eight of the INMOS T800 transputers!

So what determines the performance of a parallel processing system? Simply stated, the hardware architecture—which is largely determined by the application. One configuration may be more suitable to a specific problem than another.

For example, if an application requires much number crunching, you'd want to connect the transputers in a linear, pipeline configuration. For multiprocessing tasks such as image recognition, you want as much parallelism as possible. And for CAD applications with numerous vector recalculations, a combined parallel/pipeline topology is preferred. Let's discuss each.

Pipelining

Pipelining gets its name from the fact that several processors are connected serially, like sections of pipe, with the output of the first tied to the input of the second, whose output is tied to the input of the third, and so forth. Data that enters the pipeline is acted upon by each processor as it travels through the pipeline.

Analogous to pipelining is the operation of an assembly line. An assembly line is divided into several stages, at each of which a particular operation takes place. One station might install the engine into the body, for example, while the next puts on a door. As the partially assembled car travels down the line, more and more items are added until, finally, a finished product emerges at the end. By advancing the vehicle as each step is completed and replacing it with a vehicle from the previous station, no assembly station is idle. Therefore, it is possible to turn out a steady stream of finished cars at a rate that is much faster than if each had been individually crafted.

The same strategy can be applied to many computer functions—floating-point arithmetic, for example. To see how pipelining can improve performance, let's compare the methods used by a microprocessor and a math coprocessor to multiply two numbers.

Typically, the CPU accomplishes the job (through software) by (1) splitting each number into an exponent and a mantissa, (2) adding the exponents, (3) storing the result in temporary memory, (4) multiplying the mantissas, (5) fetching the exponent, and (6) combining the two into a final answer. Only after the entire sequence has run its course can the CPU start on another calculation.

The math coprocessor, on the other hand, multiplies the two numbers using a multi-stage pipeline, as shown in Fig. 3. The two numbers enter the pipeline's first stage, where they are identified as to exponent and mantissa. The elements are then shifted to the second stage, where the mantissas are weighted for processing. The third stage multiplies the mantissas and the fourth strips the fraction of unnecessary zeros; the fifth and final stage adds the exponents and converts the results to conventional scientific notation.

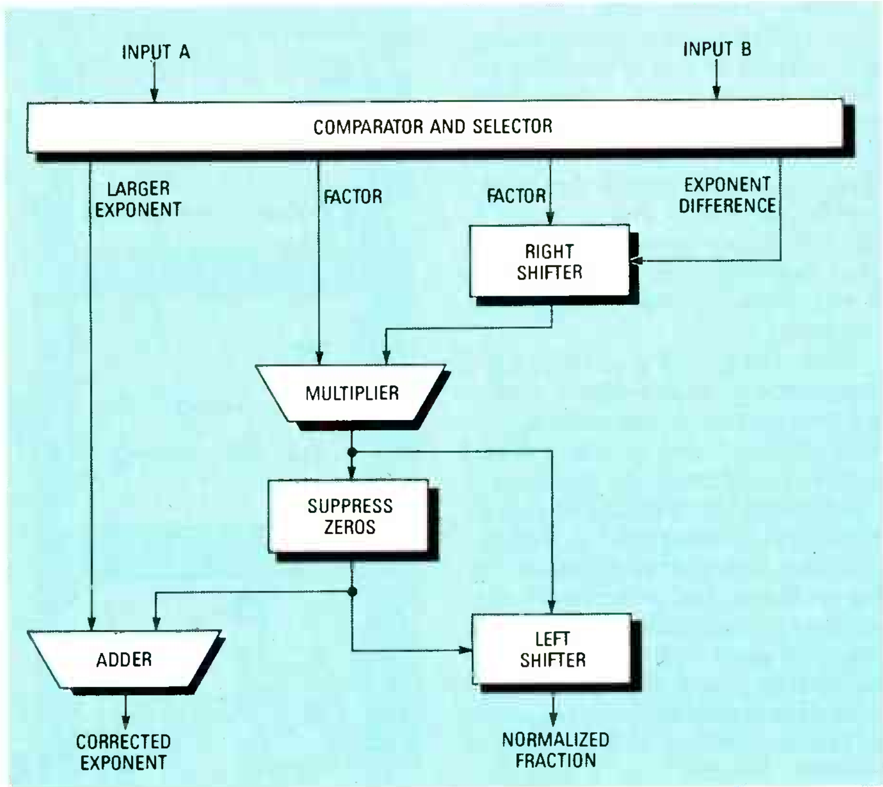


Fig. 3. BLOCK DIAGRAM of a pipelined math coprocessor.

The coprocessor really picks up speed, because after the first pair of numbers is shifted from the first stage to the second, another pair can enter the now-empty first stage. In fact, with each successive movement of data between stages, another pair of numbers can enter the pipeline, causing it to fill. After the fifth shift, results begin pouring out of the pipeline.

Of course, pipelining is not limited to Intel's math coprocessors; a pipeline can also be created using several transputers. However, pipelining is only efficient when the number of similar computations to be performed is large, as in floating-point arithmetic. Instructions are still executed one step at a time, and problems that rely on the results of one operation before invoking another are at a disadvantage. For that reason, designers developed a number of other architectures for increasing performance.

Coprocessor Or Accelerator?

One term loosely bandied about the PC industry is the *coprocessor accelerator board*, a name generally given to adapter cards that contain high-speed CPU chips to increase system throughput. Where the term originated is anybody's guess, but most of those boards are not coprocessors; they're simply accelerators.

The difference is in the way an accelerator board operates. To install an accelerator card in most cases you must remove the system's old CPU and run a jumper cable from the accelerator card to the now-empty CPU socket.

Notice that the two processors don't work together simultaneously; at best you may switch between them to accommodate temperamental software applications. By contrast, to achieve true parallel processing, both CPU's must be accessible by software at the all times—something the typical accelerator card simply cannot do.

Parallel architectures

In conventional processing, the system is fed a problem serially, one chunk at a time: do A, then B, and then C. An advanced architecture, called a *concurrent system*, might attack the problem by accepting instructions A, B, and C simultaneously, and then routing each instruction to a separate processor that acts upon it.

Planning and publishing a magazine provides a good analogy. A magazine is basically an anthology of related articles placed under one cover. To produce a magazine, the publisher draws from many sources, including authors, news services, public relation firms, and advertisers. Because the information is generated by each contributor independently, much of it can be done simultaneously without the work of one depending on the result of another. In effect, work proceeds concurrently until the results are collected and assembled into print.

Similarly, a concurrent system works on more than one aspect of a problem at once. First the problem is broken down into as many parallel elements as possible; then each processor in the system is given an assignment. When all processors have reported in, the results are assembled and analyzed. Based on those results, the software then initiates another round of processing. That winnowing process continues until a solution to the overall problem is found; the number of steps required depends on the number of parallel processors the software supports and the magnitude or complexity of the problem.

There are many ways to assemble a concurrent system, some of which are shown in Fig. 4.

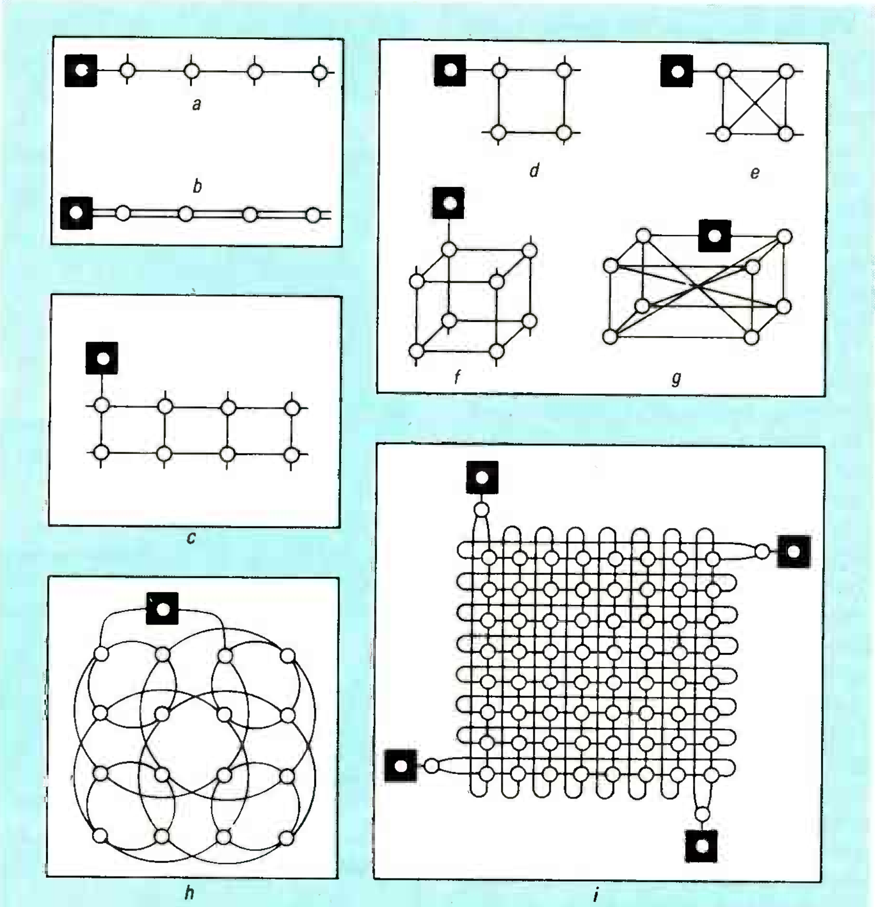


Fig. 4. SEVERAL WAYS TO INTERRCONNECT TRANSPUTERS: (a) linear, (b) fast linear, (c) 2D array, (d) cube, (e), cross-connected cube, (f) 3D cube, (g) cross-connected 3D cube, (h) hypercube, and (i) 64-node torus.

