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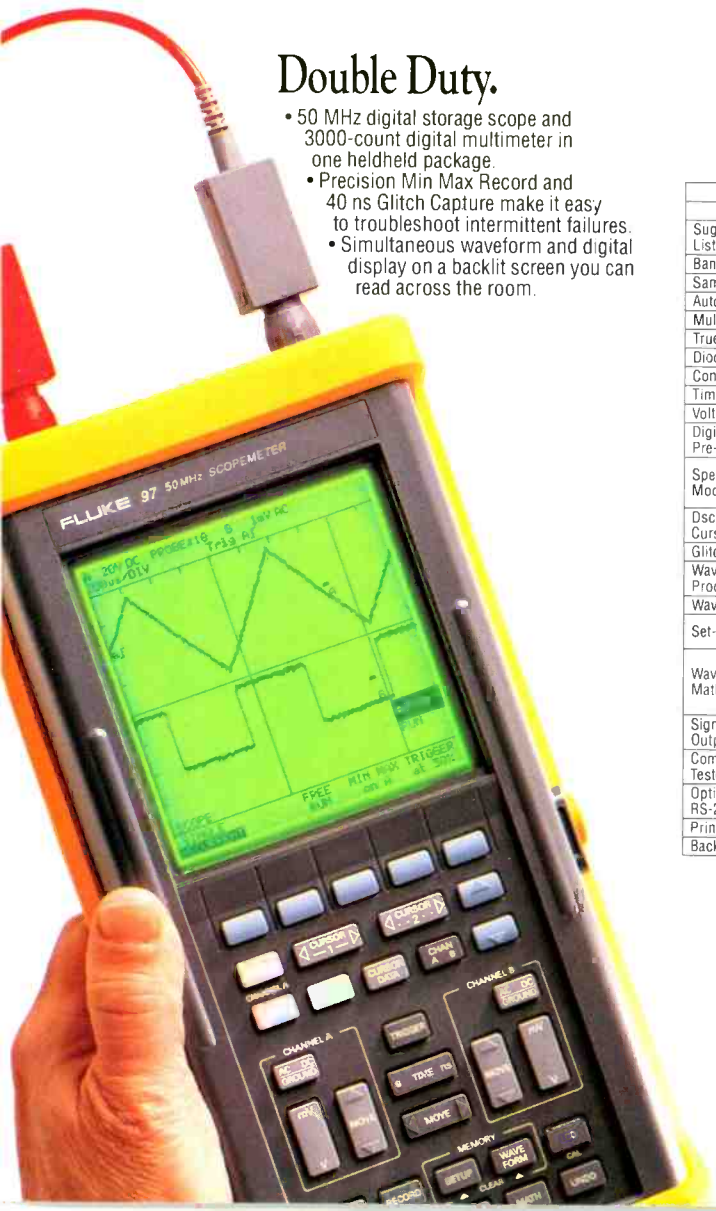

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Vol. 63 No. 1

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Generate square, triangle, and sine waves with this inexpensive benchtop instrument.
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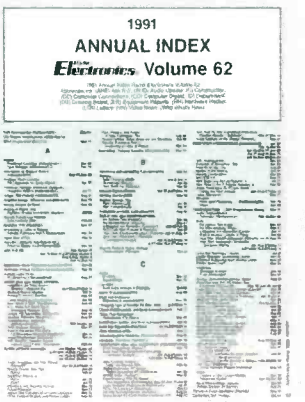

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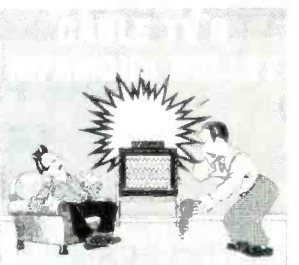

How American Cablevision's "bullet" zapped signal pirates.

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ON THE COVER

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WHAT'S NEWS

A review of the latest happenings in electronics.

Wireless data communication for mobile workers

Incorporating Motorola's RPM400i radio packet modem, a notebook-size, battery-operated computer from IBM (White Plains, NY) will allow users to access and input information to a mainframe computer from remote locations. Service technicians, for instance, could use the 9075 PCradio Model 002 to obtain technical information or order emergency parts without leaving the job site. The modem incorporates the smallest and lightest data radio currently available, according to Motorola. The PCradio operates over the ARDIS network, a partnership of IBM and Motorola that was formed last year to provide nationwide wireless communications to Fortune 1000 companies, and the Mobidata network in Canada. The unit uses an 80C186 microprocessor and operates at either 5 or 10 MHz. The model 002, whose wireless modem operates at up to 4800 bps, can also be used with telephone communications networks (at 2400 bps). PCradio can send or receive fax copies over cellular networks at up to 9600 bps and over landlines at 2400 bps. On cellular networks, with an optional handset, PCradio can be used as a telephone. Two other PCradio models will also be available: The model 001 is a basic unit for conventional telephone communications; the model 003 is designed for cellular-based communications, includes a cellular modem, and can also be used with standard telephone networks. As we go to press, FCC approval has just been granted.

INCORPORATING MOTOROLA'S radio packet modem, IBM'S PCradio can provide a wireless link to larger IBM computers via radio or cellular-based communications—ideal for police officers checking license-plate numbers, sales reps requiring immediate information on product inventories, or service technicians ordering emergency parts.

Highly sensitive moisture sensors

Researchers at Sandia National Laboratories (Albuquerque, NM) have fabricated from silicon extremely sensitive moisture sensors capable of making accurate humidity measurement inside IC's.

Besides their excellent sensitivity and quick response time, the sensors offer several other advantages, including consistent performance at temperatures higher than 100°C. But their primary advantage lies in the fact that because they are made of silicon—the same basic material used to manufacture IC's—the sensors can be made by manufacturing methods that are compatible with the standard techniques used to make IC's. That "complete compatibility" of equipment and procedures holds the promise of the future manufacture of so-called "smart sensors" that combine the sensor and microelectronic logic elements on the IC chip. That opens the door to such applications as environmental control in buildings by integrating a smart humidity sensor within heating, ventilation, and air-conditioning (HVAC) systems.

The capacitor-type sensors use a material known as oxidized porous silicon (OPS) as the moisture-adsorbing dielectric between the two electrodes in the capacitor. When water vapor contacts the sensor, it permeates through the porous volume between the electrodes, causing a net change in the dielectric constant of the porous volume, which is then monitored by measuring the capacitance of the device.

Law-enforcement aircraft

A light utility aircraft has been specially modified by the British company Pilatus Britten Norman to accommodate state-of-the-art surveillance and anti-narcotic detection equipment manufactured by Westinghouse Electronic Systems Group (Baltimore, MD). The modified plane, known as the Multi-Sensor Surveillance Aircraft, or MSSA, features a unique, bulbous nose that provides enough room for the installation of sensors and avionics systems, including the radar and infrared imaging system that form the heart of the MSSA's ability to detect and track unusual activity on the ground or in the air, night or day.

THE WESTINGHOUSE Multi-System Surveillance Aircraft (MSSA), a specially modified light plane fitted with advanced detection and interdiction technologies, is designed for law-enforcement and anti-narcotic surveillance missions.

In addition to the radar (a version of the one supplied by Westinghouse for the USAF's F-16 fighter) and the infrared system (similar to that used by the U.S. Coast Guard), the MSSA has a high-tech operations console and an advanced communications system that put the plane's capabilities at the fingertips of an onboard operator and link them to support personnel in the air or on the ground. The aircraft, which is intended for use in drug interdiction, law-enforcement surveillance, border and fisheries patrol, airspace control, etc., was scheduled to be available by the end of 1991. **R-E**

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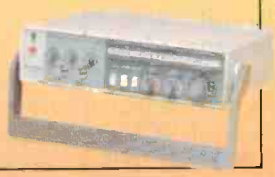

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VIDEO NEWS

What's new in the fast-changing video industry.

DAVID LACHENBRUCH

• **"Flat" tubes.** The catch-phase for next year's color TV sets will be "flat tubes." Panasonic was the first in this latest flat-tube wave, introducing the "SuperFlat" under its premium Prism brand name. The SuperFlat scored a big success in Japan under the name "Gao," which means "king of pictures." The tube has a computer-designed faceplate which isn't really flat but has considerably less curvature than a conventional tube. In addition, the faceplate is extremely dark, providing more contrast, and new electronics supply the power and focus to realize the contrast without a loss of brightness and detail.

Not to be outdone, most other Japanese companies are now preparing their flatter tube versions. Sony will field a "Super Trinitron" in the United States in 1992, and Hitachi, Mitsubishi, and Toshiba are also flattening out their faceplates in Japan. All of this raises the question: What is "flat"? In a previous go-round, Toshiba developed the "FST," which originally stood for the "flat square tube." However, the tube wasn't either flat or square, so Toshiba changed the phrase to "flatter squarer tube," still preserving the acronym "FST."

Thomson Consumer Electronics, whose European tube operation has been selling a tube with a computer-designed faceplate—not quite flat, but with a flat appearance—took a poke at Panasonic's SuperFlat at a recent trade show with the slogan, "Super Planar, world's first super flat tube—4 million sold to date." Then along came Zenith, which is developing a truly flat-faced tube, the FTM (for "flat tension mask") tube that uses a piece of plate glass for a face. Zenith filed a complaint with the Better Business Bureau's National Advertising Division urging it to stop manufacturers from advertising "reduced curvature" tubes as "flat." But, somehow, "SuperReducedCurvature" doesn't have that special ring to it. How about going back to "Gao?"

• **Digital sound for VHS.** First there was a longitudinal monophonic audio track on VHS, then longitudinal stereo, then hi-fi helical stereo. Now, finally, digital stereo is here. In Japan, JVC, Panasonic, Mitsubishi, Hitachi, and Sharp have introduced Super VHS recorders with digital audio tracks. The digital sound will be available only with S-VHS because the layout of the standard VHS signal doesn't have enough space for digital audio. The digital-sound recorders, having analog longitudinal and helical tracks as well, are compatible with previous recorders. The digital-audio system can record two channels at 48-kHz sampling frequency, 16 bits, or four channels at 32 kHz, 12 bits. Principal use of the recorders in Japan will be the tape satellite broadcasts that have digital audio. There's no word on whether the digital-sound recorders will be exported.

• **Public electronics show.** The latest advances in TV's, VCR's, camcorders, and home multimedia products will be on display to the public as the Consumer Electronics Show (CES) in Chicago opens its doors to actual "consumers" for the first time in its 25-year history. It's expected to attract as many as 100,000 visitors from the Chicago area and beyond. In the past, CES has been for the trade only, but this year's show, which will run from May 28 through May 31, will have two public days. May 28 and 29 will be trade-only days, as will the morning of Saturday, May 30, but the show will be open to all visitors from noon Saturday through 6 PM Sunday at the McCormick Convention Center and the Hilton Hotel. The nominal admission price will be $10, but it's expected that dealers and exhibitors will distribute cut-rate tickets. The show's sponsor is the Electronic Industries Association's Consumer Electronics Group (EIA/CEG).

• **Camcorder format war.** The 8mm format was the clear winner in 1991 in the battle of the camcorder formats, with the VHS-C (compact) and full-size VHS models trailing with about equal shares. The EIA tallies sales of "compact" VCR's and full-size VHS. The "compact" category includes both 8mm and VHS-C. For the six months from April through September 1991, compacts outsold full-size units by 70% to 30% (but for the nine months through September, full-size models represented 33.2% of the total). The EIA doesn't break down compacts between VHS-C and 8mm, but the U.S. Commerce Department keeps track of imports of 8mm as a separate category, without breaking down between VHS and VHS-C model imports. In the latest available figures, for 1991's first seven months, 8mm constituted 42% of imported camcorders. Applying these figures to the EIA's data, this indicates that the ratio in 1991 worked out to roughly 40% 8mm and 30% each VHS-C and full-size VHS.

But don't count VHS-C out. The VHS-C proponents, led by Panasonic and JVC, are mounting a major campaign stressing compatibility of VHS-C with VHS home VCR decks by means of the VHS adaptor that comes with all VHS-C camcorders—not to mention a forthcoming generation of VCR's that can accept both VHS and VHS-C cassettes without adaptors.

The latest trends in camcorders include "digital zoom," an electronic extension of optical zoom to provide as much as 100:1 zoom ratio, at least theoretically. At that magnification, however, so much detail is lost that the picture isn't very viewable. Other trends are color LCD viewfinders; internal titles, including pre-selected on-screen messages such as "Birthday Party," "Wedding," "Our Vacation," etc.; and remote controls to permit the user to operate the tripod-mounted camcorder while he or she is in the picture. **R-E**

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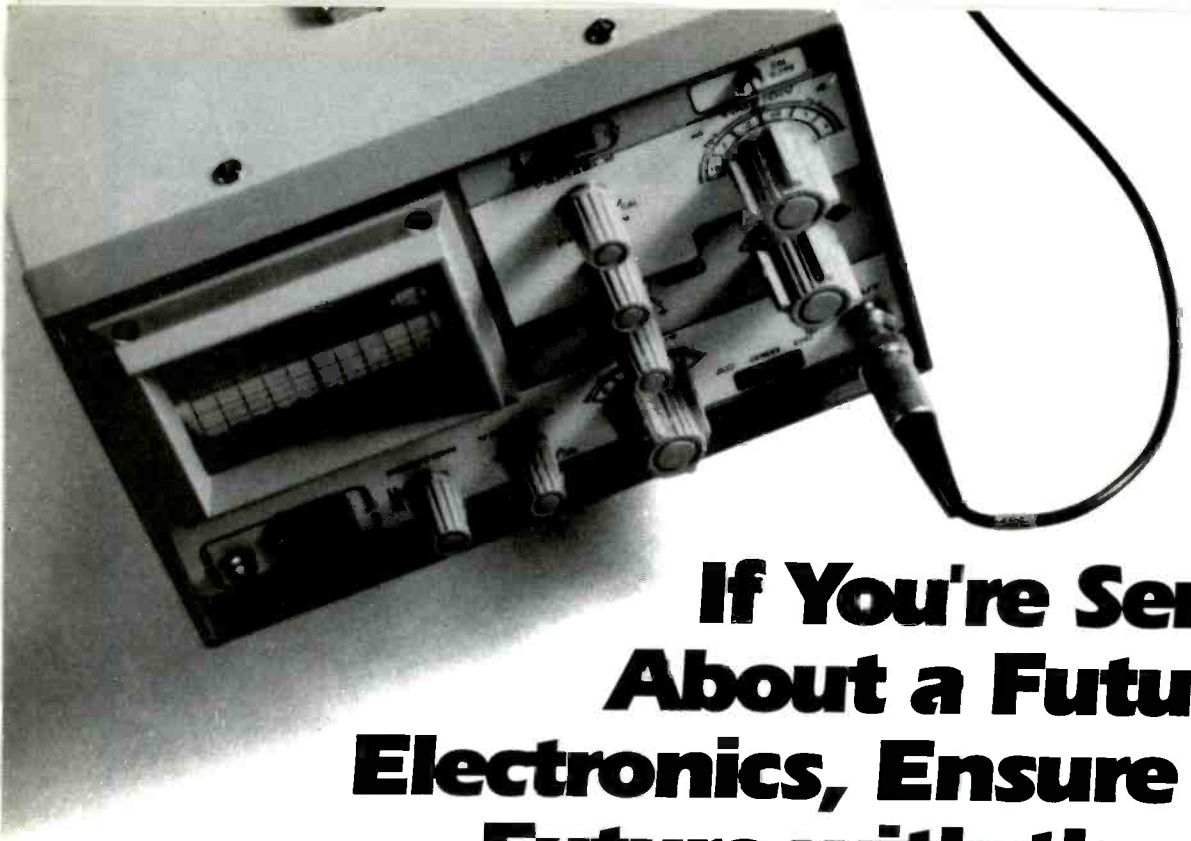

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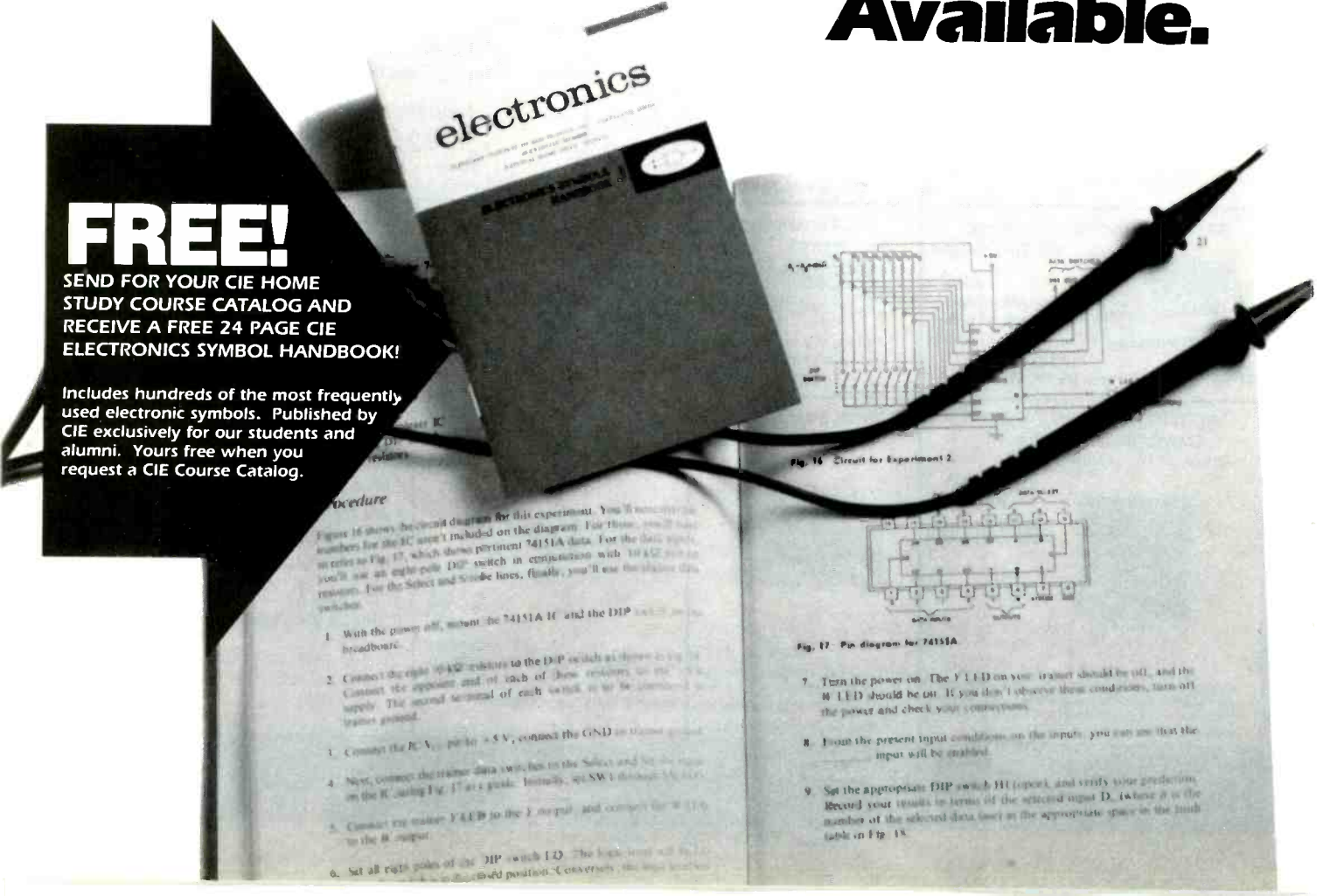

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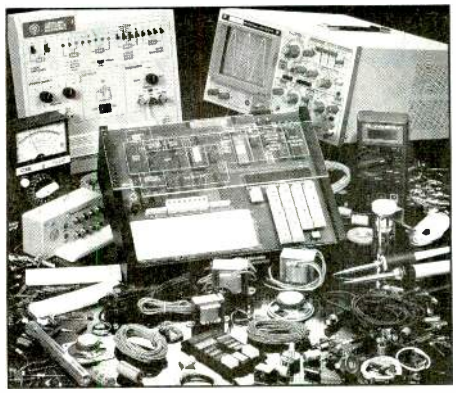

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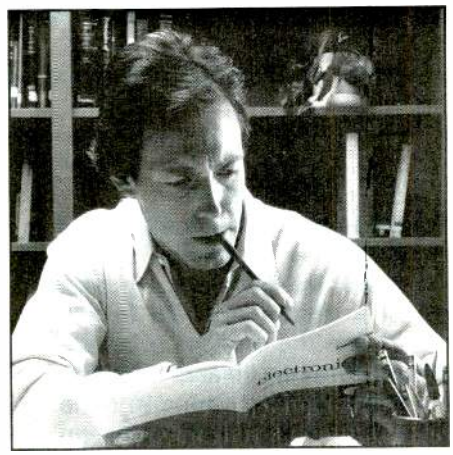

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AUDIO LIGHT

I'd like to build a device that will turn on a light if the decibel sound level of a band exceeds a preset level at a distance of 75 to 100 feet. I'd like the device to be adjustable between 60 and 120 decibels, and when the sound hits the preset level a light will come on and stay on until the sound drops again. Do you have something that can help me?—C. Jones, Broken Arrow, OK

Every time I go to a wedding or other large family affair I think about building something like that. It seems that I always wind up sitting right in front of the band's speakers.

Seriously though, this isn't a difficult thing to design but you can get yourself terribly confused by thinking about things like the distance in feet or the sound level in decibels. What you're really talking about is building yourself an amp to drive a simple VU meter that can be scaled for really high sound levels. Calibrating it to detect a particular sound level at a particular distance should be just a matter of tweaking a potentiometer.

The easiest way to put together a circuit like this is to build it around one of National Semiconductor's LM3915's. That chip will take an analog signal, do all the voltage scaling for you, and give you ten logarithmic outputs that are just what you want for a VU meter. While it's a really simple chip to use, I would suggest very strongly that you get a data sheet for it before you start using it.

The circuit in Fig. 1 is a good beginning for the project you have in mind. It will take four mike inputs, amplify them, and use the outputs to drive an LM3915 set up as a VU meter. One of the nice things about the LM3915 is that simply switching one connection will give you either a bar or dot output. The schematic has the chip arranged for a dot output since you're interested in having a light trigger from only one of the outputs. When you build the circuit, you can hang up to four mikes around the room and use the potentiometer shown in the schematic to calibrate the LM3915 outputs any way you want.

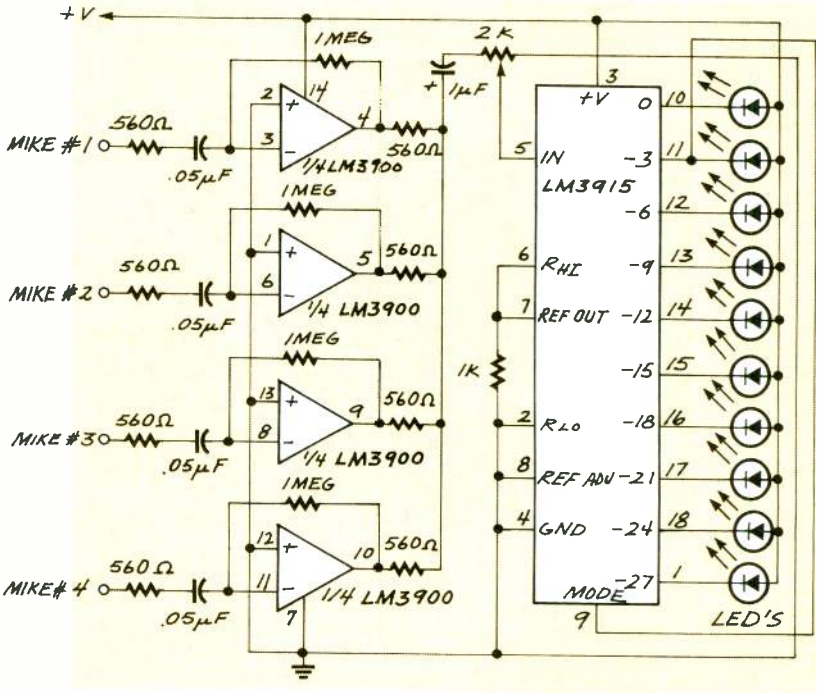

FIG. 1—TO TURN ON A LIGHT whenever the sound level in a room exceeds a preset level, you can use one of National Semiconductor's LM3915's (see text).

Even though I've shown the LED's connected to the chip's outputs, you'll probably want to use one of the outputs to trigger the light you referred to in your letter. I have no idea how bright a light you want to use, but it's a safe bet that you won't be able to connect the bulb directly to any of the outputs of the LM3915. You just won't be able to get the drive current you need.

You can, however, use any of the LM3915 outputs to drive a transistor as shown in Fig. 2, without having to disconnect the LED. Even a small-signal transistor such as a 2N2222 is chunky enough to light a bright nine-volt bulb as shown. If you want a larger bulb—something like an AC line powered 100-watt bulb—use the transistor's output to power a relay whose contacts can handle the current required by the bulb. A relay with contacts rated at two amps would certainly be more than adequate.

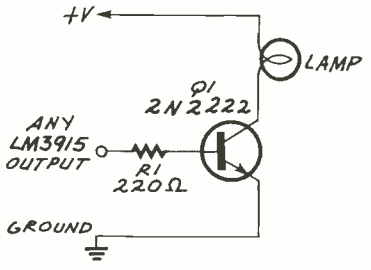

FIG. 2—TO DRIVE HEAVY current loads with an LM3915 output, you must add a transistor as shown here.

COMMERCIAL LIMITER

I've reached my limit as far as television commercials are concerned since some of them are so loud I'm afraid they're going to destroy the speaker in my television set. I've been looking for a circuit that would detect a rise in volume and reduce the level going to the speaker. I found a circuit called the "Commercial Zapper" in an old issue of Radio-Electronics (Feb., 1983), but it blanks out the audio and all I want

to do is reduce it. Do you have anything that will help solve my problem or at least point me in the right direction?—D. Alford Jr., Libuse, LA

I'm fully aware of the problem you're talking about. I don't know how it's possible for people to fall asleep in front of the TV any more since every time I try it, the commercials keep waking me up. Nothing is more annoying than just being on the verge of flaking out during some mindless pap on the tube and being jolted awake by some voice screaming out the virtues of four wheel drive, gourmet dog food or the dirt-eating power of an old detergent in a new box. Maybe we should all stick to public television, pledge drives and all.

The FCC sets strict limits on the audio level that can be sent over the publicly owned (that includes you and me) airwaves and, believe it or not, the people whose grand mission in life is to say as little as they can in as many words as possible always manage to stay within the FCC limits. I've read studies about this and even did some of my own spot measurements to verify it. I'm sorry to report that we can't get them for a violation of the FCC guidelines.

Most of the program audio on the tube has a dynamic range that goes from dead silence to the maximum allowed. The people responsible for the commercials you're complaining about keep the audio level up near the top most of the time and, as far as silence goes, hey, they're paying for thirty seconds and unfortunately they can do anything they want with that time—however obnoxious it might be.

The "Commercial Zapper" you saw in **Radio-Electronics** was designed to put VCR's in pause during commercials so you could automatically eliminate them while you were taping black-and-white movies. The theory behind it was that the color-burst reference signal would be absent during the movie and present only during the commercials. By detecting burst, you could tell when a commercial was coming on and output a signal that would put your VCR in pause.

Most broadcasters leave the burst signal active all the time now, even during black-and-white transmissions, so the Commercial Zapper, while great back then, wouldn't do a lot for you now. And, since you want to reduce only the level of the sound, there are much better ways to get the job done.

Before we start talking about schematics and circuits, there's one big thing you should keep in mind. Modifying any of the stuff inside your TV, even just the audio circuits, can be an extremely dangerous undertaking. Owning a TV set is kind of like being married—it can give you a lot of pleasure if you sit back and enjoy it but you can be in for a lot of trouble if you open it up and fool around with the way it works. There are lots of hazardous components in a TV and they're operating at voltages that can kill you if you're not careful about what you're doing.

If you don't have a good deal of electronic experience under your belt, you should stop reading this right now and switch most of your viewing to public television. Be warned about the hazards in involved.

In order to automatically cut the level of the audio from your TV when it reaches a preset level, you're going to have to modify the audio circuitry in the TV—or at least be able to identify it so you can add to it. You shouldn't do anything to your TV unless you have the paperwork and service manuals so you can locate and identify the circuitry that deals with the audio.

If you don't have or can't get the paperwork but are still determined to modify it, the safest places to get the audio are either at the volume control or the speaker. Unplug the TV from the wall and VERY CAREFULLY discharge the second anode and high-voltage capacitors to avoid a possible shock hazard. Modern TV's use very low leak components and they can hold a charge for a long time.

The circuit you're looking for is an audio limiter—one that will turn the volume down for you whenever the sound gets too loud. Since it's difficult to modify the TV's existing audio circuitry, the best way to do it is to run the audio through a small add-on board. There are lots of limiter circuits but I've been using the limiter circuit shown in Fig. 3 for several years in several applications.

All the current that is drawn by the

continued on page 82

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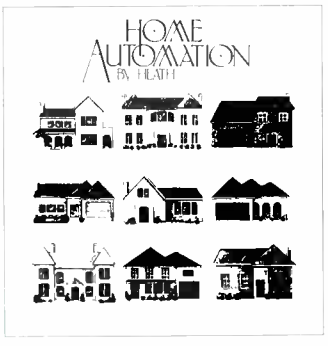

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DIGITAL SINEWAVE GENERATOR

I enjoyed the article "Digital Sinewave Synthesizer" by Steven D. Swift (**Radio-Electronics**, October 1991). About three years ago, I designed an almost identical circuit for work. I needed a precisely controlled sinewave generator that produced six specific frequencies. Based on my experience, I have some comments for the more advanced and creative hobbyists who are building this project.

I have not looked at the contents of the author's EPROM, but Fig. 2-*c* on page 44 led me to believe that his sine-lookup table contains the zero-crossing values of 80 H at 0° and 180° on the waveform. Harmonic distortion can be slightly reduced if the table is offset slightly from these values (by adding 0.5 degrees to the calculation, for example). I can prove this mathematically, but the reasoning might be clearer if you think of the zero crossings as crossover notch distortion. The rate of change of amplitude of the sinewave should be maximum at the zero crossings. It should not dwell there. The theoretical limit of the THD is 0.7% (for 256 steps in an 8-bit EPROM) if this suggestion is followed.

The author's circuit shows a discrete implementation that should work perfectly. Large programmable logic devices, such as the EP1800 series, have architectures ideally suited to the adders and registers that form the heart of the circuit. That is how I implemented my circuit. If only a few output frequencies are required, a second programmable logic device or an array of gates can be used to generate the "A" inputs to the adders. That reduces the flexibility of the circuit, but also eliminates the hassle of looking up binary codes.

If dual outputs are required, two circuits that are clocked by the same clock generator can be constructed. Those outputs can be locked together in phase, or varied in phase if an offset generator is placed between the "S" outputs and the second sine-lookup table EPROM. That then makes possible 26 discrete phases.

The author's circuit has no adjustment for amplitude or phase. Those can easily be added in one more op-amp stage. When I constructed my circuit, I had to back off from 8 bits of resolution at higher frequencies. That caused no problems because higher frequencies were nearer the corner frequency of the low-pass filter, and, therefore, harmonics caused by larger steps were attenuated anyway.

BRUCE CARTER
Port Orange, FL

AUDIO SWEEP/MARKER GENERATOR UPDATE

Anyone building my "Audio Sweep/Marker Generator" (**Radio-Electronics**, February and March 1991) might encounter a problem that we cannot explain. It concerns IC11, an 8-input NAND gate. Two sources of information on the pinout arrangement show that there is no internal connection to pin 1. In the PC layout, pin 1 is connected to pin 2 to make the foil pattern layout a little simpler. That arrangement worked well with my prototype. However, I am indebted to Mr. Gordon La Grange of Baytown, TX, for pointing out that he had to snip off pin 1 before he could get a proper output from the NAND gate. That output is not shown properly in Fig. 13-*e* on page 59 in the March issue. The correct output is properly described in the paragraph almost directly below Fig. 13-*k*. If you invert the pulses in Fig. 13-*e* and make them no wider than a single line width, you'll have a correct picture.

JOHN WANNAMAKER

TRUE TESLA COIL?

In the article entitled "Solid-State Tesla Coil" (**Radio-Electronics**, September 1991), the circuit is described as an end-fed Tesla coil.

I would like to point out that, in actuality, this is not a true Tesla coil, in that Tesla dealt with separately tuned circuits (the primary and the secondary). While it is true that Tesla did use an end-fed resonator in his Colorado Springs "Magnifying Transmitter," an actual RF-coupled coil was used as the signal generator.

The basic idea for an end-fed resonator was devised by a French inventor named Dr. Paul Oudin, who based his work on the experiments of another Frenchman, D'Arsonval. D'Arsonval's work centered around what is known as the D'Arsonval Solenoid. Its purpose was to create, via an inductive/capacitive tank circuit, therapeutic RF currents to treat various bodily dysfunctions. Oudin reasoned that high voltages could be produced if one were to attach a second coil to D'Arsonval's tank circuit.

If one examines Tesla's patents related to his work in early radio, it becomes quite evident that the true definition of the Tesla coil must include separate circuits.

I would also like to comment on the size of the secondary coil in the project. In the case of Tesla's Magnifying Transmitter, the extra (or free-resonant) coil's inductance was actually very low in comparison to the secondary winding that was driving it. The main problem is one of adjusting the frequencies so that the resonant coil runs in the current-fed mode, rather than becoming a simple extension of the driving primary. In the case of the **Radio-Electronics** project, that would imply that the external secondary winding could behave simply as additional windings of the high-frequency ferrite transformer, T2.

If any readers wish further clarification on this, I would suggest the manuscript entitled "Tesla Coils—An RF Power Processing Tutorial for Engineers," by Kenneth & James Corum, Ph.D's. It's available from Corum & Associates, 8551 State Route 534, Windsor, OH 44099.

BRENT C. TURNER
Villa Park, CA

TUBE AMPLIFIERS REVISITED

At this late date, I would like to add my two cents' worth to the ongoing discussion on tube audio amplifiers. I must first admit that I like tube amplifiers and have built several of them myself.

I believe that correctly designed tube and solid-state amplifiers probably do sound the same, as long as you don't drive either one into clipping. However, to never drive an amplifier into clipping at any point in its circuit requires that sufficient voltage and current be available from each stage, so as to always meet the demands made by the next device. In most tube audio amps, everything up to the final stage is run in Class A1, where the tube is a pure transconductance device, whereas a transistor requires current.

Another advantage to tube amps is the fact that they operate at low currents and high voltages. It is much easier to make such a supply smoother and "stiffer." Modern high-end amplifiers and home-built ones made by knowledgeable "audio amateurs" use very large values of filter capacitance in their power supplies to provide a high level of reserve input voltage.

Finally, tube amps are simpler and use fewer active devices. The classic Dynaco uses one voltage-amplifier tube and one phase-inverter triode—both in one envelope as a 7199—to drive its output tubes; the notorious Carver Silver Seven uses essentially the same basic circuit. A solid-state amplifier comparable to the Dynaco, using only discrete parts, would use two dozen transistors.

So, while I must admit that there are some great solid-state amplifiers, I am going to stick with the tube ones. The tubes are still available, the transformers can be found, and the electrical power to run the heaters doesn't cost much. The added benefit to my home-built tube gear is that I had a lot of fun building it and spent very little money.

CHRIS L. DONALDSON
Blue Springs, MO

COMPUTER CLASHES CONTINUED

I really do think that Mr. Cheng's comments in the April "Letters" column went a bit far—and so did Mr. Holtzman's reply. The entire exchange brings to mind the old tale about the blind man and the elephant; it really is tough to discern the big picture through all the fog. As one who has programmed extensively for 80X86 PC's, Amigas, and other computers, I have more comments than I can fit in a reasonably sized letter. A few will have to do.

First, on standardization: As Mr. Holtzman pointed out, the desirable part about standardization is that it facilitates communication. There are two flip sides. One is that many software (as well as hardware) suppliers don't want communication. Suppliers of programs for CAD and music scoring are especially notorious—they want you locked in tight. The second is that standards are often ages out of date—witness the NTSC television standard—to the point of stifling innovation.

The niche machines are a paradox. They owe their existence to the fact that in one important sense they are *more* standardized than PC's. No two PC's are alike, even in such fundamentals as memory organization, video graphics layout, and interrupt organization. As we all know, that causes no end of problems. Within the CPU itself, the instruction set is an unstandardized chaos, having on the order of a thousand individual quirks. Even the largest, best-capitalized organizations have been able to cope with that, so that compiled code tends to be a wretchedly suboptimal joke. The lessons of the old mainframes have yet to be learned.

The upshot is that things that aren't done often enough to support multi-billion-dollar software companies are often best done on niche machines, especially if speed, large memory, or a GUI is desired, or interrupts are needed. Sure, a Lotus or a Microsoft can handle the problems caused by dozens of graphics drivers, dozens of extended memory drivers, more than 500 printer drivers, dozens of slightly different serial and parallel ports, hundreds of quirky BIOS variants, and hundreds or maybe thousands of hard-disk variants. The person who writes a specialized program for filter analysis and sells a few hundred copies probably can't make it multi-compatible, except by resorting to lowest-common-denominator user

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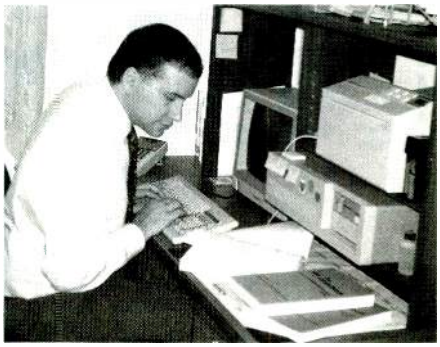

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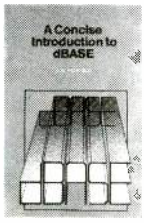

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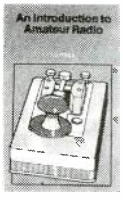

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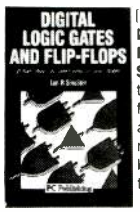

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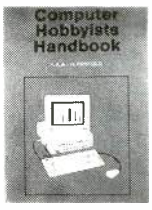

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interfaces and sticking by a 640K memory model. Even then, it's never really certain that the program that runs on my PC will run on the PC next door—and getting it to print properly on the system next door is well nigh out of the question.

So, what will become of those 60 million PC's, plus the Macs, Amigas, Ataris, and so on? It's sad, but humanity has been down this road before, and we find that horse carts, though they were once as abundant proportionally, simply aren't permitted on the freeway. Those computers aren't going to make it either, though some, notably the DOS PC, may well hang on for a long while as windows in some POSIX-OS/2-Windows-DOS-Sparc-Mac-PC-Amiga machine of the future. (After all, if it were worth the trouble, it wouldn't be all that hard to *simulate* an Apple or Commodore 64 of seven years ago on a 486 PC, high-end Mac, or high-end Amiga—*faster than real time!*)

And that raises what should be the hottest issue of all, something far more important than ranting and raving over doomed PC's versus doomed Macs versus doomed Amigas. The issue is our own data, which we must somehow get out of the DOS window and onto that machine of the future—to say nothing of moving it from one application to another or to a supercomputer. We have allowed much of our data, entered laboriously and at tremendous expense, to become embodied in files that are formatted in obtuse, secret, and unstandardized ways.

It is high time that the software manufacturers who practice this are forced to change. They are in effect thieves who have stolen from us what is rightfully our property. It is time to insist that all software that we buy have the capability to disgorge our data in full, including such things as the coordinates of graphical objects, in an open, published-data-interchange format. As a symbolic discouragement to theft and extortion by software manufacturers, and to allow third parties to assist in retrieving the stolen property without fear of litigation, it is time to amend the copyright law to explicitly permit reverse engineering in any program that stores output but won't provide it in an open format, irrespective of any and all language to the contrary in the licensing "agreement."

We have been down this road before. Compiler suppliers once swore that royalty-free function libraries would end the world. Much the same was said of ANSI-standard C, and of spreadsheet DIF files, and so on. Oddly enough, the world is still here. So to any manufacturer who feels this proposal is unreasonable, I say this: Maybe your problem is that your are making money by holding your customers up for ransom, rather than by providing a good product. If so, the sooner you are out of business, the better—preferably on terms that are as punitive as possible to you, your investors, and your bankers. You are not indispensable, regardless of who you think you are or how big you are. There are hungry hordes waiting in the wings to replace you.

PAUL SCHICK
Madison, WI

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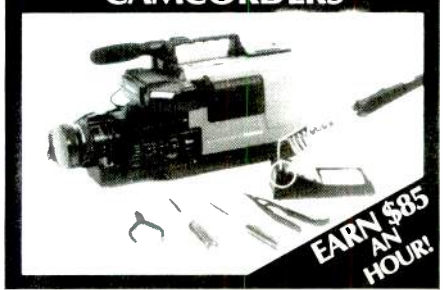
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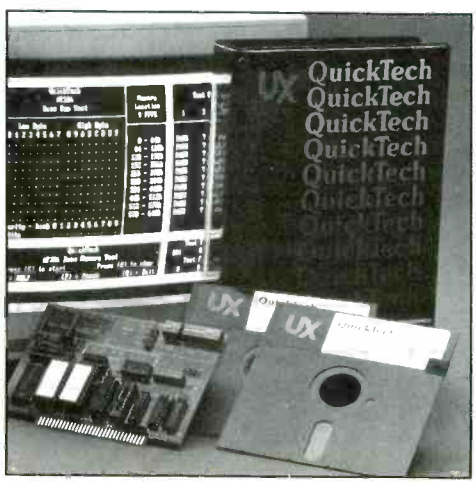

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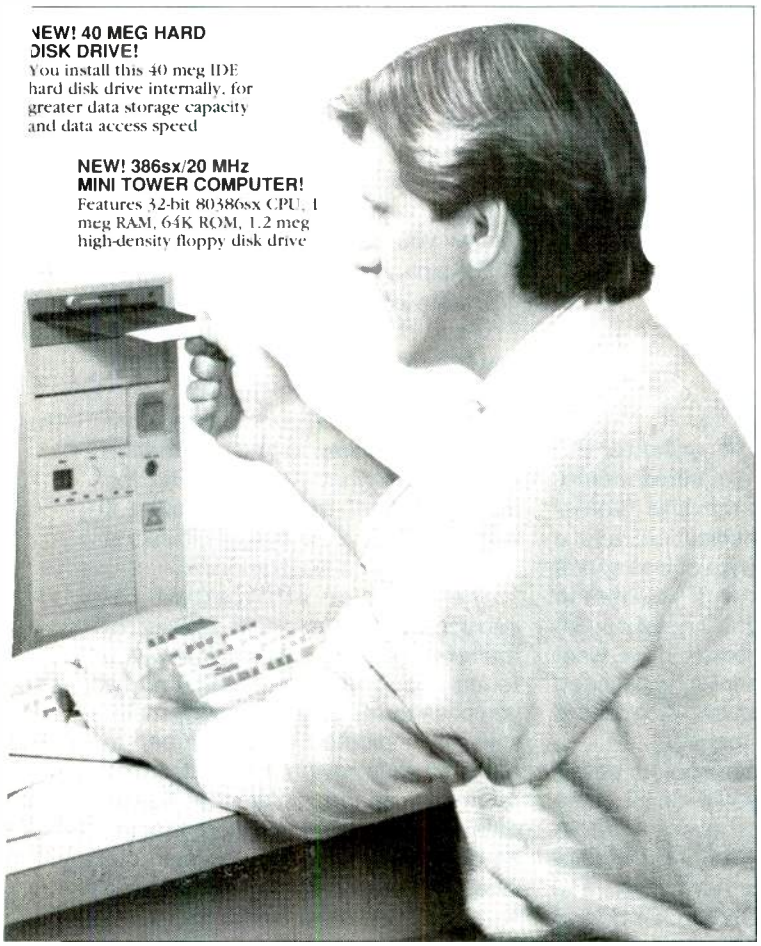

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The *Concise Encyclopedia*, which contains some 7700 articles and 1700 photos and line drawings, is a condensed version of McGraw-Hill's 20-volume encyclopedia. It has been one of our favorite desk references for the past several years because of its broad coverage of more than 75 major science and engineering disciplines. Unfortunately, the book is a bit unwieldy—it has more than 2000 pages, is 3½ inches thick, and weighs several pounds. The *Dictionary of Scientific and Technical Terms* is another impressive reference, with 117,000 terms and definitions.

Unlike a book, you need the right computer equipment to read a CD-ROM. First, of course, you need a CD-ROM drive with the Microsoft CD-ROM extensions that allow DOS to access it. (The extensions are supplied when you purchase a drive.) You also need an IBM AT or better PC with 1 megabyte of expanded memory compatible with the LIM (Lotus-Intel-Microsoft) specification, and a minimum of 1 megabyte of free space on your hard disk drive. If you want to view the graphics, you'll need a VGA graphics card and monitor. If you want to output text to a printer, you'll need a LaserJet or compatible. A mouse is supported, but not required.

As long as you have enough space on your hard disk, you'll run into little problem installing the software. A setup program on the CD-ROM copies files onto your hard disk, and modifies your CONFIG.SYS and AUTOEXEC.BAT files.

Using the database

Once the installation is finished, you're ready to jump into the database. The retrieval software, Discover, is your interface to the reference set. There are several ways to get to the information you want: graphic access, alphabetical access, link-phrases/terms, and complete text search.

Graphic access is the way to go if you don't know the precise term or phrase you want to find information on. A color graphic, "Mirror of the Cosmos" appears on the screen, reflecting the major disciplines of the encyclopedia. You could click on "Engineering," for example, and then be presented with another graphic—this time it's a laboratory bench with notebooks and textbooks scattered around and on shelves, with titles such as "Electrical Power," "Telecommunications," "Physical Electronics," and "Electronic Circuits." When you click on one of those, you're brought to another, non-graphic menu, which allows you to further narrow your choice.

For alphabetic access, you display the table of contents. But since all 7700 articles can't fit on the screen, you have to "expand" it alphabetically to get to the choice you want.

Accessing a "link phrase" is, however, the best way to find information if you know what you're looking for. It's the fastest method, because it works by finding the *hypertext* links in each article and illustration.

The provision of hypertext capabilities is an important feature of the reference set. The links allow you to jump for one article to another as you pass terms of interest. Any major links are indicated on the screen in color. You can navigate the data in the reference via the "links" that tie the data together. So if you were reading an article on electronic listening devices, you might see links to "Amplifiers" or "Radio Transmitter."

It is also possible to do a word search on the entire database, but that inefficient searching takes an awful long time.

We found the data base to be relatively easy to use, although we would have preferred to have an on-disc tutorial. After all, there's certainly enough room on the disc for a multi-megabyte tutorial.

We think that the *McGraw-Hill CD-ROM Science and Technical Reference Set* is a very strong product. Before you buy, however, consider that the paper versions are available for a total of just over $200. The CD-ROM, which has much lower production costs, sells for $495. **R-E**

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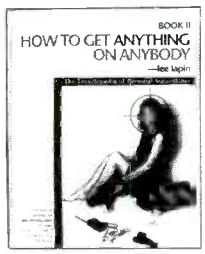

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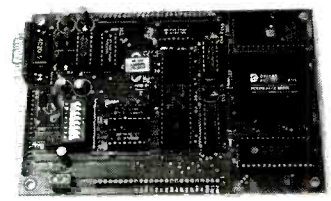

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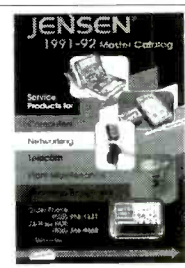

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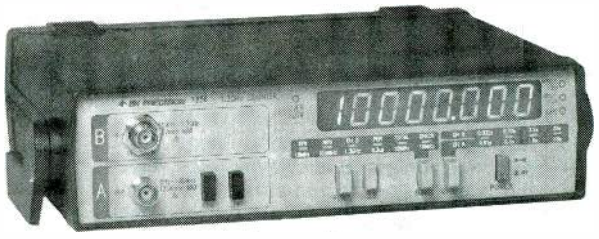
MULTIFUNCTION COUNTER. Especially well-suited for the communications industry, *B&K Precision's 1856 multifunction counter* can be used to make highly accurate and repeatable measurements of radio transmitter frequency right up to the microwave range. It exceeds the requirements for adjusting transmitter frequency to FCC standards, as required for radio stations or land mobile, radio telephone receivers. Because the 1856 extends to 1.3 GHz, it even covers cellular channels.

The counter has a 5-Hz to 1.3-GHz bandwidth and a TCXO (temperature-compensated crystal oscillator) timebase with 0.5-ppm stability at 23±5°C and 1-ppm stability from 0 to 50°C. The model 1856's functions include frequency, period, period average, and totalize. The period-measurement function, used for very low-frequency measurements, makes



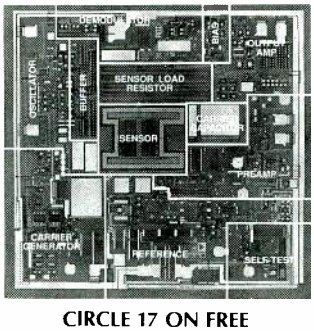
CIRCLE 16 ON FREE INFORMATION CARD

it easy to measure tone-encoding functions used in may types of communications systems. In the totalize mode, useful in counting the number of operations performed by production machines or in quality-control tests, pulses from 5 Hz to 10 MHz are counted up to 99,999,999. Reset and hold can be performed using a switch, or using a remote start/stop input.

The compact model 1856 measures 2.5×9.4×7.5 inches and weighs 3.3 pounds. It's large, high-intensity, 8-digit LED readout provides kHz/μs, MHz/ms, gate, and overflow indicators. A detachable power cord, a schematic, parts list, spare fuses, and an instruction manual are included. Optional accessories include an antenna for conveniently checking transmitter frequency and a 10:1/ direct probe.

The model 1856 multifunction counter has a suggested list price of $495.—**B&K Precision**, 6470 West Cortland Street, Chicago, IL 60635; Phone: 312-889-1448.

ACCELERATION SENSOR. According to *Analog Devices*, their *ADXL-50* is the industry's first surface-micromachined acceleration sensor (accelerometer) and the only one to offer complete signal-conditioning and self-test circuitry on-chip. Designed primarily for automotive applications such as collision detection, active suspension, and anti-skid braking systems, the device measures acceleration in a single plane of sensitivity over the ±50-g range to an accuracy of 5%. Self-test circuitry is activated by a digital command and guarantees operation of both the sensor and associated signal conditioning to stated specifications. That



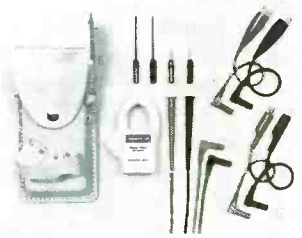
CIRCLE 17 ON FREE INFORMATION CARD

is a vital feature in applications such as air-bag systems. The ADXL-50 measures only 500μm × 625μm, much smaller than other types of micromachined sensors. Unlike other accelerometers that monitor the resistance change of stressed piezoresistors to detect acceleration, the ADXL-50 measures the changes in capacitance, and is therefore insensitive to temperature changes.

The sensor operates in a force/balance mode. Voltage is applied to the sensor, which produces a force exactly opposite to that caused under acceleration. The sensor therefore remains at rest at all times, and the nonlinear mechanical properties of the silicon structure can be effectively ignored. Signal-conditioning circuitry provides excitation signals for the sensor, then amplifies and linearizes the analog output signal to 0.25 to 4.74 volts.

The ADXL-50 accelerometer costs $23.00 (100's) and $5.00 in automotive OEM quantities.—**Analog Devices**, Literature Center, 70 Shawmut Road, Canton, MA 02021.

DMM ACCESSORIES. A new line of modular test accessories from *Fieldpiece* is designed to solve such on-site servicing problems as not having the right test lead for the job, alligator clips that pop off of test points, and too-short probe tips. The solution is simple but innovative: All the accessory connectors, including the connection between the probe tip and the probe handle, are standard banana plugs or jacks. A female banana jack, built into the "handle" of the deluxe test lead, fits a sleeved male banana plug. The line includes a variety of probe tips, alligator clips with pigtails, and a current clamp head, all of which plug onto the end of the deluxe test lead. One test lead end can be plugged into another to double the length of the test lead; with the addition of an alligator clip, it's possible to build an 8-foot



CIRCLE 18 ON FREE INFORMATION CARD

ground lead that is unlikely to come apart. The accessory kit, model *ADK10* includes a pair (red and black) of each of the following: 42-inch test leads, small and large alligator clips, and short (½-inch) and long (3-inch) probe tips, packed in a plastic box.

The box has room for the model *ACH current clamp head*, which can be used with Fieldpiece "Stick"-style DMM's as well as any multimeter with 1mVDC resolution (most meters). The small-head clamp fits into tight spaces and measures current up to 300 amps. Also available is the *ALC1 leather case*, which holds a DMM and accessories. It has a belt loop on the back and leather loops on the front hold two extra probe tips or the ACH current clamp head. The leather case can accommodate a "Stick," Fluke 70 Series (without the boot), or Beckman 220/150 Series (without the tilt stand) multimeter. It is available with the accessories and current clamp head as model *ALCK8*.

The ADK10 accessory kit, ACH current clamp head, ALC1 leather case, and ALC8 leather case with accessories and current clamp head cost $26.95, $24.95, $24.95, and $59.95, respectively.—**Fieldpiece Instruments, Inc.**, 8322B Artesia Blvd., Buena Park, CA 90621; Phone: 714-992-1239; Fax: 714-992-1239.

UV-LIGHT-BLOCKING EPROM LABEL. When used on EPROM packages, a UV-opaque write-on label from *DATAK* (*Cat# EP-1*) gives added assurance that the burned program will not be accidentally erased by stray light from fluorescent lamps or other ultra-violet sources. The label consists of a white polyurethane layer for writing, a black opaque-vinyl layer, and a layer of pressure-sensitive adhesive. The flexible film construction conforms to EPROM packages having raised windows. The label can be removed without leaving an adhesive residue on the EPROM package. Sized to fit on top of a 24-pin wide DIP, the 1.1×0.46-inch label will accommodate three lines of standard type. It can be written on with a typewriter, ball-point pen, soft pencil, or any platten feed computer printer.

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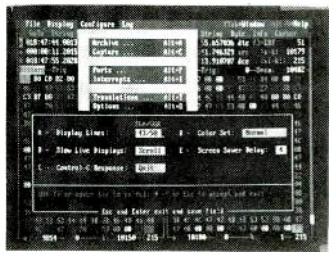
147 UV-opaque EPROM labels on three sheets, costs $4.00.—**DATAK Corporation**, 55 Freeport Blvd., #23, Sparks, NV 89431; Phone: 702-359-7474; Fax: 702-359-7494.



CIRCLE 20 ON FREE INFORMATION CARD

SERIAL LINE MONITOR/PROTOCOL ANALYZER SOFTWARE. *DataScope Version 2.0* transforms a PC into a passive or active RS-232 data and signal-line monitor that can eliminate guesswork while dealing with serial transmissions. The upgraded version of *Paladin Software's* program is still capable of collecting 8 megabytes of data and signal information with microsecond time-stamp resolution, but has been enhanced with tiled concurrent window displays and a pull-down menu interface. Up to four unique and simultaneous displays can be active at the same time, providing passive, interactive, and historic monitoring in any user-selected combination. Display tiles can be combined to create larger windows, and on of four presentation filters (mixed, alternating, COM1, or COM2) can be applied to every window. DataScope can operate at all possible rates up to 115,200 baud, while matching user-specified trigger strings against incoming data. It offers full archive-parameter control combined with pre-, center-, and post-trigger positioning. Character translation sets can be replaced or altered by the user to modify the translation strings and/or attributes for each source separately. Version 2.0 runs on all IBM-PC-compatible machines with MS-DOS 2.1 or above, 256K of available RAM, and at least one serial port.

DataScope Version 2.0, with connector shells, cables, and a comprehensive manual, costs $249.—**Paladin Software, Inc.**, 3945 Kenosha Avenue, San Diego, CA 92117; Phone: 619-490-0368.

CEBUS-NETWORK DEVELOPMENT PRODUCTS. An integrated circuit, a modem subsystem, and an evaluation system from *Intellon Corporation* will enable manufacturers and application developers to implement carrier sense/multiple access (CSMA) networks over standard AC electrical wiring. The products are based on Intellon's patented "Spread Spectrum Carrier" technology, which is being considered by the Electronic Industries Association as the power-line signalling standard for its Consumer Electronics Bus (CEBus). The CEBus power line standard offers more than 100 times the speed of the power line signalling method most widely used today, and will enable communication and control among electrical devices, sensors, and control systems in homes and commercial buildings.

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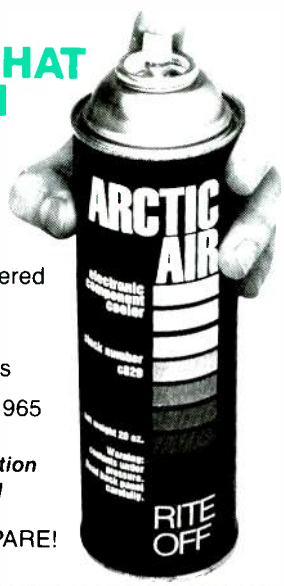

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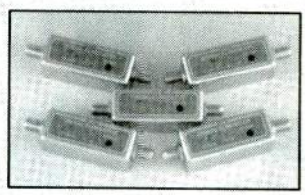

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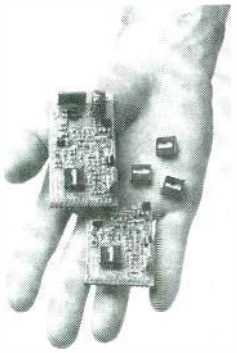
(SSPM), built around the *SSPM IC*, is said by Intellon to be the first integrated circuit to implement the EIA's proposed CEBus power line physical layer standard. The 28-pin chip operates at the CEBus standard rate of 10,000 "1" bits per second. It generates and receives all the required signalling information, handles the CEBus physical layer protocol, and assists the higher-layer protocols. The modem board, which can be attached to a power supply and a host microprocessor that supports CEBus protocols, helps speed application development by freeing engineers from developing and testing the power line network hardware.

The evaluation system allows developers to evaluate CEBus and Spread



CIRCLE 21 ON FREE INFORMATION CARD

Spectrum Carrier technology and to implement a demonstration CEBus CSMA network that communicates over AC power wiring, which can be used to model and analyze network characteristics by creating and running various traffic-loading scenarios. The system includes software that runs on any IBM or compatible PC and three complete CEBus network nodes. It features an electronic mail system to demonstrate the network and its capabilities.