Parallel programming

Because conventional programming languages are not designed to deal with parallel processors, alternative parallel-speaking languages have been developed. Some are esoteric languages written for a specific machine in a specific configuration, but many are adaptations of more familiar languages.

Transputer boards are generally programmed in modified versions of standard languages, such as Pascal, C, and Fortran. One of the more popular transputer languages, Occam, is akin to Pascal. Except for the parallelism commands, working with that type of language is similar to working with a standard dialect.

For each parallel system, however, a different software application that recognizes the number of transputer chips and their configuration must be written. You place that information in a header library that precedes the run library (the program itself). After compilation, the program will only run on that system or an identically configured system. Not one change can be made to the transputer hardware without going back to the original pro-

(Continued on page 94)

Companies Mentioned

- Intel Corporation, 3065 Bowers, Santa Clara, CA 95051. (408) 987-8080.
- Number Nine Computer Corporation, 725 Concord Ave., Cambridge, MA 02138. (617) 492-0999.
- INI Computer Systems, 6915 Hightech Dr., Midvale, UT 84047. (801) 561-1100.
- MicroWay, Inc., P.O. Box 79, Kingston, MA 02364. (617) 746-7341.
- Computer System Architects, 950 N. University Ave., Provo, UT 84604. (801) 374-2300
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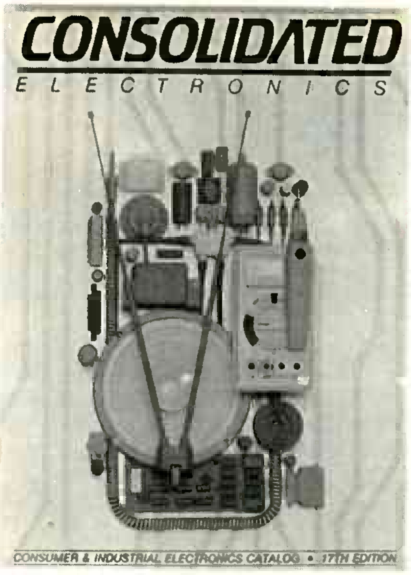

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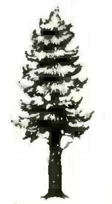

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CABLE-TV

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DECLARATION OF AUTHORIZED USE — I, the undersigned, do hereby declare under penalty of perjury that all products purchased, now and in the future, will only be used on cable TV systems with proper authorization from local officials or cable company officials in accordance with all applicable federal and state laws. **FEDERAL AND VARIOUS STATE LAWS PROVIDE FOR SUBSTANTIAL CRIMINAL AND CIVIL PENALTIES FOR UNAUTHORIZED USE.**

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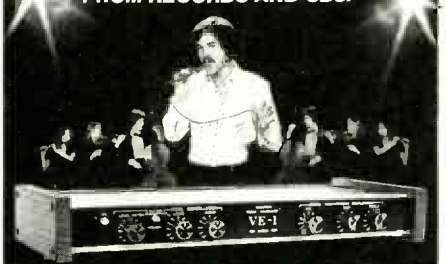

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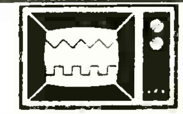

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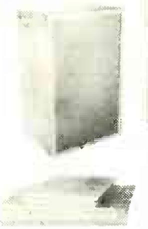

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PIONEER

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12" PIONEER SUB WOOFER

PIONEER

Dual voice coil sub woofer. 30 oz. magnet, 2" voice coil. 100 watts RMS, 145 watts max. fs = 25 Hz. 6 ohm (4 and 8 ohm compatible). SPL = 89 dB 1W/1M. Response: 25-700 Hz. QTS = .31, VAS = 10.3 cu ft. Pioneer #A30GU30-55D. Net weight: 6 lbs.

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18" EMINENCE WOOFER

EMINENCE

MADE IN U.S.A.

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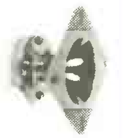

Mylar dome, 2.93 oz. barium ferrite magnet. 8 ohm. Response: 1,800-20,000 Hz. 35W RMS, 50W max. fs = 2,000 Hz, SPL = 106 dB. Pioneer #AHE60-51F.

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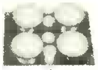
3-WAY 100W CROSSOVER



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Scrambling News, 1552 Hertel Ave., Buffalo, N.Y. 14216 COD's 716-874-2088

SATELLITE TV

CABLE TV Secrets—the outlaw publication the cable companies tried to ban. HBO, Movie Channel, Showtime, descramblers, converters, etc. Supplier's list included $8.95. **CABLE FACTS,** Box 711-R, Pataskala, OH 43062.

SATELLITE TV receiver kits! Instruction manuals! Boards! Semiconductor parts! 59 deg LNA's! LNB's! Ku-Band LNB's! Catalog $1.00 **XANDI ELECTRONICS,** Box 25647, Dept. 21SS, Tempe, AZ 85285-5647.

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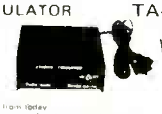

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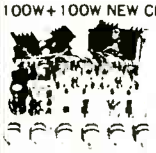

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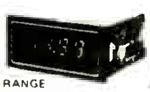

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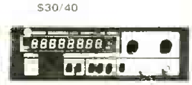

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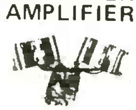
TA-477 ΔΔ

BUILD A PROFESSIONAL AMP BY YOURSELF



This amplifier consists of three super low TIM differential stages and Hitachi 2SJ49 2SK 134 match pair "MOSFET" as output component whose frequency response and transient response is superior to the other power transistor. Therefore this amplifier has high-fidelity and superior analytic power over the entire Audio Spectrum. It is suitable for reproducing classic and modern music. Heavy Duty Heat Sink with 28 radial fins is included!
Kit ... $68.00
Metal Cabinet/X'Former (Optional) ... $33.00/24.00

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8216	1.60
8224	2 25
8226	1.60
8237-5	6.50
8238	3.95
8250B	6.75
8251-A	2.40
8253	1.75
8255-A-5	1.85
8257	2.40
8259	2.40
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8279-5	2.75
8284	2.50
8288	4.75
8355	12.95
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68000L8	8.50

RAM's

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2118-4	1.75
2147-3	2.50
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TMS4050NL	1.75
MK4096-11	1.25
4108-3	1.60
4116-2	.70
4118-4	1 75
4164-15	3 40
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Z6104-4	2 50
6116-3	4 50
6264LP-15	9.80
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MM1402	1.75
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8834	2.00
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MM5369AA	1.95

DIP SOCKETS

8 PIN	.10	22 PIN	.15
14 PIN	.11	24 PIN	20
16 PIN	.12	28 PIN	.20
18 PIN	.15	40 PIN	.25
20 PIN	.18		

ROM's

INS205-1	4.50
TPB18S42	3.50
82S123	1.50
82S126	1.95
82S129	1.95
82S130	1.95
82S131	1.50
TPB28S166	9.50
82S181	4.50
82S191	4.50
74S474	3.95
2708	3.75
2716 + 5V	3.75
2732-3	3.75
2764-25	4 00
27128-30	4.75
27256-25	8.00
3347	2.95
3628A-3	3.00
8256-5	1.25

DISC Controllers

D765C	4 50
1771	4.75
1791	9.50
1793	9.50
1795	12.00
1797	12.00
WD2010A	14.95
2797	7.95

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2.000	6.144
3.000	8.000
3.12	10.000
3.579	17.32
4.000	18.000
5.000	20 000
6.000	34 550

1.75 ea.