The evaluation system costs $3,495; the SSPM chip and the modem board (pictured) cost less than $5 plus a one-time, $2500 license fee in OEM quantities and $105 in quantities of ten, respectively.—**Intellon Corporation**, 5150 West Highway 40, Ocala, FL 32675; Phone: 914-237-7416; Fax: 914-237-7616.

BEZEL SELECTION. Designed for use in the electronics industry as a frame for LCD displays, *Ili's Bezel Beautiful* comes in four popular sizes that fit most LCD small-character displays. Available in colors (red, yellow, and blue) as well as black and white, Bezel Beautiful is molded in UL-listed, machinable, engineering-grade plastic. Molded with a slightly concave, outward curve from mounting edge to mounting edge, the bezel automatically adjusts itself to align without any gaps or spaces against any panel. Once mounted, it will remain flat on the face of the product to which it has been bonded for the life of the unit. It can be attached using the heat-seal method, sheet-metal screws, or a glue gun. The bezels come in four sizes, with measurements in inches for the viewing area of 1 × 2.5, 0.7 × 1.8, 0.7 × 2.5, and 0.7 × 3.5.

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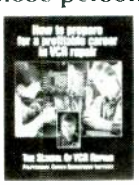

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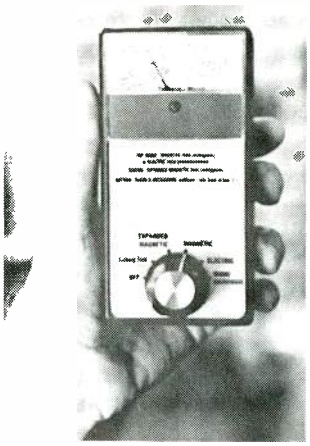
Bezel Beautiful is priced at less than a dollar each in OEM quantities.—**International Instrumentation Incorporated (III)**, Box 3751, Thousand Oaks, CA 91359; Phone: 805-495-7673.

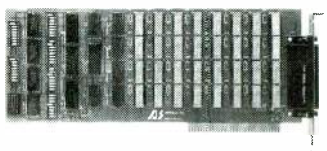
TRI-FIELD METER. The *Tri-Field Meter* from *AlphaLab* independently reads AC electric fields, AC magnetic fields, and radio/microwaves with multi-directional sensors that read field strengths in all directions simultaneously. It reads all three types of fields numerically and with a safe/borderline/high scale, weighted proportionally to the fields' effect on the body. Thresholds are based on epidemiological and laboratory studies. Although no absolute hazard thresholds have been established, reduction of relative exposure is advised. The meter comes with batteries, instructions, and a one-year limited warranty.



CIRCLE 23 ON FREE INFORMATION CARD

The Tri-Field Meter costs $100 postpaid.—**AlphaLab**, 1272 East Alameda Ave., Salt Lake City, UT 84102; Phone: 503-621-9701.

32-SWITCH CONTROL CARD. An eight-bit computer board from *AccuSys*, dubbed the *32 Switch Reed Relay Card* gives any PC the ability to select and control 32 analog or digital signals with ease. Any signal up to 100 volts and 10 watts can be controlled by the computer. Because there is no address limit to the number of boards that can co-reside in a single PC, one computer can control the connection of hundreds of signals by plugging in as many switch cards as there are available slots. The *32 Switch Card's* ability to route multiple analog signals through a single interface eliminates the need for redundant modems. When combined with higher capacity external relays, the card is capable of more active functions. For instance, when combined with an application that senses energies, it can switch off water heaters and household appliances when they aren't needed and automatically close ventilation systems or call the police or fire department when sensing a fire or break-in.



CIRCLE 24 ON FREE INFORMATION CARD

The *32 Switch Reed Relay Card*, including software interface examples with source code in Assembler, BASIC, C, Fortran, Cobol, and dBASE, costs $395.—**AccuSys, Inc.**, 3695 Kings Row, Reno, NV 89503; Phone 702-746-1111. **R-E**

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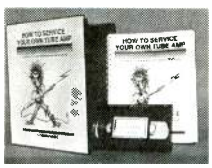
HOW TO SERVICE YOUR OWN TUBE AMP; by Tom Mitchell. Media Concepts, P.O. Box 1408, Norwalk, CT 90651-1408; 213-594-4717; $69.95.

This "how-to" course is a complete multi-media package that consists of a 247-page guidebook and a 68-minute videotape, stored in a plastic binder. Designed to save musicians money, the program instructs guitarists on the care, service, and modification of their tube-based guitar amplifiers. The author claims that, by following the instructions in the course, users can diagnose and repair more than 95% of all tube amplifier breakdowns and problems.



CIRCLE 28 ON FREE INFORMATION CARD

In a nontechnical, informal, and entertaining style, the program introduces guitarists to electronics, explaining how to recognize components, exploring basic amplifier circuits, describing tools and test equipment, and providing in-depth coverage of tubes, transformers, speakers, and enclosures. It discusses how to read schematic diagrams, how to troubleshoot with voltage charts, biasing, and the correct ways to use an amplifier. Included are voltage charts for most common amplifiers, ten troubleshooting flowcharts, a maintenance checklist, and useful reference information. Several do-it-yourself amplifier modifications are also described.

HMC FULL LINE CATALOG; from Hub Material Company, 33 Springfield Avenue, Canton, MA 02021; Phone: 617-821-1870; Fax: 617-821-4133; free.

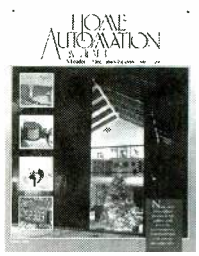
Containing a broad selection of products for electronics professionals and hobbyists, this 142-page catalog features a full index, a table of contents, and color-coded pages to help readers find specific items. The fully-illustrated guide to electronic tools, test equipment, and supplies for the manufacture, assembly, and repair of electronics contains a variety of brand-name, competitively priced products.

CIRCLE 25 ON FREE INFORMATION CARD

Included are test instruments (DMM's, oscilloscopes, and datacommunications and telecommunications test sets), tool kits and precision hand tools, soldering and desoldering systems and supplies (fluxes, solder, tips, wick, and sponges), lamps and magnifiers, and antistatic devices (bags, wrist straps, mats, runners, meters, and ionizers. Product descriptions are accompanied by photographs and prices, as well as "Tech Tips" and comparison tables to make selection easier.

HOLIDAY 1991 HOME AUTOMATION BY HEATH; from Heath Company, Dept. 350-058, Benton Harbor, MI 49022; Phone: 1-800-44-HEATH; free.

Consumer products designed for safety, security, convenience, entertainment, and energy management are featured in this 40-page, full-color catalog.



CIRCLE 26 ON FREE INFORMATION CARD

Aimed at do-it-yourselfers and electronics hobbyists, the catalog introduces several new products, including an electronic drape controller that allows drapes to be controlled by a handheld remote or be programmed to open or close at set times throughout the day, three air cleaners that electronically deep-clean the air, a gas detector that sounds a loud alarm in the event of a poisonous or explosive gas leak, and a wireless add-on light switch for installation in staircases or long hallways that need a light switch at each end. Also featured in the catalog are whole-house automation and security systems, motion-sensing indoor and outdoor lighting controls, security cameras, wireless video broadcasters, and energy-saving thermostats. The catalog provides technical information on the products, and explains how the products work. Such topics as passive-infrared technology, X-10 technology, and how time is measured are also discussed.

AUDIO FLYER; from Parts Express, 340 East First St., Dayton, OH 45402-1257; Phone: 513-222-0173; Fax: 513-222-4644; free.

Audiophiles and electronics enthusiasts alike will appreciate the selection of goods offered in this 44-page, full-color catalog.

CIRCLE 27 ON FREE INFORMATION CARD

The catalog is filled with audio sound components and accessories; cables and wires; audio accessories; cables, speaker enclosures, woofers, midranges, tweeters, and full speaker systems; P.A. equipment; and crossovers. Highlights of this issue include decorative wall plates and accessories for in-wall installed audio systems; 12-gauge neon wire; in-wall speakers; several woofers; and an iso-tip butane soldering iron. **R-E**

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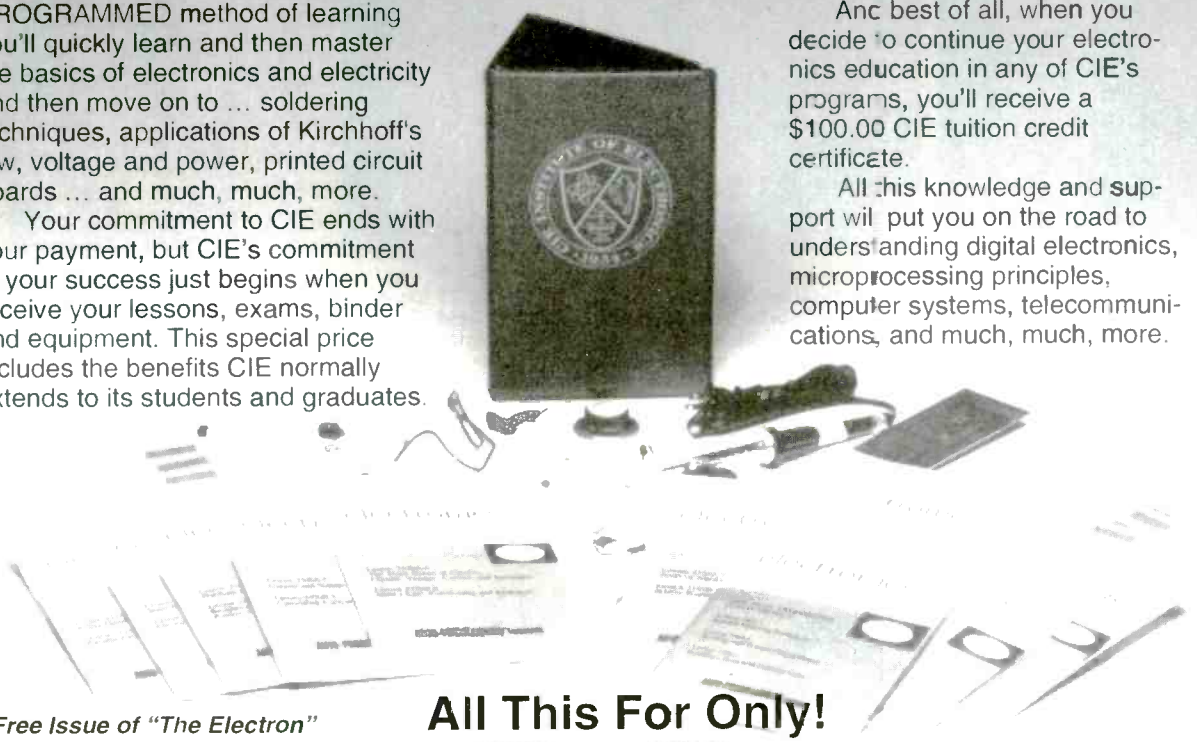

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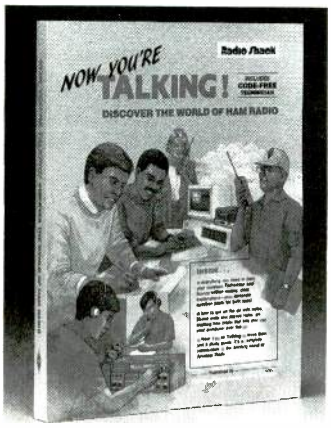

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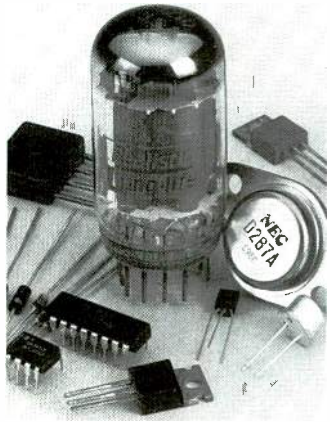

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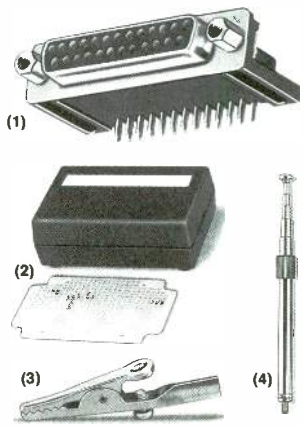

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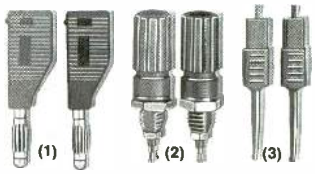

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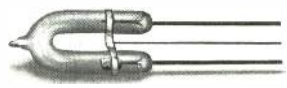

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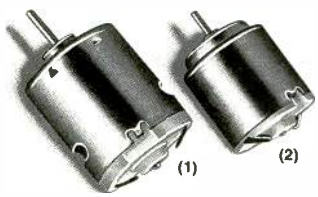

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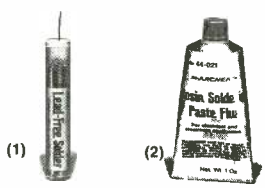

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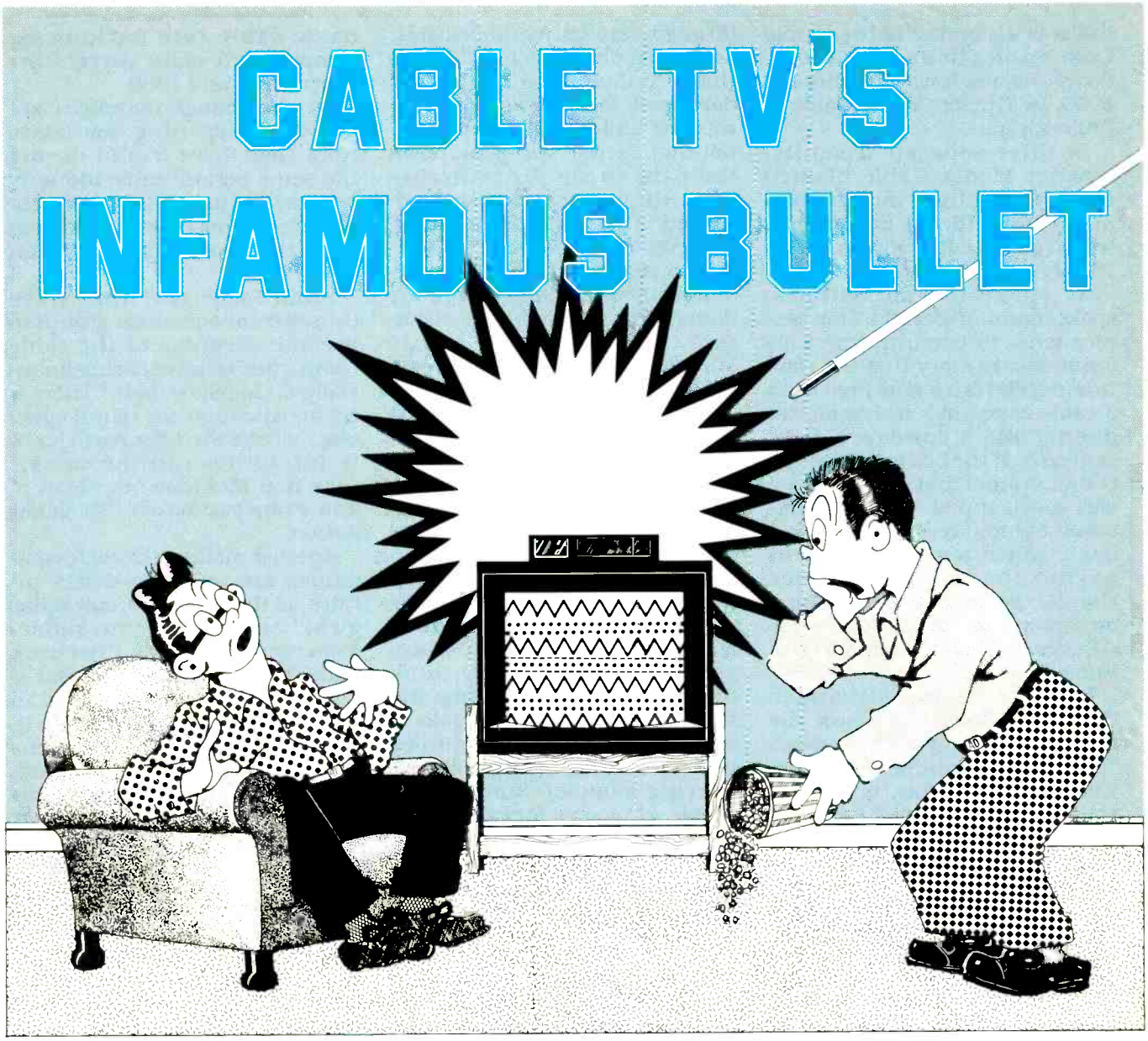


How American Cablevision's "bullet" zapped signal pirates.

KEN FOLEY

ON WEDNESDAY, MARCH 13, 1991, American Cablevision of Queens fired their first infamous electronic "bullet." According to American Cablevision, they fired a direct hit. Within minutes their switchboard was overloaded with calls from subscribers whose television sets had gone black. American Cablevision was elated—the victims had unsuspectedly taken the bait.

The next morning, American Cablevision sent armies of technicians to service the homes of the complaining customers. They replaced the cable converter boxes, and took the dead boxes back to the electronic coroner's laboratory, performing hundreds of autopsies. According to official American Cablevision records of the mass epidemic, the "Certificates of Death" were identical—illegal chip "zaps".

On Wednesday April 24, 1991, American Cablevision filed a civil suit in New York City federal court against three hundred and seventeen alleged cable pirates. That was the first time such a large number of cable crooks had been arraigned together. American Cablevision offered the defendants a deal: Pay five hundred dollars within twenty days, or face prosecution and fines from one thousand, to one hundred and ten thousand dollars.

"I think this is something that everybody's going to have to start doing," said American Cable President Barry Rosenblum. American Cablevision has approximately three hundred and thirty thousand paid subscribers in Queens and Brooklyn, and estimates it forfeits hundreds of thousands of dollars each year to video marauders, and plans to fire more bullets. The electronic

bullet is the brainchild of Jerrold Communications of Hatboro, Pennsylvania. It was first fired in 1990, by Greater Media Cable of Philadelphia.

In three separate assaults, Greater Media Cable blasted away, netting three hundred and sixty eight illegal converters, which garnered a bounty close to twenty thousand dollars.

We spoke to Jim Bathold, spokesman for Jerrold Communications, to confirm American Cablevision's story that the electronic bullet is a signal fired from a cable company's headquarters directly into a customer's cable converter. If the box is legitimate, the customer never knows he was just zapped. But if black-market chips were installed in a basic converter to circumvent paying the monthly service charge, the bullet uses the chips' own programs to neutralize the decoder and halt the cable service immediately.

Mr. Bathold then elaborated "Yes, that is basically how the bullet works," he confirmed. "But it would not be in our best interest to elaborate, or explain the operational procedure in detail. Otherwise it tells subscribers, 'Here we come.' We have not put one word out there in writing of how it works—no press packages or news releases. We especially wouldn't go into detail with electronic hobbyists," he choked out laughing.

Hoping to fare better in Jerrold's engineering division, we were fortunate to reach an engineer that was also a reader of **Radio-Electronics**. His boss' boss, technical engineering supervisor, Stan Dori, said: One of the approaches pirates have been taking for years to defeat scrambling is to physically use a decoder box to unscramble the scrambling method. That is, to reverse engineer the legitimate descrambler's software.

The bullet came into being because one of Jerrold's customers (a cable company) told them of rumors that pirates were defeating Jerrold's scrambling technology. And the cable company wanted to aggressively pursue them. So Jerrold acquired a number of the pirate devices through various methodologies, and reverse engineered them so that a counter measure could be developed. That counter measure was the bullet, an offensive signal that Jerrold can send down the data stream to neutralize what the pirates reverse engineered. That's the bullet—double-reverse engineering.

Dori continued, "So by understanding what the pirates are doing and not doing to defeat current technology, we're able to launch a counter-offensive signal, the bullet, to defeat them."

In the hopes of discouraging customers from buying illegitimate descramblers, information regarding the bullet is being leaked from the cable industry, which claims they are losing up to three billion annually from piracy.

According to Jodi Hooper of the National Cable Television Association, "People think cheating on cable services is like a school prank. They don't really think they are committing a crime and stealing. They just don't take it seriously." Hooper also indicated that some cable companies are offering complete amnesty to people who come forward before their systems are audited and the bullet is released. She says if the culprits wait until they are discovered, they will chance the possibility of criminal prosecution and heavy fines.

Richard Aurelio, president of Time Warner's New York City Cable Group, compares cable piracy to shoplifting. "Now that we have the technology, we're going to use it to rope them in." But it's a migraine for the cable industry. Most of the cable companies began scrambling their satellites in 1986, and are now concentrating on detecting people with decoders and illegal hookups.

The National Cable Television Association says about eight million homes nationwide are linked illegally to basic cable signals. And an additional three million homes illegally tap into pay services such as Cinemax and HBO.

But from 1975 through last year, the number of basic service subscribers nationwide grew from nine million to fifty-five million. The U.S. Telephone Association reports that the average basic cable rate nationwide jumped sixty-eight percent between 1986 and 1989.

So even though the cable companies are reporting that losses from theft have tripled during the same period, cable industry revenue has jumped about seventy percent from over ten billion in 1986 to almost eighteen billion last year.

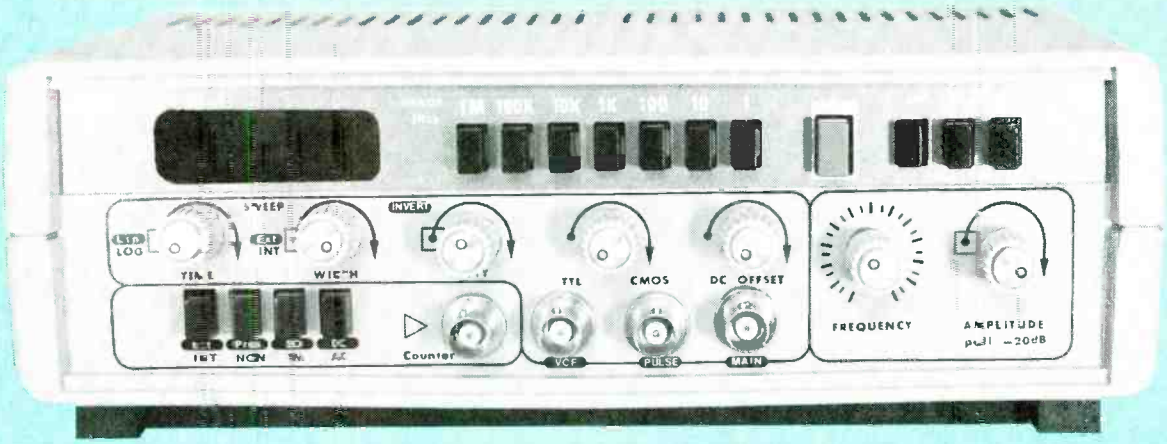
Such large revenues have caused some consumer groups to become skeptical of the cable companies' claims of being financially wounded by theft. "There is no justification for using speculative high-theft figures to justify outrageous rate increases," says Ken McEldowney, head of San Francisco-based Consumer Action.

Another method the cable companies are using to detect pirates, is the "closed circuit radar gun," or time-domain reflectometer. The major drawback with the reflectometer is that it has to be physically attached to the cable entering each home to detect unauthorized connections or decoders. Other than that, sleuthing is still done primarily by inspectors who spend their days eyeballing exterior cables for tampering.

So naturally if the cable industry succeeds in scaring thousands into confessing, it will score a two-headed victory. First by recovering millions in lost revenue having people sign up—as was the case for Utah's TCI Cablevision in 1989 where they ran a blitz advertising campaign showing guilt-ridden signal pirates imprisoned—and second by having the option of keeping the bullet in reserve as a secret weapon and not necessarily having to pay the hefty zapper fee to Jerrold Communications.

Now Time Warner, the second largest cable company with over six million subscribers in thirty six states, is threatening to start firing bullets nationwide. Are they bluffing?

If they are not bluffing, they will undoubtedly catch more cable thieves who are foolish enough to run to their cable company to complain that their pirated cable box is not working properly. **R-E**



Build this sweep/function generator and frequency counter and add to your bench-top instrument collection.

MICHAEL A. LASHANSKY

IF YOU'RE AN ELECTRONIC PROFESsional or advanced hobbyist, you know the value of a well-equipped workbench. An important piece of basic equipment is a function generator and frequency counter. Although few professionals are missing one from their bench, many hobbyists can't justify the expense of quality commercial units. If you're one of those who has put off buying such an instrument, we can show you how to build one that produces up to a 2.5-MHz square, triangle, or sine-wave output with a 1 to 20-volt peak-to-peak amplitude and a 20-dB attenuator. This instrument also has a TTL or CMOS 0.5- to 15-volt peak output as well as a sweep generator and frequency counter that can read up to 150 MHz. All of these features are combined in a single bench-top unit, for a price of $300.

Overview

Our function generator and counter produces a square, triangle, or sine-wave output with a continuously variable amplitude of one volt to 20 volts peak-to-peak. A 20-dB attenuator allows smaller amplitude signals to be generated. A variable 0.5 to 15-volt peak TTL or CMOS pulse output is also available. You can vary the DC-level content, duty cycle, or invert any of those signals.

The output frequency covers seven decades, ranging from 0.1 Hz up to 2.5 MHz. (A higher frequency limit can be attained by making some potentiometer adjustments, but at the expense of a degraded amplitude and waveform shape, which we will discuss in our next article.) Fine adjusting is achieved through a linear dial. A six-digit LED indicates the output frequency of the generator, or it can be used to display the frequencies of external signals.

Using the sweep generator, any of the output waveforms can be swept linearly or logarithmically by selecting the sweep width and/or speed with the front panel controls. You can also sweep the selected waveform under the control of an external voltage, which is useful for frequency modulation generation techniques.

The frequency-counter section can either give a readout of the frequency being generated or it can measure external signals. The counter's range is from DC to 150 MHz with an input sensitivity of 20 millivolts. Input signals can be DC or AC coupled and

the input impedance is switchable between 50 ohms and 1 megohm. A prescale/non-prescale function is provided to make maximum use of the six-digit LED to display high-frequency counts. The gate time of the counter is controlled by the frequency decade switches and offers gate times of 10, 1, 0.1, and 0.01 seconds.

Theory of operation

All low- to mid-end function generators—including this one—use a similar technique for generating a waveform. A basic triangle wave is first generated, then massaged into a sine wave and a square wave. The block diagram of Fig. 1 shows the basic workings of the main board. A frequency-controlled multivibrator drives two current switches, which alternately charge and discharge a capacitor through a resistor. The resulting triangle wave is fed either through a sine-shaper circuit, a square-wave amplifier, or straight out to the output amplifier section.

The output of the square-wave amplifier controls the polarity of the charging voltage of the capacitor. The capacitor will charge to positive, then to negative and back again to positive, thereby creating a triangle wave with an amplitude of 2 volts peak-to-peak. The waveform frequency is controlled by the RC time constant and the amount of negative voltage applied to the multivibrator. We will explore that in more detail later.

The output of the square-wave amplifier is also used to drive a TTL gate and CMOS level-shifter gate combination, which allows both TTL- and CMOS-level pulse outputs.

The sweep-generator section is made up of a voltage controlled multivibrator with a long time constant. That produces a DC voltage that varies according to the voltage applied. The output can be routed to a logarithmic amplifier to create both linear and log outputs. The signal is then fed to a buffer/level control amplifier which is then coupled to the voltage-control input of the function generator's main multivibrator.

The frequency-counter section is made up of an input-amplifier signal-conditioning circuit, a divide-by-100 prescaler, an Intersil 7216B frequency-counter chip, and a six-digit LED. Signals are routed through the front panel for measuring. Prescaling decreases the resolution of the display but allows 150 MHz to be displayed with six digits. The decimal point on the LED indicates that the display is read in kHz.

Triangle-wave generation

Figure 2 shows the schematic of the current switch and the triangle/square-wave generator. The combination of IC1–IC4 and Q1–Q4 makes up the main voltage-controlled multivibrator. A negative voltage is applied to the inverting input of IC1, which

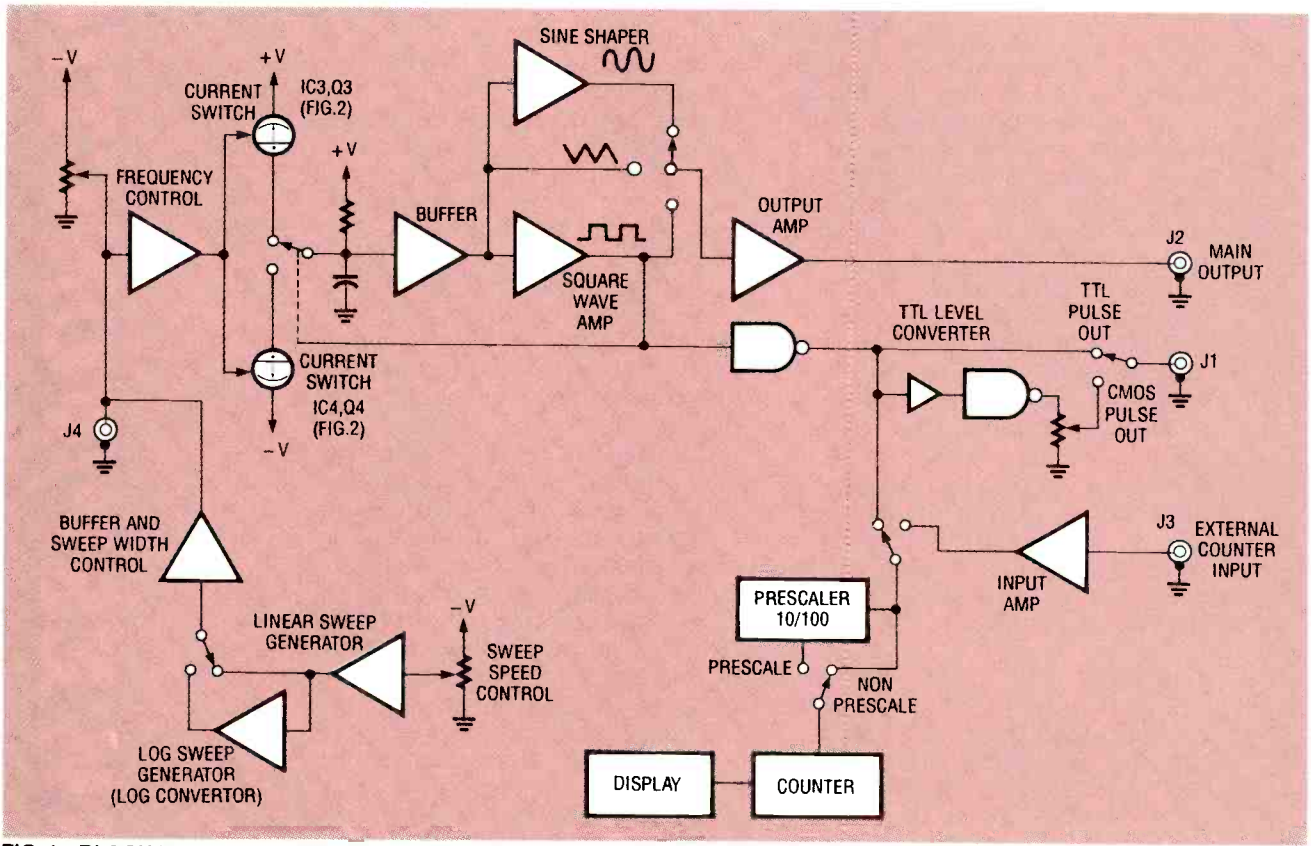


FIG. 1—BLOCK DIAGRAM OF THE FUNCTION GENERATOR. Note how the square-wave output is continuously fed back into the current-switch input. That is done to precisely align the triangle and square wave output through the hysteresis loop to prevent crossover distortion.

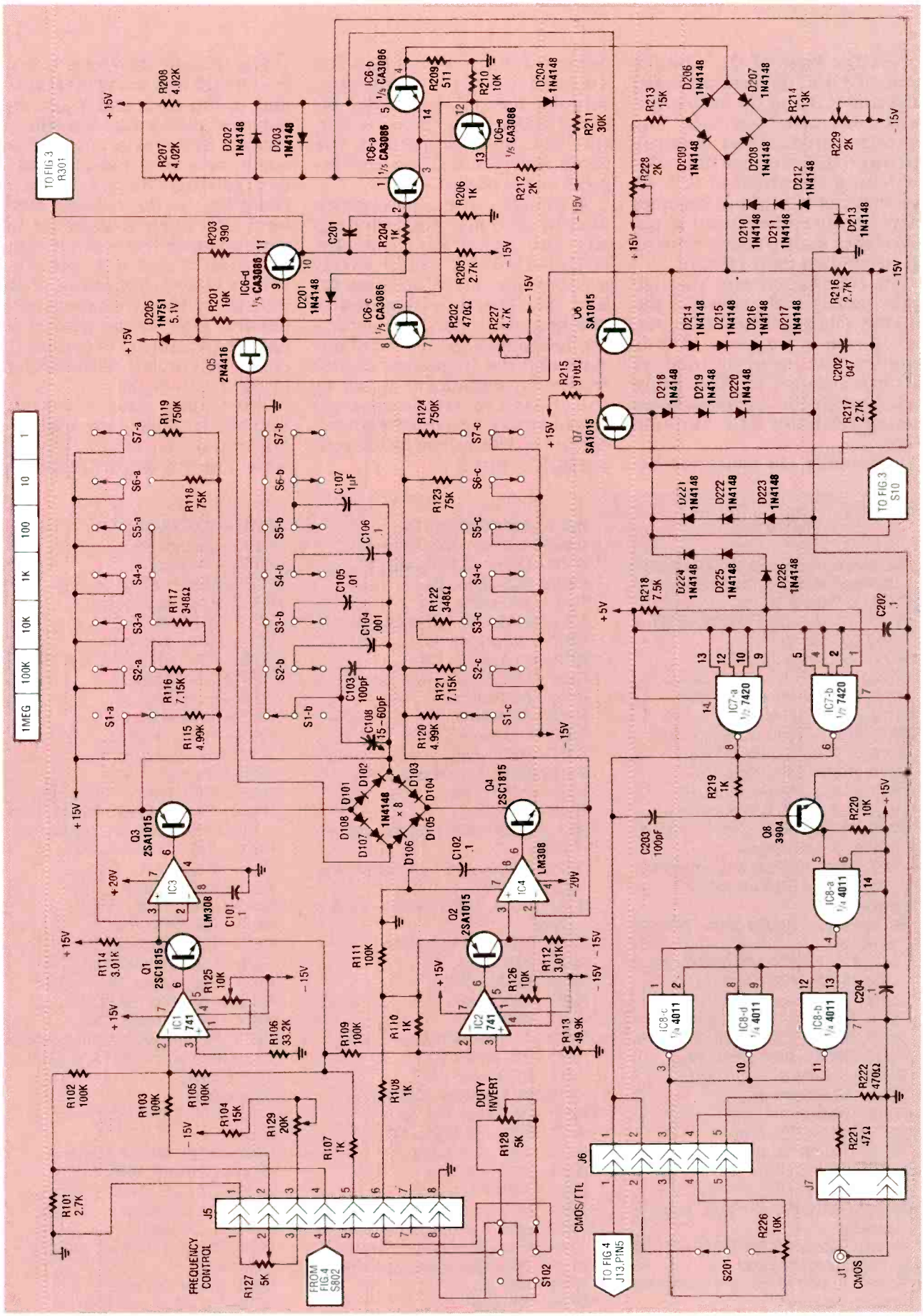


FIG. 2—CURRENT SWITCH, TRIANGLE/SQUARE-WAVE GENERATOR schematic. The triangle waveform is generated by alternately switching current sources Q3 and Q4, thereby charging and discharging C103–C107. As the triangle wave crosses the upper and lower levels of IC3's input, a square wave is generated at the output of hysteresis comparator IC6.

drives the base of Q1. Components IC1 and Q1 form a current sink and IC3 and Q3 form a current-controlled switch. The amount of current flowing through Q1 determines the switching threshold of IC3. As the input of IC1 (pin 2) becomes more negative, the output at pin 6 becomes more positive causing Q1 to conduct more current.

The collector current through Q1 generates a voltage at IC3, pin 3. That voltage causes IC3's output to switch from one state to another. The inverting input of IC3 is connected to the positive rail through the switch-selected timing resistors R115 through R119.

Transistor Q3 switches between on and off based on the amount of current flowing through the timing resistor selected and Q1. Components IC2, Q2, IC4, and Q4 perform the same function but are 180 degrees out of phase.

A triangle waveform is generated by charging and discharging the selected capacitor (C103–C107) by alternately switching current sources Q3 and Q4. The time required to charge and discharge the capacitor determines the period of one cycle and the frequency. Course frequency adjustment is set by the chosen resistor-capacitor combination, and fine frequency control is determined by the voltage at IC1, pin 2.

The triangle waveform is buffered by Q5 and transistors IC6-*c* and -*d*. IC6-*a*, -*b*, and -*e* acts as a balanced differential amplifier to form a hysteresis comparator which acts as a two-state latch controlling the direction of charging. As the triangle waveform alternately crosses the upper and lower levels of the input (IC3, pin 2 and IC4, pin 2), a square wave is generated at the output of the hysteresis comparator. That square wave is fed back to Q3 and Q4 to control the charging current path through bridge D101–D108.

The square wave is fed back into the triangle wave input for alignment with the triangle wave. The importance of the hys-

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise indicated.

R101—2700 ohms, 1%
R102, R104, R105, R109, R111—100,000 ohms, 1%
R106—33,200 ohms, 1%
R107, R108, R110—1000 ohms, 1%
R112, R114—3010 ohms, 1%
R113—49,900 ohms, 1%
R115, R120—4990 ohms, 1%
R116, R121—7150 ohms, 1%
R117, R122—348 ohms, 1%
R118, R123—75,000 ohms, 1%
R119, R124—750,000 ohms, 1%
R125, R126, R826, R827—10,000 ohms, potentiometer
R127, R128—5000 ohms, potentiometer (part of S101 and S102, respectively)
R129, R825—20,000 ohms, potentiometer
R201, R210, R220—10,000 ohms
R202, R222—470 ohms
R203—390 ohms
R204, R206, R219–1000 ohms
R205, R216, R217—2700 ohms, 1%
R207, R208—4020 ohms, 1%
R209—511 ohms
R211—30,000 ohms
R212—2000 ohms
R213, R214—13,000 ohms
R215—910 ohms, 1%
R218—7500 ohms
R221—47 ohms
R223, R828—5000 ohms, potentiometer
R224, R225, R228, R229—2000 ohms, potentiometer
R226—10,000 ohms, potentiometer (part of S201)
R227—4700 ohms, potentiometer
R301—49,900 ohms, 1%
R302, R303—11,300 ohms, 1%
R304, R306—12,100 ohms, 1%
R305—309 ohms, 1%
R307—200 ohms, 1%
R308, R309—24,900 ohms, 1%
R310—127 ohms, 1%
R311—63.4 ohms, 1%
R312, R313, R320—1000 ohms
R314—5100 ohms
R315—680 ohms
R316—150 ohms
R317—6800 ohms
R318, R319—10,500 ohms, 1%
R321—2000 ohms
R322—12 ohms
R323, R324—1000 ohms, potentiometer
R325—5000 ohms, potentiometer (part of S301)
R401, R402, R503, R504—10,000 ohms
R403, R404—22,000 ohms
R405—170 ohms, 1%
R406—12,000 ohms
R407—1200 ohms
R408—2000
R409—18,200 ohms 1%
R410—270 ohms, 1%
R411—100 ohms, 1%
R412, R414, R502—3000 ohms
R413—24,300 ohms, 1%
R415, R418—47 ohms, 1W
R416, R417—7.5 ohms
R419—50 ohms, ½W
R420—499 ohms, ½W
R421—56.2 ohms, 1%
R422, R424—10,000 ohms, potentiometer (R424 is part of S401)
R423—200 ohms, potentiometer
R501—100,000
R505—10 megohms
R701—10,000 ohms
R702—100,000 ohms
R703—1 megohm
R704—50 ohms
R705, R718—150 ohms
R706, R712—220 ohms
R707—470 ohms
R708, R715—51 ohms
R709–R711, R713, R714, R716, R717—510 ohms
R719—36 ohms
R720—1000 ohms
R801—7500 ohms, 1%
R802—33,000 ohms, 1%
R803—33 ohms, 1%
R804, R805, R807—5100 ohms, 1%
R806, R810, R816, R817, R819, R820, R822—10,000 ohms, 1%
R808—510,000 ohms, 1%
R809—2200 ohms, 1%
R811—22,000 ohms, 1%
R812—2400 ohms, 1%
R813—100 ohms, 1%
R815—150,000 ohms, 1%
R818—15,500 ohms, 1%
R821—2000 ohms, 1%
R823—15,000 ohms, 1%
R824—18,000 ohms, 1%
R830, R831—5000 ohms, potentiometer (part of S801 and S802, respectively)

Capacitors

C101, C102, C204, C205—0.1 μf ceramic
C103, C203—100 pF, ceramic
C104—0.001 μF, Mylar
C105—0.01 μF, Mylar
C106—0.1 μF, Mylar
C107—1 μF, Mylar
C108, C504—15–60 pF, variable capacitor
C201—68 pF, ceramic
C202—0.047 μF, ceramic
C301, C303—0.1 μF, ceramic

teresis loop (IC6 pin 4) is to ensure that the triangle and square wave are perfectly timed to avoid any crossover distortion.

The collector of Q7 is clipped to approximately 3 volts by D218–D226 and fed to IC7, pins 1 and 9. IC7 is a dual four-input AND gate, which logically AND's the input square wave with a logic high to produce a TTL-level square wave output. The outputs of the two gates are tied together for increased current drive, and fed to the pulse-output control circuitry. The TTL square wave is level shifted by Q8 to 15-volt CMOS levels, were it is NANDed with 15 volts in IC8-*a*. The output of the gate is fed in parallel to IC8-*b*, -*c*, and -*d*, where they are also NANDed with 15 volts.

The outputs of IC8-*b*, -*c*, and -*d* are connected in parallel for greater drive capability and routed through S201, a 10K potentiometer with a SPDT switch, which controls the pulse output mode. With the potentiometer in the OFF position, a TTL-level output is available. Turning the potentiometer throws the switch, which routes the CMOS output to the BNC connector J1. The 10K potentiometer controls the amount of signal available to J1 and will vary the amplitude of the signal from 0.5 volts to 15 volts.

Figure 3 shows the schematic of the sine shaper and output amplifier. Sine-wave generation is accomplished by taking the triangle wave from IC6-*d* and feeding it through the nonlinear network made up of D301–D312 and resistors R301–R310. The circuit attenuates the input triangle wave according to its level, producing a sine-wave equivalent. The output of the sine shaper is fed through a high-pass filter to the input of IC9, a CA3030 op-amp. Zener diodes D313 and D314 drop the 15-volt supply voltage to ±11.3 volts to accommodate the ±12-volt requirements of the IC. The gain of IC9 is about 10, and can be adjusted by potentiometer R323. The CA3030 is an inexpensive wide-band op-amp but requires some frequency compensation to work over its entire bandwidth.

C302, C304, C502—39 pF, ceramic
C305, C401—4.7 pF, ceramic
C307—15 pF, ceramic
C308, C408—5–35 pF, variable capacitor
C402—120 pF, ceramic
C403—2.2 pF, ceramic
C404, C406—6.8 µF, tantalum, 20 volts
C405, C407—0.047 µF, ceramic
C501—33 pF, ceramic
C503—10 pF, ceramic
C601, C602—1000 µF, electrolytic, 50 volts
C603, C604—100 µF, electrolytic, 50 volts
C605—1 µF, tantalum, 20 volts
C701, C704–C706—0.1 µF, ceramic
C702, C707—100 pF, ceramic
C703 10u tantalum 16 volts C801—22 µF, tantalum, 16 volts
C802, C803—220 pF, ceramic
C804, C805—100 pF, ceramic
C806—500 pF, ceramic

Semiconductors

D101–D108, D201–D204, D206–D226, D301–D312, D315–D318, D401, D402, D701, D702, D801—1N4148 diode
D205—1N751, 5.1-volt Zener diode
D313, D314–1N746, 3.3-volt Zener diode
BR1—W02M bridge diode
Q1, Q4, Q12, Q13, Q21—2SC1815 or MPSA05 NPN transistor
Q2, Q3, Q6, Q7, Q11, Q19, Q20—2SA1015 or 2N4403 PNP transistor
Q5, Q17—2N4416, N-channel FET
Q8—2N3904, NPN transistor
Q9, Q10, Q14—2SC1923 or MPSH34, NPN transistor
Q15—2N2219, NPN transistor
Q16—2N2905, PNP transistor
Q18—PN5139, PNP transistor
IC1, IC2—LM741, op-amp
IC3, IC4—LM308, op-amp
IC5, IC6, IC20—CA3086, NPN five-transistor IC (Harris)
IC7—7420, dual 4-input AND gate
IC8—4011, quad NAND gate
IC9—CA3030, op-amp
IC10—4066, CMOS quad bilateral switch
IC11—7216B, frequency counter and LED driver (Intersil)
IC12—7815, +15-volt voltage regulator
IC13—7805, +5-volt voltage regulator
IC14—7915, −15-volt voltage regulator
IC15—MC10116, ECL triple-line receiver with Schmitt trigger (Motorola)
IC16—SP8629, prescaler (Plessy)
IC17—LM324, quad op-amp
IC18—MC1458, dual op-amp
IC19—CA3140, op-amp (Harris)
SR801—1000 ohms, thermistor
DISP1–DISP6—common-cathode LED (FND357)

Other components

S1–S7—4PDT-D switch
S8—DPDT switch
S9–S11—DPDT-D switch
S12–S14—DPDT-I switch
S15—DPDT on/off switch
S101—DTDP switch used with R127 (5K potentiometer)
S102—DTDP switch used with R128 (5K potentiometer)
S201—SPDT switch used with R226 (10K potentiometer)
S301—DPDT switch used with R325 (5K potentiometer)
S401—SPDT switch used with R424 (10K potentiometer)
S801—DPDT switch used with R830 (5K potentiometer)
S802—DPDT switch used with R831 (5K potentiometer)
J1–J4—BNC panel mount connector
J5, J14—8-position female/male, 0.1-inch centers
J6—5-position female/male, 0.1-inch centers
J7, J12—2-position female/male, 0.1-inch centers
J8, J13—6-position female/male, 0.1-inch centers
J9–J11, J15, J16—4-position female/male, 0.1-inch centers
XTAL1—10-MHz AT/CUT crystal
T1—115/40 volts AC, 0.5-amp transformer
F1—0.5-amp fuse

Miscellaneous: Case (CTP-1 by Global Specialties), three 1.75-inch standoffs, two TO-5 heatsinks, three TO-220 heatsinks, three PC boards, internal wiring, fuseholder, 3-conductor 18-gauge power-supply cord and strain relief.

Note: The following items are available from Tristat Electronics, Inc., 66A Brockington Cres., Nepean, Ontario, Canada, K2G 5L1, (613) 228-7223:

- **A set of three etched, drilled and plated-through PC boards—$76.**
- **All components without the PC board and case—$250.**
- **Complete kit of all parts (unfinished front panel)—$300.**
- **Cut and silk-screened front panel—$10.**

Add $17 for shipping and handling. Send check or M.O.

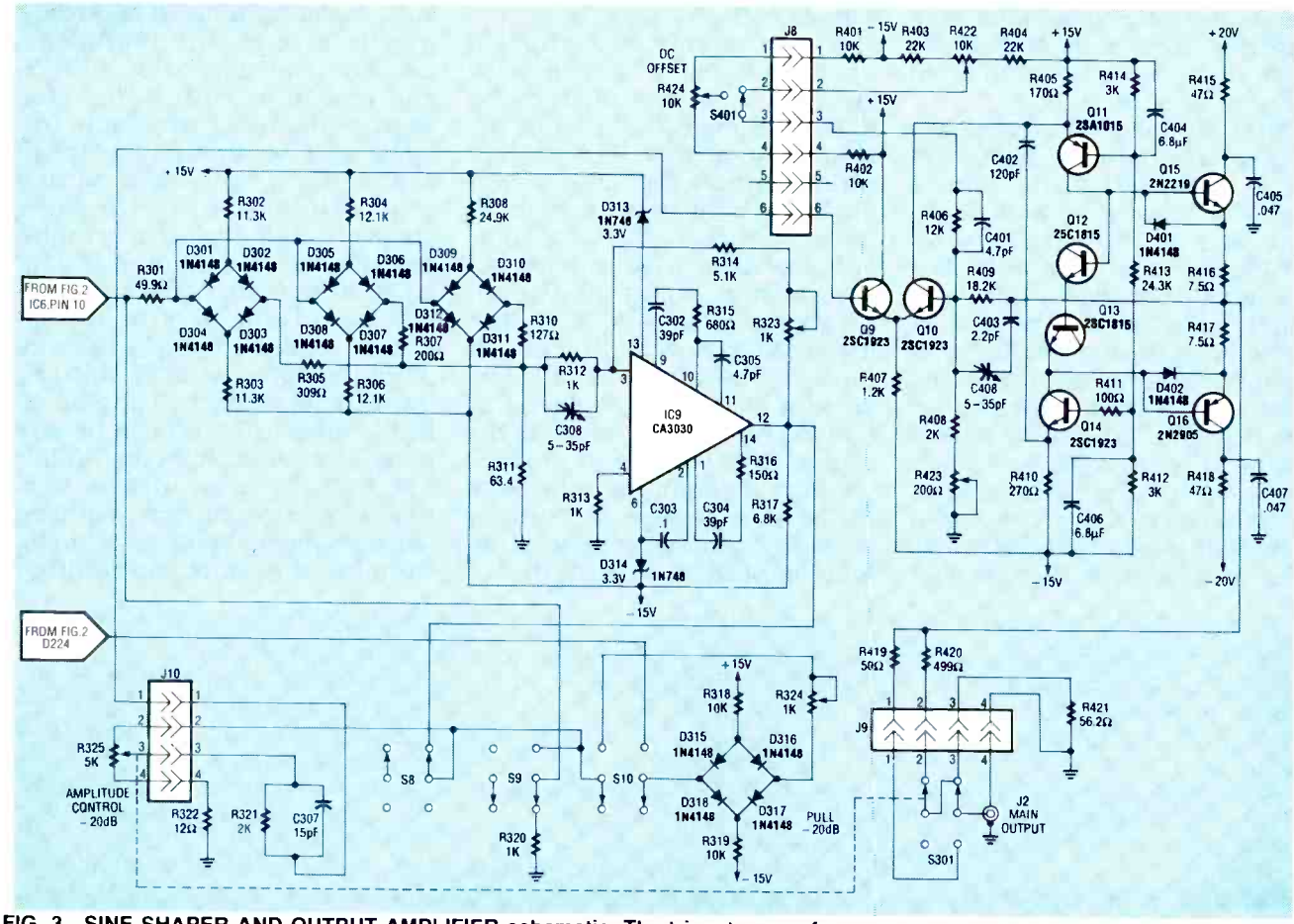


FIG. 3—SINE SHAPER AND OUTPUT AMPLIFIER schematic. The triangle wave from IC6-*d* is fed to a nonlinear network made up of D301–D312 and R301–R310. The triangle wave is attenuated according to its level, producing a sine-wave equivalent.

The main output amplifier consists of Q9 and Q10 configured as an unbalanced differential pair and transistors Q11–Q16 configured as a complementary symmetry push-pull amplifier. A differential amplifier amplifies the difference between the signals present at the base of each transistor. The input signal is fed into the base of Q9 and the output of the push-pull amplifier is fed back through the attenuating circuit of R409, C403, and C408 and coupled to the base of Q10. The output of the differential pair, Q9 and Q10, is taken from the collector of Q10 with the gain of that signal controlled by R408 and R423, which shunts the input signal to ground.

The DC content of the output signal is determined by the DC bias voltage at the base of Q10 (that value is set by potentiometer R422 and should be adjusted to give a 0-volt DC level). Panel-mounted switch/potentiometer S401 allows the user to adjust the DC base bias of Q10, which causes the output signal to ride on a DC voltage from −10 volts to +10 volts depending on the potentiometer setting.

The output of Q10 is connected to the emitters of Q11 and Q14 through DC blocking capacitor C402. Transistors Q11 and Q14 are used in the common-base mode with the input signal fed into the emitters and the outputs taken from the collectors. Transistors Q12 and Q13 are used as diodes to connect the collectors of Q11 and Q14. The output of Q11 is fed to the base of Q15, which amplifies the positive half of the signal. The output of Q14 is fed into the base of Q16 which amplifies the negative excursion of the signal. Switch S301 controls the amount of signal entering the amplifier section through the use of a potentiometer. When the ganged DPDT switch is left in its normal IN position, the output will swing 20 volts peak-to-peak (open circuit). Pulling the switch attenuates the signal by 20 dB. Output impedance is approximately 600 ohms in the normal switch position and 50 ohms in the 20-dB position.

The frequency-counter and sweep-generator circuits are shown in Fig. 4. The sweep generator consists of IC17–IC20. The potentiometer section of S801 applies a negative voltage to the inverting input of integrator IC17-*a*. The input signal is inverted and charges C801 until it reaches the switching threshold of comparator IC17-*b*. When the switching threshold is reached the output will go high, forward biasing Q21 which discharges C801 to ground through R806. The output at IC17-*a* pin 7 is a positive-going ramp and is routed through the linear/log selection switch S801 to either the output buffer amp or the logarithmic ramp generator.

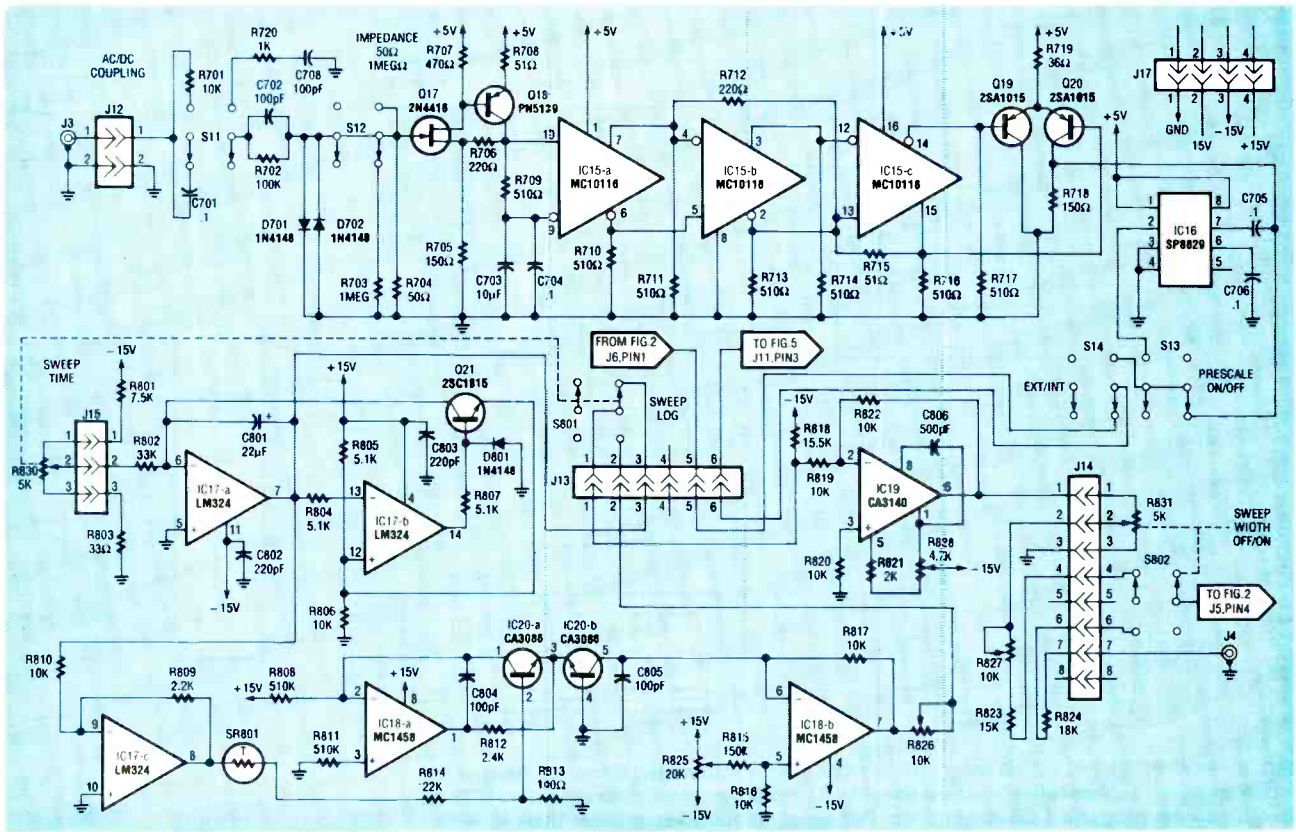


FIG. 4—SWEEP GENERATOR AND SIGNAL ROUTING. Potentiometer R830 applies a negative voltage to IC17-*a*; C801 charges until it reaches the switching threshold of IC17-*b*, which then forward biases Q1. The output at IC17, pin 7 is a positive-going ramp which is routed through the linear/log selection switch S801 to the output buffer amp or log ramp generator. IC16 is a prescaler chip used to downscale frequencies greater than 10 MHz.

An anti-log generator circuit is made up of IC17-*c*, IC18-*a*, -*b*, IC20-*a*, and -*b*, which performs an X^2 function. IC17-*c* acts as an input buffer and attenuator. IC18-*a* and IC20-*a* drives the emitter of IC20-*b* in proportion to the input voltage at the base of IC20-*a*. The collector current of IC20-*b* varies exponentially with the emitter-base voltage. The current is then converted to a voltage by amplifier IC18-*b*. Potentiometer R825 sets the balance of IC18-*b*'s output between a linear and exponential function while potentiometer R826 controls the output signal level. Thermistor SR801 is necessary to compensate for temperature drift because the output of the circuit is directly proportional to the anti-log of the input voltage, and the coefficient of the log term is directly proportional to absolute temperature. Without compensation, the scale factor would also vary directly with temperature. Constant gain is achieved by making the voltage at the base of IC20-*a* directly proportional to temperature.

The linear and logarithmic positive-going ramps are buffered by IC19, a CA3140 op-amp, and are converted to a negative-going ramp. That signal is then fed into IC1 pin 2 through R102. Switch-potentiometer S802-R831 controls the negative voltage that is coupled to IC1 pin 2 when it is in the normal IN position. IC1 is controlled by the main frequency-adjust potentiometer S101, which consists of R127 unconnected to S101.

With S802 in the OUT position, the output of IC19 will be present at IC1. Potentiometer S802 sets the level of the ramp and controls the sweep width. It should be noted that IC1 pin 2 is a summing point and the voltage present from the main frequency control and the sweep generator adds together. The sweep generator starts its sweep at the point determined by the initial voltage at pin 2. For maximum sweep control, the main frequency adjust potentiometer should be turned to its minimum level.

Frequency counter

The power supply and frequency counter circuit is shown in Fig. 5. The frequency counter can count either signals generated internally or measure external signals. The external signal is switch coupled through S11 directly through R701, or capacitively coupled through C701, as shown in Fig. 4. When the input signal is directly coupled, the low-pass filter of C708 and R720 is present. Capacitively-coupled signals by-pass the low-pass filter and pass through a high-pass filter. Diodes D701 and D702 clamp the input to protect Q17. Switch S12 selects the gate resistor and sets the input impedance of the circuit. Transistors Q17 and Q18 provide amplification and impedance matching for IC15, an MC10116 ECL triple-line receiver with Schmitt trigger. Differential amplifier Q19 and Q20 provide a single-ended output from the dif-

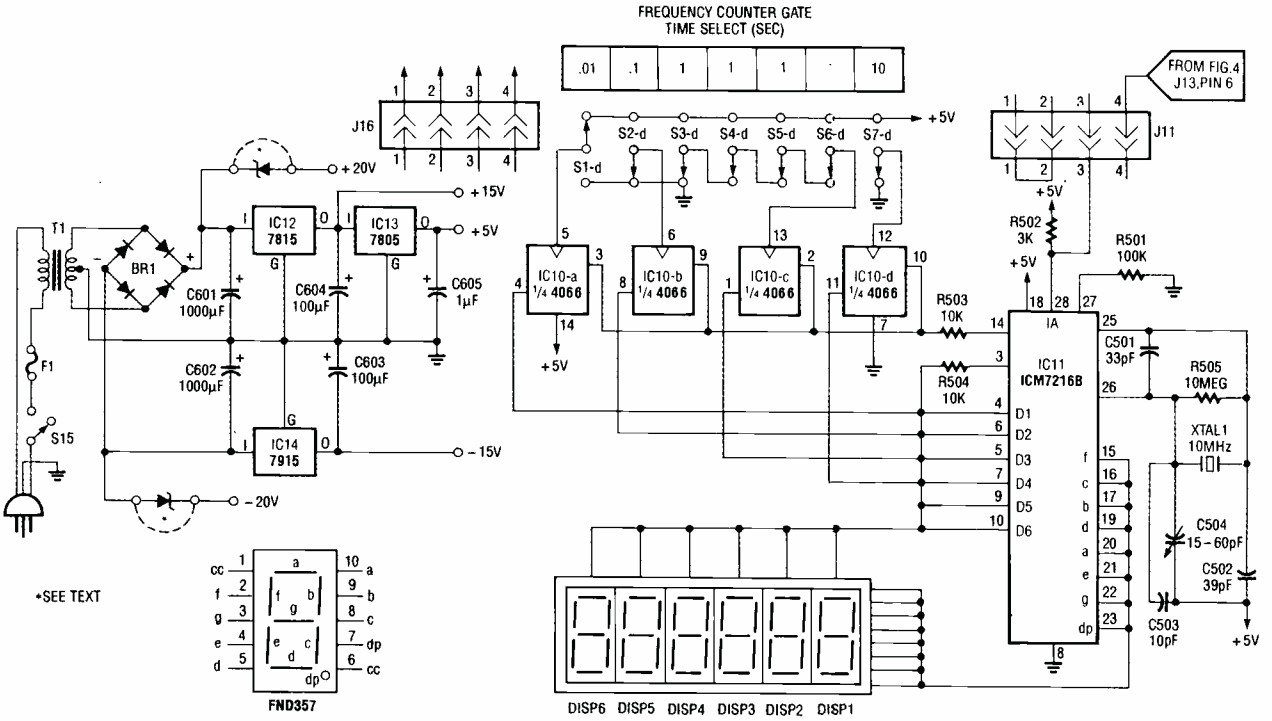


FIG. 5—POWER SUPPLY AND FREQUENCY COUNTER schematic. Either an internal or external signal source is selected via S14 (Fig. 4). Both signal sources are fed to IC11, a frequency counter and LED driver chip. For input frequencies greater than 10 MHz, prescaling is needed.

ferential outputs of IC15. Switch S13 controls whether the input signal is fed directly from the input amplifier or from the divide-by-100 prescaler to the counter section.

The counter section can take its input from the internal source or from an external source via S14. The internal signal represents the output frequency of the frequency generator and is taken from the junction of D221 and D224. Both signal sources are pulled up to CMOS levels by R502 and fed into IC11, an Intersil frequency counter and LED driver chip. The chip combines a high-frequency oscillator, decade timebase counter, an 8-decade data counter and latches, 7-segment decoder, digit multiplexes, and 8-segment and 8-digit drivers, which directly drive multiplexed LED's. The input frequency of the chip is limited to 10 MHz, so prescaling of the input is required to measure higher frequency signals. The 7216B is a multifunctional chip, performing many useful measuring tasks.

A 10-MHz crystal, XTAL1 with components C501–C504 and R505 set the internal timebase to 10 MHz. That configuration works well with our divide-by-100 prescaler because the timebase can remain the same, only the decimal point takes on a different meaning. In non-prescaled operation, the decimal point on the LED indicates the reading is in kHz, when the input is prescaled, the decimal point indicates the display is read as $\times 10$ kHz. We'll discuss more about that later.

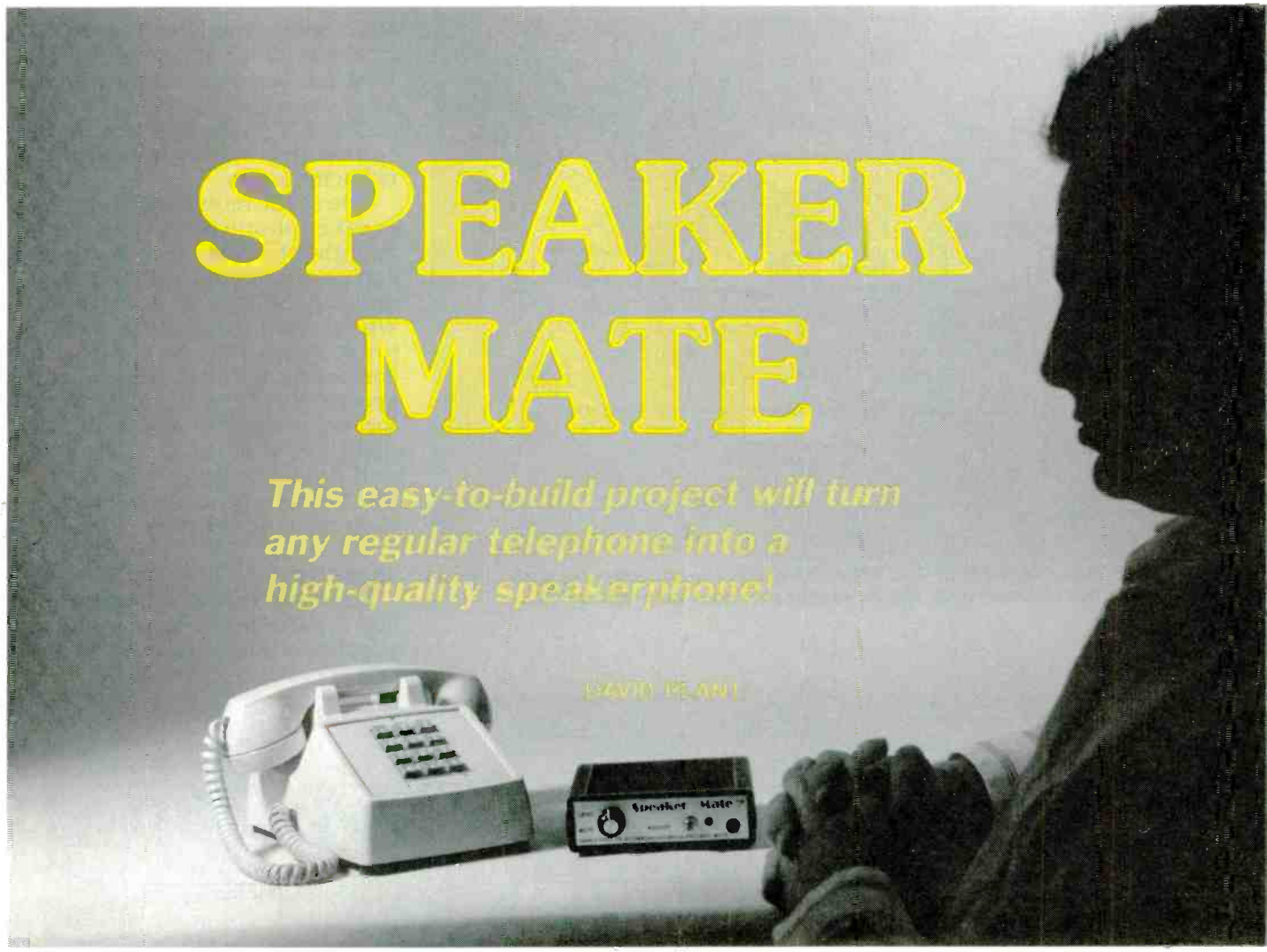
Gate-time selection is controlled by the main frequency selection switches S1-*d* through S7-*d*. They are configured to give gate times of 0.01 seconds in the 1-MHz range, 0.1 seconds in the 100-kHz range, 1 second in the 10-kHz through 10-Hz ranges, and 10 seconds in the 0.1-Hz range. The gate time select (IC11 pin 14) must be connected to the appropriate digit driver to select the required time.

Gate-time selection is achieved by applying 5 volts DC from one of the switches S1-*d* though S7-*d* to the control input of one of the quad-bilateral switches of IC10. Each of the bilateral switches of IC10 controls the digit driver that is connected to the gate-select input. Because switches S1-*d* through S7-*d* are dependent (only one can be engaged at any one time) only one of the bilateral switches will have 5 volts on its control input, all the others will be at ground. Resistor R504 hardwires the function select to implement the frequency measuring mode only. Both R504 and R503 are required to reduce ringing at the input, which could result in false selections.

The power supply is fairly straightforward. AC line current is switch-connected through S15 to fuse F1 to the primary of T1. The transformer is center tapped with a secondary voltage of 40 volts and full load current of 0.5 amps. Diode bridge BR1 rectifies the AC secondary voltage and it is filtered by capacitors C601 and C602. Voltage regulators, IC12–IC14, provide +15, +5, and −15 volts DC. The ±20 volts DC is taken right from the bridge circuit. If a 40-volt AC secondary transformer cannot be found, Zener diodes can be used to drop a high secondary voltage down to the ±20-volt range. Next time we'll discuss how to build and test the function generator. **R-E**

SPEAKER MATE

This easy-to-build project will turn any regular telephone into a high-quality speakerphone!



SPEAKERPHONES HAVE COME A LONG way since the two-piece units we used to see on the 1958 TV series, The FBI. There, an agent, played by Ephrim Zimbalist Jr., sat on his chief's desk as they "conferenced" around the country, planning the capture of the villain. In those days the units were available only by a rather expensive lease from Ma Bell, and the talk unit and receive section had to be located on opposite sides of the desk to avoid acoustic feedback—the same sort of sound that a public address system generates when the speakers are located too close to the microphone.

Today, thanks to some sophisticated electronics, the speaker and the microphone can now be used in a single enclosure. However, as we will discuss later, there are still acoustic considerations to contend with. We've all heard what the typical speakerphone sounds like, and that's probably why most of us don't already own one. Speakerphones have also had a history of being expensive—until now.

The Speaker-Mate speakerphone is inexpensive, compact, easy to build, and powered from the phone line. You'll still need a regular phone because you can't dial out on the Speaker-Mate, and it doesn't have a ringer. But its sound quality is excellent.

A quality speakerphone relies on a balanced combination of electronic design and acoustic physics. With the Speaker-Mate, once an enclosure was chosen, the microphone and speaker were moved to different positions to achieve the best possible sound before making the final design.

Operation

Modern speakerphones work on a switching principle to minimize audio feedback. Neither the talk path nor the receive path are totally off, but each are attenuated by a factor of 52 dB, and both sit in an idling mode until one person talks. It's similar to voice-controlled transmissions (VOX) used by ham operators, where both station transmitters are off until one operator talks; when they are through the other station can talk. The comparison ends here because with a speakerphone, the receiving station can interrupt simply by talking louder.

Figure 1 is a block diagram of the Speaker-Mate. The talk path goes left to right on the upper half of the drawing, and the receive path goes from right to left. Both paths go through their respective

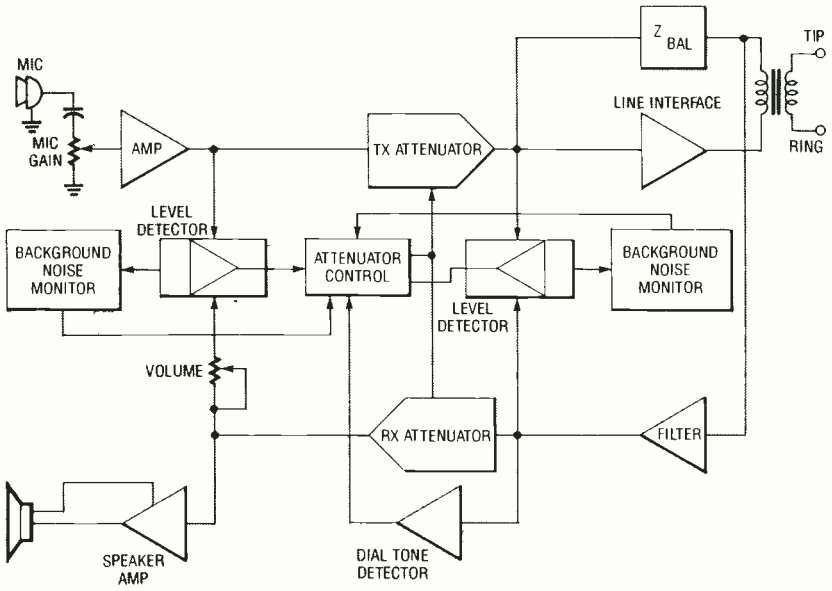


FIG. 1—BLOCK DIAGRAM OF THE SPEAKER-MATE. The talk path goes left to right on the upper half of the drawing, and the receive path goes from right to left.

attenuators which are controlled by the attenuator control block. That section gets its data from level detectors on both circuit paths. The detectors are interconnected with background-noise monitors.

One of the requirements of the speaker-phone design is to differentiate between speech, which constantly varies in amplitude, and constant background noise. When constant and unvarying noise is heard, the attenuator control mutes both paths until speech is read. A separate detector is provided to attenuate the dial tone; it is not a single tone and does not qualify as noise. The Z balance network matches both paths to the phone line.

Circuitry

Referring to the schematic in Fig. 2, the 600-ohm balanced telephone line is coupled to the

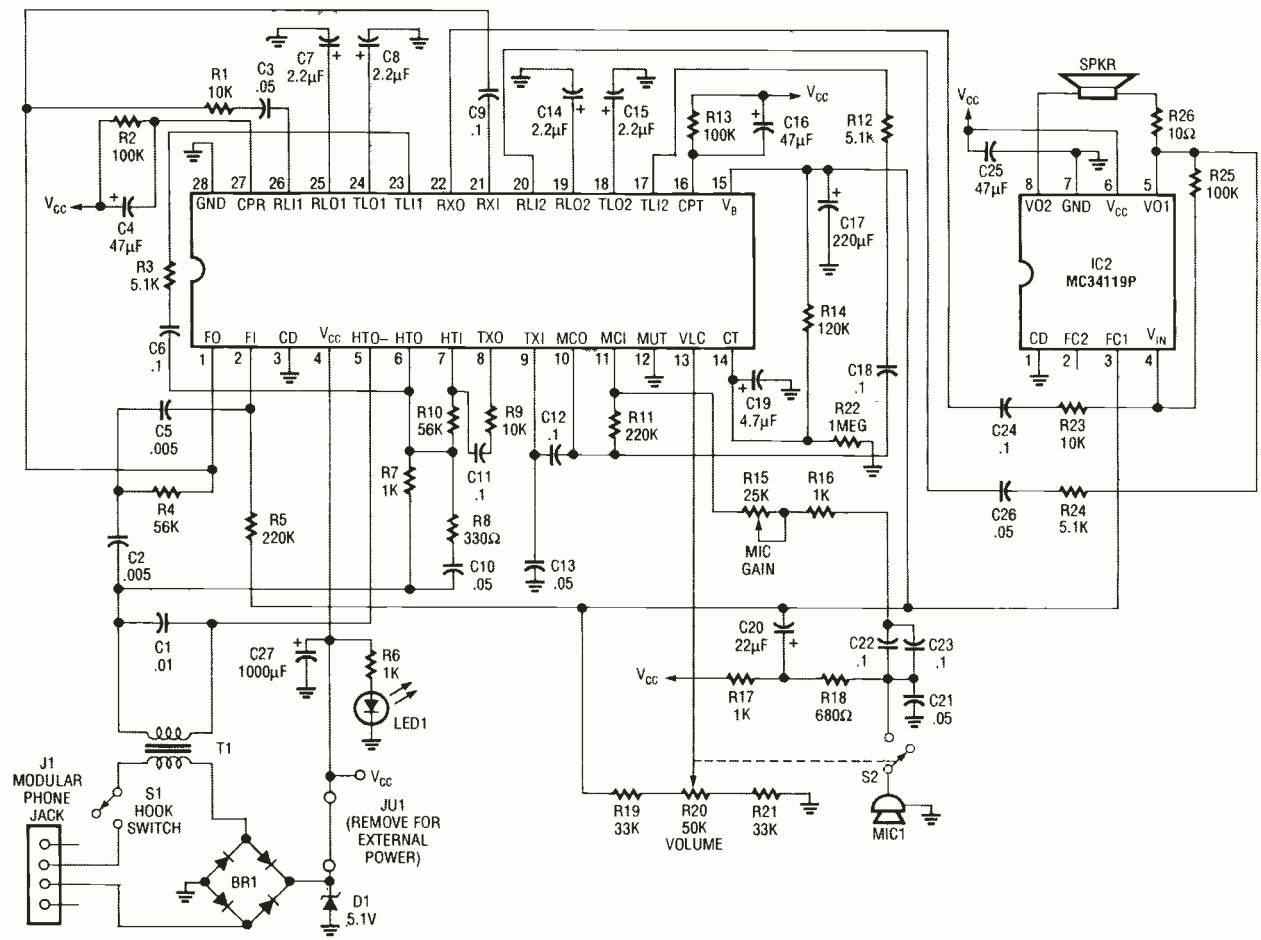


FIG. 2—SPEAKER-MATE SCHEMATIC. The 600-ohm balanced telephone line is coupled to the device through T1, a 600-to-600 ohm transformer. A Zener diode limits transient spikes and regulates the supply to 5.1 volts.

PARTS LIST

All resistors are ¼-watt, 5%
R1, R9, R23—10,000 ohms
R2, R13, R25—100,000 ohms
R3, R12, R24—5100 ohms
R4, R10—56,000 ohms
R5, R11—220,000 ohms
R6, R7, R16, R17—1000 ohms
R8—330 ohms
R14—120,000 ohms
R15—25,000 ohms, PC-mount vertical potentiometer
R18—680 ohms
R19, R21—33,000 ohms
R20—50,000 ohms, potentiometer with switch (S2)
R22—1 megohm
R26—10 ohms

Capacitors
C1—0.01 μF, ceramic disk
C2, C5—0.005 μF, ceramic disk
C3, C10, C13, C21, C26—0.05 μF ceramic disk
C4, C16, C25—47 μF, 16 volts, radial electrolytic
C6, C9, C11, C12, C18, C22, C23, C24—0.1 μF, ceramic disk
C7, C8, C14, C15, C19—2.2 μF, 16 volts, radial electrolytic
C17—220 μF, 16 volts, radial electrolytic
C20—22 μF, 16 volts, radial electrolytic
C27—1000 μF, 16 volts, radial electrolytic

Semiconductors
IC1—MC34118P voice-switched speakerphone, Motorola
IC2—MC34119P low-power audio amplifier, Motorola
D1—1N4733 5.1-volt Zener diode, or equivalent
LED1—high efficiency red light-emitting diode, GI MV5774 cr equivalent
BR1—50-volt bridge rectifier, RB115 or equivalent

Other components
MIC1—electret microphone element
T1—600-to-600 ohm PC-mount transformer, 0.75-inch mounting center
J1—modular PC-mount phone jack
S1—SPST toggle switch
S2—SPST switch (mounted on potentiometer R20)
Miscellaneous: Cabinet, PC board, ⅜-inch I.D. rubber grommet, 3-inch 8-ohm speaker, knob, modular phone cord, wire, solder, RTV silicon glue, etc.

Note: The following items are available from Project-Mate, 2727 W. Manor Pl., Seattle, WA 98199 (206) 283-4700:
- **A kit containing a PC board and all listed parts except the cabinet, speaker, and modular phone cord—$46.00.**
- **Pac-Tec cabinet with silk-screened front panel—$18.50**
- **3-inch speaker—$3.75.**
- **Drilled and plated PC board—$11.50**
- **IC1 and IC2—$18.50**
- **Ring detector kit including piezo transducer—$9.50**

Include $3.50 shipping and handling and allow 2 weeks for delivery. 15% discount on orders of 2 or more similar items.

Speaker-Mate through T1, a 600-to-600 ohm transformer. Switch S1 in series with T1 provides the answer function, and when the circuit is closed (off-hook), current flows through BR1 which produces a DC voltage of 6–8 volts. A Zener diode across the output limits transient spikes and regulates the supply to 5.1 volts which powers the circuit and optional LED1. The LED, if used, should be of the high-efficiency variety, because R6 limits its current to 2 mA to minimize telephone-loop current drain. The secondary of T1 is fed to IC1, a Motorola MC34118P voice-switched speakerphone chip, which controls all functions except driving the speaker. That is done by IC2, a Motorola MC34119P low-power audio amplifier IC. Both IC's can operate from less than 3 volts.

Potentiometer R20 controls the volume and is limited in range by R19 which sets the high level, and R21 which sets the low

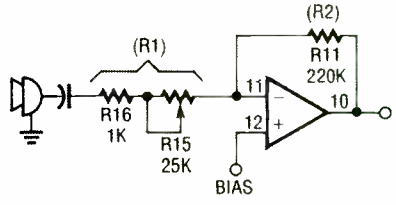


FIG. 3—YOU CAN ADD a microphone gain adjustment to allow for different environments and applications. The gain is the ratio of R2/R1. With R1 at 1K, the gain is 220, and with R1 at 26K, the gain is 8.5.

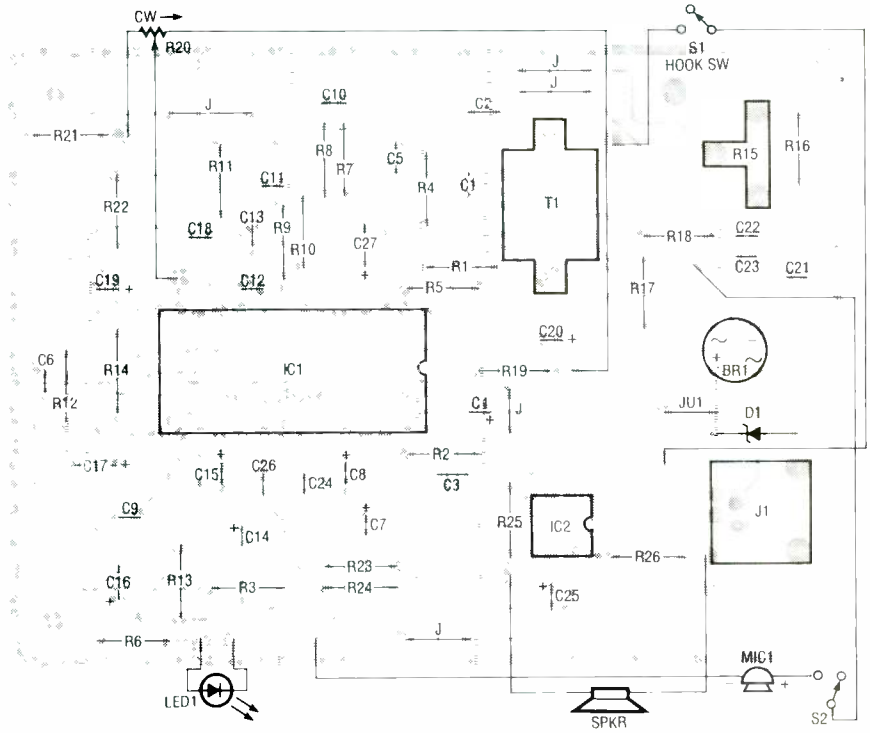


FIG. 4—PARTS-PLACEMENT DIAGRAM. Mount the two IC's first to provide a good reference for the rest of the components. Use sockets for both IC's, especially for the 28-pin chip.

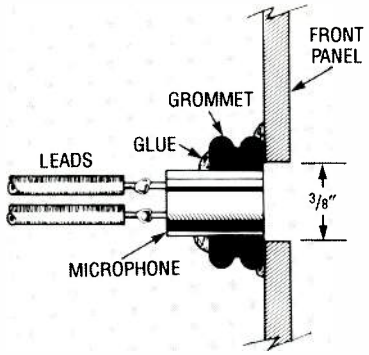


FIG. 5—MICROPHONE MOUNTING scheme. A rubber grommet is glued to the inside of the front panel behind the microphone opening. The microphone should not touch the front panel, but if it's too far recessed it will give an echo sound.

level. The low end is set to not completely turn off the audio and the high end limits the current required by the power amplifier to within the parameters allowed by the telephone loop current. Excessive audio would create a pumping sound due to the voltage dropping on audio peaks. Potentiometer R20 can be either linear or audio taper with very little effect on the sound, due to the limiting resistors.

We found it desirable to add a microphone gain adjustment to allow for different environments and applications. That was done by adding a 25K potentiometer (R15) in series with a 1K limiting resistor (R16). Figure 3 shows how the circuit works; the gain is calculated by the ratio of R2/R1. Using the actual values in the circuit, and with R1 at 1K, the voltage gain should be 220, and with R1 increased to 26K, the gain will reduce to 8.5. In actuality, these figures will be approximately 10 percent less because of other factors. Ideal AC coupling from the microphone (0.2 μF) is provided by two 0.1 μF capacitors in parallel (C22 and C23); the 0.1 μF capacitors are much easier to obtain.

The other components provide filtering and talk/listen time constants. Resistor R22, when grounded, provides approximately a 20 percent capture advantage to the speakerphone user; without it, the unit will idle halfway between listen and talk. With R20 connected to V_{CC}, the calling station will have the slight capture advantage, and of the three options, we found that R22 to ground worked best.

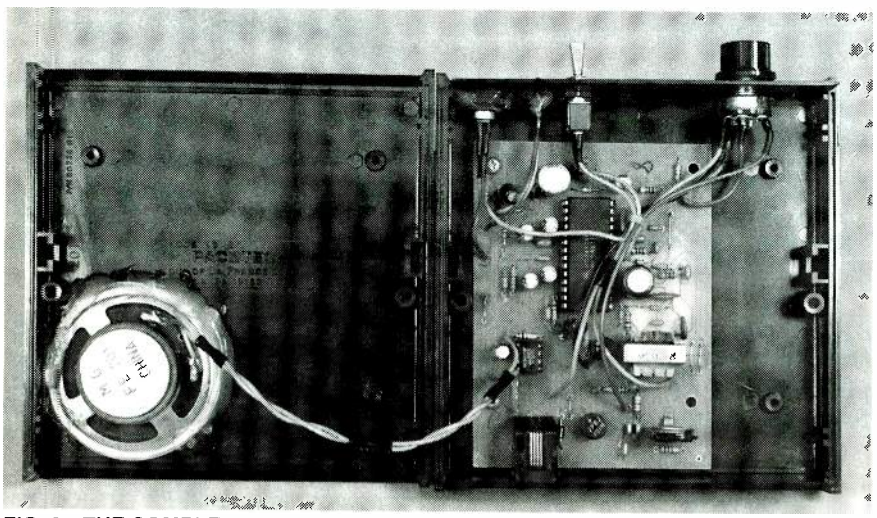


FIG. 6—THE COMPLETED PROTOTYPE. The front panel included with the kit makes for a nice finishing touch.

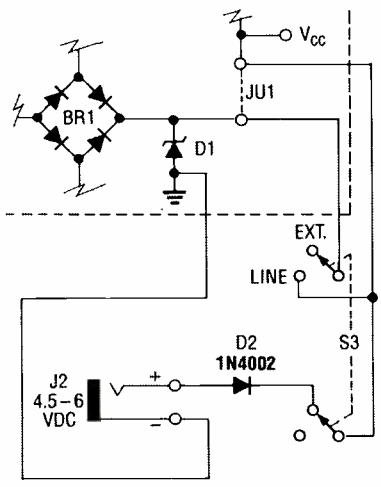


FIG. 7—EXTERNAL POWER ADDITION. The parts can be mounted on the rear panel and wired into the board. S3 will switch the unit between being line-powered and powered from an external source.

Construction

Because the Speaker-Mate is designed with some tight time constants, it is highly recommended that suggested part values be followed for optimum performance. And, although a variety of project cases can be used, the electronics and the physical layout were tuned for the enclosure used with the prototype; it is available from many different distributors as well as from the source mentioned in the parts list. The project case comes with a professionally screened front panel when purchased from that source.

With the exception of the front-panel mounted components and the speaker, all parts fit on the PC board; a foil pattern is provided if you want to etch your own board. A pre-etched board is available separately, as is a kit that includes the PC board and all other parts to completely build the Speaker-Mate project.

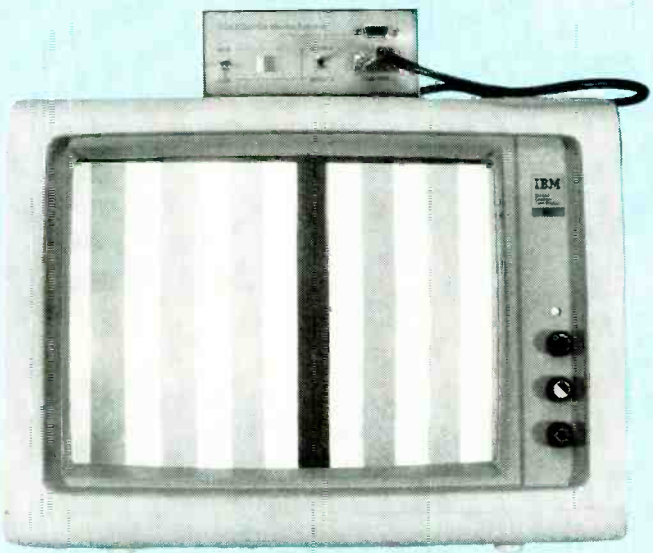
A parts-placement diagram is shown in Fig. 4. Mounting the two IC's first gives a good reference for the rest of the component mounting. Double check the polarity of each IC before soldering, and note that pin 1 goes on the square pad on the PC board. (Incidentally, the other square pads indicate jumpers or external leads.) It is suggested that you use IC sockets for both IC's, especially for the 28-pin chip.

The resistors can be mounted next, their clipped leads can be used as jumpers (J) where necessary. However, don't install the jumpers at this time. Diode D1, bridge rectifier BR1, and the electrolytic capacitors are polarized and should be checked carefully before mounting. The phone jack, J1, has plastic "feet" on the bottom of it. After positioning the jack on the PC board, the feet should be melted apart on the underside of the board with the tip of your soldering iron to provide mechanical strength. Be

continued on page 66

MONITOR TESTER

Our sync generator lets you test computer monitors without having to connect them to a computer.



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SERVICING COMPUTER monitors isn't all too different from servicing composite-video monitors and television sets. There are some very important differences, however, the most obvious of which is that most computer monitors don't operate on the NTSC horizontal frequency of 15.734 kHz and vertical frequency of 59.94 Hz. Since your standard video test gear can't be used, you need a new troubleshooting tool—a computer-video sync generator.

We'll show you how to build a "sync generator" that provides horizontal sync, vertical sync, and RGB video for three popular styles of monitors: CGA, EGA, and VGA. Without connecting the monitor to a computer, you'll be able to verify video, deflection, and DC supply generation. Once repairs are made, fine tuning adjustments can be done with the monitor connected to a computer using appropriate software. However, using the sync generator first prevents tying up a computer that could be used more productively elsewhere.

Circuit description

The sync generator is a complex frequency-divider circuit. The starting point is two TTL clock oscillators—one is 5.0688-MHz (OSC1) and the other is 4.9152-MHz (OSC2). Depending upon two switch settings, one of the clock signals gets routed to various divider stages, ultimately leading to the final stage, a 4-bit binary counter.

VGA operation

Referring to the schematic in Fig. 1, switch S2, when closed, places a logic "0" (a low) on pin 1 of IC6, a 74HC158 quad 2-line to 1-line selector, so all "A" inputs will be passed to the "Y" outputs. The output of OSC1, a TTL clock oscillator, is then passed from pin 14 of IC6 (A4) to pin 12 (Y4) and then to the CLK input (pin 8) of IC3, a 74LS164 shift register. (**NOTE:** It is important that the EGA/VGA switch S2 is in the proper position for the type of monitor in use. An improper horizontal sync frequency can easily cause damage to deflection circuits!)

At the same time, the QE output of IC3 (pin 10) is fed through a 74HC14 Schmitt inverter (IC2-d) into the A3 input of IC6 (pin 11). That signal is then passed to the Y3 output (pin 9), through R10, to the base of Q1, and to IC3's CLR input (pin 9). As a result, the clock signal is divided by five and used as a reset, so every fifth clock pulse causes a clear to occur.

As just mentioned, shift register IC3 divides its CLK input (OSC1's output) by five (5.0688/5 = 1.01376). In other words, all of the "Q" outputs have a frequency of ⅕ the clock input, but only when the chip is reset by its own QE output. The QC output (which is also ⅕ the clock input when the chip is reset by QE) of IC3 (pin 5) sends the 1.01376-MHz signal to IC4-a's (a 74LS74 D-type flip-flop) CLK input (pin 3) where it is further divided by 2, so the net division is ten.

With that division by ten, a 506.88-kHz signal is sent to pin 2 of IC6 (A1), passed through to pin 4 (Y1), and on to binary counter IC5's (a 74LS163) CLK input (pin 2). Counter IC5 divides the signal by 16 to produce a horizontal sync of 31.68 kHz with a pulse width of 2 microseconds. Counter IC5 also divides the CLK input by two for generating blue (QA, pin 14), by four for red (QB, pin 13), and by eight for green (QC, pin 12). In other words, blue video is gated eight times the horizontal sync, red video four times, and green twice. The monitor thus lights up with yellow, cyan, green, magenta, red, blue, black, and white bars, and then repeats. (Note that the CGA/EGA

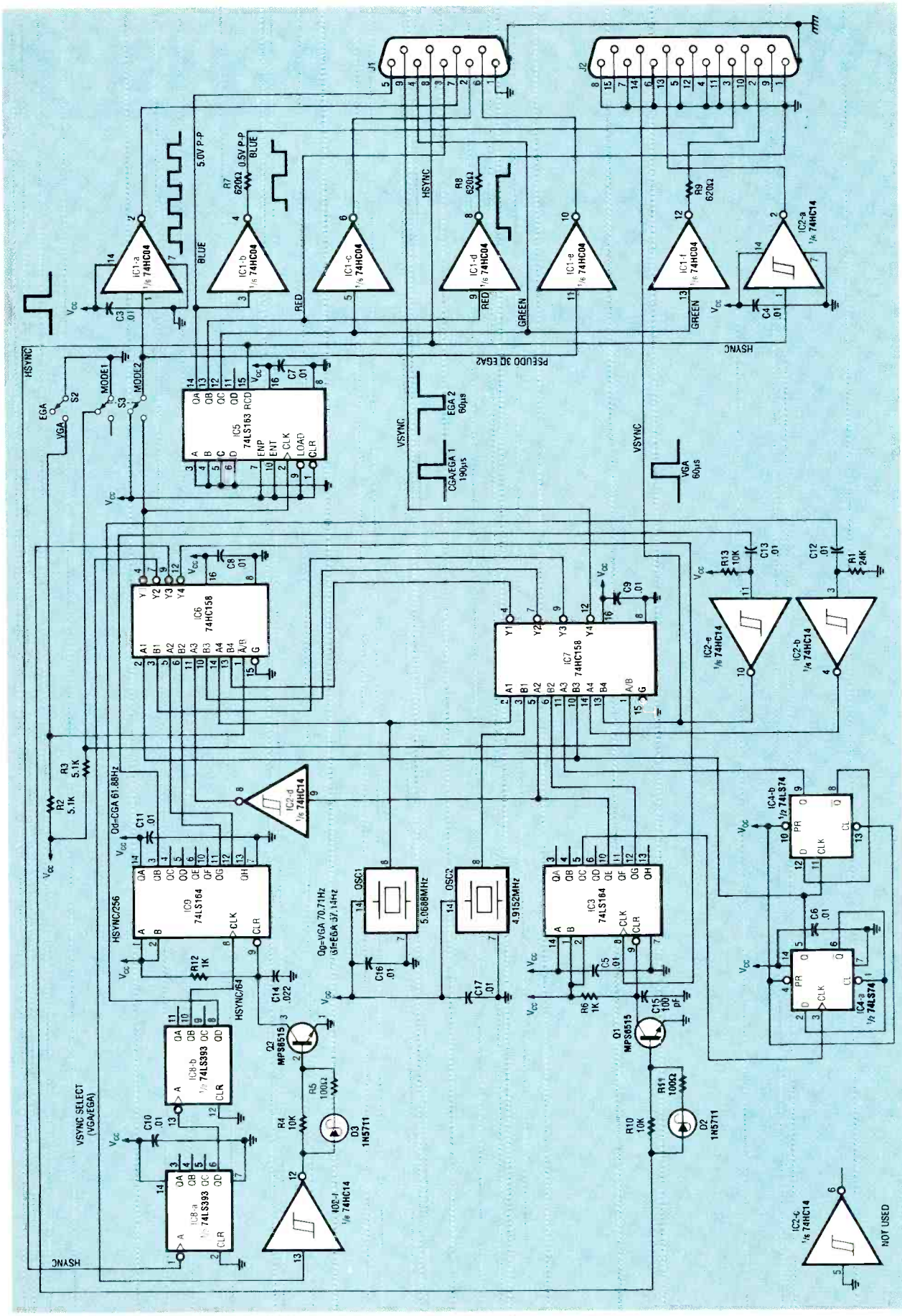

FIG. 1—MONITOR EXERCISER SCHEMATIC. When operating the unit, make sure that EGA/VGA switch S2 is in the proper position for the type of monitor in use. An improper horizontal sync frequency can cause damage to deflection circuits.

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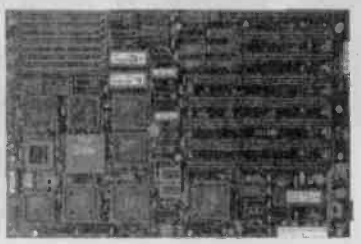

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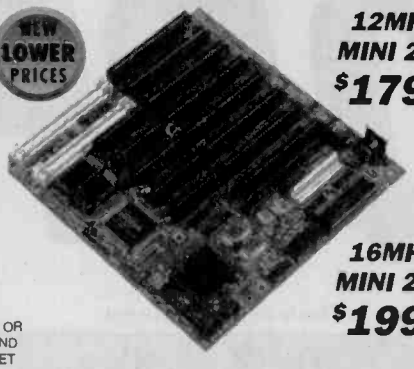

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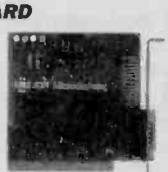

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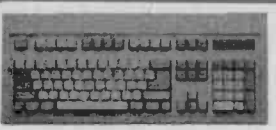

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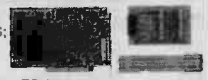

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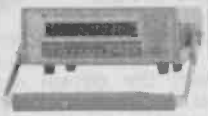

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PART#	SIZE	SPEED	Vpp	PINS	PRICE
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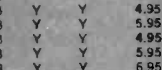
2732A	4096x8	250ns	21V	24	3.95
2764	8192x8	450ns	12.5V	28	3.95
2764-250	8192x8	250ns	12.5V	28	3.95
2764-200	8192x8	200ns	12.5V	28	4.49
27128A-200	16384x8	200ns	12.5V	28	4.95
27256	32768x8	250ns	12.5V	28	4.95
27C256	32768x8	250ns	12.5V	28	5.95
27512	65536x8	250ns	12.5V	28	5.95
27C1024-20	131072x8	200ns	12.5V	32	17.95

STATIC RAM

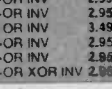
PART#	SIZE	SPEED	PINS	CMOS	LP	PRICE
HM6116-2	2048x8	120ns	24	Y	N	2.95
HM6116LP-4	2048x8	200ns	24	Y	Y	2.95
HM6116LP-3	2048x8	150ns	24	Y	Y	3.25
HM6116LP-2	2048x8	120ns	24	Y	Y	3.95
HM6264LP-15	8192x8	150ns	28	Y	Y	3.95
HM6264LP-12	8192x8	120ns	28	Y	Y	4.95
HM6264LP-10	8192x8	100ns	28	Y	Y	5.95
HM43256LP-15	32768x8	150ns	28	Y	Y	4.95
HM43256LP-12	32768x8	120ns	28	Y	Y	5.95
HM43256LP-10	32768x8	100ns	28	Y	Y	6.95

PALS



PART#	SPEED	PINS	IN	OUT	I/O'S	FUNCTIONS	PRICE
16L8	35ns	20	10	2	6	AND-OR INV	2.95
16R4	35ns	20	8	4	4	AND-OR INV	2.95
16R6	35ns	20	8	6	2	AND-OR INV	2.95
20L8	40ns	24	14	2	6	AND-OR INV	2.95
20R4A	25ns	24	12	4	2	AND-OR INV	3.49
20R6	40ns	24	12	6	2	AND-OR INV	2.95
20R8	40ns	24	12	8		AND-OR INV	2.95
20X8	50ns	24	10	8	2	AND-OR XOR INV	2.95

GALS



PART#	SPEED	PINS	REPLACES	IN	OUT	PRICE
16V8	35ns	20	10L8 TO 16RP8	8	8	2.49
16V8-15	15ns	20	10L8 TO 16RP8	8	8	2.95
20V8	35ns	24	14L8 TO 16RP8	20	8	3.49
20V8-15	15ns	24	14L8 TO 16RP8	20	8	4.95
22V10	35ns	24	PGM OUTPUTS	22	10	6.95
22V10-15	15ns	24	PGM OUTPUTS	22	10	19.95

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TYPE		ORDER BY	CONTACTS 09	15	25	37	50
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	FEMALE	DBxxS	.49	.89	.75	1.39	2.29
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	FEMALE	DExxSR	.55	.75	.85	2.49	—
W/W TYPE	MALE	DExxPWW	1.69	2.56	3.89	5.69	—
	FEMALE	DExxSWW	2.76	4.27	6.84	9.95	—
IDS TYPE	MALE	IDBxxP	1.39	1.99	2.25	4.25	—
	FEMALE	IDBxxS	1.45	2.05	2.35	4.45	—
HOODS	METAL	MI-OODxx	1.05	1.15	1.25	—	—
	PLASTIC	HOODxx	.39	.39	.39	.69	.75

IC SOCKETS DIP CONNECTORS

TYPE	ORDER BY	CONTACTS 08	14	16	20	24	28	40
SOLDERTAIL	xx PIN ST	.11	.11	.12	.18	.20	.22	.30
WIREWRAP	xx PIN WW	.59	.69	.89	1.09	1.49	1.69	1.99
ZIF	ZIF-xx	—	6.95	6.95	9.95	10.95	11.95	14.95
TOOLED	AUGATxx	.55	.59	.89	.85	.99	1.09	1.29
TOOLED WW	AUGATxxWW	1.30	1.80	2.10	2.50	3.15	3.70	5.40

IDC CONNECTORS AND CABLE

DESCRIPTION	ORDER EY	CONTACTS 20	26	34	40	50
SOLDER HEADER	IDHxxS	1.29	1.68	2.20	2.58	3.24
R/A HEADER	IDHxxSR	1.35	1.76	2.31	2.72	3.39
W/W HEADER	IDHxxW	2.98	3.84	4.50	5.28	6.63
R/A W/W HEADER	IDHxxWR	3.28	4.22	4.45	4.80	7.30
HEADER SOCKET	IDSxx	.65	.75	.75	1.19	1.19
RIBBON HEADER	IDMxx	5.50	6.25	7.00	7.50	8.50
IDC EDGE CARD	IDExx	.55	.75	.89	1.29	1.69
RIBBON CABLE	RCxx	.30	.39	.51	.60	.75

ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED. EXAMPLE: A 15-PIN RIGHT ANGLE MALE PC SOLDER PART NUMBER WOULD BE DB15PR.

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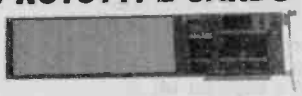

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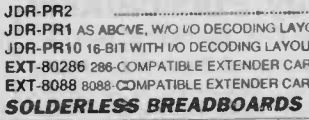

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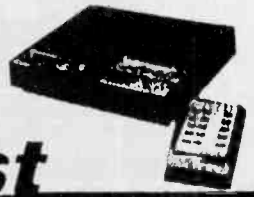

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8701	6.75	Clock Chip (251527-01)	16
82S100PLA	15.95	For C64 (U17) and C128 (906114-01) No data available	28

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Order #	Price	Organization	Pins
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2816A35	3.45	2048x8 350ns, 5V Read/Write	24
2817A25	6.75	2048x8 250ns, 5V Read/Write (Pin 1 – Ready/Busy)	28
2864A25	8.95	8192x8 250ns, 5V Read/Write (Pin 1 – N/C)	28
28C64-25	9.95	8192x8 250ns, 5V Read/Write CMOS (Pin 1 – N/C)	28
28C256-25	26.95	32,768x8 250ns, 5V Read/Write CMOS	28

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Order #	Price	Organization	Speed	Prog. Volt.	Pins
MM5203Q	2.25	256x8	2K ...1000ns	25V	24
TMS2516	4.25	2048x8	16K ...450ns	25V	24
TMS2532	6.95	4096x8	32K ...450ns	25V	24
TMS2532-30	8.95	4096x8	32K ...300ns	25V	24
TMS2532A45	7.95	4096x8	32K ...450ns	21V	24
TMS2564	5.95	8192x8	64K ...450ns	25V	28
TMS2564-50	4.75	8192x8	64K ...500ns	25V	28
TMS2716	5.95	2048x8	16K ...450ns (±5V, +12V)	25V	24
2708	4.75	1024x8	8K ...450ns (±5V, +12V)	25V	24
2716	3.45	2048x8	16K ...450ns	25V	24
2716-1	3.95	2048x8	16K ...350ns	25V	24
27C16	4.25	2048x8	16K ...450ns CMOS	25V	24
2732	3.95	4096x8	32K ...450ns	25V	24
2732A20	4.75	4096x8	32K ...200ns	21V	24
2732A25	3.45	4096x8	32K ...250ns	21V	24
2732A45	2.95	4096x8	32K ...450ns	21V	24
2732B45	4.25	4096x8	32K ...450ns	12.5V	24
27C32	4.75	4096x8	32K ...450ns CMOS	25V	24
2764-20	3.95	8192x8	64K ...200ns	21V	28
2764-25	3.75	8192x8	64K ...250ns	21V	28
2764A15	4.45	8192x8	64K ...150ns	12.5V	28
2764A20	3.95	8192x8	64K ...200ns	12.5V	28
2764A25	3.25	8192x8	64K ...250ns	12.5V	28
2764A45	2.95	8192x8	64K ...450ns	12.5V	28
2764AOTP	2.25	8192x8	64K ...250ns One Time Prog.	12.5V	28
27C64A15	3.95	8192x8	64K ...150ns CMOS	12.5V	28
27C64FP25*	3.95	8192x8	64K ...250ns One Time Prog.	12.5V	PLCC 32
27128-20	6.75	16,384x8	128K ...200ns	21V	28
27128-25	5.95	16,384x8	128K ...250ns	21V	28
27128A15	5.75	16,384x8	128K ...150ns	12.5V	28
27128A20	4.95	16,384x8	128K ...200ns	12.5V	28
27128A25	3.95	16,384x8	128K ...250ns	12.5V	28
27128A30	3.25	16,384x8	128K ...300ns	12.5V	28
27128AOTP	2.95	16,384x8	128K ...250ns One Time Prog.	12.5V	28
27C128-15	5.95	16,384x8	128K ...150ns CMOS	12.5V	28
27C128-25	5.25	16,384x8	128K ...250ns CMOS	12.5V	28
27CP128-20	5.75	16,384x8	128K ...200ns CMOS	12.5V	28
27256-15	5.75	32,768x8	256K ...150ns	12.5V	28
27256-20	5.25	32,768x8	256K ...200ns	12.5V	28
27256-25	4.75	32,768x8	256K ...250ns	12.5V	28
27256-30	3.45	32,768x8	256K ...300ns	12.5V	28
27C256-15	5.95	32,768x8	256K ...150ns CMOS	12.5V	28
27C256-25	4.25	32,768x8	256K ...250ns CMOS	12.5V	28
27C256FP25*	4.95	32,768x8	256K ...250ns One Time Prog.	12.5V	PLCC 32
27512-20	6.95	65,536x8	512K ...200ns	12.5V	28
27C512-12	8.95	65,536x8	512K ...120ns CMOS	12.5V	28
27C512-15	6.95	65,536x8	512K ...150ns CMOS	12.5V	28
27C512-25	5.95	65,536x8	512K ...250ns CMOS	12.5V	28
27C010-15	9.95	131,072x8	1MB ...150ns CMOS	12.5V	32
27C020-15	24.95	262,144x8	2MB ...150ns CMOS	12.5V	32

*Surface Mount

8000

Order #	Price
8031	3.55
80C31	7.25
8035	1.75
8039	1.75
80C39	3.75
8080A	2.75
8085A	2.95
8085A2	3.55
8086	4.45
8088	4.25
8088-1	7.25
8088-2	6.25
8155	2.45
8155-2	3.75
82C11	5.95
8212	2.45
8214	3.85
8216	1.35
8224	2.45
8237A5	4.15
8243	1.95
8250	5.75
8251A	2.25
8253	1.95
8253-5	2.25
8254	4.55
8254-2	5.95
8255A5	2.75
8256	10.75
8257	2.25
8259-5	2.25
8272	3.75
8274	6.55
8275	18.95
8279-5	3.45
8284A	2.25
8286	2.95
8288	3.75
A80286-10	19.95
N80286-12	21.95
N80L286-8	11.95
R80286-12	26.95
R80286-6	9.95
80C287A12*	49.95
82C284-8	4.95
82C284-12	19.95
82288-8	4.95
82288-12	19.95
83D87-33	199.95
8741	9.95
8742	14.25
8748H	8.95
8749	9.95
8751	24.95
8755	11.95

*For Laptops Only

DYNAMIC RAMS

Order #	Price	Organization	Speed	Pins
4116-12	1.45	16,384x1	120ns	16
4116-20	.85	16,384x1	200ns	16
4816A4	.55	16,384x1 Single +5V	250ns	16
4416-12	2.25	16,384x4	120ns	18
4416-15	1.95	16,384x4	150ns	18
4161-15	4.95	65,536x1 Video RAM	150ns	20
4164-10	1.95	65,536x1	100ns	16
4164-15	1.55	65,536x1	150ns	16
4164-20	1.25	65,536x1	200ns	16
41264-12	6.95	65,536x4 Video RAM	120ns	Skinny Dip 24
41464-80	3.25	65,536x4	80ns	18
41464-12	2.75	65,536x4	120ns	18
41256-10	1.95	262,144x1	100ns	16
41256-12	1.85	262,144x1	120ns	16
41256-15	1.75	262,144x1	150ns	16
41257-12	3.25	262,144x1 Nibble	120ns	16
51258-80	4.95	262,144x1 Static Column	80ns	16
514256-80	7.25	262,144x4	80ns	20
514256-10	6.95	262,144x4	100ns	20
514258-80	9.95	262,144x4 Static Column	80ns	20
524256VZ80	16.95	262,144x4 Video RAM	80ns	ZIP 28
511000-80	7.25	1,048,576x1	80ns	18
511000-10	6.95	1,048,576x1	100ns	18
511000-12	6.55	1,048,576x1	120ns	18
511001-80	8.25	1,048,576x1 Nibble	80ns	18

STATIC RAMS

Order #	Price	Organization	Speed	Pins
2101	1.65	256x4	450ns	22
2111	1.75	256x4	450ns	18
2112	2.45	256x4	450ns	16
5101	3.95	256x4 CMOS	450ns	22
2114L20	1.49	1024x4 Low Power	200ns	18
2114-45	1.05	1024x4	450ns	18
2148-3	1.95	1024x4	55ns	18
2149-35	3.75	1024x4	35ns	18
2147-3	3.75	4096x1	55ns	18
20C71-25	6.75	4096x4 CMOS	25ns	Skinny Dip 24
6168-45	3.25	4096x4 CMOS	45ns	20
6116LP1	2.95	2048x8 CMOS Low Power	100ns	24
6116LP3	2.75	2048x8 CMOS Low Power	150ns	24
6116-1	2.75	2048x8 CMOS	100ns	24
6116-3	2.25	2048x8 CMOS	150ns	24
6516-45	4.25	2048x8 CMOS	45ns	Skinny Dip 24
7C128-55	3.95	2048x8 CMOS	55ns	Skinny Dip 24
8128-15	2.15	2048x8	150ns	24
6264LP10	4.95	8192x8 CMOS Low Power	100ns	28
6264LP15	3.95	8192x8 CMOS Low Power	150ns	28
6264-10	4.75	8192x8 CMOS	100ns	28
8167-55	3.45	16,384x1	55ns	20
62256LP10	6.75	32,768x8 CMOS Low Power	100ns	28
62256LP15	6.25	32,768x8 CMOS Low Power	150ns	28
62256SLP12	7.95	32,768x8 CMOS Low Power	120ns	Skinny Dip 28
628128LP8	34.95	131,072x8 CMOS Low Power	85ns	32
628128LP10	32.95	131,072x8 CMOS Low Power	100ns	32

Z80A, Z80B, Z80-8MHZ, Z8000

Order #	Price	Description	Pins
Z0803008PSD	9.50	Serial Communications Controller 8Mhz	40
Z80A	1.25	CPU (MK3880-4) (780C-1) 4Mhz	40
Z80A-CTC	1.55	Counter Timer Circuit (MK3882-4) 4Mhz	28
Z80A-DART	3.95	Dual Asynchronous Receiver/Transmitter 4Mhz	40
Z80A-PIO	1.85	Parallel I/O Interface Controller (MK3881-4) 4Mhz	40
Z80A-SIO/0	3.95	Serial I/O (TxCB & RxCB Bonded) (MK3884-4) 4Mhz	40
Z80A-SIO/2	3.95	Serial I/O (Lacks SYNCB) (MK3887-4) 4Mhz	40
Z80B	2.45	CPU (MK3880-6) 6Mhz	40
Z84C0008	5.95	CPU 8Mhz (CMOS)	40
Z84C1008	10.95	DMA (Direct Memory Access) 8Mhz (CMOS)	40
Z84C2008	5.95	PIO (Parallel I/O Interface Cont.) 8Mhz (CMOS)	40
Z84C3008	5.95	CTC (Counter Timer Circuit) 8Mhz (CMOS)	28
Z84C4008	8.95	SIO/0 8Mhz (CMOS)	40
Z84C4108	8.95	SIO/1 8Mhz (CMOS)	40
Z84C4208	8.95	SIO/2 8Mhz (CMOS)	40
Z8530	4.55	Serial Communications Controller	40

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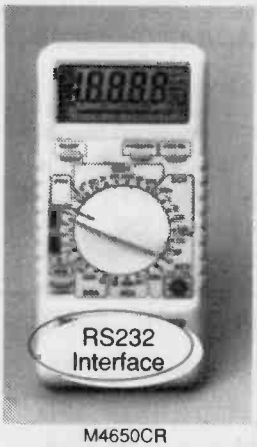
METEX 4 1/2 DIGIT LCD DMM



M4650CR

FUNCTION	RANGE	ACCURACY	RESOLUTION
DC VOLTAGE	200mV	±0.05% of rdg+3dgts	10µV
	2V		100µV
	20V		1mV
	200V		10mV
	1000V	±0.1% of rdg+5dgts	100mV
AC VOLTAGE	200mV	±0.5% of rdg+10dgts	10µV
	2V		100µV
	20V		1mV
	200V		10mV
	750V	±0.8% of rdg+10dgts	100mV
DC CURRENT	2mA	±0.3% of rdg+3dgts	100nA
	200mA	±0.5% of rdg+3dgts	10µA
	20A	±0.8% of rdg+5dgts	1mA
AC CURRENT	2mA	±0.8% of rdg+10dgts	100nA
	200mA	±1.0% of rdg+10dgts	10µA
	20A	±1.2% of rdg+15dgts	1mA
RESISTANCE	200Ω	±0.2% of rdg+5dgts	0.01Ω
	2KΩ	±0.15% of rdg+3dgts	0.1Ω
	20KΩ		1Ω
	200KΩ		10Ω
	2MΩ		100Ω
	20MΩ	±0.5% of rdg+5dgts	1KΩ
CAPACITANCE	2000pF	±2.0% of rdg+20dgts	0.1pF
	200nF		10pF
	20µF	±3.0% of rdg+30dgts	1nF
FREQUENCY	20KHz	±2.0% of rdg+10dgts	1Hz
	200KHz		10Hz

GENERAL CHARACTERISTICS:
Max. Display: 19999 counts with automatic polarity indication • **Max. Input Current of AC and DC:** 20A (max. of 15 minutes) • **Overrange Indication:**"OL" and "Bar graph flashing" figure on display • **Max. Common Mode Voltage:** 500VDC/AC RMS • **Reading Rate Time:** Approx. 1-2 readings per sec. • **Temp. for Guaranteed Accuracy:** 23°C ±5°C • **Temperature Ranges:** Operating 0°C to 40°C, 32°F to 104°F, Storage –10°C to 50°C, 14°F to 122°F • **Power Supply:** One 9V battery (Included) • **Size:** 3.4"W x 7.4"D x 1.3"H • **Unit Weight (Excluding carrying case):** 0.8 lbs. • **Accessories:** Operating manual, 9V battery, test leads, spare fuse, and carrying case. RS-232C Cable, Floppy Disk (Optional)

Order #	Price	Description	Weight
M4650CR	109.95	4 1/2 Digit LCD Multitester	1.50 lbs.
RS232C	9.95	RS-232 Interface (Cable and Floppy Disk)	3.5 oz.