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WIRE WRAP SOCKETS

14 PIN	.45
16 PIN	.50
18 PIN	.65
20 PIN	.90
24 PIN	1.10
28 PIN	1.25
40 PIN	1.80

NO. 30
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DB CONNECTOR

DB9P	-$ .80
DB9S	-$ .95
HOODS	-$ 65
DB25P	-$1.25
DB25S	-$1.50

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TIP 34 PNP Si	$ .95
TIP 111	$ .50
TIP 122 NPN Si U84	$ .50
TIP 141 NPN Si U97	$1.00
TIP 145	$1.35
2N1307 PNP GE TO-5	$ .40
DPS2000—DUAL POWER DARL.	$3.95
2N2222 NPN Si TO-92	7/$1.00
2N2907 PNP Si TO-92	7/$1.00
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MJE3055T	$ .60
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2N3904 NPN Si TO-92	7/$1.00
2N3906 PNP Si TO-92	7/$1.00
2N4901 PNP Si TO-3	$1.00
2N6296 NPN TD-220	$ .50
2N6109 PNP Si TO 220	$ .55
MRF-8004 CM RF NPN	$ .75
MPSA42 300V NPN	5/$1.00

SCR's

	1.5A	6A	35A	75A
100	.35	.40	1.40	
200	.40	.50	1.80	
400	.60	.70	2.40	9.00
600	.80	1.00	3.60	12.00

TRIAC's

PRV	1A	10A
100	.35	.60
200	.50	.80
400	.70	1.00
600	1.00	1.20

LINEAR CIRCUITS

TL062C	.95	LM393	.40	MC1391	1.00
TL064CN	1.00	LF398A	3.00	1456	.80
TL072	1.00	LF411	1.25	1458	.50
LM79BCT	.60	AD506JH	2.50	LM1808	1.75
TL062	.90	537	1.50	ULN2003A	.75
TL084	1.00	LM555	.29	AD7520LD	4.95
DG201BP	1.40	LM556	.45	LM2901	.95
LM201	.75	558	1.10	CA3018	1.95
LM301	.35	AD561	3.00	CA3045	1.20
LM307	.45	564	1.75	CA3078AT	1.50
LM308	.65	565	.90	CA3089E	1.75
LM311	.45	566	1.25	CA3094	1.30
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LM319	1.10	NE570	2.50	CA3140	.75
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LM339	.50	709CN	.80	SG3544	1.00
LM348	.65	711CH	.60	UNL3701E	1.75
LF351	.45	733	.95	LM3900	.50
LF353	.75	739	1.50	4136	.85
LF355	.35	741CV	.29	SD5000	1.75
LF356	.85	747	.50	N5534	.75
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LM370	1.60	ADC0809		SD6000	1.00
LM380	.85	CNN	8.95	8038	3.95
LM384	1.60	MC1310	1.00	8700CJ	5.95
LM386	.85	MC1350	.95	LM13080	.95
		MC1355	1.25	76477	2.95

TTL IC SERIES

7400	.19	7480	.45	74170	1.50
7401	.19	7483	.50	74173	.75
7402	.19	7485	.55	74174	.85
7403	.19	7486	.35	74175	.85
7404	.19	7489	1.90	74176	.75
7405	.25	7490	.39	74177	.65
7406	.27	7491	.40	74180	.76
7407	.27	7492	.50	74181	2.00
7408	.24	7493	.35	74182	.75
7409	.18	7494	.60	74184	1.50
7410	.18	7495	.55	74190	.80
7411	.25	7496	.60	74191	.80
7412	.25	74107	.30	74192	.75
7413	.35	74116	1.20	74193	.75
7414	.45	74121	.30	74194	.80
7416	.25	74122	.45	74195	.80
7417	.25	74123	.45	74196	.75
7420	.20	74125	.45	74197	.80
7425	.27	74126	.45	74199	1.25
7426	.30	74145	.60	74221	1.25
7427	.27	74148	1.20	74273	1.00
7430	.20	74150	1.35	74278	1.95
7432	.27	74151	.55	74279	.70
7437	.27	74153	.55	74298	.60
7438	.29	74154	1.25	74365	.65
7440	.20	74155	.55	74367	.66
7442	.46	74156	.75	74390	.90
7445	.65	74157	.55	75114	.90
7447	1.00	74158	.55	75115	.90
7450	.20	74160	.85	75150	.60
7472	.29	74161	.65	75325	1.50
7473	.35	74162	.65	75491	1.00
7474	.32	74163	.65	9602	.90
7475	.45	74164	.85	8T26	1.10
7476	.50	74165	.85	8T28	1.10
		74166	1.00	8T97	1.10
				8T98	1.10

C/MOS

74C00	.25	74C915	1.10	4027	.35	4072	.20
74C04	.25	4001	.19	4028	.65	4076	.55
74C08	.25	4002	.20	4029	.65	4077	.28
74C10	.25	4006	.65	4030	.65	4081	.20
74C14	.55	4007	.20	4034	1.40	4082	.20
74C20	.25	4008	.85	4035	.65	4093	.45
74C32	.35	4009	.35	4040	.66	4099	1.40
74C42	1.10	4010	.35	4041	.75	4501	.95
74C74	.55	4011	.19	4042	.55	4503	.45
74C76	.60	4012	.25	4043	.85	4506	.75
74C85	1.25	4013	.35	4044	.65	4510	.65
74C86	.35	4014	.65	4045	.85	4511	.65
74C93	1.00	4015	.28	4046	.85	4512	.75
74C157	.95	4016	.28	4047	.65	4514	.95
74C161	.95	4017	.45	4049	.28	4515	1.60
74C174	.95	4018	.65	4050	.28	4516	.75
74C175	.95	4019	.35	4051	.65	4518	.85
74C193	1.25	4020	.55	4052	.65	4520	.75
74C245	1.75	4021	.65	4053	.65	4528	.75
74C901	.35	4022	.65	4060	.65	4529	1.40
74C902	.40	4023	.25	4066	.28	4538	.95
74C903	.80	4024	.48	4068	.35	4539	1.50
74C907	.75	4025	.26	4069	.19	45418	1.20
		4026	1.25	4070	.28	4553	1.75
				4071	.20	4583	.90
						4585	.75

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74HC SERIES

74HC00	.35	74HC125	.50	74HC245	.80
74HC02	.35	74HC133	.50	74HC257	.55
74HC04	.35	74HC137	.75	74HC259	60
74HC08	.35	74CH138	.70	74HC273	.80
74HC10	.35	74HC139	.45	74HC354	.95
74HC11	.40	74HC153	.55	74HC373	.80
74HC20	.35	74HC154	1.75	74HC374	.80
74HC30	.35	74HC157	.50	74HC533	1.35
74HC32	.35	74HC162	.55	74HC534	1.35
74HC50	.45	74HC163	.55	74HC573	2.50
74HC58	.50	74HC164	.80	74HC595	2.50
74HC74	.40	74HC174	.60	74HC640	2.00
74HC75	.40	74HC175	.60	74HC4002	.50
74HC85	.70	74HC194	.70	74HC4020	1.10
74HC86	.40	74HC221	.90	74HC4066	.60
74HC107	.35	74HC240	.75	74HC4514	3.20
74HC109	.40	74HC242	.75	74HC4538	1.40
74HC112	.40	74HC244	.80	74HC4543	1.40

74LS SERIES

74LS00	.17	74LS112	.29	74LS241	.65
74LS01	.17	74LS113	.33	74LS242	.65
74LS02	.17	74LS114	.33	74LS243	.65
74LS03	.17	74LS122	.70	74LS244	.65
74LS04	.17	74LS123	.45	74LS245	.75
74LS05	.17	74LS125	.35	74LS246	1.40
74LS08	.17	74LS126	.35	74LS247	.75
74LS09	.17	74LS132	.39	74LS243	65
74LS10	.17	74LS136	.35	74LS251	.45
74LS11	.20	74LS137	.90	74LS253	.45
74LS12	.27	74LS138	.39	74LS257	.39
74LS13	.25	74LS139	.39	74LS258	.45
74LS14	.36	74LS145	.70	74LS259	1.20
74LS15	.25	74LS147	1.00	74LS260	.45
74LS20	.17	74LS148	.90	74LS266	.55
74LS21	.22	74LS151	.39	74LS273	.75
74LS22	.22	74LS153	.39	74LS279	.39
74LS26	.23	74LS154	1.50	74LS280	1 70
74LS27	.23	74LS155	.55	74LS283	55
74LS28	.26	74LS156	.45	74LS290	.80
74LS30	.17	74LS157	.35	74LS293	.80
74LS32	.17	74LS158	.20	74LS298	.65
74LS37	.26	74LS160	.29	74LS299	1.25
74LS38	.26	74LS161	.49	74LS320	2.00
74LS40	.17	74LS162	.49	74LS322	3.00
74LS42	.35	74LS163	.49	74LS323	2.40
74LS48	.65	74LS164	.45	74LS365	.39
74LS51	.17	74LS165	.65	74LS366	.39
74LS54	.22	74LS166	.95	74LS367	39
74LS73	.25	74LS169	.90	74LS368	.39
74LS74	.24	74LS170	.80	74LS373	.75
74LS75	.29	74LS173	.49	74LS374	.75
74LS76	.29	74LS174	.39	74LS377	.75
74LS83	.45	74LS175	.39	74LS386	45
74LS85	.45	74LS181	1.40	74LS390	1.10
74LS86	.22	74LS190	.49	74LS393	.75
74LS90	.39	74LS191	.49	74LS398	2.50
74LS92	.45	74LS192	.65	74LS446	2.00
74LS93	.45	74LS193	.65	74LS541	1.40
74LS95	.48	74LS194	.65	74LS625	1.75
74LS96	.49	74LS195	.65	74LS645	.95
81LS98	1.40	74LS196	.55	74LS668	1.45
74LS107	.35	74LS197	.55	74LS670	.95
74LS109	.36	74LS221	.55	25LS2521	1.95
		74LS240	.65		