SOLDERING STATIONS

Features – 168-3CK
•The AUTOTEMP 168-3CK soldering station offers the ultimate in controlled temperature hand soldering • The soldering tip is grounded through the power unit to ensure less than 0.4mV or 0.03mA leakage • The cartridge element wire is precision wound at the end of the stainless steel shaft to ensure max. temperature as close to the working surface of the tip as possible. This results in both rapid heating and instant recovery •AutoTemp is constructed with a lock-out feature to allow supervisors the ability to set and lock the stations at a specific temperature • Ideal for hobbyists, service technicians or production lines.

Features – XY9-60DK
•SUPERTEMP XY9-60DK solder station offers a unique electronic control circuit that maintains tip temperature to within ±3°C (6°F) of idling. This is accomplished by embedding the thermocouple sensing unit in the top of the heating element shaft so that the tip actually sits against it • Revolutionary electronic "Zero Voltage" thyristor switching protects voltage and current sensitive components (CMOS devices) against transient voltage spikes caused in stations using mechanical switching action • Heat-up time to working temperature approx. 60 seconds • Supertemp units exceed all soldering equipment military specifications regarding electro-static sensitive devices due to zero voltage switching and fully grounded tip.

Order #	Price	Description	Weight
168-3CK	69.95	60 Watt Soldering Station	2.38 lbs.
XY9-60DK	109.95	60 Watt Soldering Station (Digital Readout)	4.68 lbs.

TOOL KITS

E8305

Both units feature: DMM's, pliers, utility knife, screw driver sets, hex key sets, wrenches, soldering iron, solder, desoldering pump, solder stand and much more!

E8900

The best collection of fix-it and put-it-together tools. Ideal for do-it-yourself, handyman and professional craftsman. Designed for most maintenance and repair jobs around the house, workshop, etc. Compact vinyl covered carry-along suitcase with combination lock and sturdy removable pallets. Provides safe storage and keeps all tools clean and organized. Case Size: 17.5" x 12.5" x 3.5"

The most popular tools come packed in this large and complete kit. Use it for building, repairing and general maintenance of most electronic equipment. The heavy duty, molded poly case is built to hold 2 pallets, and has a bottom center partition. The case comes with 2 surface type locks, a durable handle, side buckles and strap. Case Size: 18" x 14" x 7"

Order #	Price	Description	Weight
E8305	119.95	51 Piece Professional Tool Kit	12 lbs.
E8900	199.95	92 Piece Electrician's Tool Kit	17 lbs.

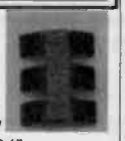
2.25" SPEAKER

"STAR"
Model SF575D
•Output: 0.2 Watt
•Impedance: 32Ω
•Diameter: 2.25"
•Terminals: Solder Lugs

Order #	Price	Description	Diam.
SP232	.95	32Ω Speaker	2.25"

HEAT SINK

"THERMALLOY"
Model THM6010
•Suit 14 & 16 Pin Dip ICs
•Can be added after assy
•Dimensions: 0.75" x 0.604"



Order #	Price	Description	Style
THM6010	.35	Heat Sink	DIP

WALL TRANSFORMER

"BPC"
Model BA-920
•Input: 115 VAC @ 60 Hz
•Output: 9 VDC @ 200mA
•UL Listed: 31J9/E82527

Order #	Price	Description	Weight
BA920	1.95	Wall Transformer	8 oz

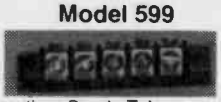
WALL TRANSFORMER

"ELECTRONICS CORPORATION"
Model AD135-700
•UL Listed: 74BI
•Input: 120 VAC @ 60 Hz
•Output: 13.5 VAC @ 700mA

Order #	Price	Description	Weight
AD135	2.95	Wall Transformer	11.4 oz

TERMINAL BLOCK

"KULKA"
Model 599



•Connection: Spade Tabs
•Mounting Holes: 5/32"

Order #	Price	Description	Pos.
TB5	.75	Terminal Block	5

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Spectrum Analyzer Display with spectrum analyzer plug-in. Goes from 0.1 to 1500 MHz, 1 KHz resolution, -117 to + 30 dBm amplitude range, calibrated.

$6500.00

HEWLETT-PACKARD 8640B

AM/FM Signal Generator, .5 to 512 MHz, + 19 to -145dBm RF output, counter, phase lock.

$2650.00

HEWLETT-PACKARD 3586B

Selective Level Meter

Makes carrier frequency measurements to 32.5 and voice channel measurements from 50 Hz to 100 KHz. Works with HP3336.

$3250.00

HEWLETT-PACKARD 3325A

Automatic Synthesizer, .1uHz to 21MHz, 1uHz resolution, 1mV to 10Vp-p, sine, square, triangle, +/- ramp, dc offset to 5V, full sweep.

$5000.00

FLUKE 8520A

Digital multimeter, 5.5 digit, AC/DC Volts, 2 & 4 wire ohms, 20ppm DC accuracy.

$795.00

HEWLETT-PACKARD 3336B

Synthesizer/ Level Generator

Bell standard, 10 Hz to 21 MHz, 4 output Z, AM, PM modulation .01-99.99 sec.

$1250.00

HEWLETT-PACKARD 8620C W/ HP 86290B *NEW*

Sweep Oscillator Mainframe, with Sweep Oscillator plug-in. 2 to 18.6 GHz, +10dBm, +/- 30MHz accuracy up to 18.6 GHz. Both pieces are new and come with manuals.

$7500.00

TEKTRONIX PLUG-INS

TEK 7A13 ***$750.00***
Differential amplifier

TEK 7A26 ***$350.00***
Dual trace amplifier

PG501 ***$850.00***
Pulse generator

SC504 ***$700.00***
Time mark generator

TEKTRONIX 576 CURVE TRACER

Accept 3 different test fixtures, delivers up to 220 watts, 2 or 3 lead devices.

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Resisitance decade box provides at the flip of a switch any resistance from 1 to 999,999 ohms for working circuits in 1 ohm steps.

$150.00

TEKTRONIX 7633

Storage oscilloscope, 100 MHz multimode storage, comes with (2) 7A18 dual trace amplifier, DC to 75 MHz. (1) 7B53A, dual time base.

$1150.00

WAVETEK 1067

Sweep generator, 1 to 400 MHz, primarily for CATV use. + 10 to - 55dBm calibrated output, RF output 75 ohm, includes manual.

$795.00

TEKTRONIX 466

100MHz Storage oscilloscope, 5 mV/div to 5V/div variable persistance, 3000 div/uS stored writing speed. Comes with 2 new Probe Master probes and a operators manual.

$1225.00

TEKTRONIX 7904

500 MHz oscilloscope with the following plug ins: 7A24, dual trace amplifier. 7A26, dual trace amplifier. 7B80, delayed time base. 7B85, delaying time base.

$2000.00

HEWLETT-PACKARD 435B

Power Meter, comes with HP 8481A power sensor & cable. Power range -25 dBm to + 20 dBm with 8481 A.

$ 1150.00

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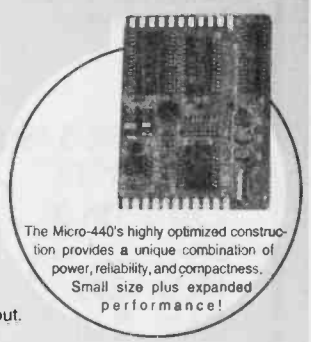
The Blue Earth Micro-440 is a versatile programmable controller designed for the demands of today's fast-paced development environment. The standard features of the Micro-440 provide you with everything needed for a quick, cost-effective solution to your project design requirements. In applications from automation to data logging, embedded control to hobby projects, see what the Micro-440 can do for you!

Standard Features:



- **83C51FB CPU** - High integration member of the popular 8051 family includes a PCA (Programmable Counter Array) with 5 high speed I/O channels and a watchdog timer.
- **Built-In BASIC and MONITOR-51** - The CPU ROM contains a floating point BASIC interpreter and an assembly language debug monitor for fast and easy program development.
- **32K RAM** - On-board memory can be used for program or data storage and includes a 10+ year lithium backup battery. A write protectable block is available for permanent program storage (no EPROM needed).
- **Dual RS-232C Ports** - Includes a primary communication channel plus a printer port and features a hardware or software selectable low power shutdown mode.
- **14 Digital I/O** - All I/O lines are TTL/CMOS compatible for easy interfacing to application circuitry.
- **Clock/Calendar Module** - Includes year, month, day, and time registers plus a programmable interrupt output.
- **Precision 5 Volt Regulator** - Allows operation from almost any filtered 6-16 volt D.C. source.
- **A/D Convertor** - An 8-bit 8 channel analog-to-digital convertor features single or differential inputs and 40µS conversion time.
- **Expansion Connector** - Contains all CPU bus signals plus power - enabling user to add Blue Earth or custom expansion modules.
- **Sturdy ABS Plastic Case** - Provides protection for electronic components and looks good, too!
- **6 Layer Board Uses SMT** - High tech manufacturing enhances performance and reliability while reducing overall size.

Expansion Modules

For fast implementation of expanded hardware requirements, Blue Earth Research has developed several ready to use add-on modules, all in their own attractive plastic case.

Application Module - For testing and demonstration. Includes 7-segment LED, beeper, potentiometer, and power MOSFETS.
12-Bit A/D Module - Four channels of high speed (8.5 µS) precision analog inputs.
I/O Expander - Adds 24 configurable I/O channels for LCD and keypad, general purpose I/O, or high current outputs.
Memory Expander - Plug in 8K to 128K bytes of RAM, EPROM, or EEPROM.

APPLICATION MODULE

Software

The Micro-440 can be purchased with a wide range of program development and support software. All software packages run on any PC or compatible and include complete documentation.

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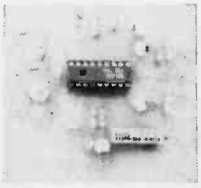

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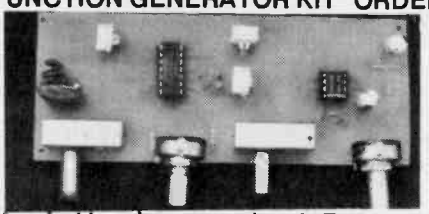

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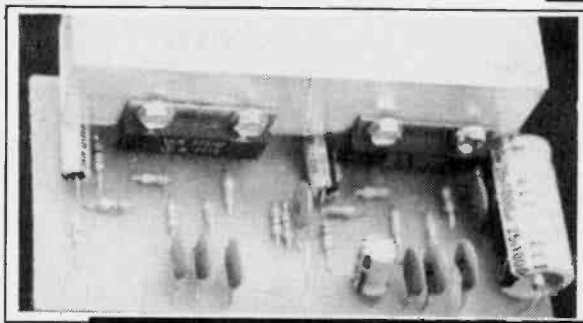

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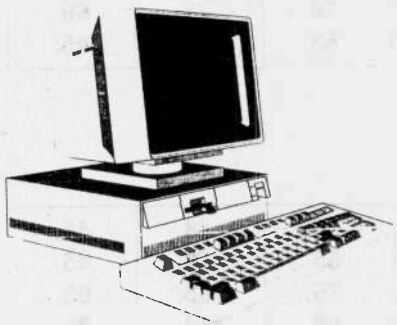

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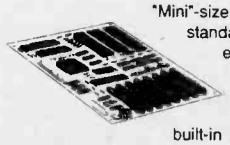

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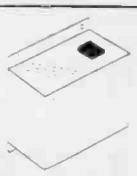

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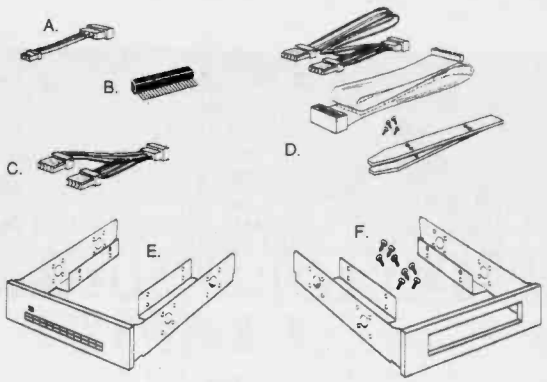

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E	3.5" to 5.25" Hard Disk Drive Bracket, New	HDK325S	9.95
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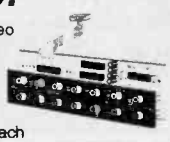

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B	9VDC @ 225mA	2.5mm	8735	$2.95
B	9VDC @ 500mA	3mm Coax	10853	$3.95
A	12VDC @ 500mA	3p. DIN	6814	$4.95
A	14VDC @ 200mA	None	7976	$2.95
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B	17VAC C.T. @ 750mA	None	12424	$3.95
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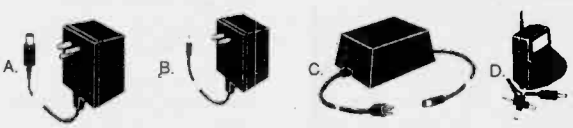

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6819 Redwood Dr., Cotati, CA 94931 (707)792-2277

Terms: Some quantities are limited; all items subject to prior sale. Minimum order: $10.00 plus shipping. Orders under $20.00 subject to $2.00 handling fee. All orders shipped FOB Santa Clara, CA (this means you pay freight!) by UPS Surface (no P.O. Boxes) unless otherwise specified, in which case prevailing carrier rate plus $5.00 handling fee applies. Prepaid orders for merchandise amounts only will be shipped freight COD. If you have questions about your order, call Customer Service at (408) 732-1854 M-F 9AM to 5PM PST.

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Call C.S.T. Monday thru Friday 9:00 - 6:00 • Sat. 10:00 - 2:00

Friendly Courteous Service • 10 Yrs. Experience • 6 Mo. Warranty

JERROLD	1-3	4 or more
NEW TRI/BI COMBO (FTB)	130.00	125.00
NEW TRI/BI PAN	89.00	80.00
NEW SB-3 COMBO	115.00	110.00
NEW SB-3 PAN	60.00	55.00
DPV-7212	CALL	
BASE BAND		
DPBB-7212	CALL	
DRZ-3105	53.00	50.00
FTB-2	89.00	80.00
SB-2	60.00	55.00
HAMLIN	1-3	4 or more
NEW HAMLIN COMBO (CH 2 or 3)	115.00	110.00
NEW HAMLIN MLD-1200	60.00	55.00
MLD-1200-2	60.00	55.00

PIONEER	1-3	4 or more
NEW SA-PIO-COMBO	160.00	155.00
NEW SA-PIO-PAN	95.00	90.00
SCIENTIFIC ATLANTA	1-3	4 or more
NEW SA-3 COMBO (SA-3B)	130.00	125.00
NEW SA-3 PAN	89.00	80.00
OAK	1-3	4 or more
NEW OAK N-12 COMBO (Vari Sync)	115.00	110.00
NEW OAK N-12 PAN (Vari Sync)	60.00	55.00
M-35-B	50.00	45.00
PANASONIC CONVERTERS	20 LOT	100 LOT
	65.00	58.00
ZENITH: CALL		
8580:	250.00	
8536:	190.00	

MOST ORDERS SHIPPED SAME DAY!

QTY.	ITEM	PRICE EA.	TOTAL PRICE

SUB TOTAL

SHIPPING Add $4.00 per unit

COD & CREDIT CARDS Add 5%

TOTAL

ABSOLUTELY NO ILLINOIS SALES —

VISA-MASTER ☐ C.O.D. ☐

CASHIER'S CHECK ☐ MONEY ORDER ☐

ORDERS ONLY: 1-800-735-5912

Card # _____ Exp. Date _____

(WAIVER) - MUST BE SIGNED FOR OUR RECORD

☐ Yes, I am paying for full service. This is only to be used as a second unit.

DECLARATION OF AUTHORIZED USE - I, the undersigned, do hereby declare under penalties 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.

SIGNATURE X _____

It is not the intent of MOVIE VIEW to defraud any television operator and we will not assist any company or individual in doing the same.

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Address _____

City _____ State _____ Zip _____

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48W

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COMPONENTS TO COMPUTERS

Ray-O-Vac Replacement Battery for AT

ACP P/N 844

ACP Only $9.95

LED's

T-1 3/4 Infared LED
Qty 10 Only $1.49

T-1 3/4 Red LED
Qty 10 Only .....79¢

T-1 3/4 Yellow LED
Qty 10 Only .....99¢

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E(E)PROM Programmers
Single socket version ....$129.
4 socket version .....$199.
8 socket version .....$269.
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UNIVERSAL
Programs E(E)PROM, PROM, PAL, GAL, EPLD, FPLD, tests TTL, CMOS, RAM etc.,
UniPro .....$549.

SUPER UNIVERSAL
Programs E(E)PROM, Flash EPROM, PROM, PAL, GAL, EPLD, FPLD (to 68 pins PLCC), tests TTL, CMOS, RAM etc. (to 40 pin),
SuperPro .....$699.

MICRO CONTROLLER PROGRAMMER
E(E)PROM, Controllers $359.

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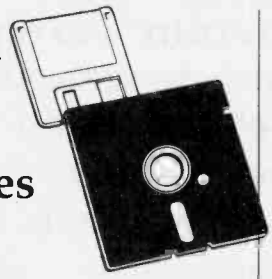
NEW! "4-in-1" Test Measurement System
Frequency Counter(100MHz), function Generator (2 MHz), 3-1/2 digit Multimeter and Power Supply all in chassis
MFI-"4-in-1" Tester .....$799.

3.5" and 5.25" Bulk Diskettes Sale



Disks certified to ANSI standards with ACP's 100% Money-Back Guarantee, sleeves and tabs included. Labels available...

5.25" Diskettes DS/DD (360K)
Qty. 1000 DS/DD .....20¢ each
Qty. 500 DS/DD .....23¢ each
Qty. 100 DS/DD .....25¢ each
Qty. 25 DS/DD .....27¢ each

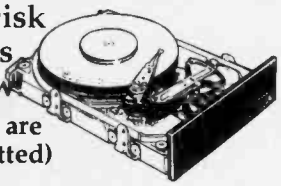
5.25" Diskettes DS/HD (1.2Mb)
Qty. 1000 DS/HD .....38¢ each
Qty. 100 DS/HD .....39¢ each
Qty. 25 DS/HD .....39¢ each

3.5" Diskettes DS/DD (720K)
Qty. 500 DS/DD .....38¢ each
Qty. 100 DS/DD .....39¢ each
Qty. 25 DS/DD .....39¢ each

3.5" Diskettes DS/HD (1.44Mb)
Qty. 500 DS/HD .....76¢ each
Qty. 100 DS/HD .....78¢ each
Qty. 25 DS/HD .....79¢ each

MASS STORAGE

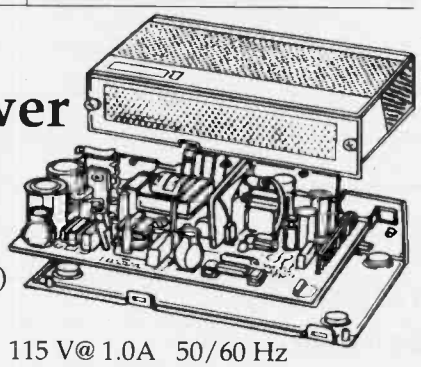
Hard Disk Specials All New!
(all sizes are as formatted)



AT Embedded Drives (IDE)
21.4Mb, 23ms, 2.5" drive,
#CP2024, list $699, ...sale $399
42.8Mb, 28ms, 3.5" drive, 1" high
#CP3000, list $549, ...sale $239
42.8Mb, 25ms, 3.5" drive, 1" high
#CP3044, list $575, ...sale $289
84Mb, 25ms, 3.5" drive,
#CP3184, list $845, ...sale $479
120Mb, 18ms, 3.5" drive, 1" high
#CP30104, list $999, ...sale $549
104.9Mb, 25ms, 3.5" drive,
#CP3104, list $930, ...sale $449
209.7Mb, 19ms, 3.5" drive,
#CP3204, list $1555, ...sale $799

SCSI Drives
42.8Mb, 25ms, 3.5" drive, 1" high
#CP3040, list $575, ...sale $289
104.9Mb, 25ms, 3.5" drive,
#CP3100, list $930, ...sale $489
21.4Mb, 19ms, 3.5" drive,
#CP3200, list $1555, ...sale $849

ASTEC Switching Power Supplies



115 V@ 2.2A,
230V @ 1.2A
50/60 Hz (10 1/2 x5x2 1/2" H)

Output 1 128W	Output 2 86W
+5V @ 10A	+5V @ 10A
+12V @ 2.5A	+12V @ 1.0A
+12V @ 3.5A	+12V @ 1.5A
-12V @ 0.5A	-12V @ 0.5A

ACP Only ..... $29.

115 V@ 1.0A 50/60 Hz
230V @ 0.6A (7 3/4 x4x2 1/2" H)
-5V @ 0.14A +24V @ 1.7A
+5V @ 2.2A
ACP Only open frame . $24.

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High Performance Data AcquisitionCard
The high-performance card, has A/D, D/A, D/I, D/O and counter/timer functions. Top specs, lot's of supporting software available
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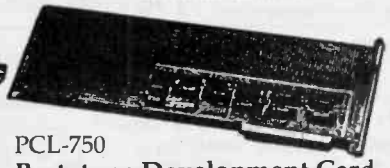
PCL-711S
Your-PC Multi-Lab Package
Low-cost fully-integrated package for general lab and industrial automation. 8 single-ended A/D inputs, one analog output (D/A), 16 digital inputs, 16 outputs, PCLD-7115 wiring terminal board and utility software.
ACP Price ..... $249.

PCL-755A/755C
Slot ExtensionCard/Kit
Compatible with IBM PC/XT and AT slots, plug in and raise the slot to top with straight pin-to-pin extension.
PCL-755A ..... $49.
The PCL 755C includes the PCL-755A plus a flat extension cable and external module to move four slots outside your PC making the slots more accessible for working with PC add-on cards.
PCL-755C ..... $79.

PCL-812
Enhanced MultiLab Card
Enhanced version of the MultiLab card offers high performance as well as low cost. 16 single-ended A/D inputs, 2 analog outputs (D/A), 16 digital inputs, 16 outputs, counter/timer (INTEL 8253), DMA and interrupt capability.
ACP Price ..... $319.



PCL-750
Prototype Development Card
Excellent alternative to a pure breadboard card for prototype developing of PC add-on cards. Built-in basic circuits, 3290 holes, independent memory and I/O decoders, sizes jumper selectable, all bus signals buffered, marked and ready for use.
ACP Price ..... $79.

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FG-8002
Function Generator
- Wide frequency range: 0.02 Hz to 2 MHz
- Versatile Waveformns: Sine Triangle, Square, Ramp and Pulse, Screwed Sine
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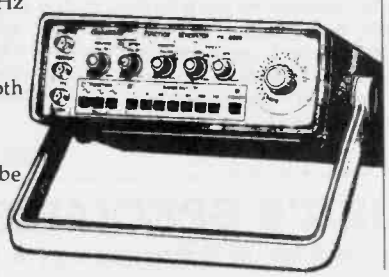
- Applied 0 to 10V to VCF input implements external sweep and output freq.
- DC Offset voltage from 0 to ±10V can be superimposed to output waveform
- Maximum Attenuation of 40db can be obtained

ACP Price ..... Call



Beckman Industrial™

Credit Card Size!

Model DM78
Digital Multimeter
- Slim-line design
- DC Volts, AC Volts, Ohms, Continuity, Diode test Functions
- Auto-Ranging
- Carry Case Included

ACP Price $29.95

Model 222F
Digital Multimeter
- 3-1/2 Digits, Auto-Ranging
- Accuracy 0.50% rdg
- DC Volts, AC Volts, Ohms, Continuity, Diode test Functions

ACP Price ..... $119.

Model 223F
Digital Multimeter
- 3-1/2 Digits, Auto-Ranging
- Audible Bar-Graph
- Accuracy 0.25% rdg
- DC Volts, AC Volts, Ohms, Continuity, Diode test Functions

ACP Price ..... $139.

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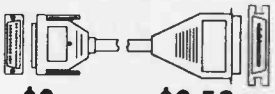
CIRCLE 222 ON FREE INFORMATION CARD

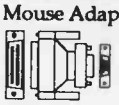
"WE HAVE GREAT CONNECTIONS"

#SPL-25
6 foot IBM/Clone parallel printer cable assembly type–biege w/thumbscrews



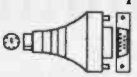
$3 ea 10 up **$2.50** ea

#SPL-29
DB25/F to DB9/M "AT" Mouse Adapter



$2 each

#SPL-31
Mini 6/M to DB9/M PS/2 Serial Adapter



$2 each

#VC-6FF
6 foot TV Cable "F" male to "F" male

6 ft **$1** Ea 12/ **$10**
12 ft **$2** Ea 6/ **$10**

#CN-433
5 Pin DIN Female cable mount–black

25¢ ea 100/ **$20**

#VA-154 Copyguard Corrector

Enjoy videotapes without flashing and tearing

Macrovision methods often make it impossible to enjoy a clear, stable picture from prerecorded video cassettes. Picture roll, jitter, snow, tearing and flashing are the annoying side effects cured by the Copyguard Corrector. Sophisticated digital circuitry inside this compact unit (no larger than two 8mm tapes!), descrambles any copy-protection scheme and delivers a stable, whistle-clean signal. Connects easily between two VCR's, or your VCR and a video monitor, with its single video in and video out jacks. Recently, copy protection developers have successfully sued to keep descramblers such as the Copyguard Corrector off the market. We cannot predict for how long this unit will be available. and suggest you order early to be safe!

Reg. $69.00 Now **$49** each or 2/ **$90** Special!

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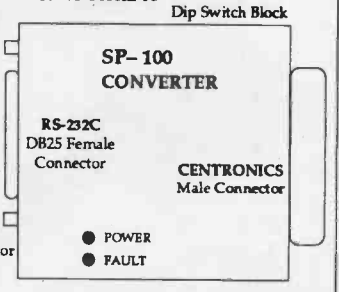
Serial/Parallel or Parallel/Serial Converter

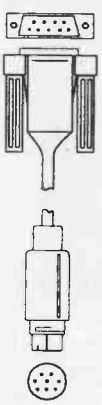
This Serial/Parallel Converter allows serial to parallel interface conversion. Examples of applications are: Computer with RS-232C output to printer with Centronics input, etc. The converter provides the following interfaces to facilitate solving your interface problems properly: TTL or CMOS compatible Centronics input interface connector, RS232C compatible output interface of DB25S type connector, baud rate selectable from 150 all the way up to 19200, and DCE/DTE selectable features, etc. Also available in Parallel/Serial version.



#CA-100SP Serial/Parallel Converter **$35** each 2/ **$60**
#CA-100PS Parallel /Serial Converter **$35** each 2/ **$60**

#CC-737

Adapter for:
- Mac 512 to Mac Plus or better.
- Mac 512 to Apple IIGS.

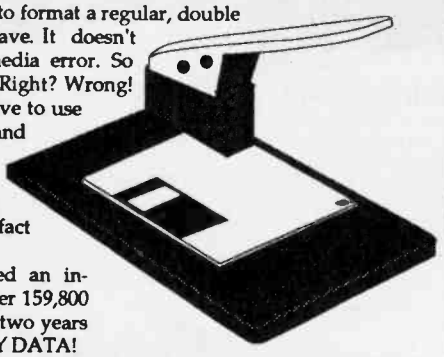


$1.50 20 up **$1** ea

#TM-319 DOUBLE DISK™ The original patented disk converter.

HOW IS THIS POSSIBLE? Have you ever tried to format a regular, double density 3.5" disk to 1.44 MB? Of course you have. It doesn't work. The computer gives you an invalid media error. So there must be a difference in the disk media. Right? Wrong! Surprisingly, manufacturers find it less expensive to use THE SAME MAGNETIC MEDIA for both HD and DD disks. THE ONLY DIFFERENCE IS THE EXTRA SENSE HOLE IN THE HD CASE. That hole tells the drive to operate in high density mode. So, how can you take advantage of the fact that the media is the same?

TWO YEARS OF TESTING. We've conducted an intensive testing program. We have converted over 159,800 disks and tested each one for data Integrity. In two years NOT ONE CONVERTED DISK HAS LOST ANY DATA! SUCCESS! "The Double Disk Converter" is a true product success story. From the moment we put it on the market the order lines have been ringing non stop! Nearly every major corporation, school, university and government agency is now using the device. In fact, over one hundred thousand satisfied purchasers are converting millions of disks and SAVING SERIOUS MONEY with the Double Disk Converter™.



STILL THE BEST
Made of heavy gauge, deep drawn steel! For all IBM/clones and Macintosh systems! Don't trust your data with anything less than The Original Double Disk Converter™!

$26.95 4 up **$25** ea

#CC-1001

100 ft RS-232 cable assembly, shielded 25 pin M/F. Gold plated pins. Fully shielded to stand shocks and misuse. Metal hoods.

$30 4 up **$25** ea

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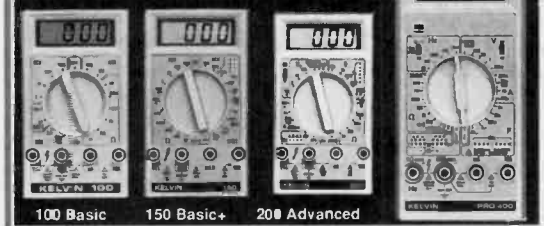
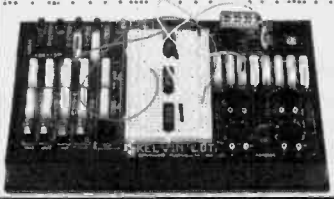
Kelvin Meters backed by a 2 Yr Warranty - Parts & Labor



100 Basic	150 Basic+	200 Advanced	PRO 400 with 20MHz Freq Counter
DC VOLTAGE AC VOLTAGE DC CURRENT RESISTANCE CONTINUITY - Test-Buzzer DIODE TEST BATTERY TEST 3½ Digit LCD LOW BATTERY ACCURACY - +/- 0.5% RDG IMPEDANCE-1 Meg	DC VOLTAGE AC VOLTAGE DC CURRENT RESISTANCE CONTINUITY - Test-Buzzer DIODE TEST TRANSISTOR hFE BATTERY TEST 3½ Digit LCD LOW BATTERY ACCURACY - +/- 0.5% RDG IMPEDANCE-1 Meg	DC VOLTAGE AC VOLTAGE DC CURRENT AC CURRENT RESISTANCE CAPACITANCE CONTINUITY - Tes -Buzzer DICDE TEST TRANSISTOR hFE 3½ Digit LCD LOW BATTERY ACCURACY - +/- 0.5% RDG IMPEDANCE-10 Meg	FREQUENCY COUNTER TO 20MHZ IDEAL FOR TROUBLE SHOOTING AC/DC VOLTAGE RANGES AC/DC CURRENT RANGES 5 FREQUENCY RANGES 5 CAPACITANCE RANGES LOGIC TEST CONTINUITY TESTER/BUZZER DIODE CHECK TRANSISTOR hFE TEST LED TEST VERIFY GOOD/BAD DISPLAY - 3 1/2 DIGIT LCD ACCURACY - 0.5% IMPEDANCE - 10 Mega Ohm
KELVIN 100 Basic $19.95	*KELVIN* 150 Basic+ $29.95	*KELVIN* 200 Advanced $39.95	*KELVIN* PRO 400 $69.95

Protective Cases — For Models 100, 150, 200 ..... $4.95 — Case For Model Pro 400 .... $9.95

DIGITAL TRAINER



Trainer Manual (100 Pgs) gives detailed instructions. An excellent training tool covering topics for High School (Beginner - Advanced), Trade School (Beginner - Intermediate) & College.

A PERFECT FIT WITHIN ANY DIGITAL CURRICULUM & YOUR CLASSROOM TEXTBOOK

FEATURES
- ONE DIGIT TRUE HEXADECIMAL DISPLAY WITH BUILT IN LOGIC (MEMORY, DECODER, DRIVERS) *FULL ALPHA CHARACTERS*
- TWO INDEPENDENT CLOCKS - USER ADJUSTABLE FREQUENCY & DUTY CYCLES
- BREADBOARD:500 PT PROTO-TYPE AREA
- TWO POWER DISTRIBUTION BUSSES (GND VCC)
- 4 DATA BIT SWITCHES
- MOMENTARY PUSH BUTTON SWITCH (SPDT)
- 4 LED DISPLAYS w/IC DRIVERS
- POWER SUPPLY: WALL PLUG-IN TYPE, U.L. LISTED
- VOLTAGE REG:+5 VOLTS, SHORT CIR. OVERLOAD PROTECT
- HOOK-UP WIRES
- COMPACT CARRYING CASE
- INSTRUCTION MANUAL FOR BEGINNER TO ADVANCED USERS

MADE WITH PRIDE IN THE USA

FREE COMPREHENSIVE TEACHER/STUDENT LAB MANUAL

THE *KELVIN* LDT™ Laptop Digital Trainer

ONLY $99.95

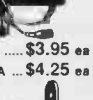
Stock No. 840460

WALL TRANSFORMERS

WALL TRANSFORMER

STOCK NO.	TYPE - Female	
220069	9V DC/500 mA	$3.95 ea
220068	12V DC/500 mA	$4.25 ea

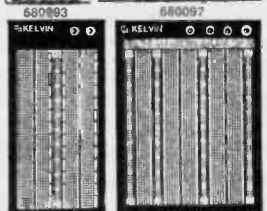
MALE JACK



STOCK NO.	TYPE	
370048	2.1 mm Male	$.49 ea ..... $.39 /10+

BREADBOARDS

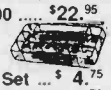
680093 — 680097



680098 — 680100

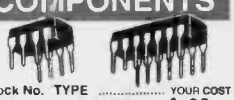
Stock No.	Post	Contacts	YOUR COST
630093	0	500	$ 4.25
630097	0	840	$ 5.95
630098	2	1380	$11.75
630100	4	2390	$22.95

WIRE JUMPER KIT
Pre-cut, Pre-Stripped



330289	140 Piece Set	$ 4.75
330290	350 Piece Set	$ 7.75

COMPONENTS



Stock No.	TYPE	YOUR COST
600021	555 TIMER	$.20 EA
600029	556 DUAL TIMER	$.40 EA
600039	LM566 PLL FUNCTION GENERATOR	$.60 EA
600018	741C OP-AMP INTERNALLY COMPENSATED	$.30 EA
600026	1458 OP-AMP DUAL 741C OP-AMP DIP	$.35 EA
630041	2N2222	$.18 EA
630383	PN2222	$.08 EA
600023	7805 VOLTAGE REG	$.36 EA

SILICON CONTROLLED RECTIFIER (Similar to GE C106C1) 4.0 AMP, 100 PIV
600014 $.89 EA $.79 EA/50+

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FLUKE 87 True RMS	$269
FLUKE 86 AUTOMOTIVE	$367
FLUKE 88 AUTOMOTIVE	$423
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Stock No. 740085

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150 MHz, X10
700073 ... $39.95

BATTERIES

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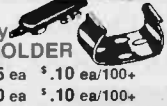
$1.95 ea
$1.75 ea/10+



9V Battery SNAP & HOLDER
Snap $.15 ea $.10 ea/100+
Holder $.20 ea $.10 ea/100+

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RED LED
As Low As 5¢ ea /1000+ Qty

JUMBO LED

TYPE - T 1 3/4, 5mm

STOCK NO.		YOUR COST	1000+ Qty
260020	Red	$.06 ea/100+	$.05 ea
260027	Green	$.08 ea/100+	$.07 ea
260026	Yellow	$.08 ea/100+	$.07 ea

LED HOLDER
for T 1 3/4 SIZE, BLACK
Stock No. 250019
$.10 ea / 100+ Qty
$.06 ea / 1000+ Qty

0.37" 7 SEGMENT LED READOUT

STOCK NO.	TYPE	COST	20+ Qty
260022	Anode	$.95 ea	$.75 ea
260090	Cathode	$1.25 ea	$.99 ea

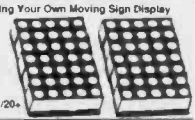
0.6" 7 SEGMENT LED READOUT

STOCK NO.		
260021	Anode Jumbo	
	COST	$1.15 ea
	20+ Qty	$.99 ea

RED LED DISPLAY
Bar Graph — 20 PIN

STOCK NO.	Color	YOUR COST	10+ Qty
260058	Red	$1.99 ea	$1.79 ea
260088	Green	$1.99 ea	$1.79 ea
260089	Yellow	$1.99 ea	$1.79 ea

MOVING SIGN DISPLAY
for Fabricating Your Own Moving Sign Display



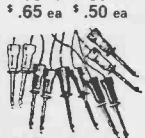
50 mm
STOCK NO. 260091
$5.95 ea
$5.45 ea /20+

TEST ACCESSORIES

IC CLIPS
SOLDER TYPE SPRING LOADED

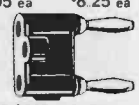
Stock No.	COLOR	COST	25+ Qty
990104	BLACK	$.65 ea	$.50 ea
990105	RED	$.65 ea	$.50 ea

IC TEST LEAD SET
5 COLOR CODED 18" LEADS WITH MINIATURE HOOK-ON PROD AT BOTH ENDS



Stock No.	YOUR COST	3+ Qty
990108	$8.95 ea	$8.25 ea

DOUBLE BANANA JACK



Stock No.	YOUR COST	3+ Qty
500056	$2.30 ea	$2.07 ea

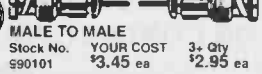
FEMALE BNC TO DUAL BANANA PLUG

Stock No.	YOUR COST	3+ Qty
990103	$2.95 ea	$2.75 ea

DUAL BANANA BINDING POST TO MALE BNC PLUG

Stock No.	YOUR COST	3+ Qty
600058	$5.95 ea	$4.95 ea

BNC TEST CABLES 3 FT.



MALE TO MALE

Stock No.	YOUR COST	3+ Qty
990101	$3.45 ea	$2.95 ea

PROJECT PARTS

Soldering IRON
with STAND, BLUE LONG LIFE TIP
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Project Speaker
2", 8 Ohm, .1 Watt
Stock No. 350009
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$1.39 ea / 10+ Qty

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Loud Penetrating Sound
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$.75 ea 9V DC
$.69 ea / 10+ Qty

DC MOTOR
for SOLAR/ROBOTIC
Stock No. 852211
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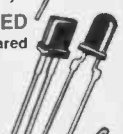
$.45 ea / 20+ Qty
1.5 to 6VDC

XENON STROBE TUBE
Stock No. 260050
$2.95 ea
$2.50 ea / 20+ Qty

TRIGGER COIL
for XenonStrobe Tube
Stock No. 320037
$1.25 ea
$.89 ea / 20+ Qty

INFRARED LED
IR Pair, LED infrared transmitter and receiver
Stock No. 260061
$2.79 ea



NEON LAMP
NE2, Long Leads
Stock No. 260003
$.15 ea
$.12 ea / 100+ Qty

PHOTO CELL
CADMIUM SELENIDE
Stock No. 260017
$.99 ea

PHOTO CELL
SULPHIDE
Stock No. 260018
$.99 ea

PUSH-BUTTON SWITCH
PUSH-ON, PUSH-OFF
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$.49 ea / 100+ Qty

SUB-MINIATURE MOMENTARY SWITCH
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$.35 ea
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MINIATURE TOGGLE SWITCH
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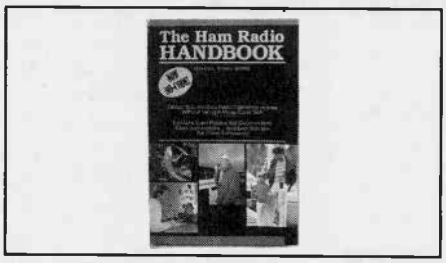

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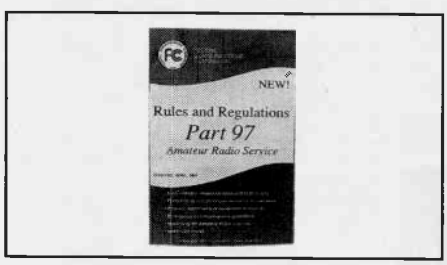

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#RN-320-190 $12.50 Each

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A good assortment of useable electrolytic capacitors. Assorted capacitance and voltage values. 50 pieces total.

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#RN-020-920 $4.95 Each

Value Kit

A comprehensive assortment of motors, switches, capacitors, connectors, lamps, transformers and more. A guaranteed wholesale value of at least $25.00.

#RN-320-145 $4.95 Each

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Kit contains 4 ft. each of the following sizes: 1/16", 1/8", 1/4", 1/2" and 3/4" sizes before heating. Assorted colors. Shrinks to 50% of original size.

#RN-320-170 $6.95 Each

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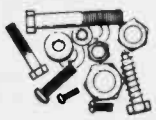
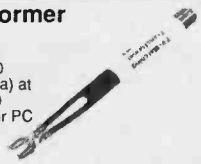
A good assortment of small wood, sheet metal and machine screws, machine bolts, nuts, washers, and other hardware. Hundreds of fasteners in different styles, sizes and finishes.



#RN-081-005 $3.95 Each

Matching Transformer

Adapts 75 ohm coax to 300 ohm twin lead (or visa-versa) at antenna or television. 5-90 MHz UHF/VHF. 3 capacitor PC board type.



#RN-180-010 49¢ (1-49) 35¢ (50-up)

F-59 Connector

Popular connector for cable TV systems. Full ferrule for hex crimp. Securely holds RG-59 cable.

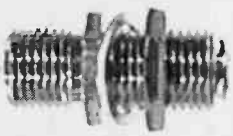
#RN-090-355 22¢ (1-49) 16¢ (50-up)

Push-On "F" Adaptor

#RN-090-357 50¢ (1-49) 38¢ (50-up)

F-81 Connector

(With nut and washer)

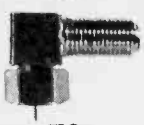


#RN-090-360 40¢ (1-49) 30¢ (50-up)

"F" Type Grounding Block

#RN-090-338 50¢ (1-49) 38¢ (50-up)

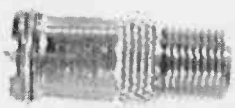
"F" Right Angle



#RN-090-337 90¢ (1-49) 70¢ (50-up)

Deluxe Push-On "F"

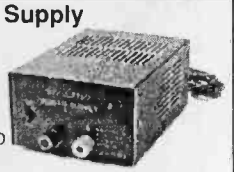
(Full attached ferrule)



#RN-090-356 60¢ (1-49) 48¢ (50-up)

3.5 Amp DC Power Supply

A quality, compact 12 VDC power supply. Perfect for testing car stereos, CB equipment, radar detectors and other 12 VDC items. Regulated 13.8 VDC, 3.5 amp continuous, 6 amp surge. LED power indicator. Binding post outputs. Net weight: 4 lbs.



#RN-120-500 List $79.50 $23.80 Your Cost

Quality 30 Watt Iron

Economical 30 watt iron with replaceable tip. Blue plastic handle. 120VAC. A quality iron at a reasonable price. Display packaged.

#RN-370-010 $4.90 (1-9) $4.70 (10-up)

Soldering Stand

Convenient weighted soldering iron stand with cleaning sponge. Display boxed.

#RN-370-020 $4.95 (1-9) $4.50 (10-up)

Mini Diagonal Plier

4-1/2" side cutters. Drop forged steel. Dipped plastic, insulated handles.

#RN-360-010 $4.25 (1-9) $3.80 (10-up)

4-1/2" Long Nose Plier

Quality drop forged steel. 4-1/2 inch overall length. Insulated, rubber dipped handles.

#RN-360-030 $3.75 (1-9) $3.35 (10-up)

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10 piece set contains two of each: Black, red, white, green, and yellow. 24 gauge, 12" length.

#RN-360-150 $3.25 (1-9) $2.75 (10-up)

Cleaning Brushes

Perfect for cleaning PC boards and other electronic assemblies. 8" overall length. Available with brass or nylon bristles.

#RN-360-400 (Nylon) 95¢ (1-9) 79¢ (10-up)
#RN-360-405 (Brass)

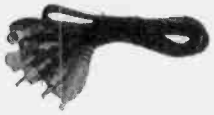
Quantity pricing applies per part number only.

Thruster Woofers

Designed to a take a beating! Specially manufactured with the automobile environment in mind. Humidity resistant polymerized paper cones. Gives them the sound quality of paper and the durability of polypropylene. Heavy duty oversized magnets. Two color printed polymerized dust caps. Red foam anti-fungal surrounds, and structurally superior stamped frame baskets.

Order#	Size	Magnet	V.C.	Z	Freq. Resp.	Power Cap.	SPL 1W/1M	QTS	fs	VAS	List	Your Cost
#293-040	8"	25 oz.	1.5"	4	35-4KHz	150W Max	95 dB	.14	39	1.94	$59.95	**$24.95**
#293-090	10"	30 oz.	2"	4	30-2KHz	175W Max	9623 dB	.12	32	3.78	69.95	**29.95**
#293-125	12"	40 oz.	2"	4	25-2KHz	200W Max	96.1 dB	.16	28	7.38	85.95	**39.95**
#293-150	15"	50 oz.	2"	4	23-2KHZ	250W Max	97.85 dB	.20	25	19.04	99.95	**59.95**

Car Stereo Patch Cables



Special extra long patch cable for connecting low level car stereo output (RCA) directly to a power amplifier. 17 foot length with ground strap to cut down on interference. Gold plated connectors.

#RN-240-140 $4.25 (1-9) **$3.95** (10-up)

12" Subwoofer Box

The perfect high volume cabinet for dual voice coil subwoofers. Cabinet volume: 2 cu. ft. with dual ports. This cabinet really performs (and it fits in most autos). It even works well behind the back seat, in the trunk of your car. Box comes with a pre-cut11" hole for a woofer and port holes. Charcoal carpet covered with carry handles and input terminals. Dimensions: 13" (H) x 13" (D) x 30" (W). Net weight: 29 lbs.

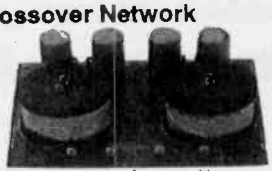
#RN-260-495 **$59.90** Each

12" Pioneer Subwoofer

12" super duty, dual voice coil subwoofer. 30 oz. magnet, 2" voice coil. 100 watts RMS, 145 watts max power handling capability. 25 Hz resonant frequency. 6 ohm impedance (4 and 8 ohm compatible). Sensitivity: 89 dB 1W/1M. Response: 25-700 Hz. QTS= .31, VAS= 10.3 cu ft. Dimensions: A= 12", B= 4-3/4", C= 3-3/4", D= 1-1/2". Hole: 11-1/4". Net weight: 6 lbs. Pioneer #A30GU30-55D.

#RN-290-145 $39.80 (1-3) **$36.80** (4-up)

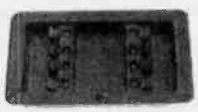
Subwoofer Crossover Network



Super duty, 200 watt RMS power handling capability. Designed specially for dual voice coil subwoofer systems. 12 dB per octave roll-off at 150 Hz into 8 ohms. Crossover also features a set of outputs for use with your existing speaker system. Network is totally passive, requiring no power source of its own.

#RN-260-220 $28.80 (1-5) **$24.40** (6-up)

Subwoofer Input/Output Terminal



This recessed terminal panel has inputs for right and left channels as well as outputs for right and left channels to route to your satellite speakers. Greatly simplifies subwoofer hook-up. Outside dimensions: 3-7/8" x 5-3/8".

#RN-260-308 $3.95 (1-9) **$3.50** (10-up)

12 Gauge Neon Wire

The competition in today's auto sound contests is so fierce that good sound alone is not enough to win. More and more installers are striving to make their installation more pleasing to the eye. Parts Express now stocks 12 gauge speaker wire in vibrant neon colors. This wire is the same high quality, made in the U.S. wire you have used before, but now it has flashy, neon colored insulating jackets. Available in neon pink, neon green, and neon orange. Sold by the foot.

#RN-100-162 (Neon pink)
#RN-100-166 (Neon orange) **49¢** /Ft.
#RN-100-170 (Neon green)

4 Ga. DC Power Cable

Large gauge cable for running power and ground to amplifiers in car stereo installations. Sold by the foot.

#RN-100-194 (Red 4 ga.) **$1.20** /Ft.
#RN-100-195 (Black 4 ga.)

8 Ga. DC Power Cable

Large gauge cable for running power and ground to amplifiers in car stereo installations. Sold by the foot.

#RN-100-174 (Black)
#RN-100-178 (Red)
#RN-100-182 (Neon Pink) **49¢** /Ft.
#RN-100-186 (Neon Orange)
#RN-100-190 (Neon Green)

High Power Speaker Cable

Extra large gauge speaker wire for use with very high power stereo systems and for use in extremely long cable runs. Rope lay construction consists of over 250 strands of 36 ga. wire. 21 picofarads per foot capacitance for use with all amplifiers. Extra thick, clear PVC insulation. Polarity is indicated by a black stripe on one conductor. Available by the foot or in 50 and 100 foot spools. **Please order in multiples of 5 feet.**

#RN-100-151 (per foot)
#RN-100-150 (50 ft.) **39¢** /Ft.
#RN-100-155 (100 ft.)

AGU High Current Fuses

Part #	Amp	Price (1-9)	Price (10-up)
#RN-070-910	25A	1.40	1.26
#RN-070-915	30A	1.40	1.26
#RN-070-920	40A	1.40	1.26
#RN-070-925	50A	1.40	1.26
#RN-070-930	60A	1.40	1.26

8 Ga. In-Line Fuse Holder

Super heavy duty fuse holder for high current car stereo installations. Screw together Bakelite fuse holder with 8 ga. wire. For use with AGU type fuses or regular AGC fuses when spring spacer is used.

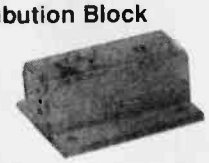
#RN-070-800 $3.20 (1-9) **$2.75** (10-up)

4-Way Fuse Block

Fuse block with 4 sets of gold plated fuse clips for use with fuses. Four LEDs indicate when a fuse is good by glowing red. A bridge bar is included for common connection of the input side. Clear plastic cover allows for visual inspection of fuse status. Uses heavy duty fuses.

#RN-070-810 $23.50 (1-5) **$21.90** (6-up)

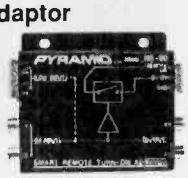
4 Ga.-8 Ga. Distribution Block



Solid brass block with connections for 1-4 ga. wire input from battery and 4-8 ga. wire outputs for power to the amplifiers. Recessed set screws hold the wire in place. Brass block is completely insulated with clear plastic to prevent accidental shorting. Rubber plugs are included to seal set screw holes.

#RN-265-800 $12.90 (1-5) $11.50 (6-up)

High To Low Level Adaptor



Converts speaker level outputs from your head unit to pre-amp level. Utilizes Op amp circuit design for high power handling and to reduce or eliminate in-line noise problems. Low level output is adjustable from 1 volt to 100 mV. For use with head units rated up to 50 watts per channel.

#RN-265-023 $11.50 (1-3) **$10.95** (4-up)

High To Low Level Adaptor With Remote Turn-On

Automatically turns your amp On or Off with your car's head unit. Converts high level to low level pre-amp output. Also features low level inputs. Utilizes operational amplifier circuit design for high power capability and to reduce or eliminate in-line noise problems. For use with head units rated up to 50 watts per channel.

#RN-265-027 $12.50 (1-3) **$11.95** (4-up)

Ultimate Woofers

Manufactured in the U.S.A. Ultimate's Polymer Laminate series of woofers are dollar for dollar the best you can buy. Featuring polymer laminate cones to maintain rigidity, extra long throat baskets, extended bump plates, vented pole pieces, double-fold reinforced baskets and more. If you are looking for a woofer that performs flawlessly and looks good too, look no further. Ultimate polymer laminate woofers are here at Parts Express.

Order#	Size	Magnet	V.C.	Z	Freq. Resp.	Power Cap.	SPL 1W/1M	QTS	fs	VAS	(1-3)	(4-up)
#292-510	8"	35 oz.	2"	4	30-3KHz	220W Max	94 dB	.39	40	.89	$46.50	$44.00
#292-515	10"	35 oz.	2"	4	25-3KHz	225W Max	95 dB	.33	29	2.89	56.90	53.50
#292-520	12"	50 oz.	2"	4	20-3KHz	250W Max	96 dB	.31	25	6.27	69.90	65.50
#292-525	15"	50 oz.	2"	4	20-25KHZ	250W Max	97 dB	.39	20	14.35	88.50	84.90

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Dayton, Ohio 45402
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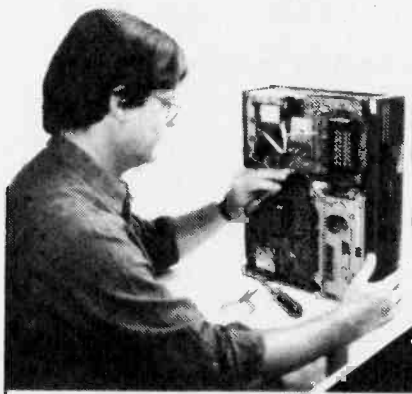

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FACT: over 77 million VCRs in use today nationwide! Average VCR needs service or repair every 12 to 18 months!
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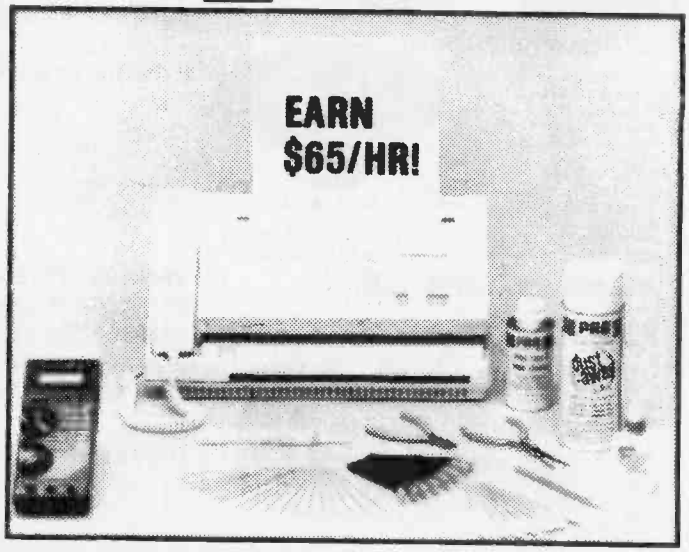

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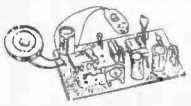
RAINBOW KITS



RADAR SIGNAL DETECTOR

If you think that a sensitive radar detector is a complicated piece of equipment, take a look at this new kit. This simple, yet effective, detector circuit can be built in less than an hour and can be tuned to respond to signals between 50MHz to 500GHz. It's a fun kit to build and play with. A cigarette lighter plug is included. Size 1"x¾" operates on 9 to 15v DC.

KIT RSD-1 **$12.95**

STROBE LIGHT

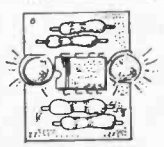
If you need an attention getter, or warning light, you need the strobe light kit. Use it for emergency light for autos, for model planes or radio towers. Even use it on your bicycle. Operates on 6 or 12v DC and has a variable strobe rate.

KIT ST-1 **$8.95**

DIGITAL THERMOMETER

Have you ever wanted to tell temperature changes fast & accurately? The DT-1 kit will turn your digital volt meter into an accurate digital thermometer with .1 degree resolution. It gives you a 250 degree window with a range from -40F to 300F degrees. It has a remote sensor .25" sq. that can be mounted many feet from the meter if need be.

KIT DT-1 **$8.95**



BLINKEY LIGHTS

Want to attract attention? These kits are perfect for decorating name tags, lighting up your hat, or flashing lights for your model trains. Some people use them to simulate a burglar alarm for autos. Put it in a box, set it on your dash and it looks like the real thing. Each kit contains two LEDs that alternates flashing. Operates on a 9v battery. Size .5"x.5"

KIT RB-2 **$3.45**

CAPACITANCE METER

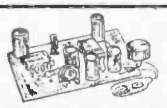
This easy to build kit will turn your digital volt meter into a CAPACITOR METER. Turn that junk box of unmarked capacitors into a fortune. Measures capacitors from (2pF to 2.2uF. Operates on a 9v battery. Size 1.75"x2"

KIT CA-2 **$12.95**

WIRELESS FM MIKE

Small but mighty .8"x1" PCB, will really stomp out a signal well over 400 yds. This is a buffered wireless mike that operates on 80 to 120 MHz FM. Comes complete with a microphone, and 9V battery connector. Operates on 6 to 12v DC.

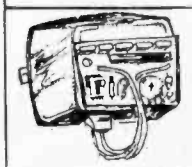
KIT WM-1 **$12.95**



SUPER SNOOPER-BIG EAR

Use this BIG EAR amplifier to listen through walls, hear conversations across the room. Beef up the sensitivity with a parabolic reflector and hear blocks away. Due to the size, the BIG EAR can be hidden about anywhere. Use the earphones from a pocket transistor radio to listen. Makes an ultra-sensitive intercom. Can also be used as a general purpose 1.5W amp. We supply a mini-microphone in the kit. You can also use any 8 to 45 ohm speaker. Operates on 6 to 12v DC. Size 1"x1.75"

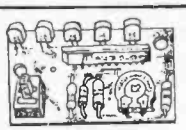
KIT AA-1 **$10.95**



AC LINE MONITOR

This is something every computer user, photographer, or anyone that must maintain a safe usable AC line voltage should have handy. Monitor the voltage of your motor home's 110v AC generator inside the motor home. Every technician's bench needs this item. The AC line monitor will indicate, with multi-color LEDs, what voltage is being distributed to your equipment at that particular outlet.

KIT LM-110 **$10.95**



12V BATTERY MONITOR

Have you ever been in your car, boat, or camper — you try to start your motor but the battery is dead? The BATTERY MONITOR kit uses the cigarette lighter plug outlet to monitor the true battery voltage. Multi-color LEDs indicate the voltage in 1v steps from 11v to 15v, green means great, yellow is good, and red — call the tow truck or get out the oars. Size 1.2"x1.75"

KIT LM-12 **$5.95**

PHONE BUG

Small but mighty, so small it fits anywhere. Telephone line powered, never needs batteries. Transmits both sides of a phone conversation loud and clear, wireless, to any FM radio at great distances away. Variable tunes 70MHz to 130MHz. It can also be used to make any phone a speaker phone. Size .55"x1".

KIT TEL-B1 **$10.95**

PHONE RECORDING SWITCH

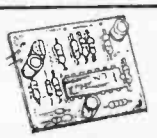
This telephone line powered switch is small enough to install anywhere only .9"x.6". Every time someone picks up the phone the tape recorder will record both sides of the conversation automatically. Use it in your office to record all phone conversations so you don't lose that important address you wrote on the back of an envelope.

KIT TEL-SW 1 **$10.95**

BUSY PHONE LIGHT

Add this little kit to any or all of your phones. When any extensions are in use the LED will light. Uses a 9v battery. P.C. Board 1"x½". Complete with etched & drilled PCB, all parts and schematics.

KIT TEL-LIT-1 **$9.95**



VOICE ACTIVATED SWITCH

This vox can be used to operate a tape recorder, ham radio, CB radio. Use it to turn on an alarm. The output can operate a load up to 100ma. It will operate a relay, lights, motor, or LEDs. What could you do with a sound activiated switch? Size 1.5"x1.25"

KIT VOX-1 **$6.95**

LIE DETECTOR

This kit can be great fun at parties. Lie and an audible tone will change, the more you lie the more the tone changes. When you lie your palms & forehead sweat. This kit allows you to measure these changes. Only a very slight amount of change will cause the tone to increase in frequency. Operates on 6 to 12v DC. Size

KIT LD-1 **$9.95**

LASER KITS

Laser Switching Power Supply Kit, input 12V DC .75-1.25A. Output 2 to 3 KV at 3-4.5 MA, trigger voltage of approx. 8-10 KV. Complete with 6.25" x 2.25" printed circuit board, schematic and all the parts.

LPS-1 ..... **$59.95**

1MW Laser Tube, NEW Mini He-Ne 1.125" dia. x 5.75" long, perfect for experimenters and laser projects. Works great with above power supply LPS-1.

L1MW-1 ..... **$39.95**

Mirror and Motor Kit—This unique kit allows you to project Lissajous patterns on walls and ceiling. Change the pattern by changing the speed of the motors. Comes complete with 2 motors, front surface mirrors, motor brackets, rheostat control to control #1 motor, and high power resistors to use on #2 motor.

MM-2 ..... **$19.95**

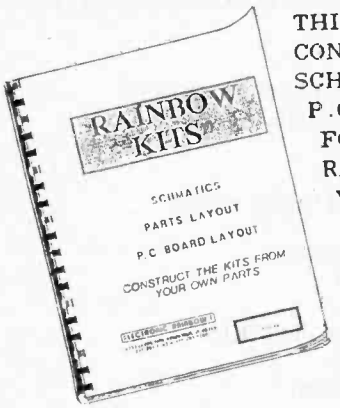
★ SPECIAL ★
Laser Power Supply Kit LSP-1
1MW Laser Tube L1MW-1
Mirror and Motor Kit MM-2
ALL 3 FOR $99.95

9V 100MA rechargeable Ni-cad batteries. This 9V Ni-cad is truly a 9V not the standard 7.2V you're accustomed to. Use ever and over.

NEW ..... **$4.00 ea. 10/$29.95**

9V battery charger kit. This kit is a must when you buy 9V Ni-cads, charges 2 batteries at once. Use on 110V AC or with a 12V DC cigarette lighter plug which is included. Comes complete with parts, P.C. board, housing and schematic.

CH-9V **$19.95**



THIS MANUAL CONTAINS ALL SCHEMATICS, PARTS & P.C. BOARD LAYOUTS FOR ALL OF THE RAINBOW KITS. USE YOUR OWN PARTS TO CONSTRUCT ANY OF OUR KITS.

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One Year Warranty

AR1000 $429

1000 Channels. 8-600MHz, 805-1300MHz

Standard Features:
- Extremely compact size.
- Continuous coverage (except UHF TV 600-805)
- Antenna attenuator switch, 10db.
- Manual tuning knob.
- Earphone jack, 3.5mm.
- AM, FM and wide band FM tuning modes.
- Backlighted LCD display.
- 10 Scan Banks, 10 Search Banks.
- Selectable Priority Channel.
- Delay, Hold Features.
- Selectable Search Increments, 5-955KHz.
- Permanent memory backup.
- 4 AA Ni Cad batteries included.
- AC adaptor/charger.
- Carry Case.
- Cigarette Lighter Charger.
- Belt Clip.
- Earphone.

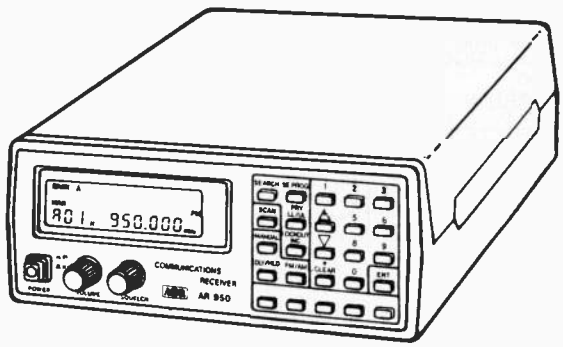
Options:

External Speaker. Mobile Mount.	MS190	$19.50
Extended Warranty. 2/3 yrs		$45/$55

Specifications:

Coverage:	8-600, 805,1300MHz
Sensitivity:	.35uV NFM, 1.0uV WFM, 1.0AM
Speed:	20 ch/sec. scan. 40 ch/sec. search
IF:	561.225, 58.075, 455KHz or 10.7MHz
Increments:	5 to 955KHz selectable/ 5 or 12.5 steps.
Audio:	.4 Watts
Power:	Input 9 - 13.8 V. DC
Antenna:	BNC
Display:	LCD
Dimensions:	6 7/8H x 1 3/4D x 2 1/2W. 12oz wt.

AR950 $239



100 Channels. Low, Air, High, UHF & 800MHz.

Standard Features:
- Extremely compact size.
- Unrestricted 800MHz coverage.
- 100 channels permanent memory
- Earphone Jack & Attenuator.
- Delay, Hold features.
- Channel 1 Priority.
- 5 Scan Banks, 5 Search Banks.
- Telescopic and Flexible Antennas w/ BNC connector.
- AC & DC Power cords w/ mtng hardware.
- One Year Limited Warranty.

Options:

Base type antenna 25 to 1000MHz w 50'coax.	AS300	$59.95
Mag Mnt Mobile Antenna. 15' coax.	MA100	$25.00
Cigarette Lighter power adaptor.	CP100	$4.00
External Speaker with mobile mount.	MS100	$19.50
Extended Warranty. 2/3 yrs		$40/$55

Specifications:

Coverage:	27-54, 108-174, 406-512, 830-950MHz
Sensitivity:	.4uV Lo,Hi. .8uV Air. .5uV UHF. 1.0uV 800
Scan Speed:	15 ch/sec.
IF:	21.4MHz, 455KHz
Increments:	10,12.5,25,30
Audio:	1W
Power:	12.8VDC, 200MA
Antenna:	BNC
Display:	LCD w/backlight
Dimensions:	2 1/4H x 5 5/8W x 6 1/2D. 14oz wt.

We offer 100's of communications products.

CIRCLE 268 ON FREE INFORMATION CARD

ACE COMMUNICATIONS

AR2500 $499

2016 Channels. 1 MHz to 1500 MHz

Standard Features

- Continuous coverage
- AM, FM, wide band FM, & BFO for SSB, CW.
- 64 Scan Banks.
- 16 Search Banks.
- RS232 port built in.
- Includes AC/DC pwr crd. Antenna, Mntng Brckt.
- One Year Limited Warranty.

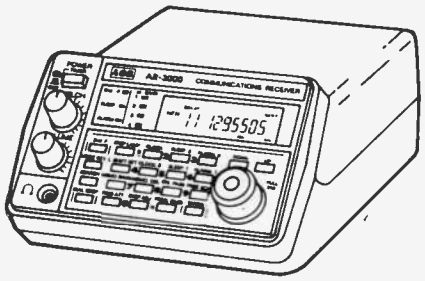
Options:

Earphone.	EP200	$2.00
External Speaker. Mobile Mount.	MS190	$19.50
Extended Warranty. 2/3 yrs.		$65/75
Mobile Mounting Bracket.	MM1	$14.90
RS232 Control Package (software & cable) offers spectrum display and database.	SCS2	$295.00

Specifications:

Coverage:	1 MHz - 1500MHz
Sensitivity:	.35uV NFM, 1.0uV WFM, 1.0AM/SSB/CW
Speed:	38 ch/sec. scan. 38 ch/sec. search
IF:	750.00, 45.0275, 5.5MHz 455KHz
Increments:	5,12,5,25 KHz
Audio:	1.2 Watts at 4 ohms
Power:	Input 13.8 V. DC 300mA
Antenna:	BNC
Display:	LCD, backlighted.
Dimensions:	2 1/4H x 5 5/8W x 6 1/2D Wt. 1lb.

AR3000 $995



400 Channels. 100KHz to 2036MHz.

Standard Features:

- Extremely compact size.
- Continuous coverage
- Attenuation Programmable by Channel.
- Manual tuning knob.
- Tuning increments down to 50Hz.
- AM, FM, wide band FM, LSB, USB, CW modes.
- Backlighted LCD display.
- 4 Scan and Search Banks, Lockout in Search.
- 4 Priority Channels.
- RS232 control through DB25 connector.
- Delay, Hold Features.
- 15 band pass filters, GaAsFET RF amp.
- Sleep and Alarm Features.
- AC adaptor/charger. DC power cord.
- Telescopic Antenna.

Options:

Earphone.	EP200	$2.00
External Speaker. Mobile Mount.	MS190	$19.50
Extended Warranty. 2/3 yrs.		$65/75
Mobile Mounting Bracket.	MM1	$14.90
RS232 Control Package (software & cable) offers spectrum display and database.	SCS3	$295.00

Specifications:

Coverage:	100KHz - 2036MHz
Sensitivity:	.35uV NFM, 1.0uV WFM, 1.0AM/SSB/CW
Speed:	20 ch/sec. scan. 20ch/sec. search
IF:	736.23, (352.23) (198.63) 45.0275, 455KHz
Increments:	50Hz and greater
Selectivity:	2.4Khz/-6db (SSB) 12KHz/-6db (NFM/AM)
Audio:	1.2 Watts at 4 ohms
Power:	Input 13.8 V. DC 500mA
Antenna:	BNC
Display:	LCD
Dimensions:	3 1/7H x 5 2/5W x 7 7/8D Wt. 2lb 10oz.

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Brand New from McLean Eng.
A Division of Zero Corp.
Square 4-11/16" by 1.5"
Thick 10" Wire Leads
120V - 60hz - .12 amps - 110CFM
Metal Housing - 5 Plastic Blades
UL and CSA Approved
$5.95 ea.

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1488	.45
1489	.45
DB25-(Solder Cup) M/F	2/1.00
DB25-Rt. Angle PC BD. F	.55
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4MT07 By Futaba
Vacuum Fluorescent Clock
And Timer - 4 Digit Display
Easy to Read - Easy to Use.
.3" Character Height
With Data 79¢

LTP 1157AE
1.2" 5x7 Matrix Displays
5x7 Array with x,y select.
This Red Orange Matrix Can Be Stacked Horizontally. Choice of Two Matrix Orientation-Cathode Column, Anode Row. Great For "Moving Message" Signs.
$1.19 Ea., 8/$6.95, 100/$75.00

74LS

LS00	.14	LS114	.25	LS241	.60
LS01	.14	LS122	.35	LS242	.65
LS02	.14	LS123	.45	LS243	.50
LS03	.14	LS124	1.35	LS244	.55
LS04	.14	LS125	.30	LS245	.55
LS05	.14	LS126	.35	LS251	.45
LS08	.14	LS132	.35	LS253	.40
LS09	.14	LS133	.25	LS257	.35
LS10	.14	LS136	.28	LS258	.45
LS11	.14	LS138	.35	LS259	1.00
LS12	.20	LS139	.35	LS260	.40
LS13	.25	LS145	.75	LS266	.30
LS14	.30	LS148	.35	LS273	.75
LS15	.20	LS151	.35	LS279	.30
LS20	.14	LS153	.35	LS280	.80
LS21	.16	LS154	.85	LS283	.35
LS22	.16	LS155	.50	LS290	.70
LS26	.14	LS156	.42	LS293	.50
LS27	.20	LS157	.30	LS298	.65
LS28	.15	LS158	.25	LS299	1.00
LS30	.14	LS160	.25	LS322	1.30
LS32	.16	LS161	.35	LS323	2.25
LS33	.25	LS162	.45	LS348	.75
LS37	.24	LS163	.36	LS353	1.00
LS38	.24	LS164	.45	LS357	.80
LS42	.35	LS165	.60	LS363	.75
LS51	.15	LS166	.75	LS364	.75
LS54	.20	LS169	.90	LS365	.30
LS55	.20	LS170	.45	LS366	.28
LS73	.33	LS173	.60	LS367	.35
LS74	.22	LS174	.35	LS368	.30
LS75	.25	LS175	.35	LS373	.50
LS83	.30	LS181	1.25	LS374	.45
LS85	.45	LS191	.45	LS375	.35
LS86	.20	LS192	.65	LS377	.75
LS90	.35	LS193	.65	LS378	.80
LS92	.30	LS194	.40	LS390	.80
LS93	.25	LS195	.52	LS393	.75
LS95	.30	LS196	.55	LS399	1.00
LS96	.33	LS197	.75	LS541	1.20
LS107	.28	LS221	.50	LS645	.75
LS109	.20	LS240	.50	LS646	.75
LS112	.25			LS670	.80
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Try The 1st Truly Low Cost LAN

- Connect 2 or 3 PCs, XTs, ATs
- Uses serial ports and 5 wire cable
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- Runs in background, totally transparent
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- Needs only 14K of ram

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6800	1.40	68A09EP	1.29
6802	2.50	68A40	4.00
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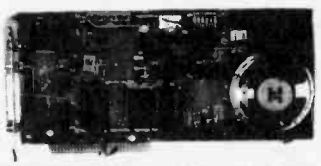

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THIS BOARD USES ONE SLOT ON THE MOTHERBOARD AND REQUIRES A COM SERIAL PORT. BOARD MAY ALSO BE USED IN A STAND ALONE ENVIRONMENT (EXTERNAL POWER SUPPLY) WITH ALMOST ANY COMPUTER THAT HAS A RS232 SERIAL PORT. TO USE THE BOARD IT IS ONLY NECESSARY TO SEND ENGLISH TEXT TO THE RS232 INPUT ON THE BOARD. THE BOARD INCLUDES A 1500 BYTE TEXT BUFFER AND HANDSHAKE LINE TO ALLOW YOU TO SEND DATA TO THE BOARD; THE SAME AS YOU WOULD SEND DATA TO AN RS232 SERIAL PRINTER. YOU CAN SET UP BATCH FILES THAT WILL MAKE YOUR COMPUTER GREET YOU WITH "GOOD MORNING MASTER," ETC. EVERY TIME YOU TURN IT ON.

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We bought a large quantity of 2708s, 2716s, 2532s, 2732s, 2764s, 27128s, 27512s and 27256s from a computer manufacturer who redesigned their boards. We removed them from sockets, erased and verified them, and now we offer the savings to you. Complete satisfaction guaranteed.

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8087-1	167.50	8259C-5	2.10
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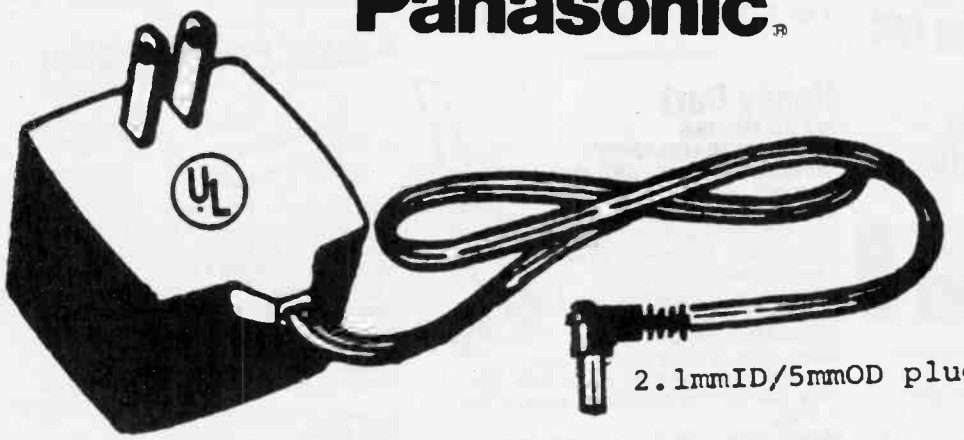

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Designed for fast accurate tests of appliances, automotive, marine, HVAC and electrical circuits. Single rotary knob with just 7 positions for fast sure set-up. Safety probes, installed battery supplied. Built-in goof proof overload protection for AC/DC volts and ohms. **Model D-906**

List $49.95 **Special $19.43**

Weller WST2 Pyropen® Jr.

Mini iron soldering that goes everywhere with temperature control. Recharged in seconds, with butane gas, the easy-to-handle WST2 requires no power cord or batteries. Temperature control. Soldering iron: 392°F–842°F (200°C–450°C); hotblow feature: 806°F (430°C) maximum; torch feature: 2372°F (1300°C) maximum. "Longlife" soldering tips deliver quick heat-up-time

Cat. No. WST2

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Special $38.43

Kenwood CS 4025 20MHz 2-Channel Oscilloscope

KENWOOD

The CS 4025 is a high quality oscilloscope that use a large number of custom IC's to achieve superior performance in an economical 20MHz package. 3 year warranty.

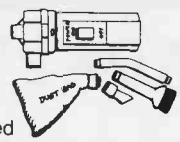
List $495.00 **Special $343.00**

Compact Disc Cleaning System

Kit contains all the necessary tools for ensuring peak performance of your compact disc system. Contents: 3 oz. can specially formulated cleaning solution, cleaning brush, chamois applicator and disc holder. **(Kit) Cat. No. 30-700**

List $21.59 **Special $9.43**

Portable Handheld Vacuum



This vacuum is designed for easy cleaning of computer keyboards and delicate camera equipment of dirt and dust. Also included with the vacuum is a reusable dust bag, brush, and detail nozzle.

NEW Cat. No. 44-275

List $15.00 **Special $7.43**

New "Trouble-Shooter" Tool Case

Compact, convenient and handy tool case for servicemen and technicians. This maintenance tool case is only 9" x 7" x 2-1/4", yet holds as many as 17 tools, meters, and test instruments. Small enough to easily carry, or will fit in your desk drawer or standard-sized tool carrying case. Contains everything service personnel need on field calls. Manufactured of the finest quality black Cordura, many features. Holds tools and meters firmly. Has great "on-the-job" utility. Ideal when servicing personal computers, printers, terminals, and the cables that link them. Made in U.S.A. (Tools not included)

Model CD-1

List $37.95 **Special $19.43**

Portable Speaker System

This pair of speakers with a DXBB amplifier circuit provides sensational sound when used with, portable CD players stereo cassette players or AM/FM radios. Additional features include volume control, an LED indicator, 3" high quality speakers and treble control. The amplifier can be powered by a DC adaptor or 4 "C" batteries (not included).

SPECIFICATIONS

Frequency Response:	**50-15,000 Hz**
Impedance:	**8 ohms**
Power Supply:	**6V DC adaptor or 4 "C" batteries**
Output Rating:	**7 watts**

New Cat. No. 90-630

List $41.59 **Special $24.43**

Universal Printer Stand

The two-piece design of this printer stand universally adapts to any size desktop printer. The stand is designed to tilt the printer at an angle, allowing the user to easily see the printout. **NEW Cat. No. 44-510**

List $14.59 **Special $7.43**

75 Channel Wireless Volume Control Cable Converter

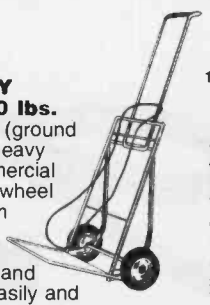
Converts any television set to receive 75 cable channels or standard TV channels between 2 and 13 to a fixed output on channel 2 or 3. Remote control features include volume control, sleep timer, last channel recall, favorite channel memory. UL listed. FCC registered.

Cat. No. 32-3590

List $152.30 **Special $119.43**

Handy Cart

MADE IN USA
10 YEAR WARRANTY
Weight Capacity 350 lbs.



Specially designed base (ground level) to accommodate heavy duty industrial and commercial applications. Extra wide wheel base to prevent cart from tilting while going down curbs and stairs. Unique stepslider glides cart up and down stairs and curbs easily and provides extra balance. Extra large and wide ball bearing wheels for easy rolling stability.

Model 1000

List $69.95 **Special $49.43**

Pocket Power Inverter

Applications: • TVs and VCRs • Sound and video equipment • Standard and fluorescent lights • Electronic test and maintenance equipment • Small appliances e.g. fans, shavers and mixers • Recharging battery powered devices • Most other electronic products.

SPECIFICATIONS

Voltage In:	**10.0-15.0 volts DC**
Voltage Out:	**115 volts AC RMS (with true RMS measuring meter)**
Continuous Power:	**100 watts**
Peak Output:	**200 watts**

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List $129.95 **Special $99.43**

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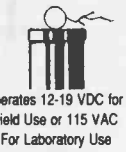
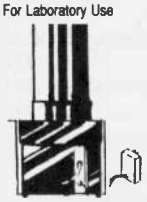
Combination Solid State Tesla Coil & Variable 100,000VDC Generator



Operates 12-19 VDC for Field Use or 115 VAC For Laboratory Use

Experiments Using Tesla Coil:
• Plasma in a Jar/Tornado, Furnace • Kirlian Photography • Wireless Energy Transmission • Induction Fields • Pyrotechnic Effects • Corona and Brush Discharge • Energizer for Neon Plasma Tubes



Experiments Using Hi Volts DC:
• Plasma Blaster Driller/Cutter • Anti-Gravity/Force Fields • Ion Reaction Motors • Lightning Generation • High Ion Source • Ozone For Air Purification • Electrification of People & Objects Particle Accelerators/Atom Smashing • High Energy Capacity Charging

HVM7 Plans Complete System $10.00
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Solar Power! *All New!*

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SOL1 4" Dia., .5V, 2A Silicon Cell & Plans ... $8.50
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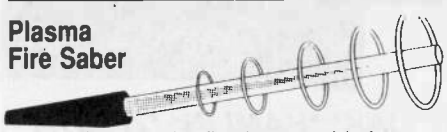
Solar Furnace

Use the power of the sun to build a device that can melt metal! Easy to build, excellent science fair project.
SOLFUR1+ Data Sheets, w/Big Fresnel Lens $14.50

Plasma Fire Saber



Produces the spectacular effect that captured the fantasy of millions of movie fans. Visible plasma field is controlled by grip pressure and adjusts saber length. Active energy field produces weird & bizarre effects. Excellent for special effects. Specify photon blue, neon red, phasor green, or starfire purple.
PFS2 Plans .... $8.00 PFS2K Kit/Plans $49.50
Special Offer PFS20 Assembled reg $89.50, $59.50

Poster Neon - At Last! Put *NEON* in your favorite poster! Ready to use, safe and simple. Includes 26" red neon tube and special energizer.
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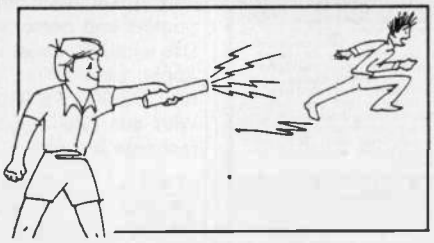


Shocker Force Field / Vehicle Electrifier

Neat little device allows you to make hand and shock balls, shock wands and electrify objects, charge capacitors. Great pay back for those wise guys who have wronged you!
SHK1KM Easy To Assemble Electronic Kit . $24.50

100,000V Intimidator / Shock Wand Module

Build an electrical device that is affective up to 20 feet. May be enclosed for handheld, portable field or laboratory applications.
ITM2KM Easy to Assemble Electronic Kit ... $49.50
ITM2 Plans Only; Credit-able to Kit $10.00

Ion Ray Gun

Projects charged ions that induce shocks in people & objects without any connection! Great science project as well as a **high tech** party prank.

IOG3 Plans ..... $10.00 IOG3K Kit/Plans $69.50

Invisible Pain Field Generator

Shirt pocket size electronic device produces time variant complex shock waves of intense directional acoustic energy capable of warding off aggressive animals, etc.
IPG7 Plans .... $8.00 IPG7K Kit / Plans $49.50
IPG70 Assembled $74.50

Homing / Tracking Transmitter

Beeper device, 3 mile range.
HOD1 Plans .... $10.00 HOD1K Kit/Plans $49.50

Listen Thru Walls, Floors

Highly sensitive stethoscope mike.
STETH1 Plans ... $6.00 STETH1K Kit/Plans $49.50

3 Mile FM Wireless Mike - *Subminiature!*

Crystal clear, ultra-sensitive pickup transmits voices and sounds to FM radio. Excellent security system, warns of intrusion. Become your neighborhood disk jockey! Monitor children and invalids.
FMV1 Plans ..... $7.00 FMV1K Kit/Plans . $39.50

Telephone Transmitter - 3 Miles!

Automatically transmits both sides of a telephone conversation to an FM radio. • Tunable Frequency • Undetectable on Phone • Easy to Build & Use • Up to 3 Mile Range • Only transmits during phone use
VWPM7 Plans .... $6.00 VWPM7K Kit/Plans $39.50

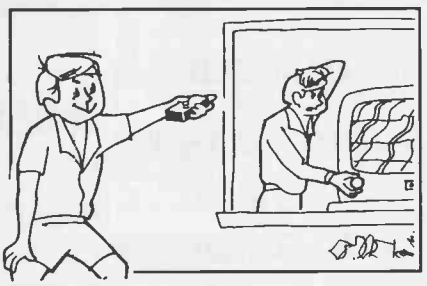
Automatic Telephone Recording Device

Connects between telephone and recorder • No power needed • Undetectable • Crystal Clear • Extends Tape Time
$PECIAL OFFER! Complete system including extended play recorder. TAXP2Z . $99.50

Sunglasses/FM Radio!

NEW!

This high tech, all new device is a full range, tune-able FM radio built in to a pair of sunglasses. Great for covert listening of wireless devices and regular entertainment.
SUGL1 Ready to Use, with batteries $24.50



TV & FM Joker / Jammer

Shirt pocket device allows you to totally control and remotely disrupt TV or radio reception. Great gag to play on family or friends. Discretion required.
EJK1KM Easy to Assemble Electronic Kit . $19.50

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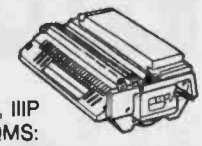

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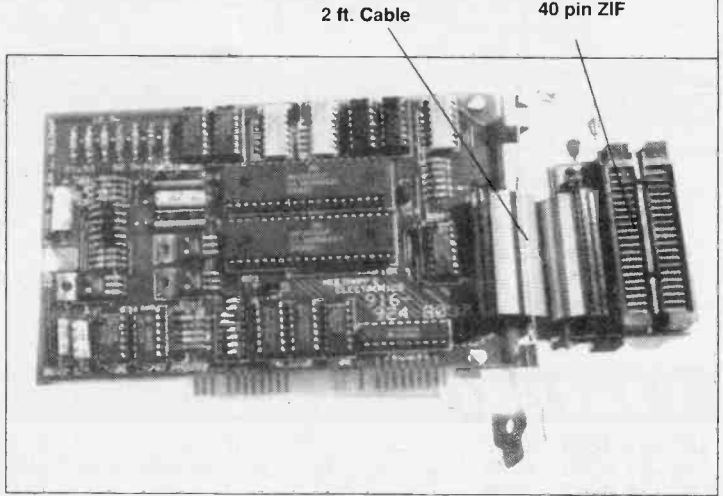

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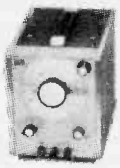

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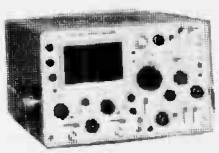

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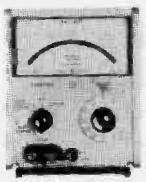

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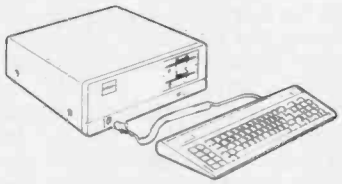
TEKTRONIX MODEL 851 DIGITAL TESTER $79.95

~~$2995.00~~ NEW PRICE!

- The 851 is an easy-to-operate portable unit containing a DMM, a counter and input signal conditioning circuits and is used for servicing digital equipment
- The DMM is an auto ranging 4 1/2 digit multimeter with floating inputs and a 500 VDC maximum input and 350 VAC maximum input
- The counter is an auto ranging 5 digit, 35 MHz universal counter with three inputs and an accuracy of ±0.005%
- The unit also has a calibrated gated square wave output at 5 KHz which is suitable for probe compensation
- All three channels feature -30 to +30 V threshold adjustments

*NEW*NEW*NEW*NEW*NEW*NEW*



NEW UNISYS PC CLONE!

New in Box Unisys PC Clone with: Keytronics 101 keyboard, 256 K memory, clock, serial port, one 360 K floppy drive, manuals, DOS, etc.	$175.00
Memory expansion card for above, bringing total memory to 640 K	+ $65.00
Unisys computer at top with used monochrome monitor, printer port and monochrome card	$250.00
Same as above but with two 360 K floppy drives	$200.00
30 meg flash card	$149.00
640 K, 2 floppy disk drives, 30 meg Hard drive, and monochrome system	$489.00

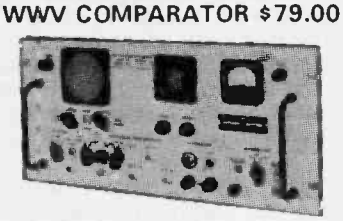
HIGH FREQUENCY OSCILLOSCOPE PROBE $23.95

NEW!

- Switchable X1, X10; Rugged probe
- Bandwidth of 10 MHz (X1); 100 MHz (X10)

Includes sprung hook, 6" ground lead, BNC adaptor, IC test tip, trimmer tool, and storage pouch.

LAVOIE LABS LA800D WWV COMPARATOR $79.00

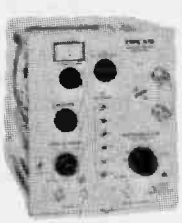


Receives WWV on 5 MHz or 15 MHz and compares the accuracy of your signal. Frequency deviation are monitored as an audio beat or on small CRT. A must for checking the accuracy of your radio!

FLASH CARD-30 $149.00

New-in-box 30 meg hard drive on a card with 65 msec access time. Easy installation in your PC.

TEKTRONIX 500-SERIES PLUG-INS!



TEK 1L10 SPECTRUM ANALYZER $ 395.00
For use with 530-, 540-, 550-, and 580-series scopes.
Dial accuracy is ±(100kHz + 1 % of dial reading)
RF attenuation of 51 dB

TEK 3A6 DUAL TRACE PLUG-IN $ 39.00
Designed for Tek 560, 561, 564, and 565 scopes
DC to 10 MHz
10 mV DIV to 10 V DIV in 10 steps
Dual Trace

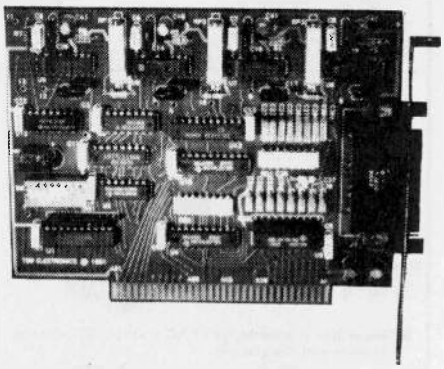
TEK 3B4 TIME BASE PLUG-IN UNIT $ 50.00
Designed for use with the Type 561A, 564 and 567 Oscilloscopes
Provides calibrated sweep rates from 0.05 µsec/div to 5 sec/div in 25 calibrated steps
Provides 5 steps of deflection sensitivity from 0.2 volts/div to 5 volts/div

CIRCLE 286 ON FREE INFORMATION CARD

REVOLUTIONARY PC BASED TEST EQUIPMENT

I1000 OUR BEST DATA INTERFACE

The I1000 Data Interface Card is a 100% IBM PC/XT/AT compatible half card. The I1000 is the heart of the TSW system, and is required to drive any or all of the T1000 series peripherals. With the TSW system, you will use only one I1000 card and one expansion slot, while having the capability of running many pieces of external test equipment. One I1000 card is capable of addressing up to 256 external pieces of test equipment. In other words, the T1001, T1002, T1003, and T1004 can all be driven simultaneously by just one I1000. Additional (I1000 compatible) members of the T1000 series are under development and will appear in future advertisements. The I1000 connects to the first peripheral using a 6 foot DB-25 male to female cable. Additional T1000 series units are simply stacked and paralleled with the first. The peripheral test equipment is powered by the computers +12 and -12 volt power lines. The current load on the +12 volt line is between 100 and 300 milliamperes per unit. The current load on the -12 volt line is between 0 and 20 milliamperes per unit. We have been running our entire product line (connected simultaneously) for 18 months. The I1000 uses a bidirectional parallel format. The maximum data output rate is one 8 bit byte per 3us or 2.6 Mega bits per second. The I1000 is addressable, or may be left at the factory preset prototype address (HEX 300).



ORDER#	1-9	10-49
I1000	$77.00 ea.	$72.00 ea.

T1000 SERIES OVERVIEW

The T1000 family of products are each housed in a 10"x7.5"x3.1" ABS plastic instrument case. All of the front panel functions are clearly silk screened. The T1000 series units stack to create a lightweight, compact, modular component system. When combined, an elegant test block is formed, eliminating the need for bulky, old fashioned equipment. We provide all of the ready to run executable software needed for each piece of T1000 series equipment. We also provide a simple BASIC tutorial and (remarked) source code for those who would like to develop personalized T1000 series applications. In this way, our products are especially suited for custom projects and industrial applications where flexibility is a must.

T1001 CAPACITANCE • FREQUENCY • EVENT/PERIOD *ALL IN ONE*

The T1001 contains a precision autoranging capacitance meter, a 100MHz frequency counter, and an event/period measurement system. Within the T1001, all measurements are governed by an on board 60MHz crystal oscillator.

CAPACITANCE

This is no ordinary capacitance meter. It is accurate and autoranging from 0pF to 1uF, and from 1uF to 10,000uF. It has a maximum step resolution of .3pF and performs approx. two conversions per second for values below 1uF. This meter works beautifully between 0 and 10pF where many other units are found lacking. Our cap meter is able to learn. If you wish a particular range to be more precise, you simply insert your reference components and ask the unit to learn the new values. We use the full power of the PC to perform matrix and curve fitting techniques. This allows us to achieve amazing accuracy. Our capacitance meter also features a "zero and read" function. Insert a reference capacitor and press "Z". Remove it and insert a different capacitor. The screen displays the difference in capacitance as well as the capacitor tolerance. If you would rather directly enter a theoretical value (for comparison), just press "D" and enter the reference value. These two features are most useful when matching or sorting. If you zero on a capacitor and leave it in place, you will easily observe component stability. Another time saving feature is our Ultra Fast Connect System. This allows the component under test to be inserted rapidly. Additionally, several capacitors may be inserted simultaneously in parallel. This is useful when trying to construct an exact value. The displayed units may be moved through pF, nF, uF, or mF at any time by pressing "U". The T1001 can be adapted to perform industrial functions such as moisture sensing. We are always available to help you implement your custom industrial applications.

FREQUENCY

This is a high stability digital frequency counter capable of >100MHz without frequency division. It is ideal for digital (logic) circuit designing. It accepts any standard TTL level input. To use a prescaled frequency just press "D" and then type in a division factor between 1 and 100. The screen will then display the frequency being fed into the prescaler. We have used the AP-90-T prescaler manufactured by Startek International and found it to work quite well. Many frequency counters offer 2 or 3 timebase settings. Ours provides you with eight. To completely calibrate all 8 timebases, you would perform the following steps: attach a frequency to the BNC input, press "C" to initiate calibration, enter the frequency used. In a minute or so, the computer will finish it's analysis and your counter will have been fully calibrated. The displayed units may be moved through GHz, MHz, kHz, or Hz at any time by pressing "U".

PERIOD

The third and final device contained within the T1001 is a complete pulse measurement system. It can be set to measure a positive or negative pulse. It has a noise immunity circuit which screens off all but the first pulse received. This device also provides a TTL compatible start pulse to the user. This start pulse (handshake) is provided to let the user's circuit know when to send the test pulse. One application which we have used many times is to use the start pulse to continuously fire a one-shot (monostable multivibrator) circuit. Displayed on the screen and continuously updating is the precise pulse width. Establishing RC timing values has never been easier. This period meter features a 16.6ns resolution and accurately measures pulses ranging from 80ns to 71.3 seconds + or - one step. The displayed units may be moved through ns, us, ms, or seconds at any time by pressing "U".

ORDER#	1-9	10-49
T1001	$179.00 ea.	$169.00 ea.

CIRCLE 276 ON FREE INFORMATION CARD

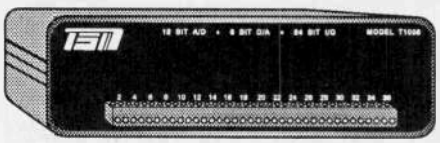
T1002 DIGITAL CLOCK SYNTHESIZER *4.29 BILLION FREQ's*

The T1002 is a digital clock synthesizer which produces a TTL compatible, 50% duty cycle square wave. This device will synthesize 4.29 billion different frequencies between 6MHz and .0055Hz. It uses a 48MHz crystal oscillator as a master reference. This unit also features an output impedance compensation control which allows you to use regular wire instead of an expensive injection probe. To select a frequency, just press "D" and type in the frequency desired. If your frequency is not available, the closest available frequency will be displayed and synthesized. Pressing the up or down arrows will increase or decrease the frequency. The T1002 can be used to generate clocks, popular baud rates, sync pulses, and period calibration waveforms. Displayed units may be moved through MHz, KHz, Hz, us, ms, seconds, or minutes simply by pressing "U". Custom osc. frequencies, multiple osc. frequencies, and other variations are available upon request.

Frequency output formula:
fo(Hz) = 48MHz/(2n) where n is an integer between 4 and 2^{32}

ORDER#	1-9	10-49
T1002	$179.00 ea.	$169.00 ea.

T1003 12 BIT A TO D • 8 BIT D TO A • 24 BIT DIG. I/O *ALL IN ONE*



The T1003 consists of an 8 channel 12 bit analog to digital converter, a single 8 bit digital to analog converter, and 24 configurable digital I/O lines. This device will allow you to interface your computer to the real world quickly and easily. If you have ever successfully breadboarded a circuit, you will find this device simple to operate.

A TO D

First, we have an 8 channel , 8 bit analog to digital converter. With the press of a key, the 8 bit converter becomes a >12 bit converter which offers 1mV resolution from 0 to 5V. You can use this device to read or monitor 8 different DC circuit voltages simultaneously. Any of these channels may be activated or deactivated with the press of a key.

D TO A

Next, we have an 8 bit digital to analog converter which produces 0 to 5V in 20mV steps. To produce a DC voltage, you would simply press "V" and then enter the desired voltage. This device is great for linear op-amp projects.

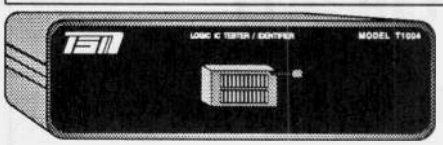
24 BIT DIGITAL I/O

Finally, we have a 24 bit digital I/O section which can be set up as three 8 bit ports, or two 8 and two 4 bit ports. Each port may be set up as input or output with the press of a key. This section has an infinite number of uses. Create your own alarm system. Generate 1's and 0's needed for digital gate control. Why build a display for a prototype circuit? Just feed the raw binary into your T1003 and see the count displayed on the screen. Your breadboard or digital trainer becomes much more powerful when you connect it to the T1003. Large corporations have been using their computers to process tedious information for years. Now the same technology is available to you at a great price. The T1003 is easily accessed through a 36 position European style terminal block mounted on the unit face. When using the included software, all of the functions which have just been described appear on the display simultaneously.

Industrial Applications:
- Count product flow
- Continuity on finished circuitry
- Monitor voltage parameters
- Automatic test equipment

ORDER#	1-9	10-49
T1003	$189.00 ea.	$179.00 ea.

T1004 LOGIC IC TESTER / IDENTIFIER



The T1004 is an advanced digital logic (ic) tester and identifier. This unit is capable of testing a vast number of logic packages including 7400,4000, custom pals, and more. This package includes a tutorial on how to add components to the existing database. The T1004 goes beyond simply running a truth table. This unit has the ability to analyze an unknown IC, and if it is within the database, identify it. Additionally, it measures the input low to high and high to low thresholds, as well as the output voltage levels. From this, the T1004 often has enough information to assist you in determining the exact logic family of the IC under test.

ORDER#	1-9	10-49
T1004	$249.00 ea.	$239.00 ea.

DB-25-6 6 FOOT INTERFACE CABLE

This cable is required in order to connect the I1000 to any peripheral unit. If you elect to construct your own, it must be fully populated, wired 1:1, and contain 24 awg (or larger) wire. Pin 20 of the male end of this cable must be removed in order to mate with the DB-25 female on the I1000.

ORDER#	1-9	10-49
DB-25-6	$12.95 ea.	$10.95 ea.

DB-RIB-(num) INTERCONNECTS (num) PERIPHERAL UNITS

This cable is required (in addition to the DB-25-6) in order to use more than one peripheral unit (T1001-T1004) simultaneously. If you elect to construct your own, it must be made using 28 awg, 25 conductor ribbon cable and contain 1 DB-25 IDC male, and (num) DB-25 IDC female connectors. Connectors must be placed at 5" intervals.

ORDER#	1-9
DB-RIB-2	$15.95 ea.
DB-RIB-3	$23.95 ea.
DB-RIB-4	$28.95 ea.

Make check or M.O. payable to:
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Sunrise, FL 33322

Add $5.00 S&H for ea. T1001-T1004
Add $2.00 S&H for ea. I1000, or cable
Florida Residents add 6% sales tax
Allow 4 weeks for delivery
For technical info call (305) 748-3387

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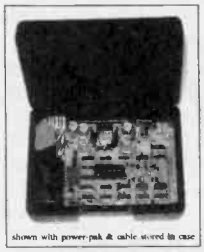
2708, 2758, TMS2716*, 2716
27C16, 2516, 2532*, 2564*
68764*, 68766*, 2732, 2732A
27C32, 2764, 2764A, 27C64
27128, 27128A, 27C128
27256, 27C256, 27512
27C512, 27513*
27011*, 27C011* (1 MEG)
27010, 27C010
27C1000, 27C1001
27C020, 27C2001 (2 MEG)
27C040, 27C4001 (4 MEG)


shown with power pak & cable stored in case

EEPROMS
2804, 2816A, 28C16
2817A*, 2864A, 28C64
28256, 28C256, 52B13*
52B33*

MicroControllers
8741A*, 8742*, 8748(H)*
8749(H)* 8751*, 87C51*
8752* 8753*, 8744*
68705*, TMS7742*
*ADAPTER REQUIRED
Diagrams included with manual
Assembled adapters are available

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- READ DISK FILE INTO BUFFER
- READ EPROM(S) INTO BUFFER
- SAVE EPROM(S) OR BUFFER TO DISK
- PROGRAM EPROM(S) FROM BUFFER
- COMPARE EPROM(S) WITH BUFFER
- COPY EPROM(S)
- VERIFY EPROM ERASED
- SELECT BUFFER EDITOR
- SELECT DEVICE TYPE
- DEVICE CHECKSUM
- SET BUFFER (0, 1, 2, 3)

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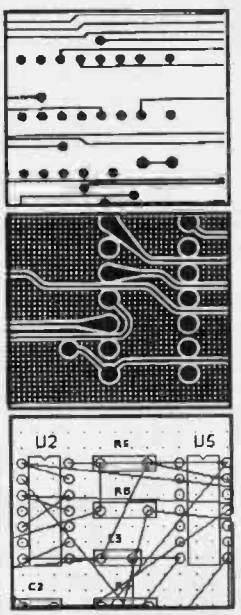

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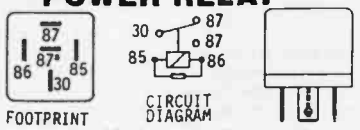

FOOTPRINT

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6 ft long, beige w/ molded plugs
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7806	TO-220	$.59
7808	TO-220	$.49
7809	TO-220	$.69
78C12	TO-202	$.49
7812	TO-220	$.49
78L15	TO-92	$.49
7815	TO-220	$.59
7824	TO-220	$.49
7905	TO-220	$.59
7912	TO-220	$.59
7915	TO-220	$.59
LM317K	TO-3	$2.99
LM317T	TO-220	$.65
LM323K	TO-3	$3.25
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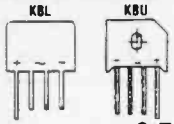


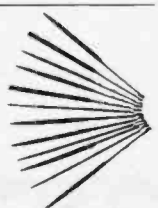
No. KBL02 **$.75**
No. KBU4D **$.75**

HIGH SPEED 12 VDC FAN

Mfg - Elina
Mfg # - DA121238M
4.7" x 4.7" x 1.5"
Operating Voltage: 10.2-13.8
Rated Current: 400 mA
4.8 watt, 2700 RPM
85 CFM, Noise level 41 dB
Hook-up via 12" color coded wires

No. 26-194 **$8.95**

12 PIECE NEEDLE FILE SET



This miniature file set has 12 different 5½" long files that can be used by hand or locked in a pin vise. Precision made for use on wood, metal or plastic.

No. 54-104 **$3.95**

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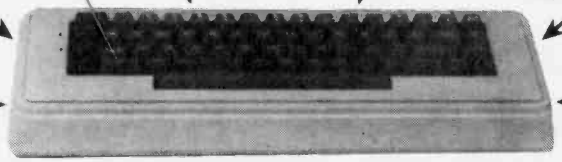

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BP82,BP83
BP83A 7.2v 750 mah
BP84 7.2v 1000 mah
BP85A 9.6v 600 mah
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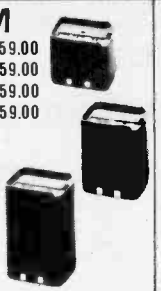

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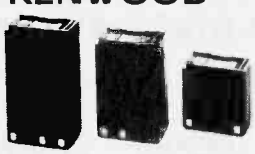

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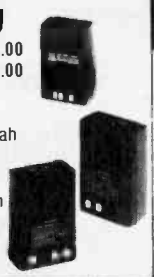

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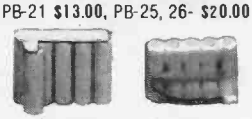

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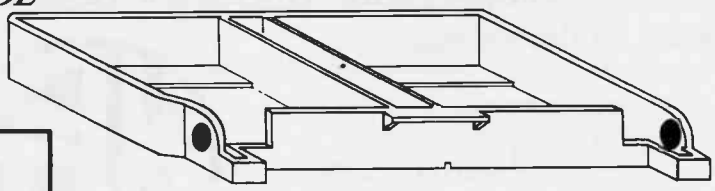

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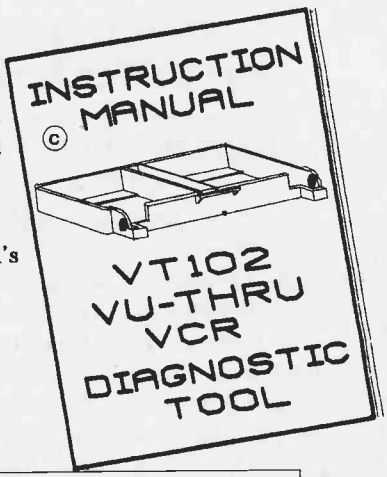

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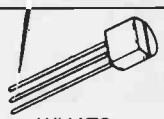

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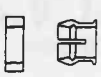

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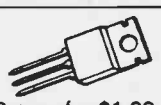

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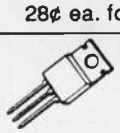

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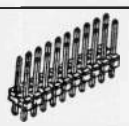

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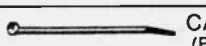

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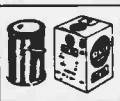

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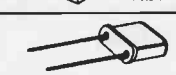

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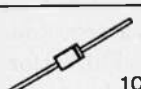

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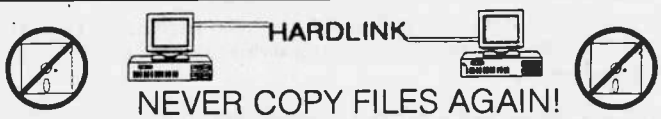

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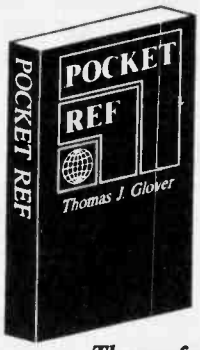

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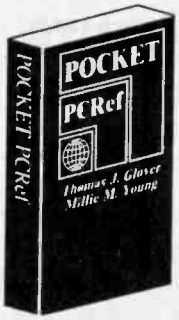

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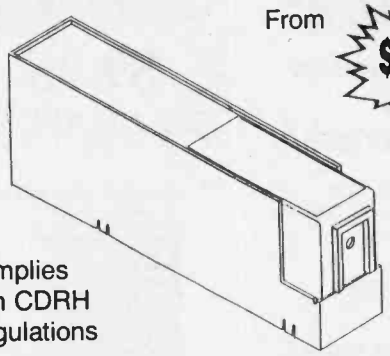

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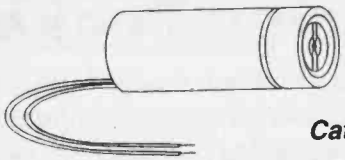

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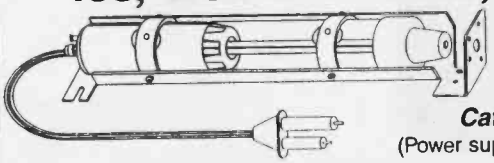

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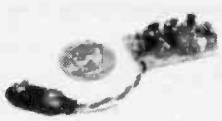

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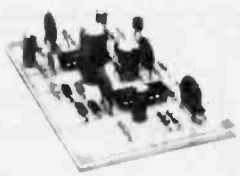
The XBD200 quickly locates hidden transmitters in the frequency range of 1 to 2000 MHz by emitting an audio output proportional to the transmit level.

XBD200(C) Kit $39.95



Use the XPS100 to call your home from any other phone and listen in using the built in microphone and amplifier.

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Use the XV200 to disguise your voice, and make it unrecognizable but understandable. Changes the pitch of your voice higher or lower than normal. the results are amazing!

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For holography, light shows, leveling and experiments. New, 12mo warranty.

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GLOSSARY:
- ***mW*** = Milliwatts (light power output)
- ***He-Ne*** = Helium Neon (red light)
- ***ARGON*** = laser that emits a blue/green light
- ***nM*** = Nano Meter (wavelength of light) (color)

ALL LASER PARTS ARE SOLD AS COMPONENTS ONLY WHEN ASSEMBLED THIS LASER MUST INCORPORATE THE SAFETY REQUIREMENTS OF THE CENTER FOR DEVICES AND RADIOLOGICAL HEALTH OF THE FOOD AND DRUG ADMINISTRATION.

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LASER PLANS

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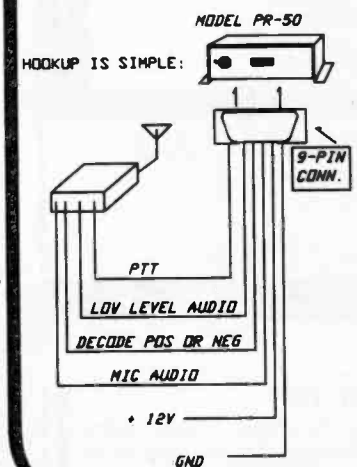

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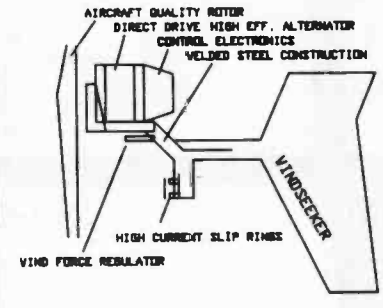

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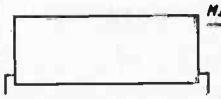

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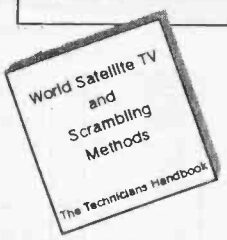

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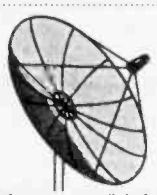

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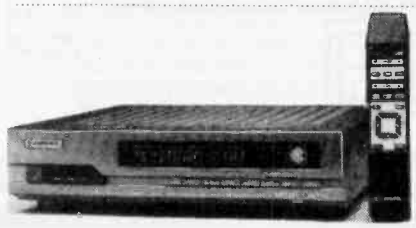
1.2db	LNB	"	"	"	119
1.1db	LNB	"	"	"	129
1.0db	LNB	"	"	"	139
0.9db	LNB	"	"	"	199
0.8db	LNB	"	"	"	249
50°	LNA	(70MHz & block)		S&H $6	$129
45°	LNA	"		"	139
40°	LNA	"		"	149
35°	LNA	"		"	159
30°	LNA	"		"	179



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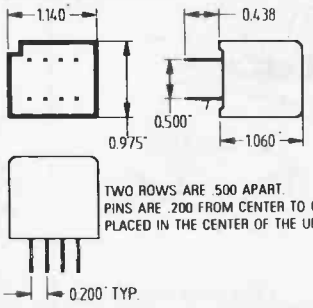

MODEL	SECONDARY VOLTAGE	AC (ma) CURRENT	1-9	10-24	25-49	50-99
MPT-5	5	24	$10.00	$8.33	$7.34	$6.90
MPT-12	12	10	10.50	8.42	7.71	7.25
MPT-24	24	5	10.75	8.95	7.89	7.42
MPT-D6	6-0-6	10	10.50	8.42	7.71	7.25
MPT-D9	9-0-9	6.7	10.75	8.95	7.89	7.42
MPT-D12	12-0-12	5	10.75	8.95	7.89	7.42
MPT-D15	15-0-15	4	11.00	9.16	8.07	7.59

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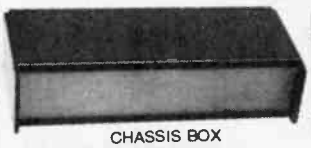
ANODIZED, TOP AND BOTTOM PANELS ARE BLACK
BRUSHED ANODIZED, END PANELS ARE BLACK ANODIZED

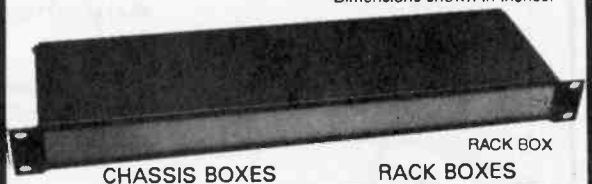
BLANK PANELS



CHASSIS BOX

MODEL	DESCRIPTION	PRICE
1 RP B	1.75 x 19	$8.95
2 RP B	3.50 x 19	13.15
3 RP B	5.25 x 19	17.35
4 RP B	7.00 x 19	21.50

1/8" Aluminum black anodized.
Dimensions shown in inches.



RACK BOX

CHASSIS BOXES

MODEL	W	D	H	PRICE
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MC-2A	6	3	2	17.85
MC-3A	8	3	2	19.95
MC-4A	4	4	3	17.85
MC-5A	6	4	3	19.95
MC-6A	8	4	3	22.05
MC-7A	4	7	4	19.95
MC-8A	6	7	4	22.05
MC-9A	8	7	4	24.15

Dimensions shown in inches.
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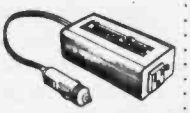

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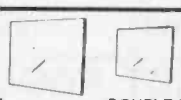

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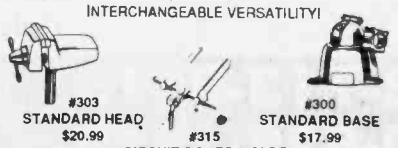

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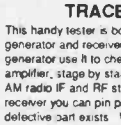

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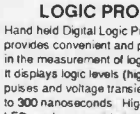

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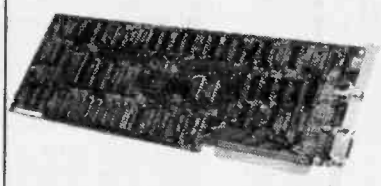

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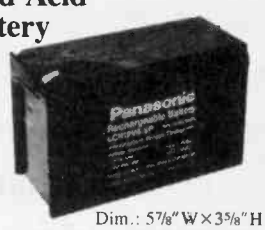

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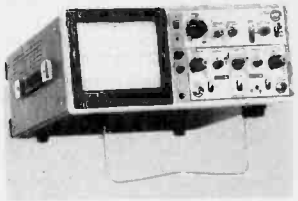

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V-1060	100 MHz, Dual Channel, Delayed Sweep, CRT Readout	1645.00	1365.95
V-1065A	100 MHz, Dual Channel, Delayed Sweep, CRT Readout, Cursor Measurement, Counter	1895.00	1645.95
	Digital Storage Oscilloscopes		
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VC-6024	50 MHz, 2 Ch, 20 MS/s, 2 KW/Ch, RS-232	2295.00	1989.95
VC-6025	50 MHz, 2 CH, 20 MS/s, 2 KW/Ch, Sweep Autorange, RS-232	2595.00	2189.95
VC-6045	100 MHz, 2 Ch, 40 MS/s, 4K Mem, Sweep Autorange, RS-232	3395.00	2989.95
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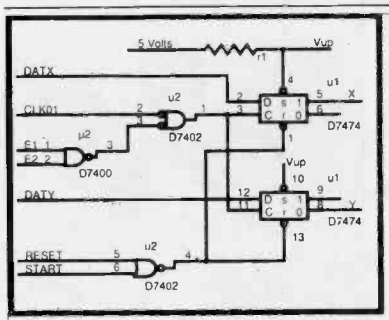

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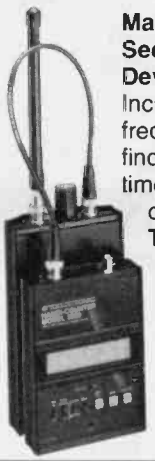

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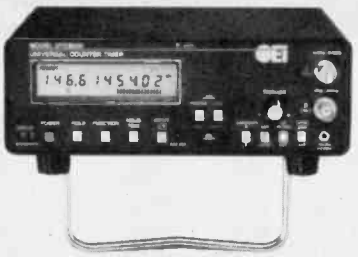

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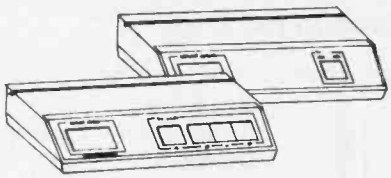
"MAX" The Remote VCR Controller



"MAX" allows you to watch and control a single VCR from other locations in the house. Transmits audio, video and IR signals up to 100 feet through mini-cable. Works on up to 4 televisions at a time, but a separate "MAX" receiver is required for each TV. Can also be used with other infrared controller devices such as CD players or stereos. Because it is hardwired, signal transmission is clearer than more expensive non-hardwired units. Includes transmitter, receiver, 100' cable, hook-up cables and wall transformer. These new units originally sold for over $100.00 .