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LINEAR AND AUDIO AMP
BAND WIDTH 30 KHz at
60 WATTS, 7 AMP OUTPUT

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LM317T	$ 90	723	$ .45
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L1411-IR Detector	3/$1.00
FP 100 Photo Trans	$ .50
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80386-20	$350.00
8087-2	$100.00
8087-3	$155.00

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PRV	2A	6A	25A
100			1 40
200	.80	1 30	2 20
400	1 00	1 65	3.30
600	1 30	1 90	4 40

DIP SWITCHES

CTS 206- 4	4 Position	.75
CTS 206- 7	7 Position	.95
CTS 206- 8	8 Position	.95
CTS 206-10	10 Position	1.25

SILICON POWER RECTIFIERS

PRV	1A	3A	12A	50A	125A	240A
100	.05	.14	.35	.90	6.00	7.00
200	.06	.17	.50	1.30	8.00	10.00
400	.09	.25	.65	1.50	10.00	12.00
600	.11	30	.80	2.00	13 00	15.00
800	.13	.35	1.00	2.50	16.00	18.00
1000	.20	.45	1.25	3.00	20.00	26.00

MULTI TURN TRIM POTS
50 OHM
100 OHM
1000 OHM
5K 10K
20K 50K 100K
3/$2.00

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CIRCLE 74 ON FREE INFORMATION CARD

SHORTWAVE RADIO

continued from page 73

source—frequencies, it has continued to solve problems. Although disputes have sometimes been heated and bitter, the participants have realized that failure to compromise could lead to the collapse of the organization, which would be detrimental to all the members.

It's surprising that similar groups, operating regionally, have not yet emerged. For example, a Far Eastern IFCC, coordinating frequencies around the Pacific rim, would certainly improve the situation in that area of the world.

Anyone wanting a free copy of a recent coordinated schedule, which consists of 32 pages of material, should write to Shirley Sandler, RFE/RL Inc., 1775 Broadway, New York, NY 10019.

Shortwave conditions

As the days lengthen in March and April, the higher frequencies will remain open for DX longer than during the winter months. During the day in the east, 15 MHz, 17 MHz, 21 MHz, and 26 MHz will be possible from early morning until several hours after sunset. The amateur 100-meter band will open to Europe, and openings to South America and Africa will also occur regularly; in the late afternoon, trans-Pacific 10-meter openings will occur.

During the evening and nighttime hours, good to excellent DX will be possible in all bands from 6 MHz to 15 MHz, depending upon the location of the transmitting station; moreover, 17 MHz will be open, especially from Africa and Latin America.

Due to approaching summer conditions, noise levels in the broadcast band will begin to increase, making DX more difficult than it has been.

During years of high sunspot activity the number of severe ionospheric storms increases. As a result, radio conditions periodically become very poor. Disturbed conditions tend to peak during the equinox months of March and September. Major storms can black out virtually the entire shortwave spectrum for a day or two at a time. In the early days of radio, many listeners and radio amateurs dismantled their radios looking for bugs that weren't there. **R-E**

LETTERS

continued from page 15

full voltage will be dumped across the remaining capacitor(s), which will also fail.

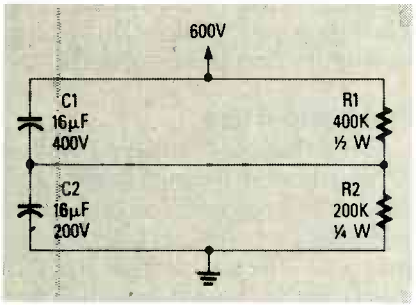

FIG. 1

Usually a resistive divider of suitable wattage, with resistance proportional to the WVDC of the capacitors, and whose total value will allow a current flow of approximately 1 mA, will protect the capacitors from that mode of failure. (See Fig. 1.) The nominal values would be 1 KΩ per volt and 0.001 × the resistance in KΩ wattage.

I enjoy your magazine a great deal. It is always full of all kinds of interesting stories, projects, and technology updates.
VIC SCHMIDTMANN
Newark, CA

ACTIVE ANTENNA

In the article "Active Antenna" (**Radio-Electronics**, February 1989), Fig. 2, which shows Q1–FET, MPF102, would lead you to believe that the middle lead is the gate. Of

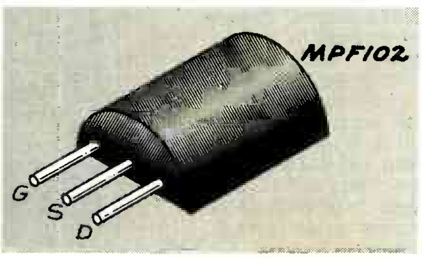

FIG. 2

course, it isn't; it is the source (or "S"). The photograph, Fig. 3 of the article, bears that out. It shows MPF102 to be twisted—if you look *very* closely.

My drawing (Fig. 2) is correct.
JOHN L. KURSCHNER
Toms River, NJ **R-E**

TRANSPUTERS

continued from page 86

gram (source code) and recompiling it using the new hardware parameters. By using a hardware header, the time it takes to change a program to fit another configuration is minimized.

The bottom line

Even though common PC's run ten and twenty times faster than their counterparts of only a decade ago, we still can't seem to get enough speed—which is why coprocessors and parallel processing are so attractive. In fact, it is predicted that by 1991, 48% of all PC's sold will contain parallel processing hardware. The drawback is that parallel processing requires special software.

But that's like what we experienced with the first PC's in the early 1980's, and many good programmers and applications programs came from that era. R-E

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UPD70116-8	(8MHz) V30 Chip	~~$9.95~~ $ 7.95
UPD70116-10	(10MHz) V30 Chip	~~$16.95~~ $15.49

7400

Part No.	1-9	10+	Part No.	1-9	10+
7400	SALE	.15	7485	SALE	.45
7402	.29	.19	7486	SALE	.29
7404	SALE	.15	7489	1.95	1.85
7405	.35	.25	7490	.49	.39
7406	.39	.29	7493	.45	.35
7407	SALE	.25	74121	SALE	.25
7408	.35	.25	74123	SALE	.35
7410	SALE	.15	74125	SALE	.35
7414	SALE	.25	74126	SALE	.35
7416	SALE	.19	74143	SALE	3.95
7417	SALE	.19	74150	SALE	1.10
7420	.29	.19	74154	1.35	1.25
7430	SALE	.15	74158	SALE	1.25
7432	.39	.29	74173	SALE	.59
7438	SALE	.25	74174	SALE	.35
7442	SALE	.29	74175	SALE	.35
7445	SALE	.59	74176	SALE	.49
7446	.89	.79	74181	SALE	1.49
7447	.89	.79	74189	SALE	1.49
7448	1.95	1.85	74193	.79	.69
7472	SALE	.25	74198	SALE	1.25
7473	.39	.29	74221	SALE	.69
7474	SALE	.25	74273	SALE	1.49
7475	.49	.39	74365	SALE	.35
7476	.45	.35	74367	SALE	.35

74LS

Part No.	1-9	10+	Part No.	1-9	10+
74LS00	SALE	.15	74LS165	.75	.65
74LS02	SALE	.15	74LS166	SALE	.69
74LS04	SALE	.16	74LS173	SALE	.25
74LS05	SALE	.16	74LS174	SALE	.25
74LS06	.59	.49	74LS175	SALE	.25
74LS07	.59	.49	74LS189	SALE	2.95
74LS08	.28	.18	74LS191	SALE	.39
74LS10	SALE	.15	74LS193	.69	.59
74LS14	SALE	.29	74LS221	SALE	.49
74LS27	SALE	.19	74LS240	SALE	.45
74LS30	SALE	.15	74LS243	SALE	.45
74LS32	SALE	.19	74LS244	SALE	.49
74LS42	.49	.39	74LS245	SALE	.59
74LS47	.89	.79	74LS259	.99	.89
74LS73	SALE	.25	74LS273	.89	.79
74LS74	SALE	.19	74LS279	.49	.39
74LS75	SALE	.25	74LS322	3.49	3.39
74LS76	.39	.29	74LS365	SALE	.35
74LS85	.59	.49	74LS366	SALE	.35
74LS86	.29	.19	74LS367	SALE	.29
74LS90	SALE	.29	74LS368	SALE	.35
74LS93	SALE	.29	74LS373	SALE	.59
74LS123	SALE	.35	74LS374	SALE	.49
74LS125	.49	.39	74LS393	SALE	.69
74LS138	.49	.39	74LS590	5.95	5.85
74LS139	SALE	.29	74LS624	1.95	1.85
74LS154	1.19	1.09	74LS629	SALE	1.95
74LS157	.45	.35	74LS640	SALE	.89
74LS158	SALE	.25	74LS645	SALE	.89
74LS163	SALE	.35	74LS670	SALE	.79
74LS164	SALE	.35	74LS688	2.39	2.29