CAT# MAX $40.00 each 4 or more **$35.00 each**

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CAT#	APPROX. LENGTH	MIN. TENSIL STRENGTH	COLOR	MAX. BUNDLE DIA.	10	100	1000
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TR-400B	4"	18 lbs	black	15/16"	.35	$3.00	$17.50
TR-600	6"	30 lbs	neutral	1 1/2"	.50	$4.00	$30.00
TR-600B	6"	30 lbs	black	1 1/2"	.50	$4.00	$30.00
TR-800	8"	50 lbs	neutral	1 3/4"	.60	$5.00	$40.00
TR-800B	8"	50 lbs	black	1 3/4"	.70	$6.00	$50.00
TR-1100	11"	50 lbs	neutral	3"	.70	$6.00	$50.00
TR-1100B	11"	50 lbs	black	3"	.80	$7.00	$60.00
TR-1500	15"	50 lbs	neutral	4"	$1.00	$8.00	$70.00
Heavy-duty 15" cable tie.							
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CAT#	WIRE SIZE	COLOR	50 PCS	100 PCS	500 PCS	1,000 PCS
2125	22-18	RED	2.50	4.50	20.00	32.00
2225	16-14	BLUE	2.50	4.50	20.00	32.00
2325	12-10	YELLOW	3.00	5.50	26.00	50.00

QUICK DISCONNECT FEMALE 1/4"

CAT#	WIRE SIZE	COLOR	50 PCS	100 PCS	500 PCS	1,000 PCS
1125	22-18	RED	2.50	4.50	20.00	32.00
1225	16-14	BLUE	2.50	4.50	20.00	32.00
1325	12-10	YELLOW	3.25	6.00	27.50	52.00

SPADE TERMINALS

CAT#	WIRE SIZE	COLOR	STUD SIZE	50 PCS	100 PCS	500 PCS	1,000 PCS
9106	22-18	RED	6	2.50	4.50	20.00	32.00
9108	22-18	RED	8	2.50	4.50	20.00	32.00
9110	22-18	RED	10	2.50	4.50	20.00	32.00
9206	16-14	BLUE	6	2.50	4.50	20.00	32.00
9208	16-14	BLUE	8	2.50	4.50	20.00	32.00
9210	16-14	BLUE	10	2.50	4.50	20.00	32.00
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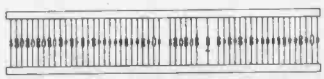

Strips of assorted parts. Each strip contains an assortment of resistors, capacitors and diodes. Each strip contains at least 200 parts.

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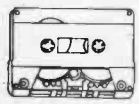

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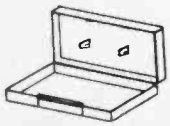

Black, unbreakable plastic audio cassette storage case.

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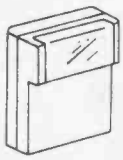
For Nintendo™ Video System



CAMERICA "Freedom Connection" ™ Turns your wired Nintendo™ control paddle into a remote control unit. Infrared remote like those used on TV's and VCR's eliminates messy wires. Allows players more mobility. Two players can use one remote unit except on games where they play simultaneously. In those games two "Freedom Connections" units are required. A well-known national discount toy chain sells these for more than twice our price.

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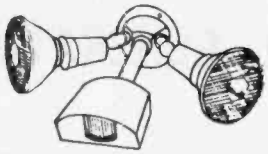

Electriko # SIL-101 - Experiment with infrared sensors with these outdoor security lights. Lots of interesting components, IR detector, photoresistor, relay,transformer, IC's, voltage regulator, and other goodies. Returned to the distributor for variety of reasons. We don't want to test them and would prefer to sell them "as-is." Infrared sensor detects movement up to 65 feet and turns on lights. Sensor can be adjusted for sensitivity and duration of lighting. Will handle two 150 watt PAR 38 lamps. Bulbs not included. ***CAT# IL-101 $7.50 each***

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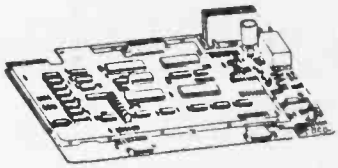
ATARI 5200 VIDEO GAME (AS-IS)



These Atari video game controllers were returned to the dealer because of various defects. None of them work properly, but they have lots of great parts which could be used in other projects. They include a RF video modulator, eight 16K dynamic RAMs in sockets, microprocessors and D-A converters in sockets, two voltage regulators on a heavy-duty heatsink and lots of other ICs, capacitors, resistors, connectors and other components all in the original chassis. Does not include the power transformer or controls (joysticks). The video modulator or the RAMs alone are worth the price.

CAT# A-5200 *WERE ~~$7.50 each • 2 for $13.50~~*

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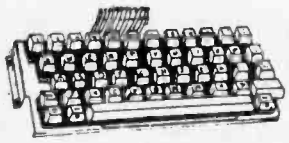

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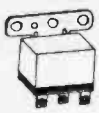

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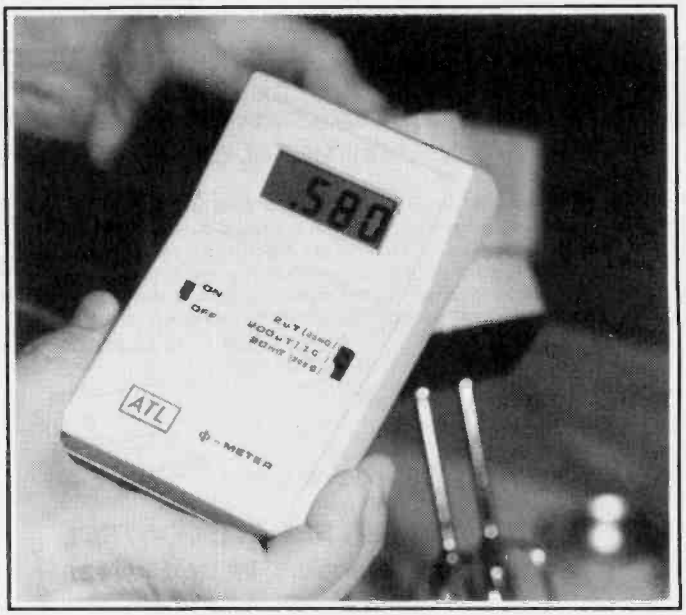

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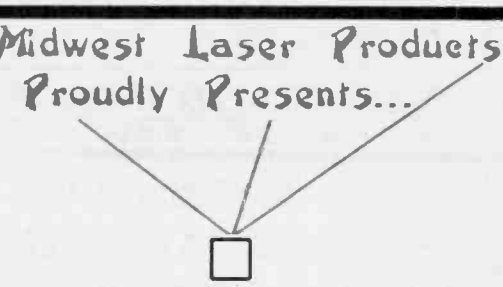

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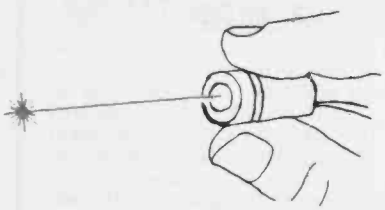

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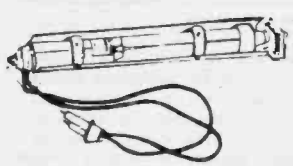
SPECIFICATIONS:
*Requires only 3 penlight batteries.
*Size: 1.6 inches by 0.625 inch diameter.
*3mW Laser Diode ; 670nm wavelength (Red)
*Beam Size: 2mm at apature ; 0.6 inch diam. at 40ft.

2-3mW He-Ne Laser Tube



Power Requirements:
1700vdc @ 4.5mA

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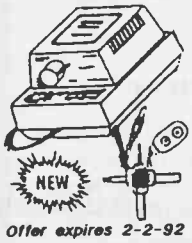

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COMPACT SIZE (75 Ohms) UHF-VHF-FM

W/FREE 35' COAX CABLE ASSEMBLY

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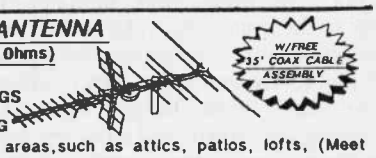

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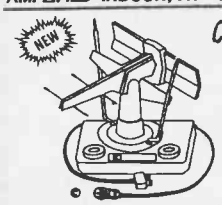

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#3:Push on F plug to F screw on Jack. 5ea.$2.50	75ΩFJ X2 75ΩFJ.$1.50ea. 75ΩFJ X3 75ΩFJ.$2.00ea. 75ΩFJ X4 75ΩFJ.$2.50ea.	#8:Switch A/B DC-900MHz. High isolation,FCC approved. #9:Transformer:UHF-VHF/FM 75ΩFJ to 300ΩT.....75cea.

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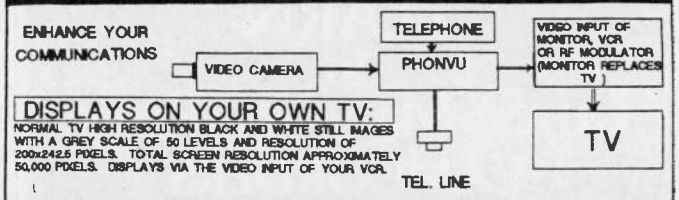

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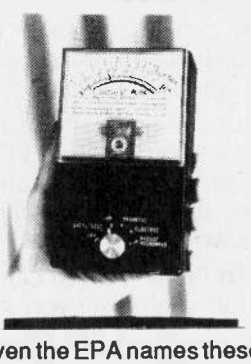

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5U4G	$4.30 each	12 at $3.90 each	25 at $3.50 each	
12AX7WA/7025	4.35	3.75	3.60	
6922 (military 6DJ8)	5.75	5.20	4.75	
EL84/6BQ5	2.60	2.25	1.75	
EL84M/6BQ5WA	5.20	4.50	3.50	
6V6GT	3.90	3.35	2.95	
6L6GC	3.50	2.95	2.60	50 CALL FOR SPOT QUOTE
5881/6L6WGC	6.75	6.20	5.75	100 CALL FOR SPOT QUOTE

The 5881 is Russia's selected military 6L6WGC and is regarded as the very best 6L6 type in the world. Eric Clapton recently replaced the Philips/Sylvania 6L6 STR's in the custom Soldano amp which he uses live, with SOVTEK 5881's because of their milky smooth sound. Discriminating musicians thruout the world are retubing with the SOVTEK 5881/6L6WGC.

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5U4G	$4.60 each	10 at $4.15 each	25 at 3.75 each	100 CALL FOR SPOT QUOTE
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6L6GC	4.70	3.95	3.70	" " " " "
12AX7a	3.85	3.25	3.10	" " " " "
12AT7	3.90	3.40	3.25	" " " " "
6146B	11.50	10.60	9.80	" " " " "
6550	9.40	8.95	8.35	" " " " "
KT88	11.60	10.50	9.95	" " " " "

EI, YUGOSLAVIA

EL34/6CA7	$5.10 each	10 at $4.65 each	25 at $4.10 each	100 CALL FOR SPOT QUOTE
6DJ8	3.15	2.75	2.35	" " " " "
12AU7/ECC82	3.15	2.75	2.35	" " " " "
12AX7/ECC83	3.15	2.75	2.35	" " " " "

SIEMENS, GERMANY

EL34	$7.25 each	10 at $6.75each	25 at $6.20 each	100 CALL FOR SPOT QUOTE

TESLA, CZECHOSLOVAKIA

EL34	$6.75 each	10 at $6.25 each	25 at $5.70 each	100 CALL FOR SPOT QUOTE

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6AS7	3.90	6CG7	6.90	6SL7	4.35	5749	3.90	OA3	1.95
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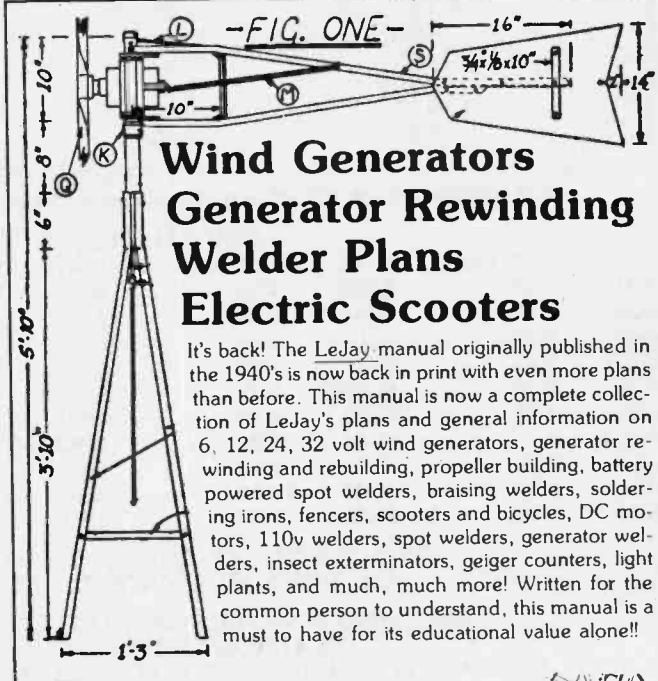

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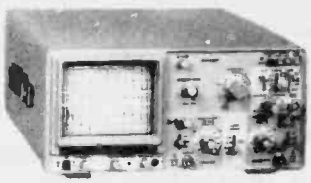

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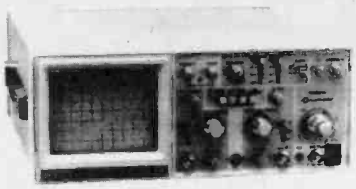

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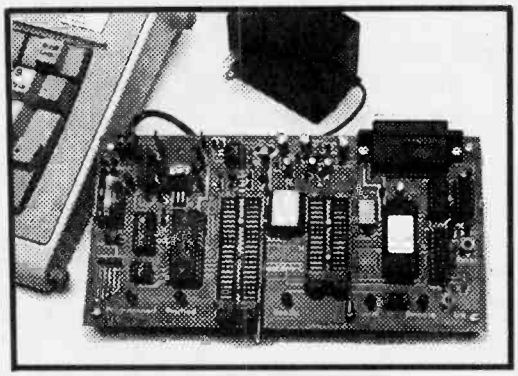

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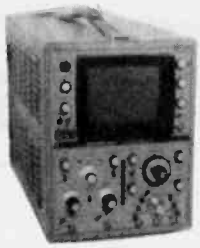

OS-189/USM-281A SCOPE, militarized Hewlett-Packard 180 with dual-trace and time-base sweep delay plug-ins and 8x10 cm CM CRT. Sensitivity: 5 mv to 20 v/div in 12 calibrated steps; vernier to 50 V. Sweep: 0.1 usec to 2 s/div in 23 steps. Delay: 0.1 us to 50 ms/div in 18 steps. 11.4x7.9x21.3; 44 lbs sh.
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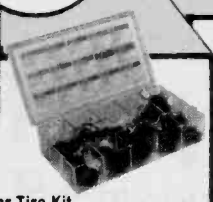

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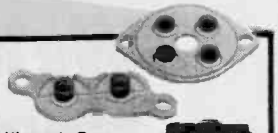

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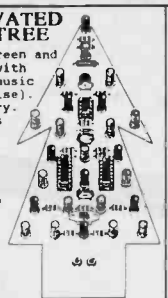

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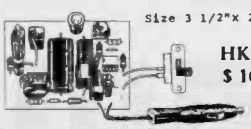

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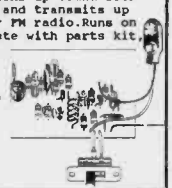

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We have received many inquiries from this news report. So we're pleased to run it again:

Silver Plating Ploy

by Jim Wenstrom, CE KFLS/KKRB

Klamath Falls OR. OK, your edge connectors don't connect. Or you want to plate your own PC creations but don't want to bother with electro-plate solutions. The plating on the socket for that 4CX15000 has worn off and no longer makes reliable contact. Your budget was shot months ago. What are you going to do now?

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"Application couldn't be easier. Use a cotton swab or ball and a little bit of water and just rub it on. In minutes you can silver-plate a circuit board or replate a power amp tube or socket.

It has saved me time, money and my sanity." 9/26/90

Thanks Jim Wenstrom for the original report and for permission to run it again. Call us at the factory for information—or to order direct. We'll also send you a brochure on our other product, Conducto-Lube—the silver-based conductive lubricant.

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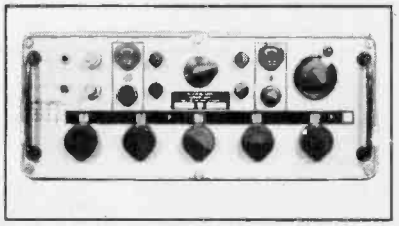

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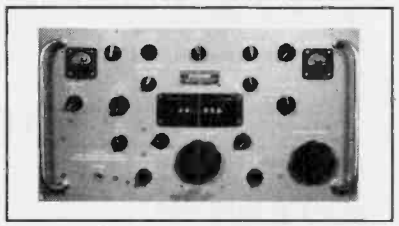

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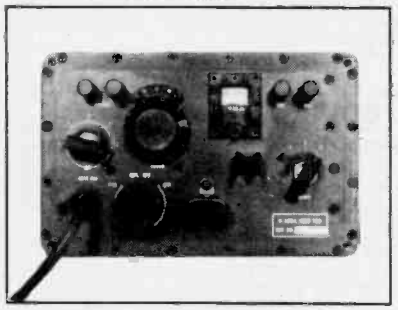

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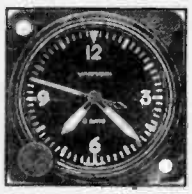

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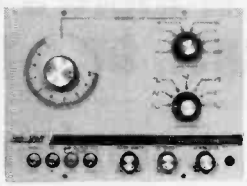

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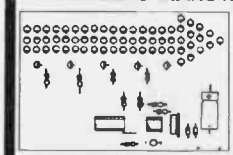

Giant bars of LEDs light up sequentially as this arrow appears to move! Absolutely amazing visual effect using 63 LEDs and a variable speed control. Kit comes with 9V battery snap (battery not included), but will also operate on any voltage between 5V and 12V AC or DC. Size of board: 5 1/2" x 4".

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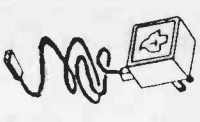

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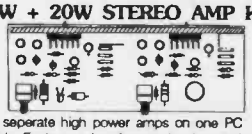

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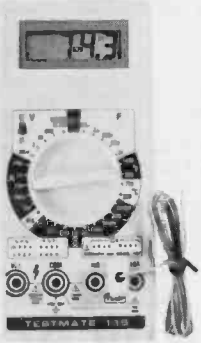

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Dissipation factor indicates leakage in capacitor and Q factor in inductor
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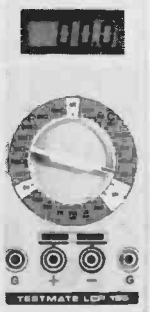

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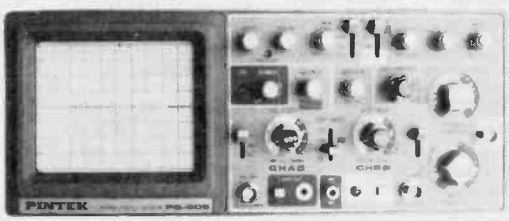

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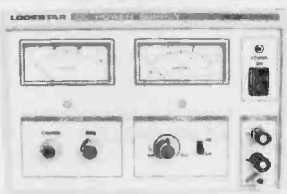

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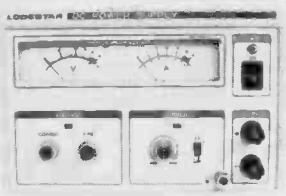

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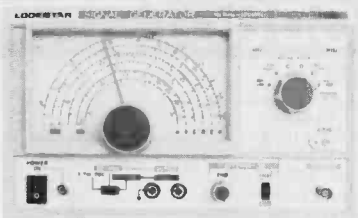

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100 kHz-150MHz sinewave in 6 ranges
Output 100mVrms to 35 MHz
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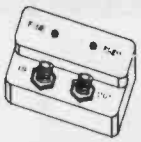

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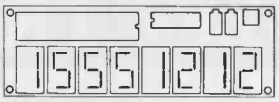

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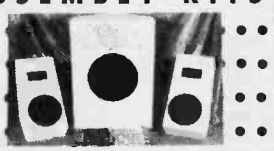

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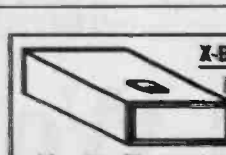

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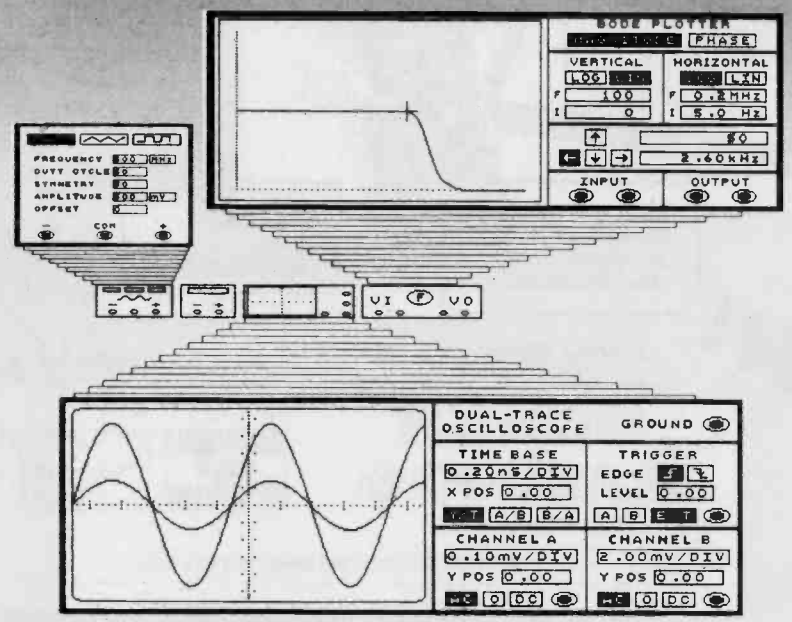

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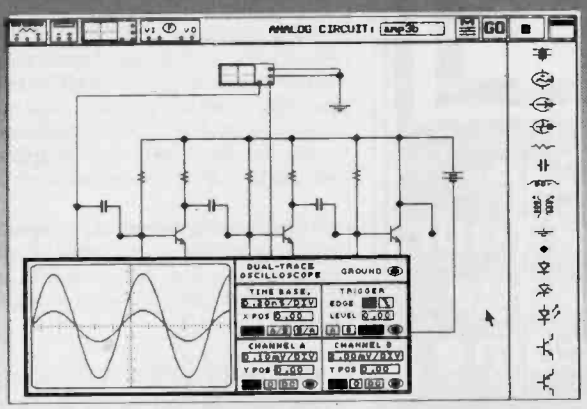

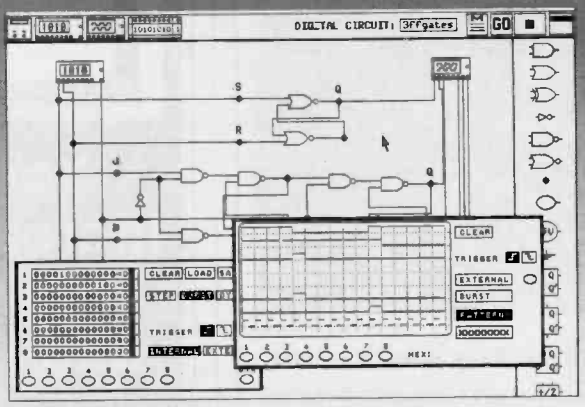

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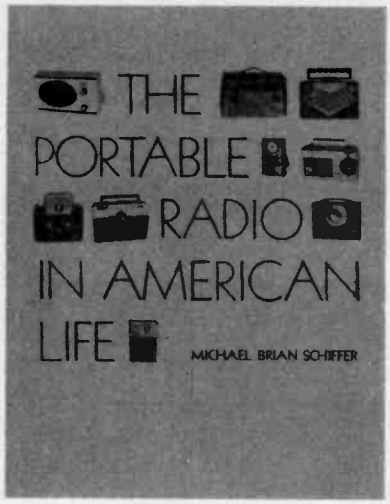

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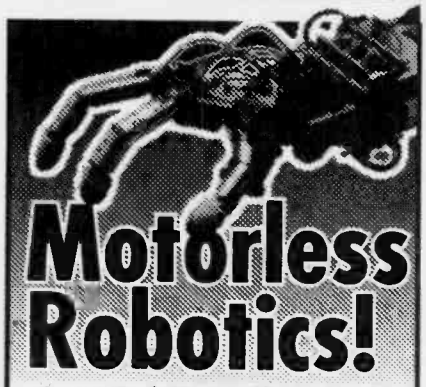

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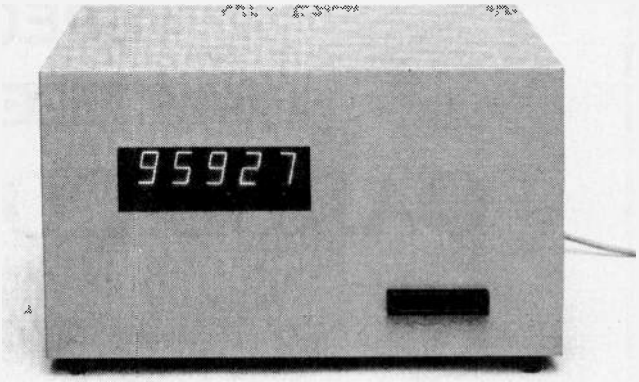

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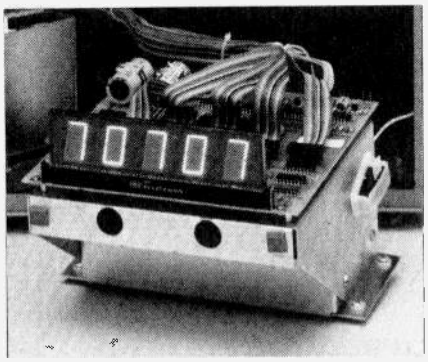

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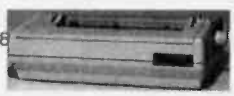

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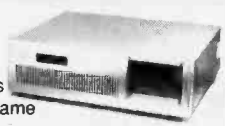

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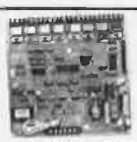

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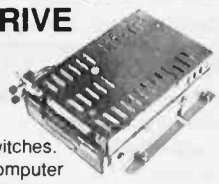

360K Disk Drive
MFG. By:Mitsumi
Model No. M57BCL-1
Complete with mounting bracket and two S&K switches. Great for hobbyist and computer buffs. 34 pin data connection and 4 pin power connection.

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Part No. 240-1104F 95¢ (ea) **75¢** (25+)

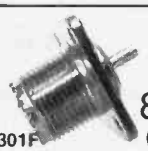
DOUBLE MALE F

Part No. 240-1229F 75¢ (ea) **45¢** (25+)

PL-259

Part No. 240-1253F 95¢ (ea) **75¢** (25+)

SO-239



Part No. 240-1301F 85¢ (ea) **65¢** (25+)

UHF T ADAPTOR

Part No. 240-1076F $2.25 (ea) **$1.85** (25+)

UG-175U RG-58U

Part No. 240-1220F 45¢ (ea) **25¢** (25+)

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Our classified ad rate is 40¢ per word. Minimum charge is $6.00 per ad per insertion (15 words). Any words that you want set in bold or caps are 10¢ each extra. Bold caps are 20¢ each extra. Indicate bold words by underlining. Words normally written in all caps and accepted abbreviations are not charged as all-caps words. State abbreviations must be Post Office 2-letter abbreviations. A phone number is one word.

CONTENT

All classified advertising in the **R-E Shopper** is limited to electronics items only. All ads are subject to the publisher's approval. We reserve the right to reject or edit all ads.

DEADLINES

Ads received by our closing date will run in the next issue. For example, ads received by April 5 will appear in the July, 1991 issue that is on sale June 4. Shopper ads will appear Jan., Mar., May etc. No cancellations permitted after the closing date. No copy changes can be made after we have typeset your ad. NO REFUNDS, advertising credit only. No phone orders.

AD RATES: 40¢ per word, Minimum $6.00.

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600 — Publications
630 — Repairs-Services
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13 - $6.00	14 - $6.00	15 - $6.00	16 - $6.40
17 - $6.80	18 - $7.20	19 - $7.60	20 - $8.00
21 - $8.40	22 - $8.80	23 - $9.20	24 - $9.60
25 - $10.00	26 - $10.40	27 - $10.80	28 - $11.20
29 - $11.60	30 - $12.00	31 - $12.40	32 - $12.80
33 - $13.20	34 - $13.60	35 - $14.00	36 - $14.40
37 - $14.80	38 - $15.20	39 - $15.60	40 - $16.00

Ad No 1—Total words _____ × .40 per word = $ _____

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Total classified ad Payment $ _____ enclosed.

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Expiration Date _ _ / _ _

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Signature _____

Name _____ Phone _____

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- On incoming calls, tells the caller to remain silent if they want to Fax.
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- New in sealed factory carton. Warranteed.

Closeout Price $79.95

MAN3840

7 segment LED display. This hard to find device is available in quantity. **$1.79 each**
100 for $150.00

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Great for security system projects, robotic applications, model railroads, etc. Metal TO-18 package, clear lens, >90KΩdark. <500Ω under room light.
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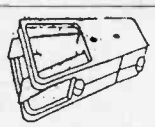
ULTRALINEAR 10.7MHz BAND PASS FILTER

Very high quality complex L-C filter. List price over $45.00. Limited Quantities **Now only $11.95 each**



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A very unique item. Made up of two piezo electric strips mounted in a plastic case. When AC voltage is applied the strips vibrate causing a fanning action. Optimum output at 110 VAC. Will work down to 20 VAC at decreasing output. 3¾" x 2" x 1⅛" with 8" leads. With specs.
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80386 MOTHERBOARD

Grab bag. BRAND NEW 20MHz 386 motherboards. *(No CPU, RAM, or ROMS)* **2 for $100.00**

2 MEGABYTE RAM CARD

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$67.50 each or 2 for $100.00

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Were over $190.00 NOW ONLY $49.95

BOOM MIKE

Electret condenser type. This versatile microphone may be wired for Handy Talkie, telephone, base station, aircraft radio, CB radio, motorcycle intercom, etc. A transistor radio type earphone may be installed in either or both muffs. The microphone unit can be easily removed and installed on another headset or helmet. **$4.95**

MINIATURE SPEAKER

This 1" diameter speaker is an ideal companion for installation in our boom mike featured above. **$1.49**

POWER PINCHER

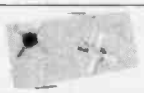
Now there's an easy, inexpensive way to save $5, $10 . . . $20 a month or even more on your home energy bills. Power Pincher reduces the energy used by your refrigerator, freezer, washer, or any other major AC electric motor-driven appliance in your home by as much as 60%. (Licensed from NASA under US Patent No. 4,052,648.)
$19.95 ea. or 4 for $76.00

PLUG PARADISE

Molex, Amp, Cannon, Viking, etc. **5 Lb. for $5.00**

'MAC' TORX DRIVER

This 13-inch long torx driver is the only tool which will open up an Apple Macintosh. **$4.95**



HP 5082-2830 QUAD HOT CARRIER DIODE RING

Use as image reject mixer in microwave downconverter. Applications. **5 for $4.95**

SILICON VALLEY "GOLD"

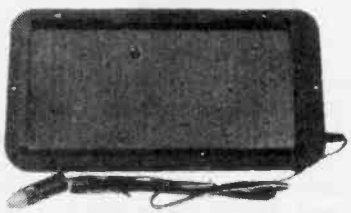
Over 50 pounds of printed circuit boards from computers, monitors, modems, test, RF and microwave equipment, all stuffed with goodies such as toroids, IC's, switches, sockets, connectors, oscillators, crystals, transistors, diodes, varactors, varistors, etc. A gold mine of usable parts.
50 Lbs. for $49.95

6 POLE CRYSTAL FILTER MODULE

(Granger P/N 269-0031-00) Set for about 4 MHz easily modified for other frequencies. **2 for $12.95**
HC18 6MHz XTAL for above, $1.00

CIRCULAR POLARIZER

SummaTech 58mm circular polarizer, excellent for Leica, Pentax, Canon, etc. **Our Price**
COMPARE AT $75 $9.95



12 VDC, 1W SOLAR PANEL

With cord and plug measures 7" x 13". New — factory sealed package. **$27.49 each**

VARO H407 HV DIODE

750 mA 6KV diode. Great for laser supply.
$1.99 or 10 for $15.00

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2N3958 — A pair of matched N channel JFET's in one package for low noise. Very stable. Differential amplifier applications. **$1.99 ea. or 10 for $17.95**

FENWAL ELECTRONICS GD13J1

Ultra-fast "mustard seed" thermistor.
$3.95 ea. or 10 for $25.00

SCANNER RF AMPLIFIER

5 MHz to 900 MHz installs at antenna and serves as a preamplifier to increase signal to noise ratio. Increase the sensitivity of your scanner or shortwave receiver over 6 times (10 db gain). Easy hookup, power supply and coupler included. **Special NOW $19.95**

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Assorted switches, may include rotary, toggle, slide, "micro", breaker and weird. **50 pcs. for $5.95**

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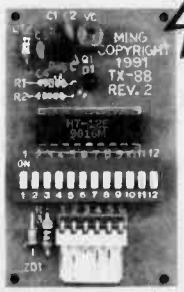
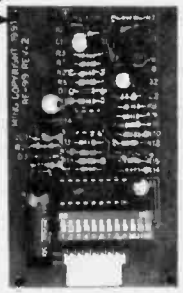
RF TRANSMITTER & RECEIVER

#TX-88 **$10.95**

NEW DESIGN REV. 2

#RE-99 **$21.95**





Tiny PCB level transmitter powered by 12VDC with a range of 100'-200' within line-of-sight. Capable of multi-channel signals and 4096 possible code combinations. SIZE:1.5" x 2.38" x 0.38"

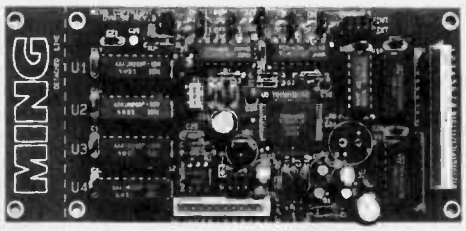
Small PCB level receiver powered by 12VDC with IC's included for both single or multi-channel decoding. 8 bit address codes and 4 bit data codes.

SIZE: 2.25" x 3.75" x 0.5"

#RC-99 *Combination of TX-88 & RE-99* **$29.95**

DIGITAL VOICE MODULE

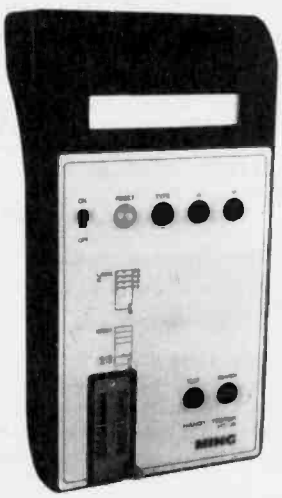
#DVM-58C **$89.95**



- Record and playback up to 2 minutes of your message on optional 4Mb of DRAM (32K bps). **1 Meg DRAM included.**
- Up to 16 variable-length messages -each w/direct trigger.
- Very low standby current, only **8 mA** w/4 Mega DRAM.
- "ENDLESS RECORDING MODE" for continuous recording.
- "REPEAT MODE" and "VOX" can be enabled.
- Selectable bit sampling rates of 16K or 32K bps
- "EOS" (end of sentence) output lets you control other devices at the end of a message in the playback mode.
- PCB dimensions- 5.75" x 2.75" x 0.5".

IC TESTER / IDENTIFIER

HT-21 HANDY TESTER **$195.00**



- Tests TTL 74, CMOS 40/45 and DRAM 4164-411000, 4416-4425 series IC's.
- Identifies any unknown IC number on TTL 74 and CMOS 40/45 series.
- 1 x 16 LCD dot matrix display.
- Automatic power shut-off to conserve battery life.
- Up to 500 hours of operation on a single 9V alkaline battery.
- 9V AC adapter included.
- Lightweight at only 9 oz.
- Dimensions 3.5" x 7" x 2".

Stop guessing with your IC's, the HT-21 Handy Tester is a complete stand alone system which is portable, powerful and a very affordable device for IC testing and identifing either in-house or in the field.

DIGITAL VOICE RECORDER

#DVR-120M **$149.95**

Incorporating the #DVM-58C Digital Voice Module within an ABS enclosure and including the following:

- 4 Mega DRAM
- Internal playback speaker
- Record/playback pushbuttons
- Reset pushbutton
- MIC and LINE OUT jacks
- 12V AC adapter
- Microphone
- Terminal strip connector

DIGITAL VOICE MODULE

#DVM-2804 **$49.95**
(EPROM not included)

A compact digital voice module designed for playback of pre-recorded message(s) from an EPROM IC.

- Up to 5 seperate messages from direct trigger inputs
- Dual socket design accepts a 256K EPROM for a total of 8 seconds or a 1 Meg EPROM for a total of 32 seconds of message(s) playback.
- Built-in 0.5W amplifier.
- SMT design, SIZE: 2.75" x 1.75" x 0.875"

DIGITAL VOICE PROGRAMMING TOOL

#DVMP **$495.00**

This programming tool is designed to be used with your existing EPROM programmer for the purpose of programming voice data onto EPROM IC's for digital voice modules such as the #DVM-2804.

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CANADIAN ORDERS:
All orders must be **PREPAID** by check or credit card (VISA, MC).

Add a flat rate of **US$15.00** for shipping and handling by U.S. POST OFFICE (air).

CIRCLE 212 ON FREE INFORMATION CARD

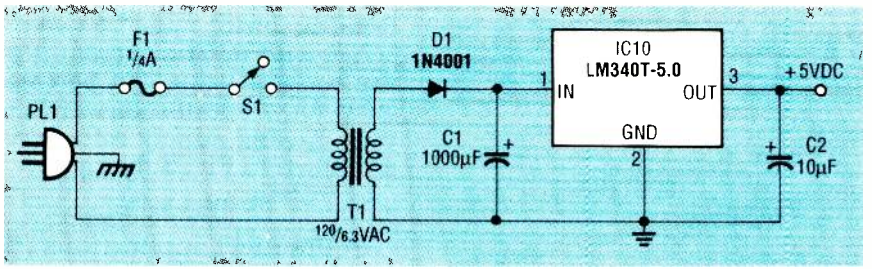


FIG. 2—POWER SUPPLY. If you don't have a suitable 5-volt DC power supply available, you can build this one.

color sequence is the reverse of VGA.)

Vertical sync is generated by sending horizontal sync to pin 1 of IC8-a, a 74LS393 binary counter, where it ends up divided by 64 at pin 10 of IC8-b and fed into the CLK input (pin 8) of IC9, another 74LS164 shift register. The CLR input to IC9 (pin 9) ultimately comes from its own Q_G output via IC6's A2 input (pin 5), its Y2 output (pin 7), Schmitt inverter IC2-f, and transistor Q2. Using IC9's Q_G output to reset itself causes a division of its clock input by 7. Therefore, the horizontal sync is first divided by 64 by IC8, then divided by seven by IC9, making a total division of 448. Therefore, a 70.71-Hz signal (31.68 kHz divided by 448) with a 60-µs pulse width is sent from IC9 pin 3 to pin 14 of J2, a 15-pin high-density VGA connector, via C13, R13, and Schmitt inverter IC2-e.

PARTS LIST

All resistors are ¼-watt, 5%.
R1—24,000 ohms
R2, R3—5100 ohms
R4, R10, R13—10,000 ohms
R5, R11—100 ohms
R6, R12—1000 ohms
R7–R9—620 ohms
R14—56 ohms
Capacitors
C1—1000 µF, 50 volts, electrolytic
C2—10 µF, 10 volts, electrolytic
C3–C13, C16, C17—0.01 µF, 50 volts, ceramic
C14—0.022 µF, 50 volts, ceramic
C15—100 pF, 50 volts, ceramic
Semiconductors
IC1—74HC04 hex inverter
IC2—74HC14 hex Schmitt trigger inverter
IC3, IC9—74LS164 shift register
IC4—74LS74 D flip-flop
IC5—74LS163 4-bit binary counter
IC6, IC7—74HC158 2-line to 1-line selector
IC8—74LS393 dual 4-bit binary counter
IC10—LM340T-5.0 5-volt regulator
OSC1—5.0688-MHz TTL clock oscillator
OSC2—4.9152-MHz TTL clock oscillator
D1—1N4001 diode
D2, D3—1N5711 Schottky diode
Q1, Q2—MPS6515 NPN transistor
Other components
F1—0.25-amp AGC fast-blow fuse
J1—DE9S 9-pin female connector
J2—HD DB15S 15-pin high-density female connector
S1, S2—SPST switch
S3—DPDT switch
T1—120/6.3VAC transformer
Miscellaneous: AC linecord, wire-wrap IC sockets, metal enclosure, wire, solder, etc.

CGA/EGA1 operation

When switch S2 is set to "EGA," it places a logic "1" (a high) on pin 1 of IC6, which then connects its "B" inputs to the "Y" outputs. When S3 is set to "Mode 1," it places a logic "0" (a low) on pin 1 of IC7, another 74HC158 selector, which connects its "A" inputs to the "Y" outputs. Now IC7 uses OSC1 as its timing source which is input at pin 2 and output at pin 4. That, in turn, is input to pin 13 of IC6 and output at pin 12. From pin 12 of IC6, OSC1 is to IC3's CLK input (pin 8). Because IC3's Q_E output (pin 10) is tied back to its CLR input (pin 9) via IC7 pins 5 and 7, IC6 pins 10 and 9, R1, and Q1, IC3 divides OSC1 by five.

Output Q_C of IC3, which is also OSC1/5 because Q_E is used as the clear signal, routes 1.014 MHz (5.0688/5) to pin 3 of IC4-a, causing further division by four at pin 9 of IC4-b for a total division of 20 (253.44 kHz). The 253.44-kHz output from IC4 pin 9 is connected to pin 3 of IC6 via IC7 pins 11 and 9. The input to pin 3 of IC6 is output at pin 4, and from there it goes to S3 and the CLK input of IC5 (pin 2). After IC5 divides the 253.44 kHz by sixteen, the horizontal sync measures 15.84 kHz.

Vertical sync is generated by dividing horizontal sync (15.84 kHz) by 256 at pin 8 of IC8. That output connects to C12, R1, IC2-b, and pin 14 of IC7. The 61.88 Hz vertical sync signal with a 190 µs positive pulse width is then sent to pin 9 of output jack J1 via IC7 pin 12.

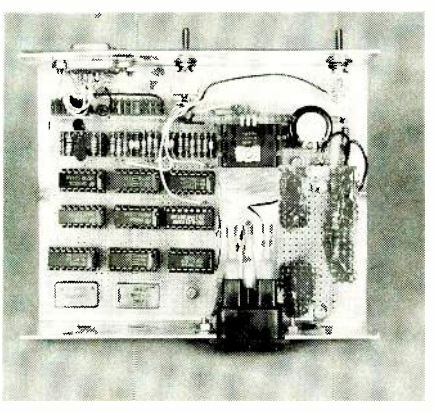


FIG. 3—THE AUTHOR'S PROTOTYPE. Perforated construction board and wire-wrap techniques were used to assemble the project.

EGA2 operation

When S2 is set to "EGA," it places a high on pin 1 of IC6, which then selects its "B" inputs. With S3 set to "Mode 2," it places a high on pin 1 of IC7 so it also selects "B" inputs. With the "B" inputs selected, IC7 uses OSC2 as its timing source and 4.9152 MHz passes from pin 4 of IC7 to pin 13 of IC6. The signal then connects to IC3's CLK input (pin 8) from pin 12 of IC6. The Q_G output from IC3 is connected to IC6 pin 10 via IC7 pins 6 and 7. The signal is then output at pin 9 of IC6, and connects back to the CLR input (pin 8) of IC3. The OSC2 signal is divided by seven by IC3 producing 702.17 kHz at IC3's Q_C output. The Q_C output from IC3 ties to IC4-a, which causes an additional division by 2, for a net of 14. The 351.08 kHz from IC4-a pin 5 is connected to IC5's CLK input (pin 2) via IC7 pins 10 and 9, and IC6 pins 3 and 4. The signal is further divided by

continued on page 94

WORKING WITH LED'S

We begin our in-depth survey of opto-electronic systems by taking a close look at a wide variety of LED circuits.

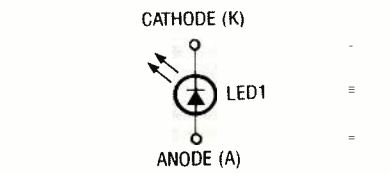
RAY MARSTON

OPTICAL ELECTRONIC DEVICES ARE so widely used in today's consumer-electronics that it's hard to come across a product that doesn't use light-emitting diodes (LED's) in one way or another. If you've ever had a need to use LED's or specialized flashing devices in your circuit design, we might be of some help to you. We'll start by presenting some basic information on LED's, then we'll take a look at some multi-LED packages. Finally, we'll round-off with a discussion of different types of flasher circuits used for controlling LED's.

LED basics

LED's are commonly used as visual indicators because of their fast response time and high efficiency. When compared to tungsten-filament lamps, their typical energy conversion efficiency is ten to fifty times greater and their response time is one hundred to one thousand times faster. LED's are widely available in red, orange, yellow and green colors.

Figure 1 shows the standard LED symbol and typical forward voltages of different colored LED's. The device is a genuine diode, and a voltage of approximately 2 volts is produced across it when it is passing a forward current of 20 milliamps. If an LED is reverse biased, it will avalanche or "Zener" at a fairly low voltage value, as shown in Fig. 2. Most LED's have maximum reverse voltage ratings in the range of 3 to 5 volts.



COLOR	RED	ORANGE	YELLOW	GREEN
V_F	1.8V	2.0V	2.1V	2.2V

FIG. 1—LED SYMBOL AND TYPICAL forward voltages of standard LED's at $I_F = 20$ milliamps.

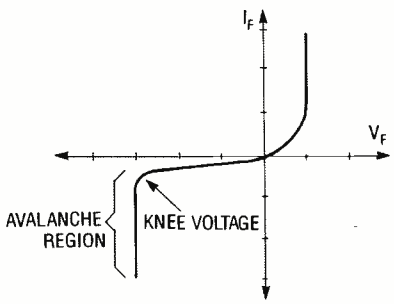


FIG. 2—GRAPH SHOWING REVERSE biased LED responding as a Zener diode.

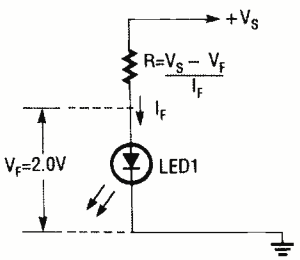


FIG. 3—METHOD OF FINDING the current-limiting resistance value for a given V_S and I_F.

When an LED is used, a resistor or other suitable current-limiting device must be wired in series with it. The current-limiting resistor value can be calculated for a specific forward current, I_F, and supply voltage, V_S, as shown in Fig. 3, being,

$$R = (V_S - V_F)/I_F.$$

In practical applications, the series resistor can be connected to either the anode or the cathode of the LED. The LED brightness is proportional to the LED current; most LED's will operate safely up to absolute maximum currents of 30 to 40 milliamps. With a DC supply voltage and a suitable line dropping resistor, the current through the LED should be maintained at a constant value of approximately 20 milliamps.

An LED can be used as an indicator in an AC circuit by wiring a diode in inverse parallel with it, as shown in Fig. 4. The diode prevents the LED from becoming reversed biased on the negative half of the sine wave cycle. For a given brightness, the line dropping resistance value in an AC circuit should be one half that used in a DC circuit. When an LED is used in an AC circuit, the forward current conducts through the LED only during the positive half of the sine wave cycle, after the LED has reached its threshold voltage of about 1.5 volts. Therefore, the LED conducts current less than one half the time in an AC circuit as it does in a DC circuit. In order to achieve the same *average* current through the LED with an AC supply, approximately twice as much current must flow so the resistance value must be reduced by one half.

One of the first problems you will encounter when using an LED is identifying its polarity. The cathode on most LED's is identified by a notch or flat surface on the component, or by a short lead. That practice is not universal, however, so the only accurate way to identify the polarity of an LED is to test it in the basic circuit of Fig 3; try the LED in both positions, when it glows, the cathode is the most negative of the two terminals. It is always a good practice to test an LED before soldering it onto the PC board.

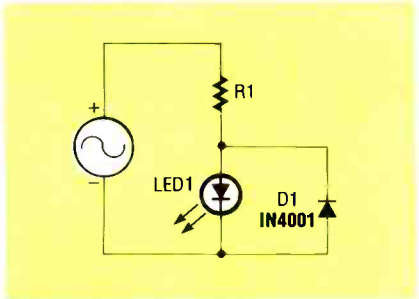


FIG. 4—AN LED USED IN AN AC circuit; D1 is wired in inverse parallel to prevent the LED from being reverse biased.

Special mounting kits are available for securing LED's onto PC boards and front panels. Those kits consist of a special mounting grommet and grooved ring shown in Fig.5-*a*. If mounting hardware is not available, you can drill panel holes and either epoxy the LED into place or solder its leads into a PC board, which can support the LED. That method is shown in Fig. 5-*b*.

LED packages

LED's can be purchased as single components, as shown in Fig. 1, or in a multi-LED package. The most common type of multi-LED package is the 7-segment display, comprising seven or eight LED's packaged for displaying alphanumeric characters. Another well-known type of multi-LED package is the bar-graph display, which is made up of ten to thirty linearly-mounted LED's. An example of a ten-element LED package is shown in Fig. 6-*a*.

Most LED's provide only a single output color. There are, however, a few specialized LED packages that provide multi-color outputs. Those devices actually consist of two LED's contained in one package. Figure 6-*b* shows a bi-color LED which is comprised of a pair of LED's connected in inverse parallel. The color green is emitted when the device is biased in one direction,

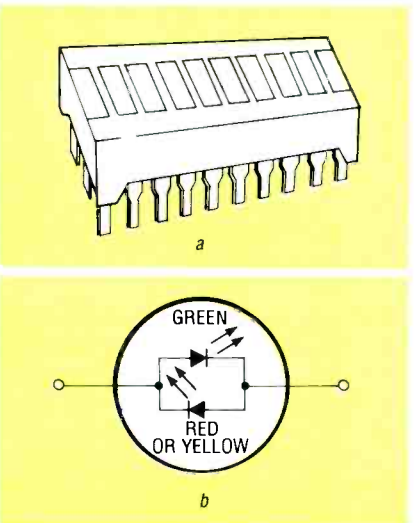


FIG. 6—MULTI-LED PACKAGES; (*a*) is a 10-element LED, and (*b*) is a 2-color LED which contains two LED's connected in inverse parallel.

and red or yellow is emitted when it is biased in the reverse direction. The bi-color LED is useful for giving polarity indication and null detection.

Another type of multi-color LED is shown in Fig. 7. This four color LED is made by mounting a green and red LED in a 3-pin common-cathode package. That device can generate green or red colors by turning on only one LED at a time, or it can generate orange and yellow by turning on the two LED's in the current ratios shown in the table.

A very important practical point concerns the use of "second-grade" or "out-of-spec" devices advertised as bargain packages. Those devices often have forward voltage drops in the range of three to ten volts. Although "second grade" LED's may be suitable for many applications, it's always a good idea to test those devices before using them in your circuit, as we said earlier.

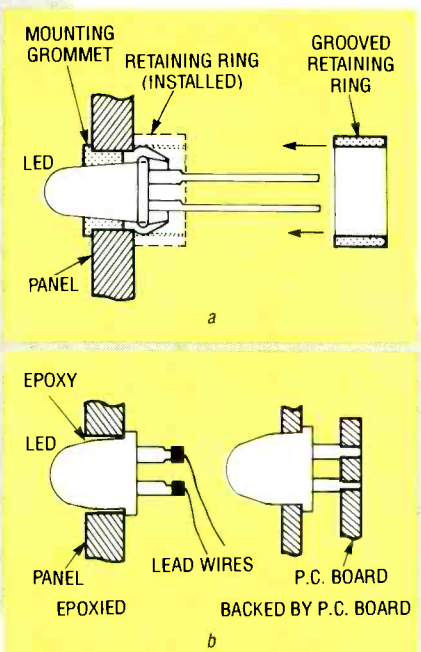
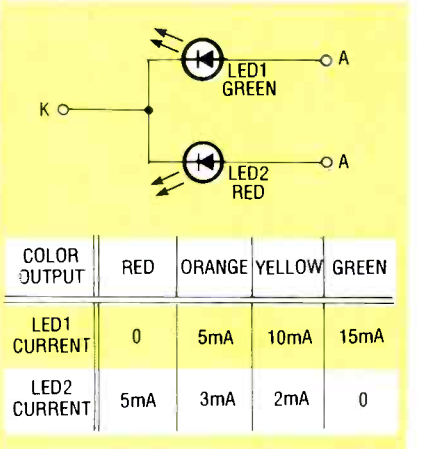


FIG. 5—LED MOUNTING METHODS; (*a*) shows an LED mounting kit consisting of a grommet and retaining ring, and (*b*) shows an LED mounted in a drilled hole with epoxy or soldered leads.



COLOR OUTPUT	RED	ORANGE	YELLOW	GREEN
LED1 CURRENT	0	5mA	10mA	15mA
LED2 CURRENT	5mA	3mA	2mA	0

FIG. 7—MULTI-COLOR LED; this LED gives four colors from two junctions as shown in the current ratios given in the table.

Multi-LED circuits

A number of LED's can be driven from a single source by wiring all LED's in series as shown in Fig. 8. The supply voltage used in that circuit is equal to the sum of the individual LED forward voltages and the voltage drop across the line-dropping resistor. The line-dropping resistance value can be calculated by using the equation

$$R = (V_S - V_{FT})/I_F.$$

The total forward voltage, V_{FT}, is the sum of the forward voltage drop of each LED.

The circuit shown in Fig. 8 draws minimal total current, but is limited in the number of LED's that it can drive. A number of those series LED circuits can,

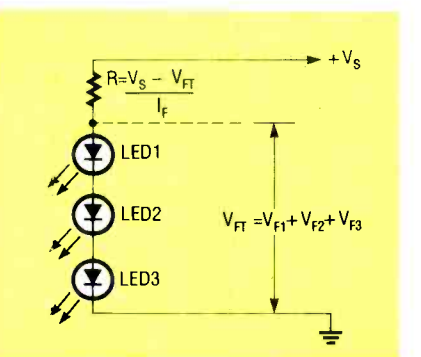


FIG. 8—LED's WIRED IN SERIES and driven by a single current-limiting resistor.

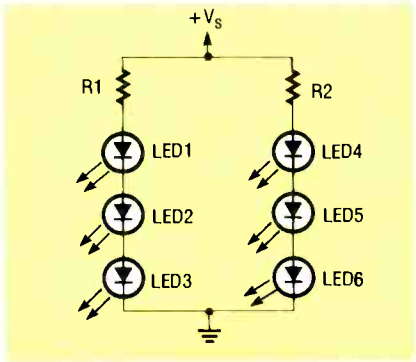


FIG. 9—A NUMBER OF SERIES LED circuits can be wired in parallel, to drive multiple LED's.

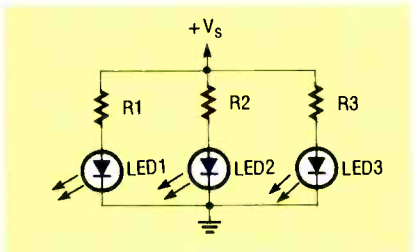


FIG.10—THIS CIRCUIT CAN DRIVE a large number of LED's, but at the expense of high current.

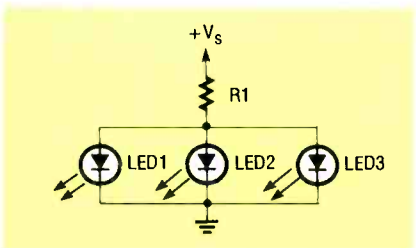


FIG. 11—NEVER USE THIS LED driving circuit. One LED will draw all of the current.

however, be wired in parallel, so that almost any number of LED's can be driven from a single source, as shown in the 6-LED circuit of Fig. 9.

An alternate but less efficient method of driving multiple LED's is to simply wire a number of dropping resistors and LED's in parallel, as shown in Fig. 10. That type of circuit will work, but it draws a significant total current, which is equal to the sum of the individual LED currents.

Since we're on the subject of how to connect multiple LED's, lets discuss what *not* to do. Never hook-up multiple LED's as shown in Fig. 11. That circuit will not work properly because of inevitable differences in the forward-voltage characteristics of the LED's, one LED will usually draw most of the available current, leaving little or none left for the remaining LED's.

Three widely used types of visible-output LED-control circuits are those used for LED flashing, LED sequencing, and LED dot or bar analog-value indication. LED flasher circuits are designed to turn an LED alternately on and off, to give an eye-catching display action. Those circuits may control a single LED, or they may be designed to control two LED's in such a way that one turns on as the other turns off.

A special LED-flasher IC is available, the LM3909, which can be used to flash an LED from a low voltage DC supply, and does so at a very low average current level. Some practical LED flasher circuits using the LM3909 IC are shown later in this article.

LED sequencer circuits are designed to drive a chain of LED's so that each LED in the chain is switched on and off in a time-controlled sequence, so that a ripple of light seems to run along the chain.

LED analog-value indicator circuits are designed to visually appear and respond as an analog meter. An analog-value LED circuit drives a chain of linearly-spaced LED's in such a way that the length of the chain that is illuminated is proportional to the analog value of a voltage applied to the input of the driver circuit.

LED-flasher circuits

One of the simplest types of LED display circuits is the LED flasher, in which a single LED repeatedly switches alternately on and off, usually at a rate of one or two flashes per second. A 2-LED flasher is a simple modification of this circuit, but is arranged so that one LED switches on when the other switches off. A 2-LED transistor flashing circuit is shown in Fig. 12.

In the flashing circuit shown in Fig. 12, Q1 and Q2 are wired as astable multivibrators, with their switching speeds determined by time constants R3 × C1 and R4 × C2. The circuit operates at about 1 flash per second using the component values shown. The 2-LED flashing circuit can be converted to single-LED operation by replacing the unwanted LED with a short circuit.