74S/PROMS*

74S00	SALE	.19	74S188*		1.49
74S04	SALE	.19	74S189		1.49
74S08	SALE	.19	74S196	SALE	.99
74S10	SALE	.19	74S240		1.39
74S32	SALE	.19	74S244	SALE	.75
74S74	SALE	.19	74S253	SALE	.29
74S85	SALE	.49	74S287*		1.49
74S86	SALE	.19	74S288*		1.49
74S124	SALE	1.25	74S373	SALE	.99
74S174	SALE	.25	74S374	SALE	.99
74S175	SALE	.25	74S472*	SALE	2.49

CD—CMOS

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CD4008	.59	CD4081	.22
CD4011	.19	CD4082	.22
CD4013	.29	CD4093	.35
CD4016	.29	CD4094	.89
CD4017	.49	CD40103	1.49
CD4018	.59	CD40107	.49
CD4020	.59	CD4510	.69
CD4024	.45	CD4511	.69
CD4027	.35	CD4520	.75
CD4030	.35	CD4522	.79
CD4040	.65	CD4538	.79
CD4049	.29	CD4541	.89
CD4050	.29	CD4543	.79
CD4051	.59	CD4553	3.95
CD4052	.59	CD4555	.79
CD4053	.59	CD4559	7.95
CD4063	1.49	CD4566	1.95
CD4066	.29	CD4583	.59
CD4067	1.49	CD4584	.49
CD4069	.19	CD4585	.69
CD4070	.29	MC14411P	7.95
CD4071	.22	MC14490P	4.49
CD4072	.22		

EEPROMS

2816A	2048x8	350ns (9V-15V) 5V Read/Write	5.25
2816A-25	2048x8	250ns (9V-15V) 5V Read/Write	5.49
2817A	2048x8	350ns 5V Read/Write	6.95
2864A	8192x8	250ns 5V Read/Write (Pin 1, No R/B)	13.95
2864A-30	8192x8	300ns 5V Read/Write (Pin 1, No R/B)	12.95
2865A-30	8192x8	300ns 5V Read/Write	9.95
52B13	2048x8	350ns (21V) 5V Read Only	1.49

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Z80	1.19
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Z80-PIO	~~1.29~~ .99
Z80A	1.29
Z80A-CTC	1.65
Z80A-DART	~~4.95~~ 3.95
Z80A-PIO	~~1.89~~ 1.49
Z80A-SIO/0	~~3.95~~ 2.95
Z80B	2.75
Z80B-CTC	~~3.95~~ 3.25
Z80B-PIO	3.95
Z8530	4.95
Z8671	7.95
Z8681B1	8.95
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80C31	~~9.95~~ 8.95
8035	~~1.49~~ 1.25
8039	~~1.95~~ 1.59
8052AHBASIC	24.95
8080A	~~2.25~~ 1.49
8085A	2.49
8086	3.95
8086-2	~~6.95~~ 5.49

8000 SERIES Continued

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8087-1 (10MHz)	194.95
8087-2 (8MHz)	159.95
8088 (5MHz)	~~4.95~~ 3.49
8088-2 (8MHz)	~~6.95~~ 5.95
8116	~~4.95~~ 3.95
8155	2.49
8155-2	3.49
8156	2.95
8212	2.29
8224	~~2.25~~ 1.95
8228	~~1.95~~ 1.49
8237-5	~~4.25~~ 3.95
8243	1.75
8250A	~~4.95~~ 3.95
8250B (For IBM)	~~5.95~~ 4.95
8251A	1.69
8253-5	1.95
8254	3.95
8255A-5	2.95
8259-5	~~2.25~~ 1.75
8272	~~3.95~~ 2.95
8279-5	~~2.95~~ 2.75
8741	9.95
8742	~~19.95~~ 17.95
8748 (25V)	7.95

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80287 (6MHz)	159.95
80287-8 (8MHz)	229.95
80287-10 (10MHz)	279.95
80386-16 PGA	309.95
80387-16 (16MHz)	439.95
80387-20 (20MHz)	589.95
80387-25 (25MHz)	689.95
80387-SX (16MHz)	599.95
82284 (8MHz)	9.49
82288 (8MHz)	9.95
DATA ACQUISITION	
ADC0804LCN	2.79
ADC0808CCN	~~5.95~~ 5.49
ADC0809CCN	~~3.69~~ 3.29
ADC1205CCJ-1	19.95
DAC0808LCN	~~1.75~~ 1.49
DAC1008LCN	5.95
AY-3-1015D	~~4.95~~ 3.95
AY-5-1013A	1.95

STATIC RAMS

Part No.	Function		Price
2016-12	2048x8	120ns	~~4.95~~ 3.75
2018-45	2048x8	45ns 300MIL	6.95
2102	1024x1	350ns	.89
2114N	1024x4	450ns	~~.99~~ .79
2114N-2L	1024x4	200ns Low Power	1.49
21C14	1024x4	200ns (CMOS)	.49
5101	256x4	450ns (CMOS)	~~2.95~~ 2.49
6116P-1	2048x8	100ns (16K) CMOS	~~6.25~~ 3.95
6116P-3	2048x8	150ns (16K) CMOS	~~4.95~~ 3.49
6116LP-1	2048x8	100ns (16K) LP CMOS	~~6.49~~ 4.39
6116LP-3	2048x8	150ns (16K) LP CMOS	~~5.99~~ 3.95
6264P-10	8192x8	100ns (64K) CMOS	~~10.49~~ 9.95
6264P-15	8192x8	150ns (64K) CMOS	9.25
6264LP-10	8192x8	100ns (64K) LP CMOS	10.95
6264LP-12	8192x8	120ns (64K) LP CMOS	10.49
6264LP-15	8192x8	150ns (64K) LP CMOS	10.25
6514	1024x4	350ns (CMOS)	~~3.75~~ 3.49
43256-10L	32,768x8	100ns (256K) Low Power	20.95
43256-15L	32,768x8	150ns (256K) Low Power	18.95
62256LP-85	32,768x8	85ns (256K) LP CMOS	22.95
62256LP-10	32,768x8	100ns (256K) LP CMOS	21.95
62256LP-12	32,768x8	120ns (256K) LP CMOS	20.95

DYNAMIC RAMS

THM91000L-10	1,048,576x9	100ns 1Megx9 SIP	~~549.95~~ 399.95
THM91000S-10	1,048,576x9	100ns 1Megx9 SIM	399.95
THM91000L-80	1,048,576x9	80ns 1Megx9 SIP	419.95
THM91000S-80	1,048,576x9	80ns 1Megx9 SIM	419.95
TMS4416-12	16,384x4	120ns	~~7.75~~ 6.75
TMS4416-15	16,384x4	150ns	~~7.25~~ 6.25
4116-15	16,384x1	150ns (MM5290N-2)	~~1.39~~ 1.25
4128-15	131,072x1	150ns (Piggyback)	5.29
4164-100	65,536x1	100ns	3.49
4164-120	65,536x1	120ns	2.95
4164-150	65,536x1	150ns	2.59
41256-60	262,144x1	60ns	14.49
41256-80	262,144x1	80ns	13.49
41256-100	262,144x1	100ns	12.49
41256-120	262,144x1	120ns	11.95
41256-150	262,144x1	150ns	11.49
41264-12	64Kx4	120ns Video RAM	19.95
41464-10	65,536x4	100ns	15.95
41464-12	65,536x4	120ns	14.49
41464-15	65,536x4	150ns	13.95
51258-10	262,144x1	100ns Static Column	12.95
85227-10PL	262,144x9	100ns 256Kx9 SIP	149.95
85227-10PS	262,144x9	100ns 256Kx9 SIM	149.95
511000P-10	1,048,576x1	100ns (1 Meg)	~~39.95~~ 29.95
511000P-80	1,048,576x1	80ns (1 Meg)	42.95
511000P-85	1,048,576x1	85ns (1 Meg)	~~44.95~~ 41.95
514256P-10	262,144x4	100ns (1 Meg)	~~59.95~~ 44.95

EPROMS

TMS2516	2048x8	450ns (25V)	~~6.95~~ 5.95
TMS2532	4096x8	450ns (25V)	~~5.95~~ 4.95
TMS2532A	4096x8	450ns (12.5V)	~~4.49~~ 3.25
TMS2564	8192x8	450ns (25V)	~~6.95~~ 4.95
TMS2716	2048x8	450ns (−5V, +5, +12V)	~~6.95~~ 6.49
1702A	256x8	(1μs)	4.95
2708	1024x8	450ns	6.95
2716	2048x8	450ns (25V)	3.75
2716-1	2048x8	350ns (25V)	~~4.25~~ 3.95
27C16	2048x8	450ns (25V) CMOS	~~4.25~~ 3.75
2732	4096x8	450ns (25V)	3.95
2732A-20	4096x8	200ns (21V)	4.25
2732A-25	4096x8	250ns (21V)	3.95
27C32	4096x8	450ns (25V) CMOS	~~4.95~~ 4.25
2764-20	8192x8	200ns (21V)	4.25
2764-25	8192x8	250ns (21V)	3.59
2764-45	8192x8	450ns (21V)	3.39
2764A-25	8192x8	250ns (12.5V)	3.69
27C64-15	8192x8	150ns (12.5V) CMOS	5.95
27128-20	16,384x8	200ns (21V)	~~6.95~~ 6.49
27128-25	16,384x8	250ns (21V)	5.95
27128A-15	16,384x8	150ns (12.5V)	7.75
27128A-20	16,384x8	200ns (12.5V)	~~5.75~~ 5.25
27128A-25	16,384x8	250ns (12.5V)	~~5.25~~ 4.95
27C128-25	16,384x8	250ns (21V) CMOS	5.95
27256-15	32,768x8	150ns (12.5V)	8.95
27256-20	32,768x8	200ns (12.5V)	~~6.95~~ 6.25
27256-25	32,768x8	250ns (12.5V)	5.49
27C256-15	32,768x8	150ns (12.5V) CMOS	7.95
27C256-25	32,768x8	250ns (12.5V) CMOS	~~6.25~~ 5.49
27512-20	65,536x8	200ns (12.5V)	10.95
27512-25	65,536x8	250ns (12.5V)	9.95
27C512-25	65,536x8	250ns (12.5V) CMOS	~~10.25~~ 9.49
27C1024	131,072x8	200ns (12.5V) CMOS (1 Meg)	27.95

6500/6800 68000 Series

Part No.	Price
6502	2.65
65C02 (CMOS)	7.75
6520	1.95
6522	2.95
6532	~~5.49~~ 4.95
6551	2.95
65C802 (CMOS)	~~15.95~~ 14.75
6800	~~1.95~~ 1.49
6802	2.95
6810	~~1.25~~ .99
6821	1.75
6840	~~3.49~~ 2.95
6845	~~2.75~~ 2.49
6850	~~1.95~~ 1.49
6852	~~.75~~ .59
6854	~~1.19~~ .99
MC68000L8	9.95
MC68000L10	~~11.95~~ 10.95
MC68010L10	~~49.95~~ 39.95
MC68020RC12B	99.95
MC68701	14.95
MC68705P3S	~~9.95~~ 8.95
MC68705U3L	10.95
MC68705U3S	10.95
MC68450L10	49.95
MC68881RC12A	129.95

Commodore

LAG570	9.95
WD1770	~~8.95~~ 7.49
S13052P	~~1.25~~ .99
6504A	1.19
6507	2.95
6510	12.95
6522	2.95
6525	~~4.95~~ 3.95
6526	~~14.95~~ 13.95
6532	~~5.49~~ 4.95
6545-1	3.95
6560	~~10.95~~ 8.95
6567	24.95
6569	~~15.95~~ 13.95
6572	~~10.95~~ 7.95
6581 (12V)	~~12.95~~ 10.49
6582 (9V)	~~14.95~~ 12.95
8502	7.95
8564	~~4.95~~ 2.95
8566	~~9.95~~ 7.95
8701	9.95
8721	~~14.95~~ 9.95
8722	~~13.95~~ 10.95
310654-05	9.95
318018-03	~~12.95~~ 10.95
318019-03	~~12.95~~ 10.95
*82S100PLA**	15.95
901225-01	~~15.95~~ 13.95
901226-01	~~15.95~~ 13.95
901227-03	15.95
901229-05	15.95

*No specs. available

**Note: 82S100PLA = U17 (C-64)

74C/CMOS

74C00	Sale	.19	74C174	Sale	.39
74C02	Sale	.19	74C175	Sale	.59
74C04	Sale	.19	74C192	Sale	.99
74C08	Sale	.19	74C194	Sale	.49
74C10	Sale	.15	74C221		1.79
74C14		.49	74C240	Sale	.75
74C32	Sale	.19	74C244		1.79
74C74		.49	74C373	Sale	1.49
74C85		1.49	74C374	Sale	1.49
74C86	Sale	.19	74C911		6.95
74C89		2.95	74C912	Sale	7.95
74C90		.99	74C915	Sale	1.19
74C151	Sale	1.49	74C917	Sale	3.95
74C154	Sale	2.75	74C920	Sale	3.95
74C157	Sale	1.25	74C921	Sale	2.95
74C160	Sale	.49	74C922		3.95
74C161	Sale	.49	74C923		3.95
74C162	Sale	.49	74C925		5.49
74C173		.59	74C926		5.95

MISC. COMPONENTS

TANTALUM CAPACITORS

TM1/35 .1μf @ 35V	.19	TM4.7/35 4.7μf @ 35V	.45
TM1/35 1μf @ 35V	.19	TM6.8/35 6.8μf @ 35V	.49
TM2.2/35 2.2μf @ 35V	.25	TM10/35 10μf @ 35V	.59

POTENTIOMETERS

Values available (insert ohms into space marked "XX"): 500Ω, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 200K, 1MEG

43PXX ¾ Watt, 15 Turn	.99	63PXX ½ Watt, 1 Turn	.89

TRANSISTORS AND DIODES

PN2222	.13	PN2907	.13	1N4004	.12
2N2222A	.29	2N4401	.12	1N4148	.07
2N3055	.65	1N270	.25	1N4735	.29
2N3904	.12	1N751	.15	C106B1	.49

SWITCHES

JMT123 SPDT, On-On	1.19	206-8 SPST, 16-pin DIP	1.25
MPC121 SPDT, On-Off-On	1.19	MS102 SPST, Momentary	.39

D-SUB CONNECTORS

DB25P Male, 25-pin	.69	DB25S Female, 25-pin	.75

LEDS

XC556R T1¾, Red	.13	XC556Y T1¾, Yellow	.17
XC556G T1¾, Green	.17	XC556C T1¾, Clear/Red	.17

IC SOCKETS

Low Profile		Wire Wrap (Gold) Level #2	
8LP	.11	8WW	.59
14LP	.12	14WW	.65
16LP	.13	16WW	.69
24LP	.25	24WW	1.19
28LP	.27	28WW	1.39
40LP	.29	40WW	1.59

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

74HC HI-SPEED CMOS

Part No.		Price	Part No.		Price
74HC00	SALE	.17	74HC175		.59
74HC02	SALE	.17	74HC221	SALE	.69
74HC04	SALE	.17	74HC240	SALE	.59
74HC08	SALE	.17	74HC244		.79
74HC10	SALE	.19	74HC245	SALE	.69
74HC14		.29	74HC253	SALE	.39
74HC30	SALE	.19	74HC259		.49
74HC32	SALE	.25	74HC273	SALE	.49
74HC74	SALE	.29	74HC373		.69
74HC75	SALE	.29	74HC374	SALE	.59
74HC76	SALE	.29	74HC595		1.29
74HC85		.55	74HC688	SALE	1.25
74HC86	SALE	.25	74HC943	SALE	7.95
74HC123	SALE	.49	74HC4040	SALE	.79
74HC125		.49	74HC4049	SALE	.25
74HC132	SALE	.39	74HC4050	SALE	.25
74HC138		.45	74HC4060	SALE	.69
74HC139	SALE	.35	74HC4511	SALE	.99
74HC154		1.49	74HC4514	SALE	1.79
74HC163	SALE	.39	74HC4538	SALE	.99
74HC174		.59	74HC4543	SALE	.99

74HCT — CMOS TTL

74HCT00	SALE	.15	74HCT139	SALE	.29
74HCT02	SALE	.15	74HCT157	SALE	.19
74HCT04	SALE	.17	74HCT174	SALE	.25
74HCT08	SALE	.15	74HCT175	SALE	.25
74HCT10	SALE	.15	74HCT240	SALE	.59
74HCT32	SALE	.17	74HCT244	SALE	.49
74HCT74	SALE	.25	74HCT245	SALE	.49
74HCT86	SALE	.15	74HCT373	SALE	.45
74HCT138		.39	74HCT374	SALE	.45