An IC version of the 2-LED flasher is shown in Fig. 13. That design is based on the dependable 555 timer chip, or its more modern CMOS counterpart, the 7555. The IC is wired in the astable mode, with its time constant determined by R4 and C1. The output at pin 3 of the IC alternately switches between the ground and the positive supply voltage, alternately shorting out

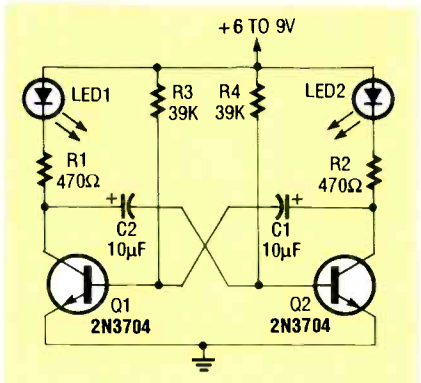


FIG. 12—TWO-LED FLASHER circuit operates at 1 Hz; Q1 and Q2 respond as astable multivibrators while LED1 and LED2 alternately flash on and off.

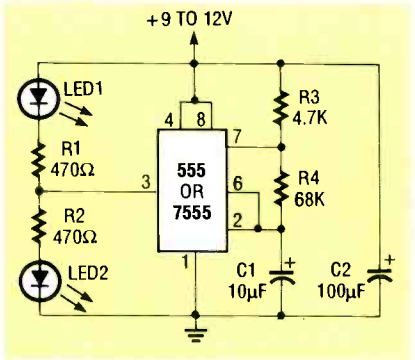


FIG. 13—TWO-LED FLASHER circuit operates at 1 Hz using a 555 or 7555 timer IC.

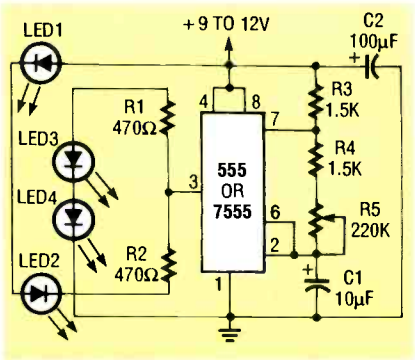


FIG. 14—FOUR-LED DOUBLE-BAR flasher in a "cross" configuration; the flashing rate is variable from 15 to 2000 flashes per minute.

and disabling LED1 or LED2. The flashing circuit can be converted to single-LED operation by shorting out the unwanted LED and its associated current-limiting resistor.

A visually interesting display can be produced with a useful modification of the above circuit, shown in Fig. 14. Two pairs of series-connected LED's are connected in the form of a cross so that the visual display alternately switches between a horizontal bar (LED1 and LED2 on) and a vertical bar (LED3 and LED4 on). The flash rate is made variable via potentiometer R5 and can range between 15 and 2000 flashes per second.

Flasher IC LM3909

A seemingly trivial task that sometimes faces the design engineer is that of providing illuminated power indication of the ON state of an electronic unit or the location of a passive device such as a fire extinguisher or emergency switch in a darkened room. LED's operate reliably when main power is available, but a serious problem arises when battery-powered equipment is involved.

LED indicators typically draw about 12 milliamps when illuminated and can therefore place a fairly heavy strain on small supply batteries. Since LED's drop two or more volts under the ON condition, they can not readily be powered from battery voltages below about 3 volts.

National Semiconductor provides an ingenious solution to the problem of LED power drain and operation from weak batteries with the 8-pin LM3909 LED flasher/oscillator IC. The LM3909 IC is a low-duty-cycle (brief ON period, long OFF period) oscillator that provides a voltage-doubled, high-current pulse to an external LED. High pulse currents of up to 100 milliamps are produced from the IC, while still drawing very low *average* currents of about 0.3 to 1.5 milliamps. Because of the voltage-doubling capability, the LM3909 can flash an LED even when powered from battery voltages as low as 1.1 volts, and can provide months, or even years, of continuous flashing operation from a single 1.5-volt cell.

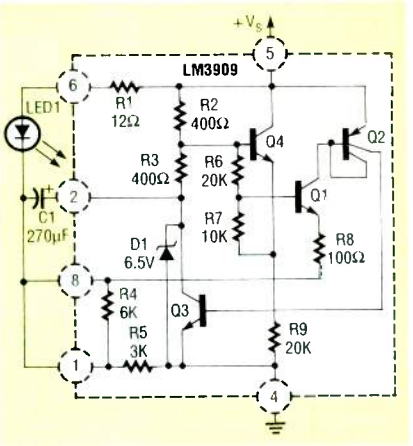
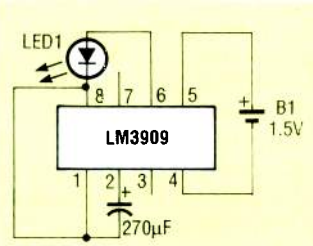


FIG. 15—INTERNAL CIRCUIT AND external connections of the LM3909 low-voltage LED flasher IC.

The LM3909 requires the addition of only a battery and a timing capacitor to function as an LED flasher. The internal circuit of this IC, together with typical external connections for 1.5-volt flasher operation, are shown in Fig. 15. In that particular application, the LED receives current via the 270-μF timing capacitor C1, R1, and Q3 for only about 1% of the time. All transistors except Q4 are off for the remaining part of each operating cycle. Resistor R9 draws only about 50 μA. The timing capacitor C1 is charged through R2 and R3 and through R5 connected between pins 1 and 4 of the IC.



CELL SIZE	ESTIMATED BATTERY LIFE UNDER CONTINUOUS 1.5V OF FLASHER OPERATION	
	STANDARD CELL	ALKALINE CELL
AA	3 MONTHS	6 MONTHS
C	7 MONTHS	15 MONTHS
D	15 MONTHS	30 MONTHS

FIG. 16—LED FLASHER USING 1.5 VOLT SUPPLY. TABLE shows estimated battery life under continuous 1.5-volt LED flashing operation.

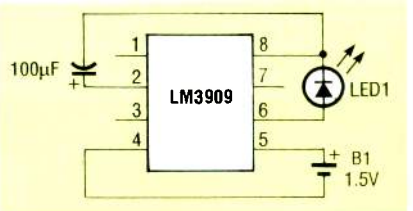


FIG. 17—MINIMUM POWER, longer life, 1.1-Hz flasher. Average drain current is 0.32 milliamps.

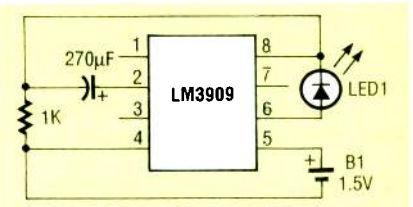


FIG. 18—FAST 1.5-VOLT BLINKER; flash rate is 2.6 Hz and drain current is 1.2 milliamps.

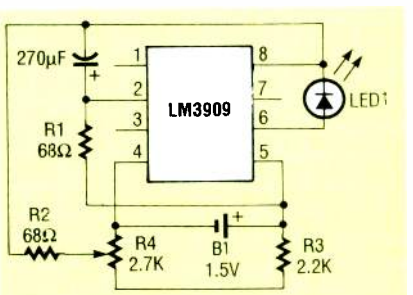


FIG. 19—VARIABLE-RATE FLASHER.

Transistors Q1 through Q3 remain off until C1 becomes charged to about 1 volt. That voltage is determined by the junction drop of Q4, its base-emitter voltage divider, consisting of R6-R7, and the junction drop of Q1. When the voltage at pin 1 becomes a volt more negative than that at pin 5 ($+V_S$), Q1 begins to conduct and turns Q2 and Q3 on. The IC then supplies a pulse of high current to the LED. The current gain of Q2-Q3 is approximately 500. Transistor Q3 can handle over 100 milliamps of collector current, and rapidly pulls pin 2 close to ground, pin 4. Since C1 is charged at that time, it forces the pin 1 terminal *below* the ground potential value. As a result of the pin 1 terminal being less than the ground potential, the one-volt drop across the LED is greater than the supply voltage value—R1 then limits the LED current to a safe value.

Capacitor C1 alternately charges via the timing resistor R5 and discharges via the LED and R1 in this application. In some other applications, the

short between pins 1 and 8 can be removed, enabling the capacitor to charge through a total of 9 kilohms, increasing the duty cycle and reducing the average current drawn. If voltage boosting is not needed, loads can be wired directly between pins 2 and 6 or pins 2 and 5 of the IC.

The LM3909 IC is thus a fairly versatile device. A variety of useful applications are shown in the remaining part of this article.

Practical LM3909 circuits

The LM3909 circuits shown in Figs. 16 and 17 can be used as locator beacons for fire extinguishers, emergency switches, and boat-mooring floats because of their low voltage operation and low current drain. The circuit shown in Fig. 16 gives a brief flash once every second or so, and typically draws an average current of only 0.63 milliamps. As shown in the table, that circuit will continually operate for three to thirty months from a battery, depending on the size and type of cell that is used.

An even longer life can be obtained from the minimum-power flasher circuit shown in Fig. 17. That circuit is similar to the one described above, except that the short is removed from between pins 1 and 8, causing the capacitor to charge via 9 kilohms of internal IC resistance (R4 + R5). The IC then operates with an increased duty cycle, and reduced average current is drawn. That circuit has a typical current drain of 0.32 milliamps.

A circuit similar to that of Fig. 17 can be designed for use with a 3-volt power supply. For 3-volt operation, the timing capacitor value should be increased to 270 µF for approximately the same flash rate of 1 Hz. The average drain current for that circuit is 0.77 milliamps, which is more than twice the drain current of the 1.5-volt flashing circuit.

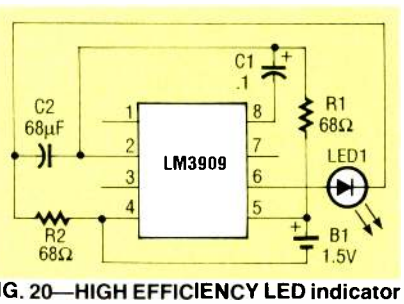
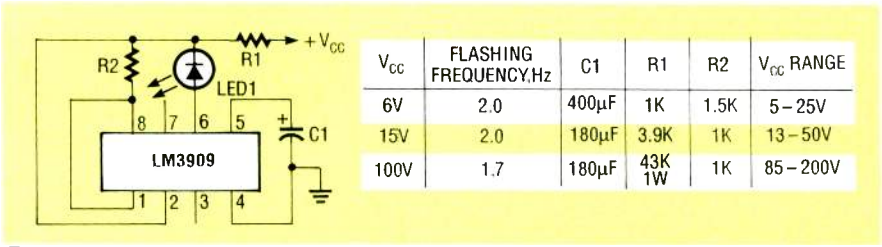


FIG. 20—HIGH EFFICIENCY LED indicator gives seemingly "continuous" operation from 1.5 volts. The current drain is 4 milliamps.



V_{CC}	FLASHING FREQUENCY, Hz	C1	R1	R2	V_{CC} RANGE
6V	2.0	400µF	1K	1.5K	5–25V
15V	2.0	180µF	3.9K	1K	13–50V
100V	1.7	180µF	43K 1W	1K	85–200V

FIG. 21—THIS WARNING FLASHER CAN OPERATE within a voltage range of 5 to 200 volts according to capacitor and resistor values specified in the table.

Another variation of the 1.5-volt flasher shown in Fig. 18 operates at a frequency of 2.6 Hz. In that circuit, the internal timing resistors are shunted by an external 1-kilohm resistor; the charging time constant is reduced, the duty cycle is decreased and the average current drain rises to 1.2 milliamps. The circuit gives a far more noticeable flasher indication than the three previous circuits, but at the expense of a much higher current drain.

If you enjoy experimenting with circuits, you can build the variable-rate flasher shown in Fig. 19. The flashing rate is variable from zero to 20 Hz via potentiometer R4. Resistors R1 and R2 are used to stabilize the duty cycle of the circuit and maintain a fairly steady apparent brightness level as the flashing rate is varied.

The Fig. 20 circuit is designed to give apparently continuous illumination of the LED when powered from a 1.5-volt cell. The circuit operates as a 2-kHz square-wave generator; resistors R1 and R2 are used to approximately equalize the ON and OFF times of the generator. The circuit gives a fairly dim LED illumination and has a rather modest battery drain of about 4 milliamps.

All of the LED flasher circuits we have discussed in Figures 16 through 20 are intended for operation from 1.5- or 3-volt supplies. The LM3909 can also be used with much higher supply voltages, ranging from 5–200 volts DC. The internal 6.5-volt Zener diode, wired between pins 2 and 4 of the IC, regulates the voltage between the LED cathode and ground. Those circuit configurations can be made with a minimum number of external components, as shown in the schematic of Fig. 21.

As a final circuit suggestion, you can built a useful flashlight-finder shown in Fig. 22. The LM3909, 200-µF timing capacitor and LED are installed inside a translucent cap mounted on the end of the flashlight. An insulated contact strip connects to the positive terminal of the battery and passes through the case for connection to pin 5 of the IC. The negative terminal of the battery connects to pin 4 (ground) of the IC. If a single-cell light is used, short pins 1 and 8. Drawing current through the lamp filament simplifies wiring and causes negligible power loss since the resistance of a cold bulb is less than 2 ohms. **R-E**

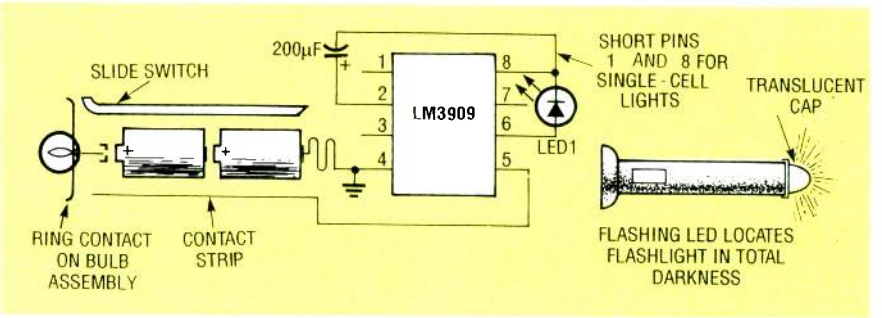


FIG. 22—A SIMPLE FLASHLIGHT FINDER; THE LM3909, capacitor and LED are installed inside a translucent cap mounted on the end of the battery.

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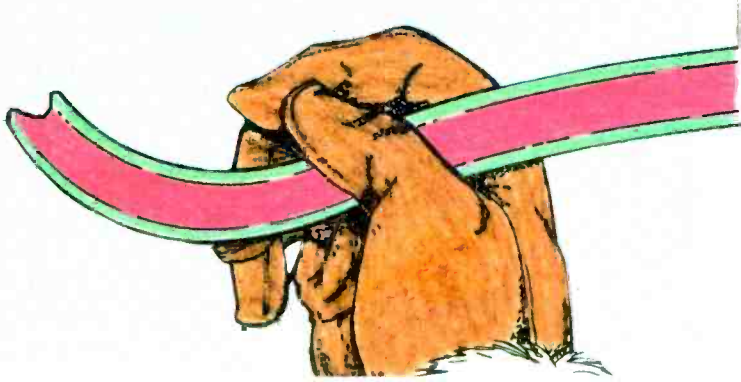

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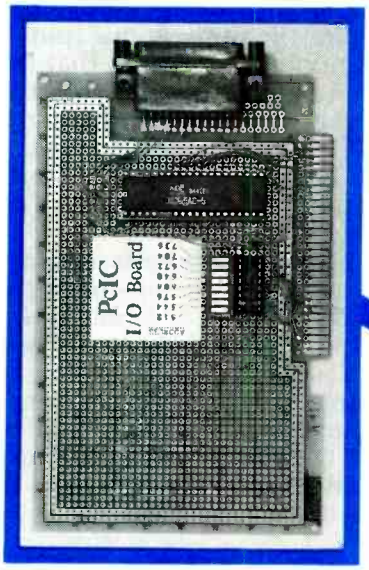
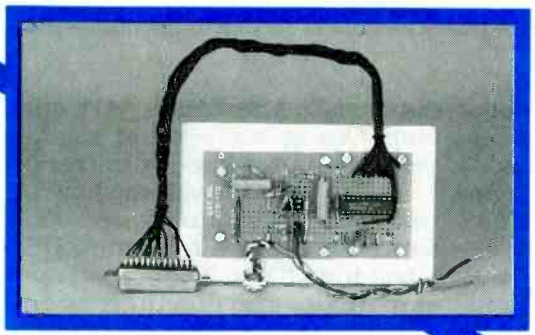
EXPERIMENTING WITH ADC FOR YOUR PC





JAMES J. BARBARELLO

Build our low-cost data-capture system and let your PC measure temperature, displacement, and other quantities.

IN PREVIOUS ARTICLES, WE INTRODUCED several general-purpose analog and digital I/O systems for the PC. (See "Experimenting With PC-Based Test Equipment" in May, June, and July of 1991.) The first installment described a test instrument for measuring capacitance; the second described a digital R/C meter. Both devices interfaced to the PC via a standard parallel port. The third installment described a simple PC expansion card, the PC IO, that adds 24 digital I/O lines by means of an 8255 Parallel Input/Output (PIO) device, the standard in the PC architecture.

In this article, we'll build a very low cost analog-to-digital converter (ADC) interface that allows you to measure temperature, displacement, audio signals, and any other 0–5 volt analog signal. Our ADC builds off the PC IO: By adding an amplifier and ADC circuit, and some simple BASIC software, you can capture and display data and log it to your PC at a rate of 1000 (or more, depending on the speed of your PC) data points per second.

This article shows you how to use the ADC to build an accurate temperature sensor, but it's easy to modify the circuit to accept other types of analog input devices.

Circuit theory

As shown in the block diagram of Fig. 1, the circuit consists of two functional blocks: a signal conditioner and an A/D converter. The signal conditioner is a variable-gain amplifier with an adjustable DC offset that allows you to calibrate the circuit for a variety of sensors. To understand why calibration is necessary, let's look at the IC that does the actual analog-to-digital conversion, a standard eight-bit device called the ADC0804. Unlike a traditional voltmeter, the ADC0804 responds to AC voltage changes very quickly, in fact at a rate greater than 1000 per second. The ADC0804 converts each sample to digital form, after which a computer may read the digital outputs for display or subsequent analysis.

The ADC0804 accepts an analog input of 0–5 volts DC and converts it to a binary number between 0 and 255. With a maximum range of 5 volts, and 256 steps between 0 and 5, resolution is 5/256 = 0.0195 volts, or almost 20 millivolts. So for any analog input voltage between 0.0000 and 0.0195, the ADC0804 will produce a binary 0 (00000000); for any voltage between 0.0195 and 0.0390, a binary 1 (00000001), and so on.

Twenty millivolts may seem like more than enough resolution, but what if you wanted to measure a signal with a maximum value of 40 millivolts? You'd only be able to distinguish two values in the given range. That's where the signal-conditioning portion

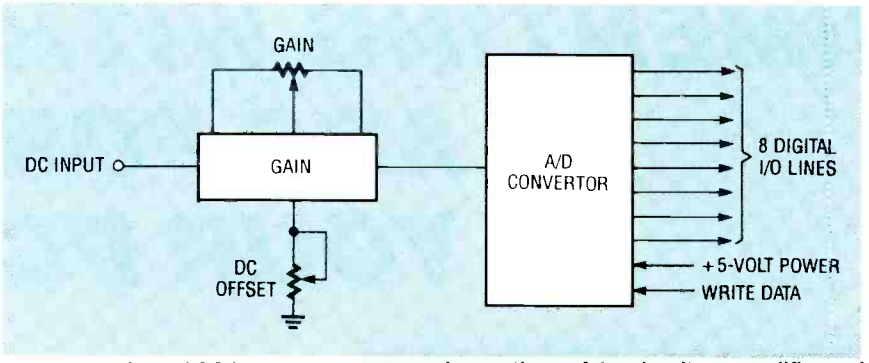


FIG. 1—BLOCK DIAGRAM shows the two major sections of the circuit, an amplifier and the ADC proper.

of the circuit comes in. By amplifying the signal so that it has an effective range close to the maximum range of the IC, we can break it down into much finer increments, and then let software scale it back to the appropriate value.

The DC offset portion of the signal conditioner lets us cancel any steady-state DC voltage and measure only the change in the DC voltage. That's required for the temperature sensor probe, which is built around the base-collector junction of a standard 2N2222 transistor. More on that in a moment.

The circuit

Referring to the schematic diagram shown in Fig. 2, IC1 is a standard 1458 (dual 741) op-amp. One op-amp (IC1-a) amplifies the input voltage by the ratio −R3/R6. With the values shown, that's a voltage gain of −10. Resistor R8 ensures minimum DC offset from IC1-a. The second op-amp (IC1-b) also functions as an amplifier, but in this case, voltage gain is −(R5 + R11)/R7, where R11 is a 15-turn, 10K potentiometer that allows the gain to be adjusted between values of −1 and −2. Like R8, R9 ensures minimum DC offset from IC1-b. The two inversions in the op-amps result in a non-inverted output signal.

The voltage divider consisting of R2 and R12 allows insertion of a DC offset voltage of 0–+2.5 volts DC. This can offset any positive quiescent DC voltage from an input device.

The ADC is IC2; it is configured for a free-running mode that samples the input signal (pin 6) continuously. To ensure that the A/D is initialized properly, the software drives pins 3 ($\overline{WR}$) and 5 ($\overline{INTR}$) low momentarily on start-up. The eight digital outputs (IC2 pins 12–18) drive the PIO directly, by way of P1.

A pair of 9-volt batteries supplies power for the op-amps; the host PC supplies +5-volt power for the voltage-divider circuit and IC2 via pin 25 of P1. Doing so ensures a more stable reference voltage than if the batteries were used. Of course, you're free to use a dual-polarity power supply in place of the batteries.

Temperature sensing

A standard 2N2222 transistor can readily serve as a $0.20 temperature sensor. Referring to Fig. 3-*a*, note that the emitter and base of Q1 are shorted together. That connection provides a diode—the base/collector junction. When power is applied across the junction, we would expect a constant drop of about 0.7 volts across it. The term *about* is important here, because the actual drop depends on the temperature of the junction.

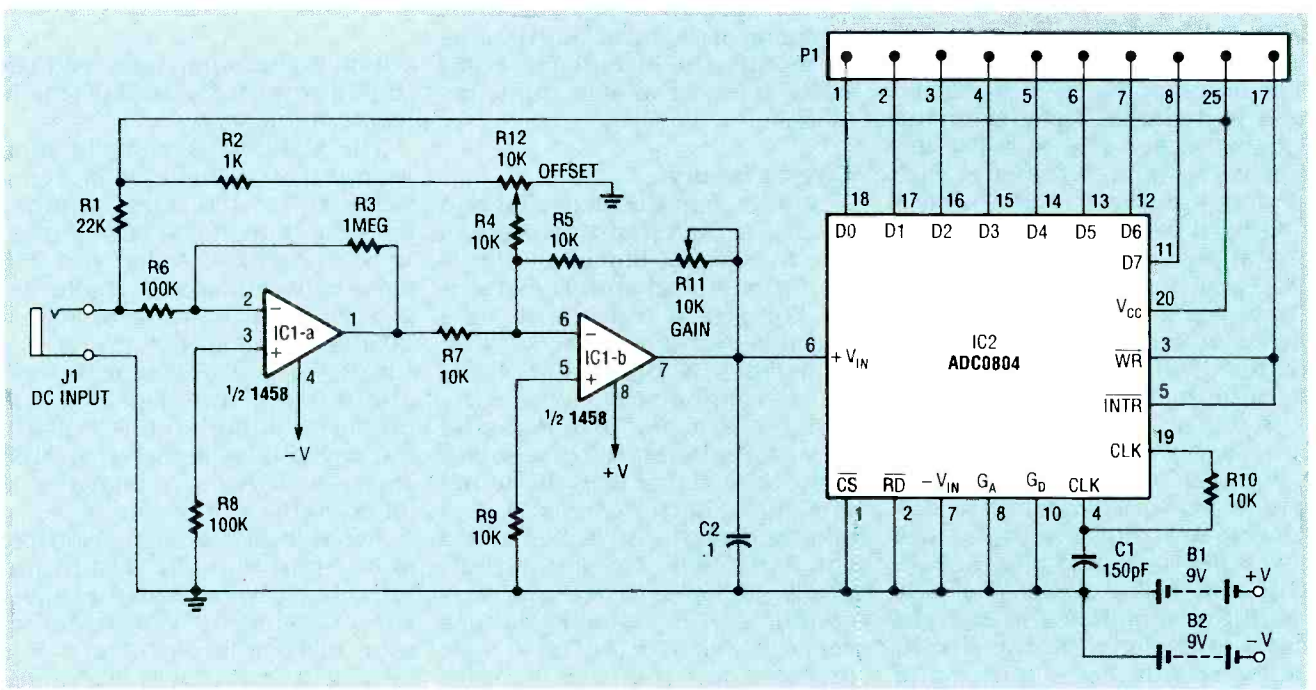


FIG. 2—COMPLETE SCHEMATIC shows the two gain stages (IC1-a, IC1-b) and the A/D converter (IC2).

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.
R1—22,000 ohms
R2—1000 ohms
R3—1 megohm
R4, R5, R7, R9, R10—10,000 ohms
R6, R8—100,000 ohms
R11–R13—10,000 ohms, 15-turn potentiometer
Capacitors
C1—150 pF, ceramic disk (any value between 150–330 pF OK)
C2—0.1 μF, ceramic disk
Semiconductors
IC1—5558 or 1458 dual op-amp, 8-pin DIP
IC2—ADC0804 or ADC0803 8-bit A/D converter
Q1—2N2222 or PN2222 general purpose transistor
Other components
B1, B2—9-volt battery
J1—miniature (⅛-inch) phono jack
P1—DB-25 male connector
Miscellaneous: 24-gauge stranded wire, perforated construction board, 9-volt battery clips, housing for probe, shielded cable.

Note: The complete PC IO Board (with PC board, and all components) is available for $39.95 (part #PCIO). The ADC0804 and a calibrated PN2222A temperature sensor transistor are available for $8.00 (part #ADC). Software, including compiled and source code versions with continuous and interval sampling and data logging/listing is available for $8.00 (part #ADC-S). Specify part numbers and send check or Money Order to JJ Barbarello, 817 Tennent Road, Manalapan, NJ 07726. The author will be glad to answer any questions, but they must be accompanied by a self-addressed stamped return envelope.

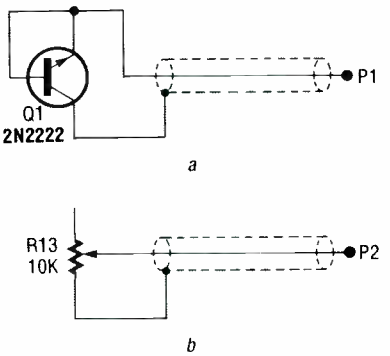


FIG. 3—DRIVE THE ADC with a temperature-sensing transistor (*a*) or a calibration potentiometer (*b*).

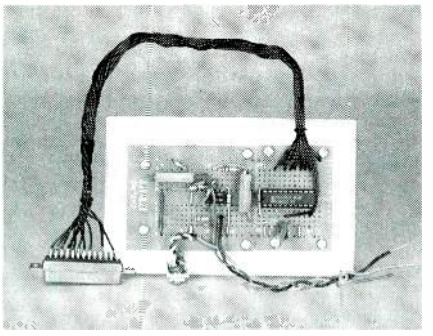


FIG. 4—THE AUTHOR'S PROTOTYPE was built on several pieces of scrap perforated construction board.

Silicon transistors used in this way have a temperature coefficient of about −2mV/°C. That is, at 0°C, the drop would be about 0.6 volt. As the temperature increases, the drop decreases. At 100°C the drop will be about 0.4 volt. Although every transistor has a slightly different temperature coefficient, all transistors vary linearly with temperature. So by calibrating for the particular transistor used, it's possible to obtain an accurate yet low-cost temperature sensor.

Construction

Assembly is not critical; you can build the circuit on perforated construction board as shown in Fig. 4. We recommend using sockets for the IC's.

To connect to the PC IO board, connect eleven one-foot lengths of wire to the appropriate points on IC2, and the other ends to the corresponding pins of P1, a standard DB-25 male connector.

Next, build the temperature probe. Use either a 2N2222A (metal case) or PN2222A (plastic case) and a length of shielded cable. Twist the base and emitter leads together, and solder them to the center conductor of the cable. Connect the collector to the shield. To avoid shorts, cover the leads near the transistor with heat-shrink tubing. Mount the transistor in a cylindrical case (a hollowed-out ballpoint pen body, for example), making sure the case can withstand the temperature range you will be measuring. Fill the probe with silicone or epoxy. Then attach a miniature phono plug to the free end of the cable, making sure that the center conductor goes to the tip and the shield to the ring.

The software

The QuickBASIC program that reads the voltage output of the circuit and converts it to a temperature is shown in Listing 1; note that line numbers are included for reference only. (The software is also available on the RE-BBS, 516-293-2283, 1200/2400, 8N1, as a file called PCADMATE.LST.) The program requires several constants to work. Rather than store that information in the QB file, which would require recompiling every time we recalibrate, we store it in a sequential data file, TEMP.DAT, which contains the values we need, each separated by a comma. First comes the decimal I/O port address of the PC I/O card (described in July), followed by the voltage at the low temperature, the low temperature, the voltage at the high temperature, and the high temperature. (Voltages should be specified in volts and temperatures in °C.)

For example, if those values were 640, 4.1, 0, 0, and 100, TEST.DAT would contain

640, 4.1, 0, 0, 100

followed by a carriage return and line feed. The file can be created with any word processor; just remember to save it in ASCII or text format, not the word processor's native format.

Lines 2–4 of the program open TEMP.DAT, read the values, close the file, and then set up the 8255 on the PC IO card so that lines 1–16 are inputs, and 17–22 are outputs.

Lines 5–8 format the screen for a pleasing look.

Lines 9–17 are the real meat of the program, the measuring and display loop. Line 10 pulses the $\overline{\text{WRITE}}$ line low to obtain a reading. Line 11 then retrieves that reading into variable X. The program converts that number into a voltage (V) between 0 and 5.0. Next, line 12 calculates the Centigrade (cent) and Fahrenheit (faren) temperature values. Then lines 13–15 format and display the values. Line 16 pauses before the next sample is taken, and line 17 checks whether the Escape key has been pressed. If so, the program ends; otherwise, execution loops back to line 10.

Calibration

First create the data file (TEMP.DAT) with nominal values for port address, voltages, and temperatures (640, 4.1, 0, 0, 100); we'll fine-tune those values momentarily. Then run the program to initialize the PC IO card.

Next, connect the ADC circuit to the PC IO card, plug the probe into J1, and place the tip of the probe against a piece of ice. Using a digital voltmeter on a low range, measure the voltage across the tip and ring of the plug. Record the temperature (0°C) and the resultant voltage.

Pour some boiling water in a styrofoam cup, place the probe in the water, and repeat the process, recording both temperature (100°C) and voltage. Use the two voltage values to determine the temperature coefficient of your probe. For instance, if the 0°C reading were 552 mV and the 100°C reading were 342 mV, the temperature coefficient would be $(0.342 - 0.552)/(100) = -2.1$mV/°C.

Prepare a 10K potentiometer as shown in Fig. 3-*b*. At this point, the ADC board should be connected to the PC IO, the 9-volt batteries (or other power source) should be connected, and the BASIC program should be running. Connect a DVM across J1, set the calibration potentiometer so the value on the DVM equals the high value taken earlier, and adjust R12 for 0.000 volts, as shown on the PC's screen. Then set the calibration potentiometer so the value on the DVM equals the low value, and adjust R11 for a value (as shown on the screen) between 4.0 and 4.5 volts. The actual value doesn't matter, just the difference between the high and low values.

Check the high reading setting again to make sure it is still 0.0 volts, and recalibrate if necessary. Go back and forth between the two readings several times.

Now enter the correct values into TEMP.DAT. Make sure the file is stored in the same subdirectory as the program.

Now you're ready to use the probe. Just place it against the item to be measured, and hold it there until you get a steady temperature reading.

LISTING 1

```
REM**************************************
REM** ADCTEMP.BAS - V910629  *
REM** ADC0804 A/D IC & 2N2222 Temp Probe *
REM**************************************
1 CLS : DEFINT A, X: DEF SEG = 64
2 OPEN "TEMP.DAT" FOR INPUT AS 1
3 INPUT #1, add,lowvolt, lowval, hivolt, hival
4 CLOSE #1: OUT ADD + 3, 146
REM*************** SET UP SCREEN ********************
5 LOCATE 1, 23: PRINT "PcTEMP TEMPERATURE MEASURING SYSTEM"
6 LOCATE 2, 1: PRINT STRING$(79, 220): LOCATE 8, 32: PRINT
STRING$(16, 220)
7 FOR i = 9 TO 16: LOCATE i, 32: PRINT CHR$(219); SPACE$(14);
CHR$(219): NEXT
8 LOCATE 12, 33: PRINT STRING$(14, 220): LOCATE 16, 33: PRINT
STRING$(14, 220)
REM*************** SAMPLING LOOP ********************
9 again:
10 OUT add + 2, 0: OUT add + 2, 1:  REM:  Take A Sample
11 x = INP(add): v = x * 5 / 255
12 cent=hival - (v * (hival - lowval) / lowvolt):faren = 1.8 *
INT(cent) + 32
13 LOCATE 4, 33: PRINT USING "Output = #.## v"; v
14 LOCATE 10, 37: PRINT USING "###"; cent; : PRINT CHR$(248); "C"
15 LOCATE 14, 37: PRINT USING "###.#"; faren; : PRINT CHR$(248);
"F"
16 FOR i = 1 TO 500: NEXT
17 IF INKEY$ = CHR$(27) THEN END ELSE GOTO again
```

LISTING 2

```
IF CENT < 10.5 THEN OUT ADD+1, 1
IF CENT > 10.5 THEN OUT ADD+1, 0
```

LISTING 3

```
4 CLOSE #1: OUT ADD + 3, 146: OFEN "READING.DAT" FOR OUTPUT AS 1
16 FOR i = 1 TO 500: NEXT: OUTPUT #1, V
17 IF INKEY$ = CHR$(27) THEN CLOSE: END ELSE GOTO again
```

LISTING 4

```
OPEN "READING.DAT" FOR INPUT AS 1
DO WHILE NOT EOF(1)
INPUT #1, V: PRINT V
LOOP
CLOSE: END
```

Alternate ranging

It is possible to adjust the circuitry and the computer program to any temperature range you desire. Just recalibrate the circuit and adjust the constants in TEMP.DAT. For example, assume you want to measure temperatures between −35°F and +104°F.

First, determine the temperature coefficient as described above. Next, convert the desired temperature range from °F to °C using the formula $C = 5/9 \times (F - 32)$. In our example, +104°F is 40°C, and −35°F is −37.2°C. Then calculate the drop at those two temperatures using the following formula.

$$V_D = V_Z + (T \times TC)$$

where V_Z is the voltage drop at 0°C, T is the temperature in °C, and TC is the temperature coefficient.

At 40°C, V_D = 600 mV + (40°C × −2.1 mV/°C) = 600mV −84mV = 516mV.

At −37.2°C, V_D = 600 mV + (−35°C × −2.1 mV/°C) = 600 mV + 78.17 mV = 678.17 mV.

Now plug in the calibration potentiometer (shown in Fig. 3-*b*), set it to the high-temperature drop (516 mV), and adjust R12 until the output is 0.000. Then set the potentiometer to the low-temperature drop (678 mV), and adjust R11 for a value between four and five volts. Last, insert the temperature values and the high-temperature output voltage into the data file. Now the circuit is fully calibrated for the new temperature range.

Software modifications

You could use the probe as a low-temperature detector. Connect a sensitive 5-volt relay to pins 9 (+) and 23 (gnd) of P1. If the temperature goes below a

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He's listening to a radio station in China.

It's a microphone.

64K! And you call yourself a man...

SPEAKER MATE

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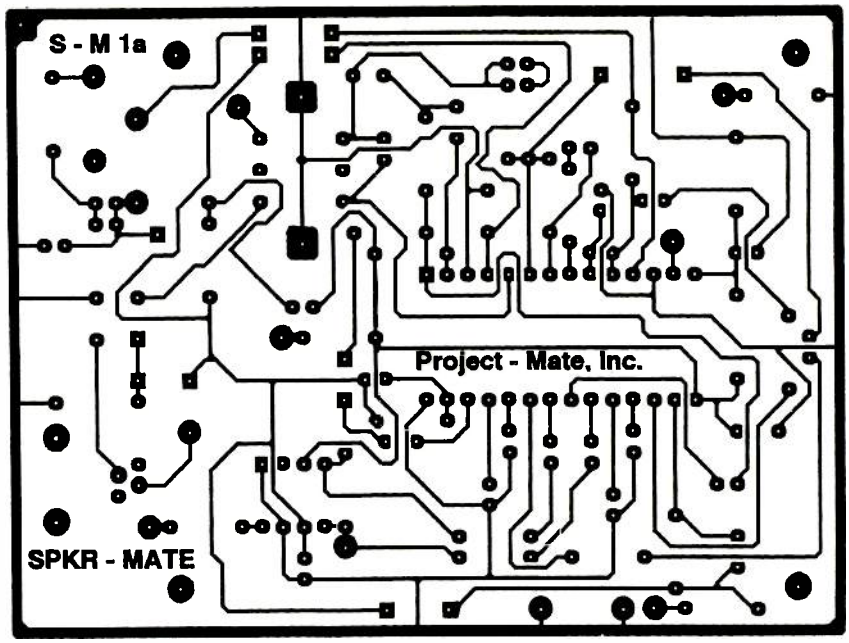
sure to wipe off the tip of your iron on a wet sponge immediately after melting the plastic. Transformer T1 should be mounted with its marker, if any, toward the input jack side.

The last step is installing all jumpers (J) and JU1; the JU1 jumper is installed for phone-line powered applications, and left out for use with an external power source. So install JU1 for now, and we'll go into greater detail on it later. If a jumper runs close to existing circuitry, you might place some shrink tubing on the bare lead. The kit mentioned in the parts list includes some shrink tubing.

There are some options for the front-panel configuration. In the prototype, SPST toggle switch S1 is used as the ANSWER switch and is mounted next to LED1, the "power on" indicator. Cut the leads long enough to reach the front panel without too much excess. Volume control R20 has its attached switch, S2, wired in series with the microphone element to provide a "mute" function. The mute setup works well because the low-impedance microphone circuit doesn't pick up interference when open. If the mute function is not needed, R20's switch can become the ANSWER switch and you can eliminate toggle switch S1. However, the complete kit does include the toggle switch.



FOIL PATTERN for the Speaker-Mate.

In preparing the circuit board for the cabinet, leave the speaker leads long enough to attach the speaker on the top half of cabinet. We have found that a spare piece of perforated construction board makes an excellent drilling guide for making a neat speaker grille on top of the cabinet. Cutting out a notch on the cabinet rear for the modular telephone jack (J1) and drilling a ½-inch hole for access to the microphone gain potentiometer completes the cabinet back.

Completion of the front panel is next. Figure 5 shows how we mounted the microphone. A ⅜-inch inside-diameter rubber grommet was glued to the inside of the front panel behind the ⅜-inch microphone opening. You can use either hot-melt glue or RTV silicone. Insert the microphone element (with leads attached) into the grommet so that it sits back just enough to not touch the front panel, but no more; a recessed element will give an echo sound we want to avoid. This step acoustically and mechanically decouples the microphone from the speaker output, yet gives some directional effect. It will be glued in such a position in the grommet in just a minute. Note that an electret microphone is polarity-sensitive; the pin that connects to the case of the microphone is ground.

Finish up by wiring R20 and its switch S2, LED1, and S1. We found that prewiring these components first makes assembly easier. The final step is to fit the panel into the enclosure and glue LED1, the microphone, and the speaker in place with RTV silicon, making sure that the electret element is positioned as mentioned before. Set the microphone gain potentiometer, R15, to about half way. Figure 6 shows the completed Speaker-Mate prototype.

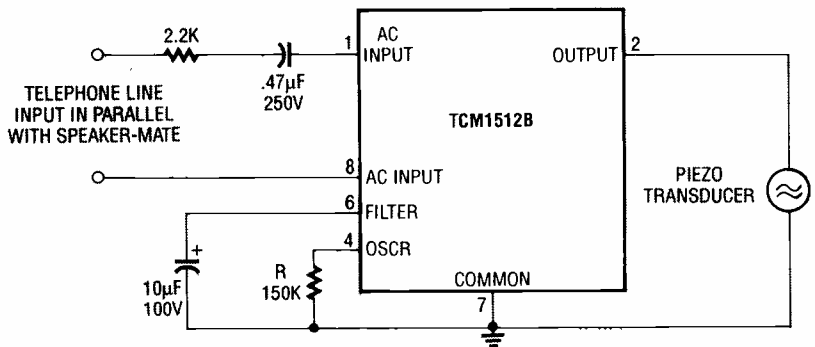


FIG. 8—YOU MAY WANT TO ADD a ringer to the Speaker-Mate. The tone ringer chip (IC3) monitors the telephone line for a ring signal of 15 to 68 Hz, 40 to 150 volts AC. Resistor R sets the warble and center frequency; with R at 150K, the warble is approximately 10 Hz and the center frequency is 1250 Hz.

Testing and use

For acoustical reasons, the proven approach to testing the unit is with the board mounted in a closed case. At an extreme setting of microphone gain, the microphone may pick up the speaker output. This extreme

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HARDWARE HACKER

VGA adapter for the Mac LC, computer monitors, flyback, shielding, and GPS navigation resources.

DON LANCASTER

It seems I did miss an obvious source in our recent *Tesla and High Energy Resources* sidebar. This is the *Tesla Society* up in Colorado, who runs a great museum and now offers annual Tesla and nontraditional energy conferences. Their *High Energy Enterprises* division has lots of books and videotapes.

These range the gamut from hard-to-find and genuinely useful research materials on down (*way* on down) through bunches of "Boy-a-whole-flock-of-them-flew-over-that-time!" pseudoscience titles.

On the other hand, if you are into antigravity, the 1000 miles per gallon carburetors, Russian weather control conspiracies, *Reed* motors, all those pangalactic happy faces on Mars, or zero point scalar energy, these books and videos are definitely for you. This is *most* fascinating reading and watching, either way.

Actually, I'll freely admit that I firmly now believe in one trilateral conspiracy. That's the one involving the first, second, and third laws of thermodynamics. But that's just me. And if you want to prove me wrong, just show to me any simple and independently verifiable experiment that anyone can reliably duplicate.

Some more info on wavelets: The *Wavelets* book offered by *Jones and Bartlett* is at long last in print. And a major new tutorial just came out in the October 1991 IEEE-SP *Signal Processing* magazine on pages 14–38.

Shields and shielding

These have been popular topics lately on our helpline, so perhaps it is time to go over some fundamentals. You can *shield* something electronic either to keep objectionable signals from getting out or getting in. For instance, on any light dimmer, you might want to suppress the horrible AM radio interference caused by a triac suddenly turning on. On a low-level audio circuit, you might want to prevent power-line hum and noise from getting to you.

If you do know ahead of time that you're going to have interfering noise or signals present, one very powerful technique is to change over to fully *balanced* circuits. They sense only the *differences* between their inputs, rather than any absolute values with respect to ground. Thus, any *common mode* interfering signals that bounce both inputs up and down together will automatically be rejected. Or at least suppressed. Several fancy audio studios have even gone to totally balanced power lines to dramatically reduce their hum and noise problems.

There are usually two paths that interference can travel. One is with *radiated* energy, which can propagate directly through space to emit from or interact with your circuit. The other is *conducted* energy, which enters along your power connectors and input or output cables.

Since separate tricks are needed to deal with any radiated or conducted energy, step one is finding out *which* path is the one you will want to deal with first.

The radiated energy interference will usually have two components. They are that "E" or *electric* field, which largely concerns itself with induced *voltages* and that "H" or *magnetic* field, which creates induced *currents*. Once again, you have to know *which* field component you are going to suppress before you pick a proper method.

Any old conductor should usually block an E field. One obvious hacker choice that works well are boxes built up out of double-sided printed-circuit board. See Fig. 1.

But there are gotchas. At lower frequencies, there is the lack of a well-developed *skin effect*, which causes an E field to penetrate *deeper* into a conductor. Thus, *thicker* shields are needed to suppress *lower* frequencies. Say 20 mils for an AM broadcast band use or 80 mils for the high ultrasonic frequencies.

A shield can also act as a shorted turn to any nearby inductor, possibly lowering the Q and detuning. A slot or other continuity break can sometimes help this problem.

While some small shield holes are often tolerable, any poor contacts are definitely not. A continuous solder bead or else lots and lots of individual screws may be needed for really high shielding effectiveness.

It's very important that unintended currents don't ever run through any shields. Unwanted signal drops can often end up in *series* with your input signals, making things much worse rather than better. Which is also why you should keep all your digital and analog grounds separate.

The H fields can be blocked by use of any strongly magnetic materials. These materials are said to have a very high *permeability*. The simplest magnetic shield is a piece of scrap sheet steel from the air conditioning shop or trailer hitch works. But things get messy in a hurry if you need lots of magnetic attenuation.

Those special and fancy shielding materials are optimum only in certain thicknesses and over a specific frequency range. Worse yet, some of these cannot be cut or drilled without a complex reannealing process. And

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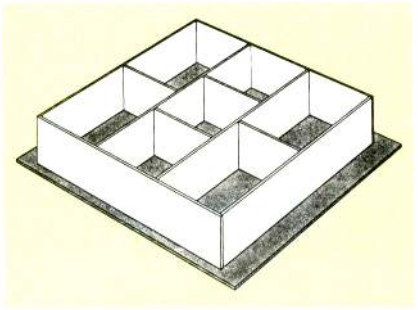

FIG. 1—SIMPLE E-FIELD SHIELDS for radio-frequency hacker projects are easily built up from pieces of double-sided printed circuit board stock.

too strong of a magnetic field could *saturate* a shield, making it useless.

To be effective, a magnetic shield should completely surround the volume it is protecting.

A good free booklet on all of the fundamentals of magnetic shielding is available from *Amuneal*, while other sources of custom shield materials now include *Advance Magnetics* and *Magnetic Shield Corp.*

Conducted interference can be best eliminated by some blocking filter. These filters should freely pass the signals of interest, but present a high series impedance and a low shunt impedance to all others. *Murata-Erie* is one good source.

The *ferrite bead* is a remarkably cheap and super effective interference suppressor. As Fig. 2 shows us, you simply hang them on a wire or else run a turn or two through them. Ferrite beads act as a broadband high-frequency lossy transformer. There are various materials and sizes, again depending on frequency. Sources of ferrite beads include *Fair-Rite*, *FerriShield*, *Ferroxcube*, *Intermark*, and *Siemens*.

One *very* little known ferrite bead gotcha: Do *not* ever cast a ferrite bead in epoxy or otherwise constrain it so it cannot move. The beads *must* be able to physically change their size slightly, or else the performance will sharply degrade.

Two trade journals that involve themselves with shields and shielding are *Electronics Test* and *Compliance Engineering*.

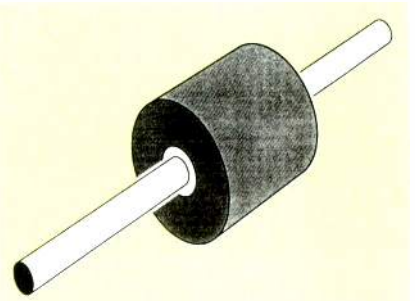

FIG. 2—FERRITE BEAD interference suppressors are simply slipped onto any conductor. The ferrite beads behave as lossy and broadband high-frequency transformers. Multiple turns can also be used.

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Monitor fundamentals

We sure do get a lot of computer-monitor and TV compatibility calls. Let's start off with the obvious: The performance and bandwidth of an ordinary TV or VCR using *composite NTSC* video is severely limited. That is why all the computer folks went to special RGB monitors in the first place. And that is why nearly all the computers are *totally incompatible* with ordinary television gear.

Yes, there now are all sorts of ways you can use your computer for real video editing or to record computer screens on a VCR. But note that there is *no way* I know of that you can record plain old 80-column text as composite video on your VCR. Or display it on any unmodified TV set.

How does a monitor work? Inside is a cathode ray "picture tube" with one or more guns that squirt lots of electrons at a phosphor screen. At

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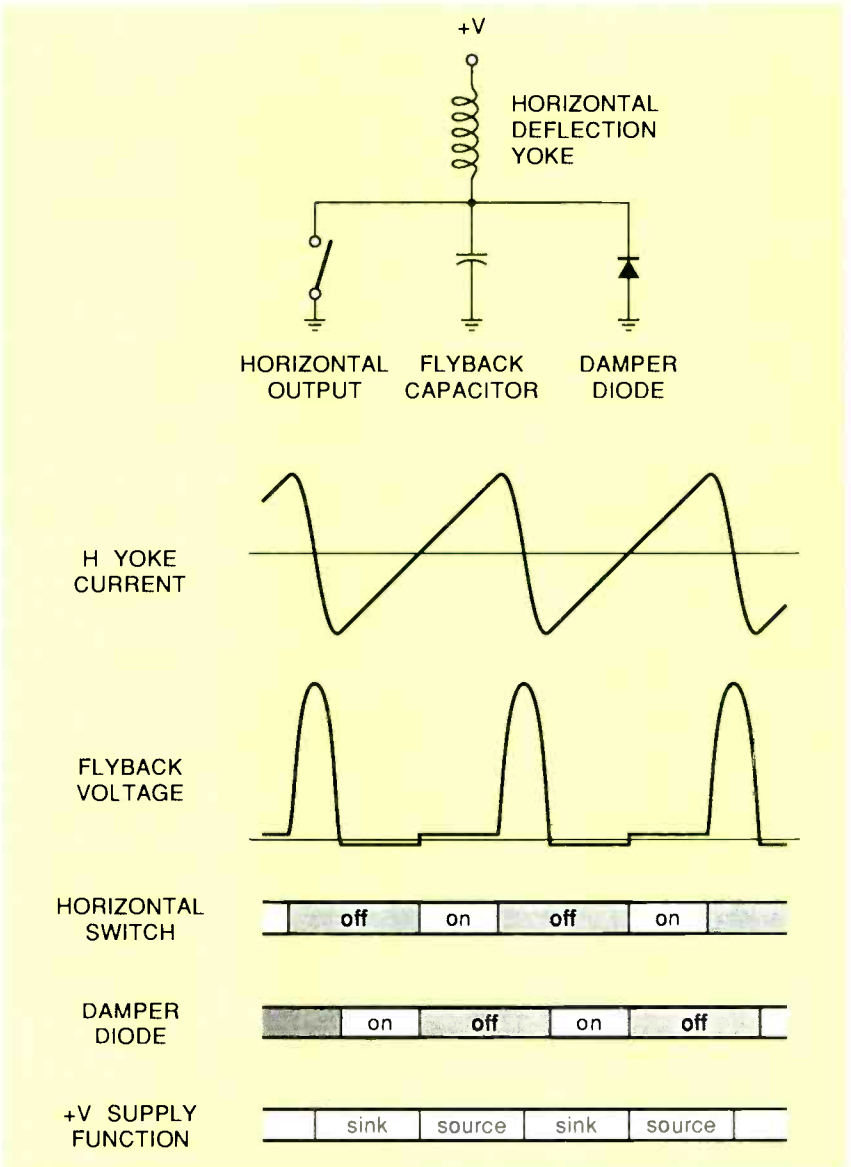

FIG. 3—THE RECURRENT FLYBACK SWEEP on television sets and computer monitor displays is extremely energy efficient, but will only work over a VERY limited range of horizontal scan rates.

any instant, *only one single dot* appears on the screen. That dot gets moved around by the scanning process, and will get brightened and dimmed by rapidly setting its intensity at a *video* modulation rate.

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Television uses what is known as an *interlaced* scan. To build up a TV *frame*, the dot starts at the upper left and rapidly scans to the right and slowly on downward, painting every *second* scan line. When it gets to the bottom of this *field*, it goes back to the top and picks up what it missed, painting a second field. The normal field rate is usually 60 hertz for black and white or 59.94 hertz for color.

The NTSC (National Television Standards Committee) standard uses 512 lines per frame, or 262.5 lines per field. That leads to standard horizontal scan rates of 15750 Hertz for black and white or 15735 Hertz for color. The two numbers end up slightly different to get all the rest of those color magic numbers to properly drop in place.

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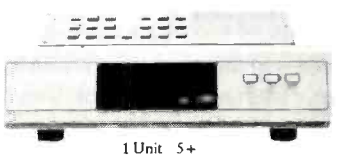

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Interlaced scan is used by NTSC to minimize flicker. But *interlaced scan is totally unsuitable for data displays, especially small text!* The reason is that interlace works only if successive lines are more or less the same. This is clearly *not* the case between dot lines of finer text. Thus, most computer screens *demand* a *noninterlaced* display where each field is complete and identical.

Most computer monitors also will use a 59.94- or a 60-hertz vertical scan rate. Less than that and you'll end up with too much flicker. If you try to lengthen the phosphor persistence you may end up with "comets" for traveling balls.

The horizontal scan rate is decided by how many horizontal lines you are using per field. *As you increase the number of lines in a display, the horizontal scan rate goes up.* Scan rates from 22 to 45 kilohertz are typical, with some exotic displays going much higher.

Now for the kicker: *Most monitors will work only over a VERY limited range of horizontal scan frequencies!* Unless you go to some *very* fancy *multi-sync* techniques.

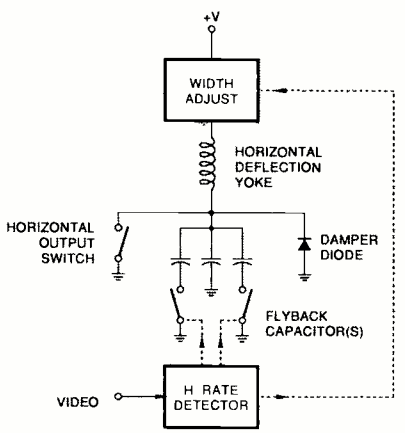

FIG. 4—MULTI-SYNCING MONITORS change their sweep values to try and match an input horizontal scanning rate. But once selected, they still operate only over a very limited frequency range.

Flyback deflection

Why can't someone just build a monitor that accepts an ultra-wide range of horizontal scan frequencies and be done with it? The answer to that has much to do with both energy conservation and the way things have been done in the past.

A set of coils known as a *deflection yoke* normally goes on the neck of the display tube. These are plain old coils that will move your electron beam to wherever you want it to go. Normally, the horizontal yoke is where all the action is, since it does things several hundred times faster than the vertical one.

Since several kilowatts or more of deflection power are involved in the horizontal deflection of a larger color display, sneaky tricks will have to be played to reuse and recycle all of the energy involved. These sneaky tricks go by the name of *recurrent flyback deflection*, and are shown to you in Fig. 3

The basic rule of any inductor is

that...

$$e = L\Delta i/\Delta t$$

Let's rearrange things a tad...

$$\Delta i/\Delta t = e/L$$

Now Δi is the change in current and Δt is the change in time, so $\Delta i/\Delta t$ will be a *linear current ramp* whose rate of change should equal your supply voltage divided by the inductance of your horizontal yoke.

Say that the switch in Fig. 3 is now open and has been that way for a long time. There is no current in the yoke, and no deflection. The spot will still be in the middle of the line.

Now, close the switch, but just for around *one-half* of the live scan time. What happens? We now apply a positive voltage to an inductor, and start building a linear current ramp. That current ramp in the deflection yoke creates one linearly increasing magnetic field, and the spot moves to the right. When you get to the right side of the screen, you'll have bunches of energy stored in the horizontal yoke's magnetic field.

What are you going to do with it? If you just burn it up as heat, you'll end up with bad reliability and high power consumption. Besides needing *far* tougher electronics. Instead, let's work smarter instead of harder.

Open your switch. Your equivalent circuit now consists of a yoke coil in series with the *flyback* capacitor. A standard and high-Q series-resonant circuit. But one that started out with zero volts on your capacitor and a strong current through the coil.

At this time, all of the energy is in the coil and none is in the capacitor. Let the circuit resonate for a while, exactly like any other series-resonant circuit. In one quarter of a cycle, the capacitor will be charged up to a large positive voltage, often in the 800–1200 volt range. At the peak, the current will be zero, and the inductor will be "empty" and field-free.

You have now transferred all of the magnetic energy that was in the yoke into electrical energy stored in the flyback capacitor! And done so with very little loss.

Let the circuit continue to resonate. The current will *reverse* in direction, and energy will start transferring back *into* the inductor. Note that the current is now going in the *opposite direction.*

Let the circuit resonance continue

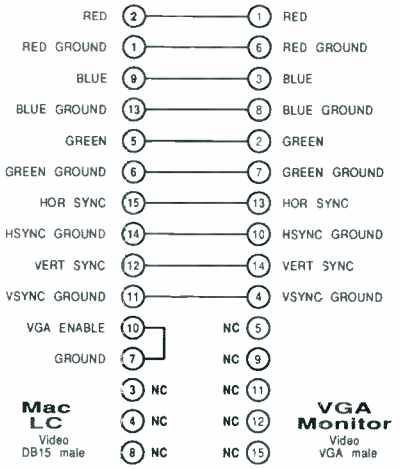

FIG. 5—THE MACINTOSH LC definitely can NOT be used with a NTSC monitor. But this simple cable and jumpering lets you use it with most VGA color monitors. The configuration jumper from pin 7 to pin 10 selects VGA scan rates and standards.

until the capacitor gets to zero volts. You will now have placed all of the original magnetic energy right back into the deflection yoke, with one very important difference: Since the current is going in the opposite direction, you're now at the *maximum left* spot position, compared to the maximum right that you were half a resonance cycle ago. And, again, you have done this with very little loss.

This process is known as a *flyback*, and the retrace interval is called the *flyback time*. The beam is turned off during the flyback time so the retrace is invisible.

Let the circuit resonance try and continue. The flyback capacitor will try and go negative but, at that time, a *damper diode* will turn itself on. Your circuit now consists once again of a coil connected between a positive voltage and ground. It will once again start generating a positive current ramp. Only this time, it starts from a *negative* initial current. Thus, your sweep starts linearly moving from the left to the center. As you move on towards the center of your scan line, the yoke energy gets sent back *into* the positive supply.

When you get to the center of the screen, you once again close your switch to repeat everything for the next cycle. The damper diode shuts down just as soon as you cross cen-

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ter screen. Automatically.