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DS0026CN	1.95	LM1458N	.35
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TL084CN	.89	DS14C88N (CMOS)	1.19
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LM311N	.39	MC1648P	2.95
LM317T	.65	LM1871N	1.95
LM318N	.99	LM1872N	1.95
LM319N	1.29	LM1896N-1	1.49
LM323K	3.49	ULN2003A	.75
LM324N	.35	XR2206	3.95
LM338K	4.49	XR2211	2.95
LM339N	.39	XR2243	1.95
LF347N	1.49	26LS29	2.95
LM348N	.69	26LS31	.99
LM350T	2.95	26LS32	.99
LF351N	.49	26LS33	1.49
LF353N	.49	LM2901N	.25
LF355N	.79	LM2907N	1.29
LF356N	.79	LM2917N (8 pin)	1.79
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LM361N	1.49	MC3471P	.99
LM380N-8	.99	MC3479P	3.95
LM386N-3	.89	MC3486P	1.19
LM387N	1.09	MC3487P	.99
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LM399H	3.49	LM3905N	1.19
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TL497ACN	1.49	LM3914N	1.79
NE540H (C540H)	.99	LM3916N	1.49
NE555V	.29	NE5532	.69
XRL555	.59	NE5534	.69
LM556N	.45	7805K (LM340K-5)	1.29
NE558N	.79	7812K (LM340K-12)	1.29
LM565N	.89	7815K (LM340K-15)	1.29
LM567V	.75	7805T (LM340T-5)	.45
NE592N	.75	7812T (LM340T-12)	.45
LM741CN	.29	7815T (LM340T-15)	.45
LM747CN	.49	7905K (LM320K-5)	1.35
MC1350P	.89	7905T (LM320T-5)	.49
MC1377P	2.29	75472	.49
MC1398P	4.95	75477	.89
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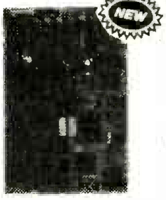
COMPUTER PRODUCTS

Jameco IBM AT Compatible 16MHz 80286 *NEAT* Motherboard



- Expandable to 8MB RAM (Zero-K included)
- 8/16MHz switchable
- Supports all *NEAT* functions including shadow RAM, EMS 4.0, RAM remapping and selectable wait states
- 80287-10 Coprocessor capability
- Norton SI rating of 15.6
- AMI BIOS ROMs included
- One-year warranty

JE3010 8/16MHz *NEAT* (AT) . . **$469.95**

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JE1001	4.77/8MHz (PC/XT)	$ 89.95
JE1002	4.77/10MHz (PC/XT)	$109.95
JE3005	8/12MHz (AT)	$329.95

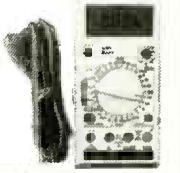
Jameco IBM PC/XT/AT Compatible Computer Cases

JE1019 Pictured

JE1010	Standard PC/XT Flip-Top Case	$34.95
JE1011	Standard PC/XT Slide Case	$39.95
JE1014	Baby XT Turbo Flip-Top Case	$69.95
JE1017	Baby AT Flip-Top Case	$54.95
JE1018	Baby AT Slide Case. . . . ~~$69.95~~	$59.95
JE1019	Baby AT Flip-Top Case	$69.95

TEST EQUIPMENT

Metex M4650:



- Handheld, high accuracy
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M4650. . . . $99.95

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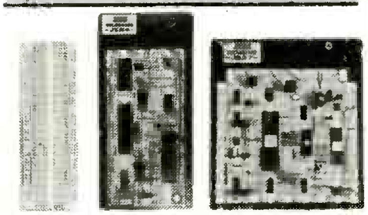

JE23 JE24 JE27

Part No.	Dim. L" x W"	Contact Points	Binding Posts	Price
JE20	6½ x ¾	200	0	$ 1.95
JE21	3¼ x 2⅛	400	0	$ 4.95
JE22	6½ x 1⅜	630	0	$ 5.95
JE23	6½ x 2⅛	830	0	$ 7.95
JE24	6½ x 3⅛	1,360	2	$12.95
JE25	6½ x 4¼	1,660	3	$19.95
JE26	6⅞ x 5¾	2,390	4	$24.95
JE27	7¼ x 7½	3,220	4	$34.95

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400042	NSC Linear Data Book-Vol. II (88)	$ 9.95
400043	NSC Linear Data Book-Vol. III (88)	$ 9.95
210830	Intel Memory Handbook (88)	$17.95
230843	Intel Microsystem Hndbk. Set (88)	$24.95

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- *Free! QAPLUS Diagnostic Software Included!*
- *Free! PC Write Word Processing Software Included!*
- *256K RAM Included, Expandable to 640K*
- *4.77 or 8MHz Switchable*
- *AMI BIOS ROM Included*
- *Save $128.06*

Part No.	Description	Price
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JE1010	Flip-Top Case	34.95
JE1015	XT/AT Compatible Keyboard	59.95
JE1020	5.25" DSDD Disk Drive (Black Bezel)	89.95
JE1030	150 Watt Power Supply	59.95
JE1040	360K Floppy Controller	29.95
JE1050	Mono/Graphics Card with Printer Port	59.95
AMBER	12" Monochrome Amber Monitor	99.95
41256-150	256K RAM (9 chips)	103.41

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JE1061	RS232 Serial Half Card (PC/XT)	$29.95
JE1062	RS232 Serial Half Card (AT)	$34.95
JE1065	I/O Card w/Serial, Game & Parallel Printer Port (AT)	$59.95
JE1081	2MB of expanded or extended memory (zero-K on-board) (AT)	$119.95
JE1082	3MB of expanded or extended memory, parallel printer port, serial port and game port (zero-K on-board) (AT)	~~$169.95~~ $149.95

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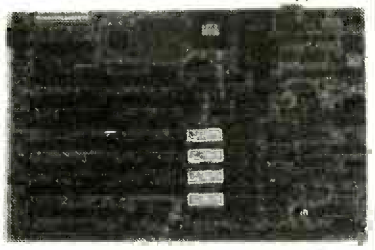
JE1043	360K/720K/1.2MB/1.44MB Floppy Disk Cont. (PC/XT/AT)	$49.95
JE1044	360K Floppy/Hard Disk Controller Card (PC/XT)	$129.95
JE1045	360K/720K/1.2MB/1.44MB Floppy/Hard Disk Controller Card (AT)	$149.95

COMPUTER PERIPHERALS

AMI 80386 Motherboards

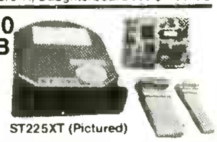
NEW



- Expandable to 2MB (Zero-K incl.) of 32-bit RAM with expansion board (included)
- Expand an additional 8MB using the JE3030 (below, Zero-K incl.)
- XT footprint-AT compatible
- 80387-16/20 capability
- Built-in set-up and diagnostics
- Includes AMI BIOS ROMs
- One-year warranty

JE3020	16MHz 80386 (AT)	$1199.95
JE3025	20MHz 80386 (AT)	$1499.95
JE3030	8MB (Zero-K) Daughterboard	$249.95

Seagate 20,30 40 and 60MB Half Height Hard Disk Drives



ST225XT (Pictured)

ST225	20MB Drive only (PC/XT/AT)	$224.95
ST225XT	20MB w/Controller (PC/XT)	$269.95
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ST238	30MB Drive only (PC/XT/AT)	$249.95
ST238XT	30MB w/Controller (PC/XT)	$299.95
ST238AT	30MB w/Controller (AT)	$389.95
ST251	40MB Drive only (PC/XT/AT)	$379.95
ST251XT	40MB w/Cont. Card (PC/XT)	$419.95
ST251AT	40MB w/Controller Card (AT)	$489.95
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ST277	60MB Drive only (PC/XT/AT)	$449.95
ST277XT	60MB w/Controller (PC/XT)	$499.95
ST277AT	60MB w/Controller Card (AT)	$589.95

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DJ10	40MB Back-Up and Tape	$349.95
TB40	40MB Tape Cartridge	$24.95

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JE1022 (Pictured)

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JE1021	360K Beige Bzl. (PC/XT/AT)	$89.95
JE1022	1.2MB Beige Bzl. (PC/XT/AT)	$99.95

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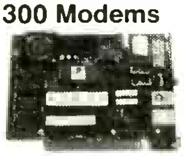
Datatronics 2400/1200/300 Modems



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EPROMS

PART	SIZE	SPEED	Vpp	PRICE
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2716	2048x8	450ns	25V	3.49
2716-1	2048x8	350ns	25V	3.95
2732	4096x8	450ns	25V	3.95
2732A	4096x8	250ns	21V	3.95
27C64	8192x8	250ns	12.5V	4.95
2764	8192x8	450ns	12.5V	3.49
2764-250	8192x8	250ns	12.5V	3.69
2764-200	8192x8	200ns	12.5V	4.25
27128	16384x8	250ns	12.5V	4.95
27128A-200	16384x8	200ns	12.5V	5.95
27C256	32768x8	250ns	12.5V	7.95
27256	32768x8	250ns	12.5V	5.95
27256-200	32768x8	200ns	12.5V	7.95
27512	65536x8	250ns	12.5V	11.95
27C512	65536x8	250ns	12.5V	12.95
27C101-20	131072x8	200ns	12.5V	34.95

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PART	SIZE	SPEED	PRICE
2114	1024x4	450ns	.99
2114L-2	1024x4	200ns	1.49
TC5516	2048x8	250ns	3.95
TMM2016-200	2048x8	200ns	3.25
TMM2016-150	2048x8	150ns	3.29
TMM2016-100	2048x8	100ns	4.29
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HM6116-3	2048x8	150ns	5.95
HM6116-2	2048x8	120ns	6.45
HM6116LP-4	2048x8	200ns	5.95
HM6116LP-3	2048x8	150ns	6.45
HM6116LP-2	2048x8	120ns	6.95
HM6264LP-15	8192x8	150ns	9.95
HM6264LP-12	8192x8	120ns	10.95
HM43256LP-15	32768x8	150ns	17.95
HM43256LP-12	32768x8	120ns	19.95
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PART	SIZE	SPEED	PRICE
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4116-150	16384x1	150ns	.99
4164-150	65536x1	150ns	2.89
4164-120	65536x1	120ns	3.19
4164-100	65536x1	100ns	3.95
TMS4416	16384x4	150ns	8.95
41128-150	131072x1	150ns	5.95
TMS4464-15	65536x4	150ns	14.95
TMS4464-12	65536x4	120ns	15.95
41256-150	262144x1	150ns	12.45
41256-120	262144x1	120ns	12.95
41256-100	262144x1	100ns	13.45
41256-80	262144x1	80ns	13.95
MK4332	32768x1	200ns	6.95
HM51258-100	262144x1	100ns	13.95
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1 MB-100	1048576x1	100ns	37.95

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8087-2	8 MHz	139.95
8087-1	10 MHz	194.95
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80287-8	8 MHz	229.95
80287-10	10 MHz	289.95
80387-16	16 MHz	449.95
80387-SX	16 MHz	599.95
80387-20	20 MHz	599.95
80387-25	25 MHz	699.95

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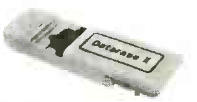
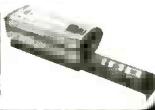


SPECTRONICS CORPORATION

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



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82C83	LATCH	$5.95
82C84	CLOCK GENERATOR	$4.95
82C88	BUS CONTROLLER	$7.95

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6526	13.95
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* CMOS

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6800	1.95
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68B09E	5.49
6808	2.49
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8200

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8255-5	2.49
8256	15.95
8259	1.95
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8272	4.39
8274	4.95
8275	16.95
8279	2.49
8279-5	2.95
8282	3.95
8283	3.95
8284	2.25
8286	3.95
8287	3.95
8288	4.95

8200

8205	3.29
8212	1.49
8216	1.49
8224	2.25
8228	2.25
8237	3.95
8237-5	4.75
8238	4.49
8243	1.95
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8251	1.29
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8253	1.59
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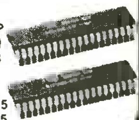

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7407	.29
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7411	.25
7414	.49
7416	.25
7417	.25
7420	.19
7432	.29
7447	.89
7473	.34
7474	.33
7475	.45
7476	.35
7586	.35
7489	2.15
7490	.39
7493	.35
74121	.29
74123	.49
74151	.55
74154	1.49
74157	.55
74166	1.00

74LS00

74LS00	.16
74LS02	.17
74LS03	.18
74LS04	.16
74LS05	.18
74LS08	.18
74LS10	.16
74LS11	.22
74LS14	.39
74LS20	.17
74LS21	.22
74LS27	.23
74LS30	.17
74LS32	.18
74LS38	.26
74LS42	.39
74LS47	.75
74LS51	.17
74LS73	.29
74LS74	.24
74LS75	.29

74LS76	.29
74LS83	.49
74LS85	.49
74LS86	.22
74LS90	.39
74LS92	.49
74LS93	.39
74LS109	.36
74LS112	.29
74LS123	.49
74LS125	.39
74LS132	.39
74LS138	.39
74LS139	.39
74LS151	.39
74LS153	.39
74LS154	1.49
74LS155	.59
74LS156	.49
74LS157	.35
74LS158	.29
74LS161	.39
74LS163	.39
74LS164	.49
74LS165	.65
74LS166	.95
74LS175	.39
74LS192	.69
74LS193	.69
74LS197	.59
74LS221	.59
74LS240	.69
74LS241	.69
74LS244	.69
74LS245	.79
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74S

74S00	.29
74S02	.29
74S04	.29
74S74	.49
74S86	.35
74S112	.50
74S287	1.69
74S288	1.69
74S374	1.69
S32	.35
S138	.79
S240	1.49
S244	1.49
S373	1.69

74F

74F00	.35
74F04	.35
74F08	.35
74F32	.35
74F74	.39
74F138	.79
74F244	1.29

74HC

74HC00	.21
74HC04	.25
74HC08	.25
74HC14	.35
74HC32	.35
74HC74	.35
74HC138	.45
74HC139	.45
74HC154	1.09
74HC157	.55
74HC244	.85
74HC245	.85
74HC373	.69
74HC374	.69

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74HCT138	.35
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8.0	1.95
10.0	1.95
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14.31818	1.95
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18.432	4.95
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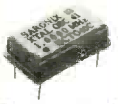

STD. CMOS LOGIC

4001	.19	4050	.29
4011	.19	4051	.69
4013	.35	4060	.69
4015	.29	4066	.29
4016	.29	4069	.19
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4046	.69	4538	.95
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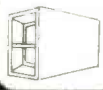

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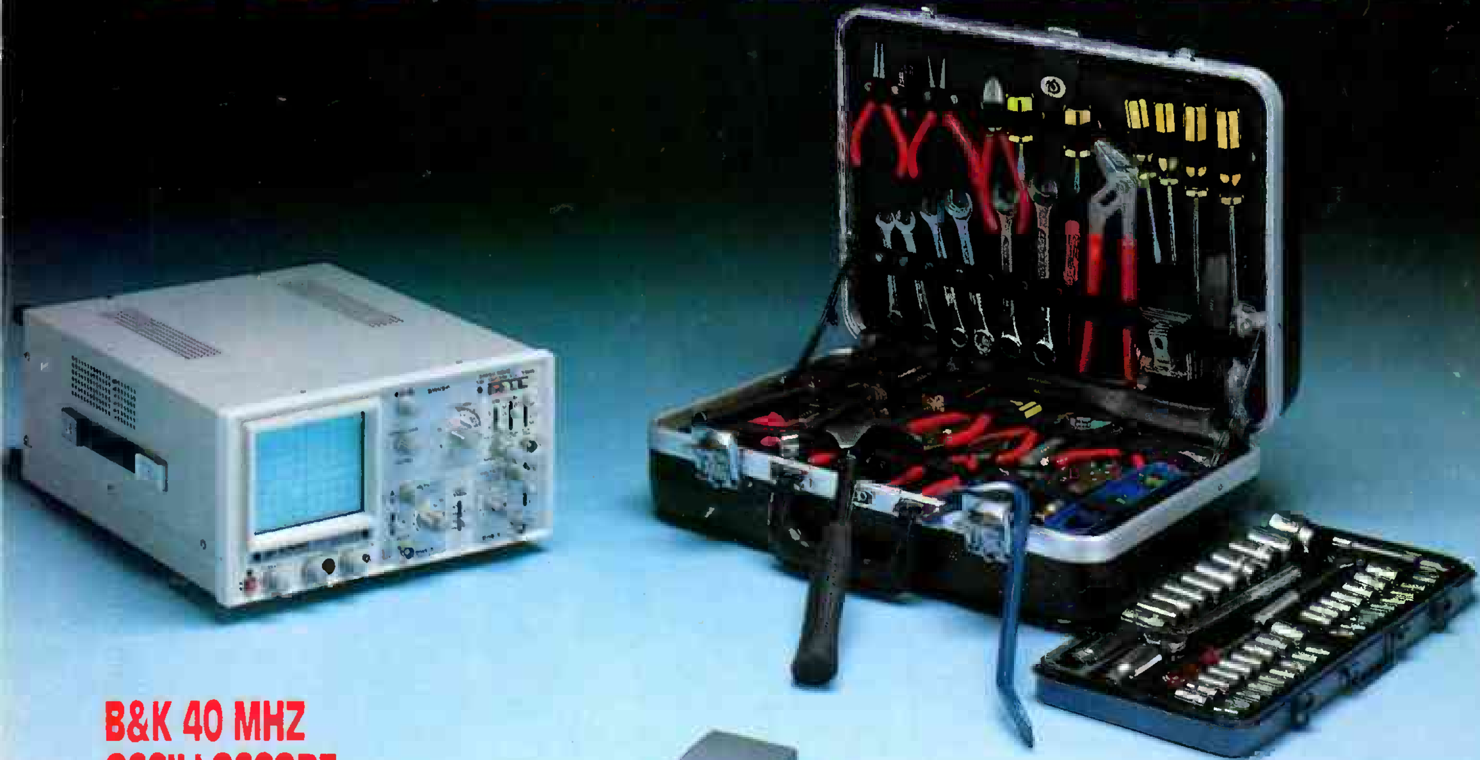

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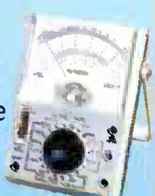

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