Once again: Close your switch to move from center to right. Transfer the coil energy to a flyback capacitor. Resonate half a cycle and transfer the flyback capacitor energy back to the coil *inverting its sign* and putting you far left. Turn on the damping diode to move from left to center. And repeat the process once each scan line.

Several details I've omitted: That flyback pulse also gets sensed and routed to a current step-up transformer called a *flyback transformer*. The flyback transformer steals a minor part of the energy and uses it to create the high voltage DC supply that is needed by the display tube. Other windings can be used for blanking, horizontal phase comparison, and boosted supply voltages elsewhere in the TV or monitor. And games have to be played to keep any uncenter DC bias out of the horizontal yoke. But regardless of these details, the basic concept of recycling your deflection energy remains.

This very elegant, highly tested, and ultra conservative flyback scheme inherently works best only at *one* horizontal scan frequency. And that is why you can't normally get a monitor that can accept any old horizontal rate.

Yes, there are multi-sync monitors. These usually work by measuring the intended input scan frequency and then switching in one or more flyback capacitors and adjusting the supply voltage accordingly. Figure 4 shows one multisync scheme. Once switched, a multisync monitor is a narrowband system just like any other flyback-driven circuit.

VGA for the Mac LC

The Macintosh LC computer was designed for use with the Mac color monitors to the Mac color standards. Since these can be expensive, lots of hackers are often on the lookout for lower-cost substitutes. But note that you definitely can *not* use an NTSC color monitor because of the higher scan rates on the LC.

And also do note that you should *never* buy a substitute monitor without making certain it works and is good enough for your uses.

Happily, there is a hidden "secret" provision on the Mac LC that lets you change your LC output so it is VGA-compatible. Quality VGA monitors are often available much cheaper in far wider selections than are "real" Mac monitors.

The secret jumper that changes the LC scan rates for VGA compatibility is shown in Fig. 5.

GPS Nav resources

From time to time we've looked at the *Navicube* concept right here in *Hardware Hacker*. The *Navicube* is a magic $5 cube 3 inches on a side which always knows where it is and which way it is pointing. Several recent developments that should ultimately make the Navicube possible include low-cost accelerometers, advances in fiber-optic gyros, and the ongoing GPS navigation system.

GPS is short for *Global Positioning Satellites*, a military navigation system that has recently seen several dramatic improvements in price, reliability, and availability. I've tried to gather together some GPS info for you as this month's resource sidebar.

The system consists of a flock of roving satellites, any five or six of which should be overhead at any given time. The satellites broadcast a series of low microwave-frequency radio signals. By intercepting and comparing the signals from several overhead satellites, you can extract your current absolute position and do so to around a fifty-foot accuracy. Your speed, acceleration, and current time can also be determined to surprisingly high accuracies. Within two inches per second even.

And by shifting to a *differential* scheme from any one known and fixed point, you can improve your accuracy to a fraction of an inch.

Amazingly, the antennas needed are no big deal. They can easily fit inside a small shoebox. Unlike video satellites, the GPS antennas need a wide beamwidth, a narrow-frequency bandwidth, plus a pseudorandom modulation which works acceptably well with lower signal-to-noise ratios. The antennas do require line-of-sight operation, so they have to be used outdoors, on a rooftop, or on the top of a vehicle or boat.

Since the reception electronics are incredibly complex, it is unlikely that you would want to try and build up your own GPS receivers by using discrete components.

Thankfully, sophisticated chip sets are now becoming readily available from *Rockwell, Magellan*, and others. Their initial pricing is in the $500 range. But it is reasonable to expect Japanese GPS chips within a year or two for under $35. So now is the time to start on your GPS hacks.

The leading trade journal in the field is called, of all things, *GPS World*. It is free to qualified subscribers. An interesting hacker newsletter that deals with navigation and communications of interest to cavers is Frank Reid's great *Speleonics*. Some other GPS info appears from time to time in *NASA Tech Briefs*. Several other sources of GPS gear include *Ashtech, Bancomm, Texas Instruments*, and *Trimble Navigation*. Trimble has a nice GPS intro book available. It's called *GPS—A guide to the next utility*.

New tech lit

From *Actel*, a new databook on *Field Programmable Gate Arrays*. And from *Mini-Circuits* a new *RF/IF Signal Processing Guide* on higher frequency mixers, splitters, amplifiers, transformers, and such. Their broadband amplifiers cost around a dollar or so each.

A free update on our Santa Claus machine technology is now titled an *Insiders Guide to Rapid Prototyping*, and is available from *Management Roundtable*. These folks also put on annual conferences.

A new quarterly hacker newsletter on lower-cost vacuum projects and techniques is now available through *Steve Hansen*. It's called *The Bell Jar*.

Free samples of *Liquisorb*, a low-cost cornstarch colloidal absorbent, are available from *American Colloid Company*. Since these sample packets dramatically swell up in the presence of liquid water, one obvious use is as a low-cost flood alarm.

And through *Aremco*, a *Materials Catalog M12* that includes a wide variety of high-temperature ceramic materials, including machinable and pourable versions.

For the fundamentals of digital integrated circuits, be sure to check out my classic *CMOS Cookbook* and *TTL Cookbook*. You can also reach me via *GEnie* PSRT (800) 638-9636, where you'll find lots of resource stuff not available elsewhere. **R-E**

AUDIO UPDATE

Reader questions: Real and imagined, serious and silly

LARRY KLEIN

After several decades of answering readers' hi-fi questions for various electronics and audio publications, one can get a little nostalgic. I look back with fondness to the days when I had all the answers—or at least thought I did—and was pleased to provide them to curious readers. Today I certainly don't have all the answers, and occasionally I don't even understand the questions. In any case, herewith is a selection of updated Q's and A's that, if not my greatest hits, at least reflect some of the interesting concerns of the audio public in the last decade.

Subliminal Satanism

I keep hearing that some heavy-metal rock bands put subliminal Satanic messages on their albums. The messages are supposedly in the form of words recorded in reverse at the ends of certain cuts. What effect do these messages have on listeners?
L.B.
Everetts, N.C.

Mostly it causes them to write silly questions to magazine columnists. The term "subliminal" is usually applied to stimuli that are outside the range of conscious perception but are nevertheless said to reach the brain and affect thinking. The purported danger in such a technique is that the messages bypass conscious evaluation and cause their hearers (or viewers) to uncritically buy products, vote for certain candidates... or worship Satan. Since there appears to be no legitimate research indicating any effect at all from subliminal motivational messages, good or bad, I wouldn't worry about it... unless, of course, you experience sudden inexplicable urges to buy large quantities of toothpaste, to vote for Jesse Helms, or join your local coven after a long evening of heavy-metal head banging.

My comments also apply to "subliminal" self-help tapes. A recent study by the National Academy of Sciences concluded that such tapes "have no proven value." That seems logical, considering that any messages recorded below the threshold of hearing would necessarily be buried in normal tape noise.

Record and tape wear

I hope you can settle a bet for me. I maintain that, unlike LP records, cassettes don't wear out. My friend insists that they both wear with use. And what's the situation with CD longevity? I've read some troubling reports lately.
J.S.
Evanston, IL

They both wear, but the effects are different for tapes and discs. When vinyl discs begin to wear, noise and distortion are *added* to the signal. Worn tapes, on the other hand, tend to suffer signal losses. There are momentary "dropouts" that reflect damage to the tape's oxide coating caused by friction against the player's heads, capstan, and guides. There may also be a partial erasure of the high frequencies brought about by an accumulation of residual magnetism in those same metal parts. Periodic cleaning and demagnetizing of the player help minimize the damage.

Over time, there may be a marked increase in cassette wow and flutter. Assuming that the player is okay, and that the tape or the cassette shell mechanism has not been damaged through overheating on a car's dashboard, the fault is probably caused by an overly tight winding inside the cassette. The tape pack can be restored to its normal looseness by repeatedly, but gently, slapping the cassette face down against a semi-hard surface such as a magazine or book. Squeal can sometimes be helped by a *very* small amount of silicone lubricant applied in the areas where the tape hubs meet the shell, but most of the time it reflects a problem (sometimes brought about by aging) in the composition of the tape coating.

Recently questions have been raised about CD longevity, with claims that CD's suffer from "laser rot" over time. The reasons given for the self-destructive tendencies of CD's have been varied, but the claim is that today's CD's have, at best, a very limited life span.

I think that such predictions should be taken with a sack of salt, considering their original sources are the same "underground" audio publications that disparaged CD's from the outset.

I spoke to a gentleman in charge of preservation research at the Library of Congress, and he says he knows of no evidence that supports the view that normal, properly manufactured CD's will spontaneously "fail" over time. All of which is not to say that some CD's haven't had playback problems because of mishandling or manufacturing defects.

Undriven drivers

There's a hi-fi dealer in my area who features what he calls "Single Speaker Demonstrations." He claims that it was discovered in England that the presence of other non-playing speaker systems in a listening room can affect the sound produced by the playing speakers. Does the removal of non-playing speakers really help a listener evaluate different systems more accurately?
J.S.
Los Angeles, CA

I don't think so, particularly since it would certainly prevent a fast A/B comparison between systems. It's probable that there is a slight measurable acoustic effect in a showroom produced by stacks of unconnected speaker systems. Theoretically, acoustic-suspension speakers would function as Helmholtz absorbers at the frequency of their system resonances, and vented systems would do the same at their port resonances. In either case, the suck-outs would occur in the same low-frequency areas where

most standing-wave problems occur and conceivably might moderate the effects. But given the very large (10–20 dB) bass-response irregularities found in most rooms—including dealer demo rooms—it seems unlikely that even the most golden of ears could isolate a positive or negative effect produced by the presence of a dozen or so undriven speaker systems.

Incidentally, I understand that some lunatic fringe audiophiles even advocate removing telephones, clocks, and watches from listening rooms in the belief that they somehow resonate destructively with the music. As with so many other superstitious beliefs, this one also has in it a small—very small—grain *of* truth.

If you were to feed an audio oscillator through your system and sweep it slowly at high volume from, say, 40 to 200 Hz, you would find that small and large objects in the room vibrate slightly at their specific resonant frequencies. But with music there is usually not enough sustained acoustic energy at any one frequency to produce audible resonances. However, it is not a good idea to place small art objects on top of your speakers as there might be enough coupled vibration to cause them to dance sympathetically to whatever tune is playing.

Sonic shatter

I'm curious about the old Memorex wine glass shattering commercials. Exactly what technology was involved? Was it anything like Caruso's vocal trick?
M.H.
Mendenhall, MS

Like all good wine glasses, the goblets used in the commercial were both rigid and relatively fragile. To calibrate the goblets, each was placed directly in front of a loudspeaker driven by an audio oscillator. The oscillator was swept slowly through the range of approximately 700 to 850 Hz, which covered the resonant frequencies of the glasses used by Memorex. During the frequency sweep, a finger resting lightly on the rim of the goblet could easily detect the increase in vibration at the goblet's specific resonant frequency. That was marked on the crystal goblet for future reference.

At glass-breaking time, a tape recording (on a Memorex cassette) was made of the celebrity singer producing a sustained note at the previously determined critical frequency. When the cassette tape was played back *very* loudly through a speaker, the wine glass—which had an approximately 140-dB sound field impinging on it—would react by flexing itself to pieces.

Given the above, it should be clear that shattering a glass by an unamplified voice is no easy trick. Not only does the singer have to produce an enormous sound pressure level, but also the frequency has to be within a hertz or so of the wine glass's specific—and unknown—resonant frequency. Perhaps in Caruso's day voices were stronger and crystal more fragile. **R-E**

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More on automotive voltage regulators.

ROBERT GROSSBLATT

Once again I have to apologize to everyone out there who's waiting for us to get back to the design of a digital scope. We won't be doing that until next time because I need this space to finish going through our discussion of generators, alternators, voltage regulators, and all the rest of the stuff you meet when you take a trip to the always amazing world of charging systems.

As I mentioned last time, I was amazed by the amount of interest in this and, as a certified member in good standing of the old car and bike freak club (with a particular emphasis on British stuff), my duty is clear.

We've already gone through the basics of the charging system and seen that there are really only two ways an alternator can be wired into a bike or car. One side of the field winding is tied to either the hot side of the battery (a pulled-up field), or to ground (a grounded field). Most British cars and bikes use a pulled-up field and you'll find a lot of American cars using a grounded field. I said this last time but it's really important so let me repeat it. Before you can build your own voltage regulator, you HAVE to know how your alternator is wired. Using the wrong regulator will destroy the regulator and probably trash the alternator as well.

The easiest way to tell what system is used in your car or bike is to use a multimeter. With the ignition turned on, but the engine not running, measure the voltage from the hot side of the battery to the terminal marked "F" on your existing regulator. If you get a reading between 12 and 13 volts (the battery voltage), your car is using a pulled-up field.

If you get a zero, or near-zero reading, you're probably looking at a grounded field. You can make sure by reading the voltage from the regulator's "F" terminal to ground. You should see the 12- to 13-volt battery voltage there. If you don't see the battery voltage anywhere you either have a bad connection or you're measuring from the wrong terminals. Check the multimeter leads and, if that doesn't cure the problem, get out a flashlight and trace the wires. You absolutely have to know what you're dealing with before you add a voltage regulator!

Anyone who finds that they have a pulled-up field can stop reading right now and skip ahead a bit because the regulator we designed last month is exactly the one needed. If you've got a grounded-field alternator, there's still some work to do. The regulator we designed has to be modified before you can use it.

The easiest way to see the changes is to compare the original pulled-up field circuit (last month's Fig. 3) to the modified design for a grounded-field regulator shown in Fig. 1. One of the first things you should notice is that R7 and R8 are now in parallel. Electrically, there's no real reason for having those two resistors in parallel. The only reason I left them both there is to help make the similarity between the two circuits more evident. You can leave them wired in parallel or simply do the arithmetic necessary to come up with an equivalent single-resistor replacement.

The major change to the circuit is that the alternator field connection is now made off the emitter of Q3 rather than the collector. All the changes in the circuit are aimed at varying the voltage at Q3's emitter. The Darlington pair made from Q2 and Q3 is still controlled by the voltage at the collector of Q1 in exactly the same way as it is for the pulled-up field regulator. The positive feedback (supplied by C3 and R8) that speeds up the switching of the circuit from fully on to fully off now comes from Q3's emitter rather than its collector.

The reasons for the changes in the circuit are all based around the idea of being able to vary the output voltage. Since, in the case of a grounded field, the given is that one side of the field is tied to ground, the job of the regulator is to increase the output voltage at the "F" terminal when the control voltage at the base of Q1 falls below the point set by R10. The LED has been moved so it will monitor the field voltage and D1 has been moved so it can soak up any back-voltage generated when the alternator field collapses. You'll also see that the value of R7

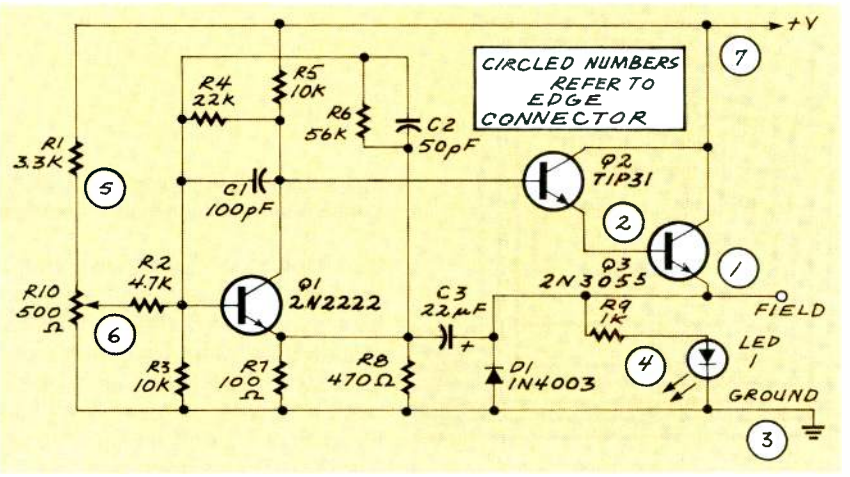

FIG. 1—COMPARE THE ORIGINAL pulled-up field circuit (last month's Fig. 3) to the modified design for a grounded-field regulator shown here.

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has been dropped to 100 ohms but, as I said earlier, you can replace it and R8 with a single resistor.

Before we take this any further, a word or two has to be said about C3. When the voltage on the output side of the regulator changes, some voltage is bled off through C3 and used to help speed up the action of the regulator. That is true both when the regulator is supplying current to the alternator field and when it's shutting the field current down as well. So, when the regulator is working, current will flow back and forth through C3.

Whenever you have that situation with an electrolytic, the right component to use is a non-polarized capacitor. Telephone circuits use them all the time. If you can't find a non-polarized electrolytic of the proper value, a standard substitute is to use a pair of polarized capacitors wired front-to-back in parallel. When I was building the circuit, I didn't have a non-polarized 22 µF capacitor around so, since I was in a hurry to get the circuit in my car, I just used a regular polarized capacitor instead. Once the car was back on the road, I figured I'd be able to drive to the parts supplier, get the right component, and make the correct substitution.

That was several years ago and, even though I've made many trips to Capacitors-R-Us since then, I've never replaced the original polarized capacitor. I know it's the right thing to do

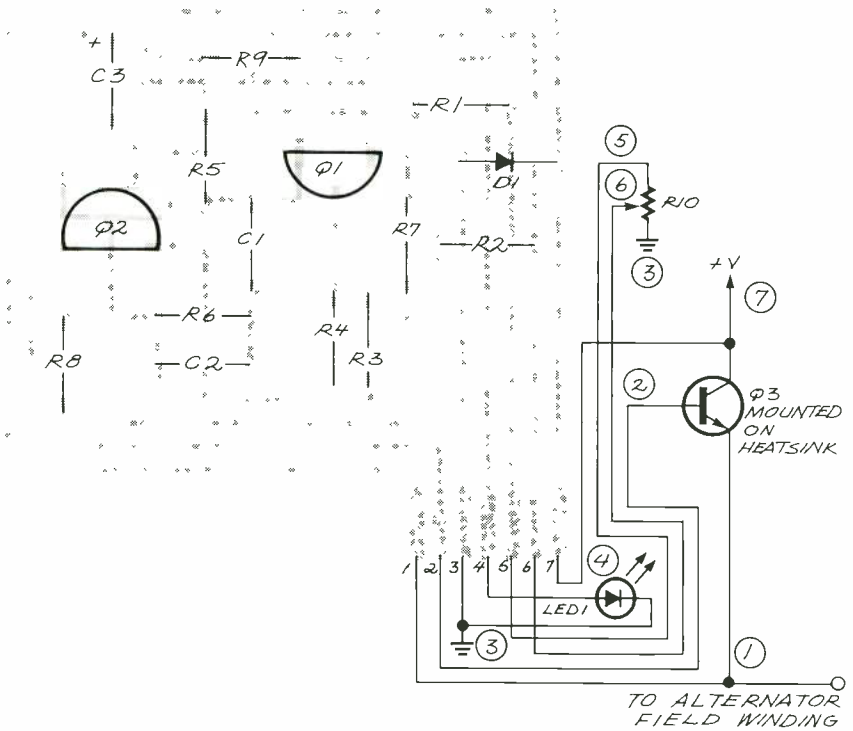

FIG. 3—PARTS-PLACEMENT/WIRING DIAGRAM. Use at least 14-gauge wire for the three connections to the vehicle's electrical system.

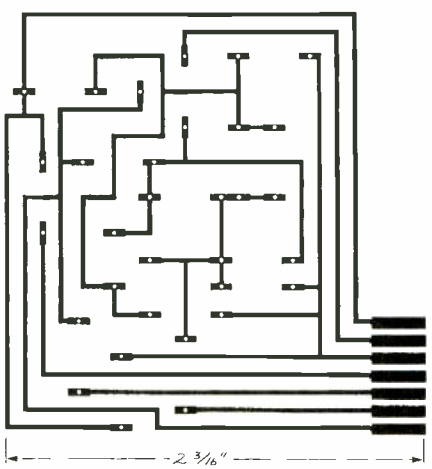

FIG. 2—FOIL PATTERN for the grounded-field regulator.

but I've never gotten around to it. The choice is yours.

The foil pattern for the grounded-field regulator is in Fig. 2, and the parts-placement/wiring diagram is shown in Fig. 3. If you have last month's column around, you'll see that the new pattern is not very different from the pattern for the previous regulator.

Once you have the regulator ready to install in your car, use at least 14-gauge wire for the three connections to the vehicle's electrical system. Remember that the field windings in the alternator have an impedance of only about four ohms so, with a minimum of twelve volts from the battery, the wire has to carry at least four amps. If you have any doubts about the gauge of the wire, use the same stuff that was there originally.

The only other precaution to take when you're using either one of the two regulators is to realize that, since they're designed to be adjustable, they're capable of making the alternator put out a lot of power. While that isn't so bad for short periods of time, having the electrical system run at a constant level of sixteen or seventeen volts is a good way to blow stuff up.

As soon as you have the circuit connected and you're sure that the whole charging system is working, spend a little bit of time with your multimeter to calibrate the potentiometer (R10). Adjusting the potentiometer will change the trip point of the regulator and you should have those voltages marked wherever you have the potentiometer mounted. Red-line the settings at sixteen volts—you never, NEVER want the system voltage to get beyond that point.

If you're one of those unfortunate people who have a generator as your system's electrical engine, none of the circuits we've developed are suitable. As we discussed last month, since the amount of current you get from a generator is solely dependent on how fast it's turning, the only way to control the current being fed to the electrical system is to have a make-and-break type switch between the generator's output and the rest of the electrical system.

You can always use an alternator/regulator combination in place of a generator. The only problems you'll have are mechanical ones, since you'll more than likely have to fabricate your own mounting brackets and you may be forced to do a bit of surgery to make everything fit in securely. While doing a substitution like this is simple in theory, in practice there are a couple of nasty things that can screw you up if you're not careful.

The two big hassles are the substitute alternator's maximum current output for a given RPM and the size of the alternator pulley. As your starting point, you want the alternator to be able to generate enough current when the engine is idling. I can't give you exact figures since they'll depend on your vehicle. You might be able to get them from the paperwork covering your existing generator.

Once you have a ballpark current figure, you're ready to start the search for a suitable alternator. Most alternator pulleys are about half the diameter of the main one driven by the engine. That means the alternator generally turns twice as fast as the engine and the alternator you need should have a high enough maximum current output at about twice your engine idle speed. The voltage regulator will take care of determining how much below that maximum current is right for your system. All you'll have to do is put a multimeter across the battery and adjust R10.

What makes everything complicated is the fan belt. You want to be absolutely sure that, once you have the new alternator mounted next to the engine, you can use a standard-size fan belt. This is such a big deal that I'd remake the alternator mounts to change the circumference of the needed fan belt. Nothing is worse than not being able to get replacement fan belts from any auto supplier in the universe.

I wish I had a simpler answer to the problem of generators but all I've ever done is replace them with alternators. I'll admit that it's a lot more work than building a replacement regulator but the ultimate outcome is a lot better. **R-E**

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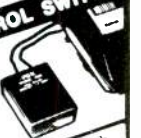

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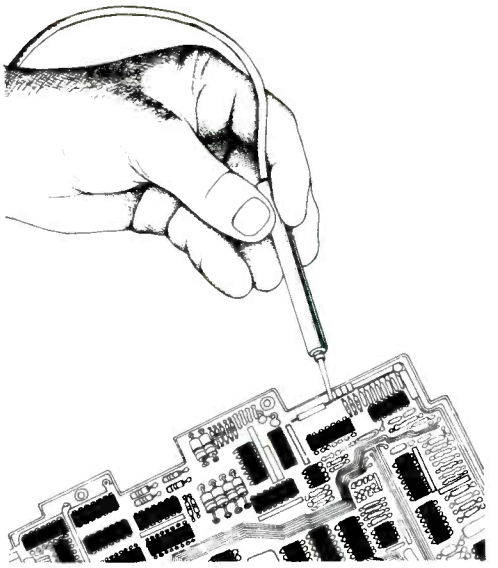

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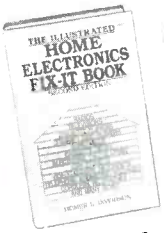

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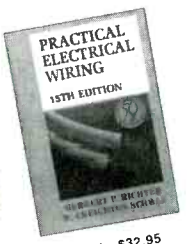

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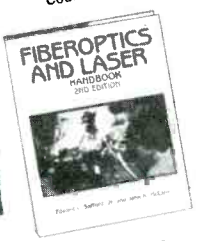

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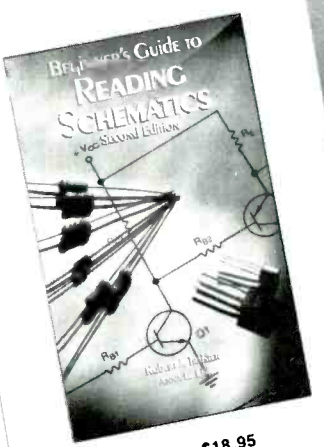

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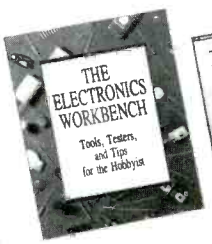

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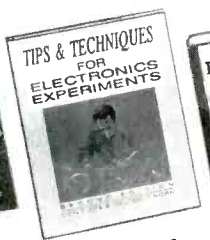

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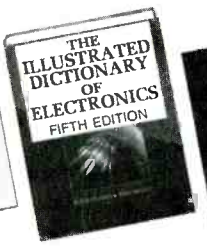

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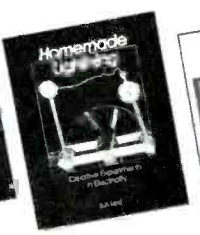

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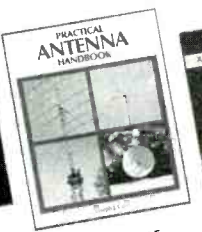

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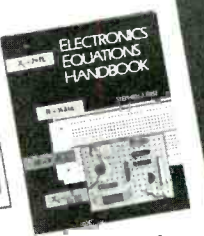

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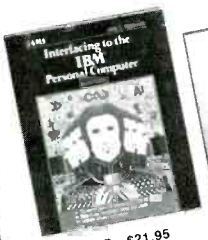

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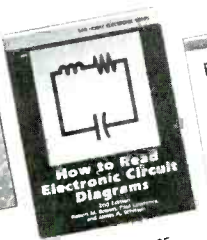

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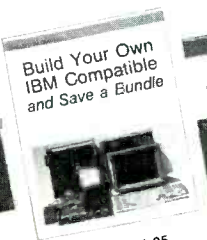

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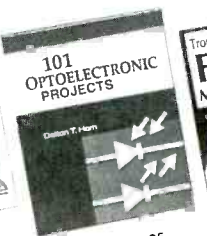

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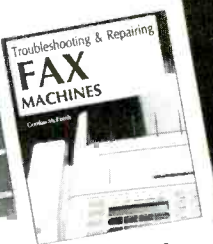

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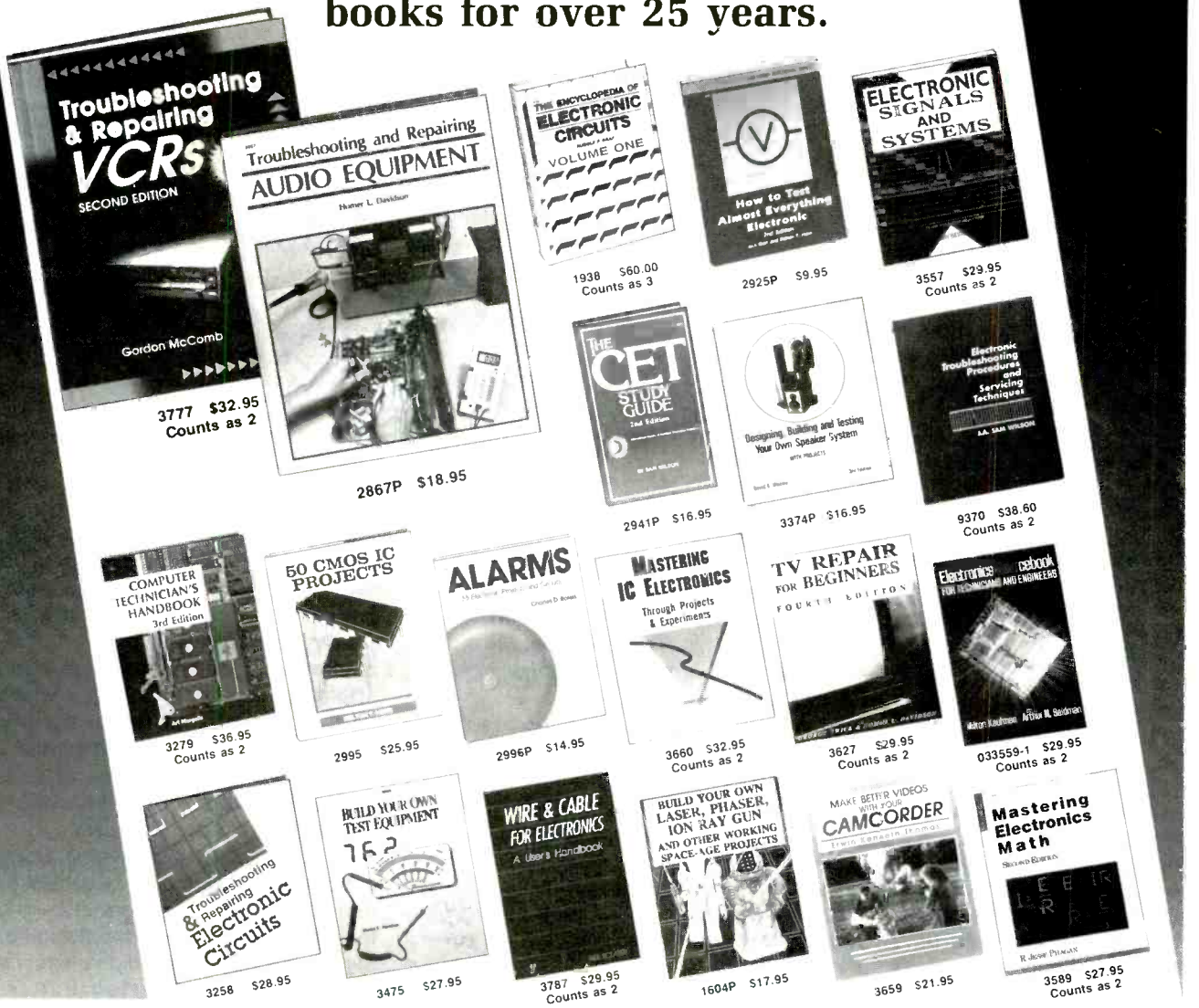

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PC-BASED TEST EQUIPMENT

continued from page 62

specified value, the relay will be energized. When the temperature rises again, the relay will be de-energized. For example, to trip at 10.5°C, add the lines shown in Listing 2 between lines 16 and 17 of the original program.

You can also change the value in the FOR-NEXT loop to alter the time between samples. For instance, on the author's system, changing the value to 5000 causes samples to be collected once every 10 seconds. The exact time depends on your PC's speed, so you'll have to experiment.

With a longer time between samples, you can log data samples to disk. To do so, change lines 4, 16 and 17 as shown in Listing 3.

To read and display the resultant data, run the program shown in Listing 4.

Other inputs

The signal conditioner circuit can accept other input sources, including linear-displacement potentiometers (LDP's), piezoelectric transducers, and microphones. An LDP is a specialized potentiometer whose wiper moves linearly instead of in the normal circular fashion. Usually these extremely accurate devices, which can be purchased from surplus electronics suppliers, are mechanically connected to a moving mechanism. They convert linear motion into a corresponding resistance. If a DC voltage is placed across the LDR, the output at the wiper is a voltage proportional to the amount of displacement of the slider.

Piezoelectric devices can be attached directly to a surface to measure tension and stress. Unlike an LDP, a piezoelectric device produces a voltage directly, hence doesn't need a DC voltage source. A microphone can also be used to measure sound-related phenomenon.

In fact, any device that can provide a voltage that varies between zero and a few hundred millivolts can be connected to the circuit described in this article. **R-E**

ASK R-E

continued from page 13

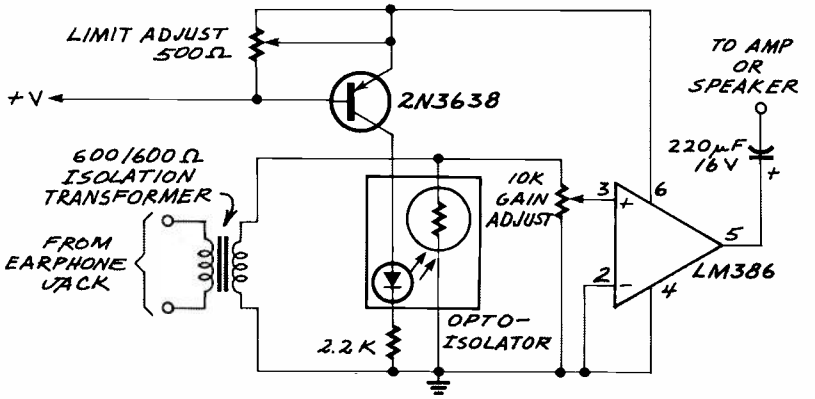

FIG. 3—AN AUDIO LIMITER will turn the volume down for you whenever the sound gets too loud.

amplifier has to pass through the resistor on the +V line. The amount of current drawn by the amp will vary in direct proportion to the amount of work the amplifier has to do. As the input signal increases, so does the amount of current the amplifier needs to handle it.

The voltage created across the resistor is a DC analog of the AC audio voltage at the amplifier's inputs. The DC voltage controls the transistor and, when it's high enough, the transistor will turn on and energize the LED in the optoisolator. That will change the resistance of the photoresistor wired into the amplifier's feedback loop and, as a result, cause a change in the gain of the amplifier. All the parts used in the limiter are easy to find with the possible exception of the optoisolator. That isn't a big deal since you can make one of your own by using a standard LED and photoresistor. Just put them next to each other in a small tube and seal up the tube ends to make it light-tight.

Building the circuit is a lot easier than getting it into your TV set. If you have any doubts at all about doing it, you're much better off forgetting the whole idea. You really don't want to blow up the TV or yourself in the process of modifying the audio.

If you're TV has an earphone jack, you can build the circuit in a small box and run the audio from the jack, through a small isolation transformer, through the limiter, and finally connect it to a separate amplifier and speaker.

POWER-SUPPLY REPAIR

I have an IBM-compatible computer and the power supply died on me. I took it out of the case and, after some investigation, I'm pretty sure that one of the transformers is shorted. It seems like a shame to buy a new supply since all it would take to repair my old one is replacing one component. Do you have any sources of supply for the transformer I need?—G. Benfisch, New York, NY

All of the IBM-type power supplies are regulated switchers and they all use at least two transformers—one for the AC line voltage and the other for the switcher. You didn't specify which one was shorted but remember that both of them have to fit exactly on the printed circuit board. You can probably find a replacement transformer that has the same specs as the one you need but you also have to make sure it fits on the board.

If you are willing to devote a lot of time to catalogs, ads, and the telephone, you might come up with something suitable, but since a whole replacement supply costs only about forty or fifty bucks from just about every supplier in the universe, I can't see any reason to screw around with fixing your old one.

Your time has to be worth something, and even if you found a replacement transformer I wouldn't be surprised if it costs as much as a whole new power supply. But then again, the education just might be worth the expense. **R-E**

SPEAKER MATE

continued from page 66

gain is built into the unit to allow for different electret microphones, but it can be set very high before any feedback occurs. You can actually set the gain to the point where you can be heard on the speakerphone in an adjacent room.

With the unit plugged into your phone line, turn the ANSWER switch on and you should hear a dial tone. (You may need a "Y" adaptor to put the Speaker-Mate in parallel with an existing telephone.) The dial tone will not be very loud because the device is designed to limit the volume of the dial output, but you will hear it. The LEVEL control will respond only a little bit due to the limiting action of the dial-tone detector within IC1.

The next step is to get a friend to help you set up the microphone gain. The mid setting will probably be close, but you may want more gain depending on the environment and if you want to be able to use the device at some distance. Remember, though, that at higher settings background noise will also come through and the speech may have an echo. For desk use, a setting can be found that allows talking in a normal voice with the unit placed about 15 to 20 inches from the user. Remember that the person you are talking to is the judge of the microphone setting, and the VOLUME control affects only your received listening level.

Once set up, you must call someone on a conventional phone, turn on the Speaker-Mate, and then hang up the regular phone. To receive calls, simply answer with the Speaker-Mate and speak in a normal voice. The sound quality is so good that the calling party will probably not even know you are using a speakerphone.

User add-ons

In a rural installation, the added distance from the central phone office can cause a reduction in loop current to the point where line-powered operation of the project may become marginal. Performance in the talk path is normal, but the received audio may have a pumping sound due to the lack of available current to reproduce the audio peaks.

While the project would still be usable, Fig. 7 shows a simple external power addition which consists of adding a ⅛-inch miniature jack (J2), a DPDT slide switch (S3), and a diode (D2). The parts can be mounted on the rear panel of the project case and wired into the printed-circuit board. The PC board is prepared by removing jumper JU1 and connecting the two wires from S3 in place of JU1; the ground connection can be made to a spare hole in the board provided for this purpose.

As shown in Fig. 7, S3 will switch the unit between being line-powered and powered from an external source. If you're using the external-power modification, a 4.5- or 6-volt DC wall adaptor is perfect. Do not exceed 6 volts, as the Zener diode is not in the circuit when using external power.

The Speaker-Mate is not a stand alone telephone because a ringer is needed to hear incoming calls and a dialer is required to make outgoing calls. You may want to add the ringer to the Speaker-Mate, as shown in Fig. 8. The tone ringer chip (IC3), manufactured by Texas Instruments, monitors the telephone line for a ring signal of 15 to 68 Hz, 40 to 150 volts AC. The ring signal powers a two-tone warble signal generated by IC3. The output of the device drives a solid-state piezoelectric transducer. The circuit can be installed within the Speaker-Mate's enclosure and the transducer can be mounted on the front or rear panel, with a small hole drilled as an audio port.

There is also a dialer circuit you can build using Motorola's MC145412 IC and a handful of other miscellaneous parts. The schematic for the dialer circuit is available from Project-Mate (see the parts list) if you send a self-addressed stamped envelope (SASE). **R-E**

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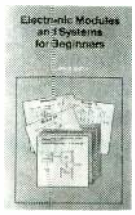

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COMPUTER CONNECTIONS

Multimedia mayhem

JEFF HOLTZMAN

Multimedia. It may be the first overhyped buzzword of the 90's. Or it may be the beginning of Gutenberg II. Gutenberg I occurred around the year 1440, when Johannes Gutenberg invented movable type, thus clearing the way for high-volume printing. High-volume printing did two things: it vastly increased the variety of literature available, and it vastly increased the audience for that literature. Sixty years later, millions of books had been printed, and Europe was home to thousands of what we today might call "QwikPrint" shops. Five hundred and fifty one years later, we're on the threshold of another revolution in publication technology. Gutenberg I brought to the masses media for the efficient transmission of language; Gutenberg II will bring to the masses media for the efficient transmission of all aural and visual information.

That's a grandiose claim. However, the confluence of several social and technological factors makes it a likely one.

Socially, traditional forms are losing out to other media. Literacy is dropping; mixed-media forms of education and entertainment are becoming increasingly popular. People depend more on CNN than the New York Times to keep abreast of current events. Computer-generated graphics receive frequent showings in major art centers. Electronic music has received the attention of serious composers. Live drama is now minuscule compared to film. Traditional print publishers are dabbling in new forms—books on tape, encyclopedias on CD-ROM. And video games are preparing an entire generation for a lifetime of interaction with electronic media. High schools are graduating illiterate, innumerate people; to compensate, corporations are spending billions educating, re-educating, and preeducating this increasingly unqualified work force.

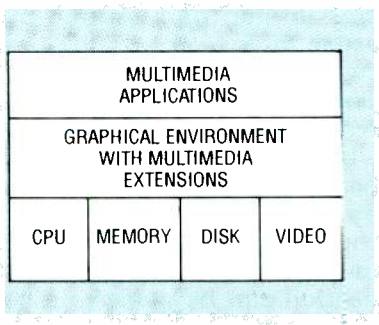

FIG. 1—MULTIMEDIA ARCHITECTURE provides a standard interface for multimedia applications to build on.

You may bemoan the loss of traditional modes of communication—and I would join you. Nonetheless, it's happening. So you can either throw up your hands or find a way of preserving the old while embracing the new. And that's where multimedia fits in.

Gutenberg II

In addition to those social factors, there's a whole lot of technology coming together to set the stage for Gutenberg II. The basic architecture is shown in Fig. 1.

Multimedia demands computing power, including a fast CPU, lots of memory (RAM) and permanent storage (disk), and high resolution video. Now this base technology level is here, at affordable prices.

On top of the base technology layer is a user-friendly graphical environment, with special extensions to handle new media (sound cards, CD-ROM drives, MIDI interfaces, laserdisc and other motion video sources, etc.). The graphical environment is a highly contentious area right now, but recent events lead me to the conclusion that when all the smoke clears, there's going to be much less different among the competing systems than there is in common. Windows, OS/2, and the Mac environment are all headed toward standards. Architectural layering will hide underlying technologies, so it won't matter whether you're running the Mac Finder, Windows' Program Manager, or the OS/2 Desktop. It'll matter even less whether it's an Intel or Motorola CPU under the hood. When you plug in the latest multimedia extravaganza, it'll just run.

At the highest level are the applications. There are some 2500 CD-ROM titles in "print" right now. Few of these are multimedia based; the vast majority consist of pretty boring text/numeric databases. However, several dozen full multimedia titles will be released between the time this is written and the time you read it; 1992 promises the release of hundreds of new titles. Such as? How about: Compton's Multimedia Encyclopedia, the Guinness Multimedia Disk of Records, Just Grandma and Me: A Broderbund Living Book, Countries of the World, Composer Quest, The Electronic Library of Art, Berlitz language lessons (Spanish, French, German, Italian), Great Cities of the World, Battle Chess, SimCity, The Macmillan Dictionary for Children, Multimedia Beethoven, Introductory Games in French and Spanish, World Atlas, Desert Storm.

There are other factors contributing to this revolution in publishing. Hypertext research initiated by Ted Nelson in the early 60's plays a prominent role. Advances in cognitive and instructional psychology also contribute significantly.

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TABLE 1—MULTIMEDIA HARDWARE LEVELS			
Component	**Base Level**	**Power User**	**Developer**
CPU	80286/10 MHz	80386/25 MHz	80486/33 MHz
RAM	2 MB	4 MB	16 MB
Hard disk	30 MB	80 MB	0.5–1.0 GB
Video	VGA (16 color)	VGA (256 color)	1024 × 768 × 256 color, non-interlaced, video overlay
Optical storage*	CD-ROM with audio output		
Audio*	8-bit DAC, 8-bit ADC, 11 and 22 kHz sampling rates. 16-bit DAC and ADC preferred. Multi-voice synthesizer. MIDI		
*Note: Required for upgrade kit			

Getting in step

Chances are you don't own a multimedia-compatible PC right now. But as those titles are released, you're going to start thinking strongly about buying one, or about buying an upgrade kit for your existing PC (or buying separate components for an upgrade.)

Microsoft has defined a basic multimedia PC as shown in Column 2 of Table 1; performance-conscious users will want a system like that in Column 3; developers will opt for something like Column 4. An upgrade kit consists of a CD-ROM drive, along with an audio board that provides ADC, DAC, and MIDI support.

NCR, CompuAdd, Tandy, NEC, Olivetti, Zenith, Fujitsu, and Philips have all announced or begun shipping multimedia PC's; prices start around $2500. Upgrade kits starting around $700 are available from CompuAdd, Creative Labs, Headland, Media Vision, and Tandy.

It's only a matter of time before all major hardware vendors provide similar offerings.

Standards and competition

Microsoft initiated formation of a trade group, the Multimedia PC Marketing Council (MPMC). Since its formation, however, the MPMC has attached itself to the Software Publishers Association, thereby guaranteeing that no one vendor's interests will be served at the expense of others—or the consumer's.

Nonetheless, there is IBM, which has been strangely silent about the MPMC. The IBM/Microsoft battle is one thing, but bear in mind that IBM is heavily involved in multimedia technologies. A few years ago Big Blue introduced a touch-screen system that is widely used in training applications. The company has an entire division dedicated to educational systems; it has funded or sponsored projects that we'll soon be hearing lots about, including one on the voyage of Columbus. Other IBM titles include Ulysses, the Declaration of Independence, and Hamlet. Expect a strong showing—when IBM is ready.

There are some other technologies that have been hanging around for years, waiting to become economical and adopted by large numbers of users. DVI (Digital Video Interactive) is one; CD-I (Compact Disc Interactive) is another. It's too soon to tell whether the Microsoft/MPMC standards will really take hold. It's likely that they will, however. These standards are comprehensive, are built on general-purpose computing platforms, and are supported by a fairly broad spectrum of vendors. Why would the average consumer buy a CD-I player when he or she can get the same effect on a PC that also allows word processing, checkbook balancing, etc? DVI, CDI, and similar technologies will either become compliant with emerging standards, remain as they are and carve out niche markets, or simply die.

Conclusions

Above I said that Gutenberg II would support all sound and visual information. Want to guess what Gutenberg III will support? Even better, when it'll happen?

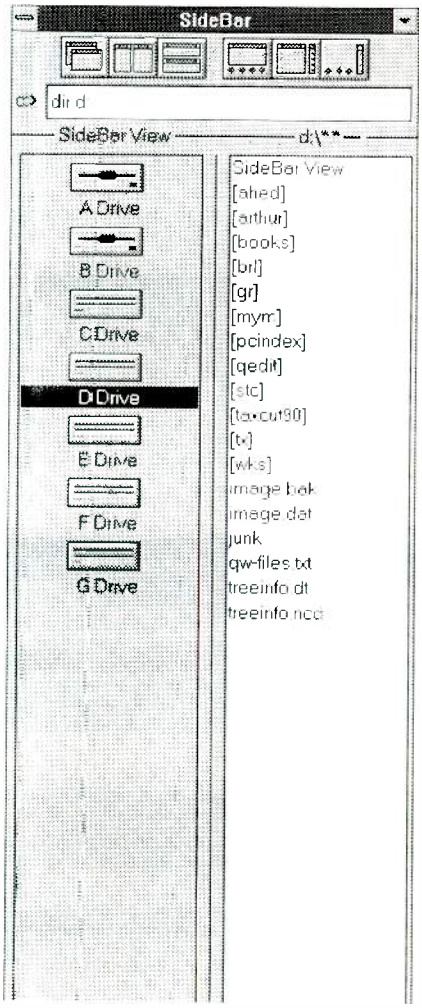

FIG. 2—SIDEBAR is the most elegant Windows shell on the market. It won't overload you with features; rather it adheres to a small-is-beautiful philosophy. Nice work.

News bits

Intel's microprocessor line is coming under increasing pressure. **Chips & Technologies,** which has suffered financial hardships in recent years, has bet the farm on two new chip lines that the company hopes will restore it to the glory of former days. One line comprises a set of 386DX and 386SX CPU's; the other is a complete PC-on-a-chip. The latter combines fully compatible versions of the major system components (8086 CPU, 8254 timer, 8259 interrupt controller, DMA emulator, XT bus controller, CGA graphics controller, and 16C450 UART) in a single package called the F8680. Building a system with the F8680 amounts to

continued on page 92

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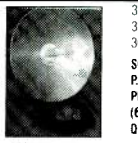

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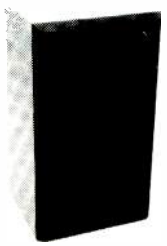

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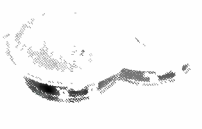

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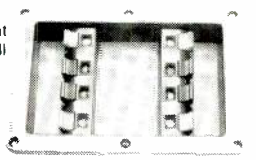

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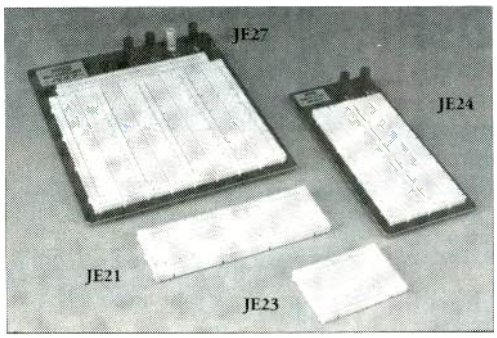

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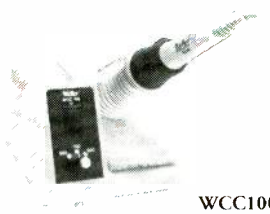

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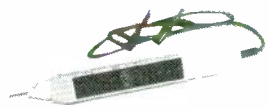

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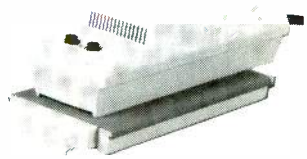

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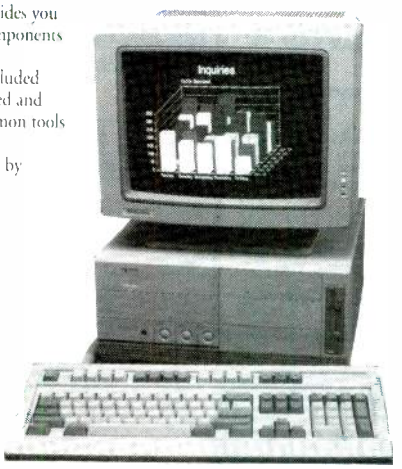

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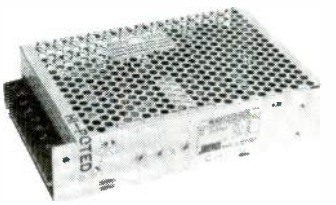

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COMPUTER CONNECTIONS

continued from page 85

adding some SRAM or DRAM—that's it. Who wants it? In the era of $2000 386 boxes and $3000 486 boxes, who cares about a CGA-level 8086? Makers of laptop and handheld devices like HP's 95LX. That's the theory, anyway. It may be that we're about to witness an explosion of PC Gadgets, miniature DOS-like devices that surpass calculators and the Sharp Wizard type of device. The other line consists of 386 clones that provide 10–15% better performance. Both lines incorporate a new technology called SuperState that provides an interrupt level higher than all normal IRQ's and the NMI, and which when entered gives a totally new address space for executing code. SuperState could be used to implement power management functions, to emulate missing instructions (e.g., 286

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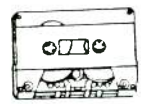

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MONITOR TESTER

continued from page 49

16 by IC5 to produce a horizontal sync of 21.94 kHz.

Vertical sync is generated by dividing the horizontal sync by 64 at IC8's Q_B output (pin 10). The Q_F output of IC9 connects back to its own CLR input via IC6 pins 6 and 7 causing IC9 to divide by 6, for a net division of 384. That gives us a vertical sync of 57.14 Hz at IC9's Q_A output. That Q_A output is connected to IC2-e pin 11, which is configured as a one-shot, and outputs a 60-microsecond negative pulse to IC7 pin 13. The pulse is output at pin 12 of IC7 which is connected to pin 9 of connector J1. Switch S3 routes 351.08 kHz to the low-byte RGB inputs of an EGA monitor. That causes the monitor to display a pseudo three-dimensional pattern to display on the monitor.

As a few final notes, VGA RGB inputs are 75-ohm impedance. Resistors R7–R9 reduce the amplitude of the color signals to 0.5-volt p-p. 400-line operation is produced by making horizontal sync negative polarity and vertical sync positive. EGA monitors switch from Mode 2 (enhanced) to Mode 1 by changing the polarity of vertical sync; in Mode 1 it's positive, in Mode 2, it's negative.

Construction

The use of perforated construction board and wire-wrap is recommended for this project. Try to keep the TTL clock oscillators (OSC1 and OSC2) as close to IC6 and IC7 as possible. Also, decouple all IC's and the oscillators with the 0.01 µF ceramic disc capacitors as shown in the schematic in Fig. 1. (You can solder them directly to the V_{CC} and ground wire-wrap pins).

This project requires +5-volts to operate. If you've already got a suitable power supply you can use it. Otherwise, Fig. 2 shows a suitable one for the project.

Once the circuitry is completed, you should put the assembled boards in a metal project box and tie earth ground to the case. Figure 3 shows the author's completed prototype. **R-E**

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LS9201	TOSHIBA	670 nm	5 mW	80 mA	2.4v	59.99
LS9211	TOSHIBA	670 nm	5 mW	50 mA	2.3v	69.99
LS9215	TOSHIBA	670 nm	10 mW	45 mA	2.4v	109.99
LS3200	NEC	670 nm	3 mW	85 mA	2.2v	79.99
LS022	SHARP	780 nm	5 mW	65 mA	1.75v	19.99

Dynamic RAMS

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41256-80	256K x 1	80 ns	2.19	2.08	1.87
41256-100	256K x 1	100 ns	1.99	1.89	1.70
41256-120	256K x 1	120 ns	1.89	1.80	1.62
41256-150	256K x 1	150 ns	1.79	1.70	1.53
511000-70	1 meg x 1	70 ns	5.49	5.22	4.70
511000-80	1 meg x 1	80 ns	5.29	5.03	4.53
511000-10	1 meg x 1	100 ns	5.09	4.84	4.36
514256-70	256K x 4	70 ns	6.49	6.17	5.55
514256-80	256K x 4	80 ns	6.09	5.79	5.21
514256-10	256K x 4	100 ns	5.69	5.41	4.87
541000-80	4 meg x 1	80 ns	26.99	25.64	23.08
544256-80	1 meg x 4	80 ns	31.99	30.39	27.35

EPROMS

STOCK #	SPEED	1-24	25-99	100+
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2732	450 ns	4.19	3.98	3.58
2732A	250 ns	3.29	3.13	2.82
2764	250 ns	3.49	3.32	2.99
2764A	250 ns	3.09	2.94	2.65
27128	250 ns	4.79	4.55	4.10
27C128	250 ns	4.79	4.55	4.10
27256	250 ns	4.59	4.36	3.92
27C256	250 ns	4.29	4.08	3.67
27512	250 ns	5.49	5.22	4.70
27C512	250 ns	5.49	5.22	4.70
27C1024	200 ns	10.99	10.44	9.40
27C2048	200 ns	21.99	20.89	18.80

LASER TUBES

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LT7770	543nm (Green)	0.5mW	1.0mW	0.71mm	≤ 1.2 mrad	random	1750v ± 110v	6.5 mA	≤ 8 kV	81k Ω	37 x 350	200	II	799.99	749.99
LT7650	632.8nm (Red)	0.5mW	2.0mW	0.49mm	≤ 1.7 mrad	>100:1	1000v ± 100v	3.5 mA	< 7 kV	68k Ω	25 x 146	70	IIIa	529.99	479.99
LT7656	632.8nm (Red)	0.5mW	2.0mW	0.34mm	≤ 2.4 mrad	random	1050v ± 100v	2.8 mA	≤ 8 kV	82k Ω	22.5 x 118	60	IIIa	134.99	124.99
LT7655	632.8nm (Red)	0.5mW	2.0mW	0.49mm	≤ 1.7 mrad	random	1000v ± 100v	3.5 mA	≤ 7 kV	68k Ω	25 x 150	70	IIIa	144.99	134.99
LT7655S	632.8nm (Red)	1.0mW	2.0mW	0.49mm	≤ 1.7 mrad	random	1000v ± 100v	3.5 mA	≤ 7 kV	68k Ω	25 x 150	70	IIIa	159.99	144.99
LT7632	632.8nm (Red)	1.2mW	3.0mW	0.61mm	≤ 3.0 mrad	random	1300v ± 100v	3.5 mA	≤ 7 kV	81k Ω	20 x 210	70	IIIa	249.99	229.99
LT7621S	632.8nm (Red)	2.0mW	5.0mW	0.75mm	≤ 1.2 mrad	random	1300v ± 100v	5.0 mA	≤ 7 kV	68k Ω	30 x 255	140	IIIa	204.99	191.99
LT7634	632.8nm (Red)	2.0mW	5.0mW	0.75mm	≤ 1.2 mrad	>500:1	1300v ± 100v	5.0 mA	≤ 7 kV	68k Ω	30 x 255	140	IIIa	209.99	194.99
LT7621MM	632.8nm (Red)	5.0mW	15mW	1.0mm	≤ 2.5 mrad	random	1250v ± 100v	6.5 mA	≤ 7 kV	68k Ω	30 x 255	140	IIIb	359.99	334.99
LT7627	632.8nm (Red)	5.0mW	15mW	0.80mm	≤ 1.1 mrad	random	1900v ± 100v	6.5 mA	≤ 8 kV	81k Ω	37 x 350	200	IIIb	369.99	344.99
LT7628	632.8nm (Red)	5.0mW	15mW	0.80mm	≤ 1.1 mrad	>500:1	1900v ± 100v	6.5 mA	≤ 8 kV	81k Ω	37 x 350	200	IIIb	389.99	364.99
LT7627MM	632.8nm (Red)	10mW	30mW	1.2mm	≤ 4.0 mrad	random	1750v ± 100v	6.5 mA	≤ 8 kV	81k Ω	37 x 350	200	IIIb	479.99	444.99

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COMPUTER CONNECTIONS

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or even 386 op codes), to perform multitasking, and all sorts of other things creative designers will enjoy thinking up.

Product Watch

If you've bitten the Windows bug, you've probably heard about Norton's Desktop for Windows (NDW), an everything-including-the-kitchen-sink collection of Win3 utilities. If that sort of overblown approach turns you off, check out SideBar (Fig. 2). This is quite simply the most elegant Windows program I've seen in four or five years of Windows watching. As the name suggests, SideBar places a bar along the side of your screen; this bar gives you the best of both DOS and Windows. At the top, the bar contains several pushbuttons for arranging icons on your desktop. Beneath the buttons is a text box for entering DOS commands (dir, cd, md, etc.). SideBar interprets your commands itself; it does not run a copy of COMMAND.COM. The remainder of the space is occupied by a set of drive icons, file/directory listings, or both. The dual display can locate two file windows horizontally or vertically. You can select one or more files from one window and drag them to the other. The same approach works for copying, moving, deleting, renaming, changing attributes, associating (documents to applications), and placing icons on SideBar to execute directly.

SideBar can replace Windows' Program Manager, File Manager, or both. It provides a text-menu approach to launching applications, that while not as visual as NDW, is really elegant and easy to use.

SideBar is extremely resource aware and efficient. You can force it to unload itself and thereby save memory when running applications; just double-click on the background to bring SideBar back. The documentation is quite well done; all product packaging is made from recycled materials.

I really like some of NDW's utilities. But for the time being, I'm going to use SideBar as my main Windows interface. **R-E**

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