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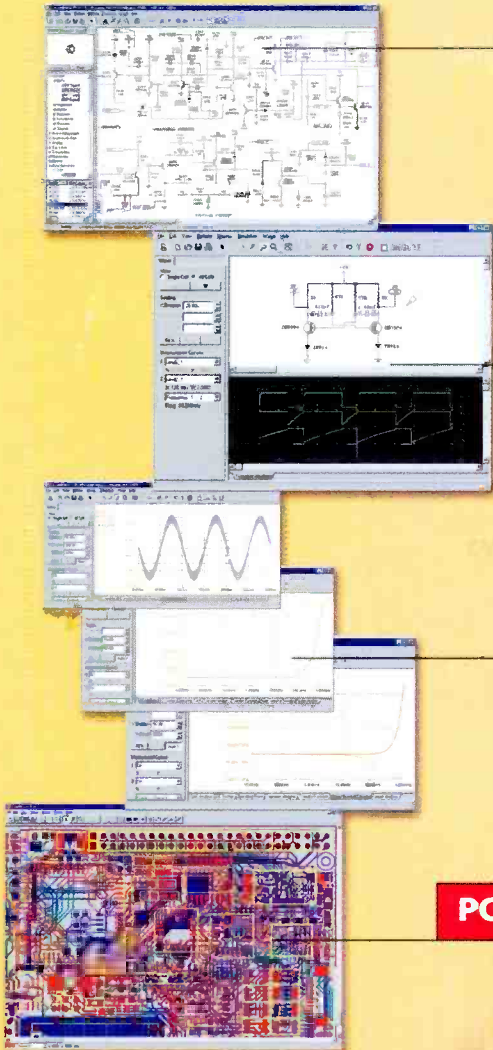

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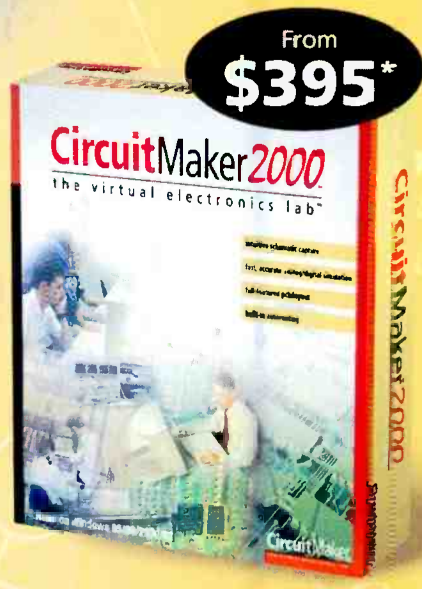

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Address Correction

*It has come to our attention that the wrong address was published for Motorola in an item on the P935 Personal Interactive Communicator in the "Gizmo" section (**Poptronics**, December 2000). The correct address is Motorola, 1500 Gateway Blvd., Boynton Beach, FL 33426-8292. We regret any inconvenience this misprint may have caused.—Editor*

Memory Errors

In Stanley J. York's otherwise fine article, "Analog Memory Module" (**Poptronics**, February 2001), there are some errors. On page 38, in Fig. 1, R3 in the schematic should read 111 K not 11 K. If you have trouble finding a 111 K resistor, try using a good digital ohmmeter and parallel 220 Ks to approximate 111 K. Also, in the text on page 38 in the middle column, D7 should be D5. Two more errors appear in Fig. 8, on page 43. The lead coming from left side of R13 should go to pin 3 of IC2 (not to pin 2) and the capacitor, C3, should be moved from that pin 3 of IC2 to pin 4 of IC2.

I also would like to congratulate you on adding Dean Huster to your staff. I like someone like that who gets down to the board-level stuff.

ROGER HAMEL, KG8XC
via e-mail

Servicing Nightmare

I am writing about the story, "Loaded 42-Volt Electrical Systems" in the "Prototype" section (**Poptronics**, February 2001). Looking at the photo of the BMW/42-volt engine, I can see another servicing nightmare (and expense) in the making. The starter/alternator/flywheel is apparently on the *rear* of the engine (clutch side). It would appear that to reach that part for service, someone would have to pull the engine or transmission to service the alternator or starter. No thanks! I've changed enough of both to know what "monsters" that could unleash.

Perhaps we should go back to the 30s and Chrysler's "Silent Start," when starters were mounted on the front.

JOSEPH J. SYCZYLO
N. Fork, ID

Flashing Lights

I am a self-taught electronics enthusiast who enjoys **Poptronics**. There's an article I would like to see. It would feature a circuit that shows the fundamentals of a high-end professional-type strobe flash—the kind used on emergency and fire equipment.

Perhaps you could publish a simple project incorporating the huge strobe "tube" found in these devices. In addition, there could be various circuit designs offered showing how to select different flash patterns, such as comet-flash, random-flash, and sequential-flash.

Thanks for listening to my suggestions.

FRANK AUSTIN
Toledo, OH

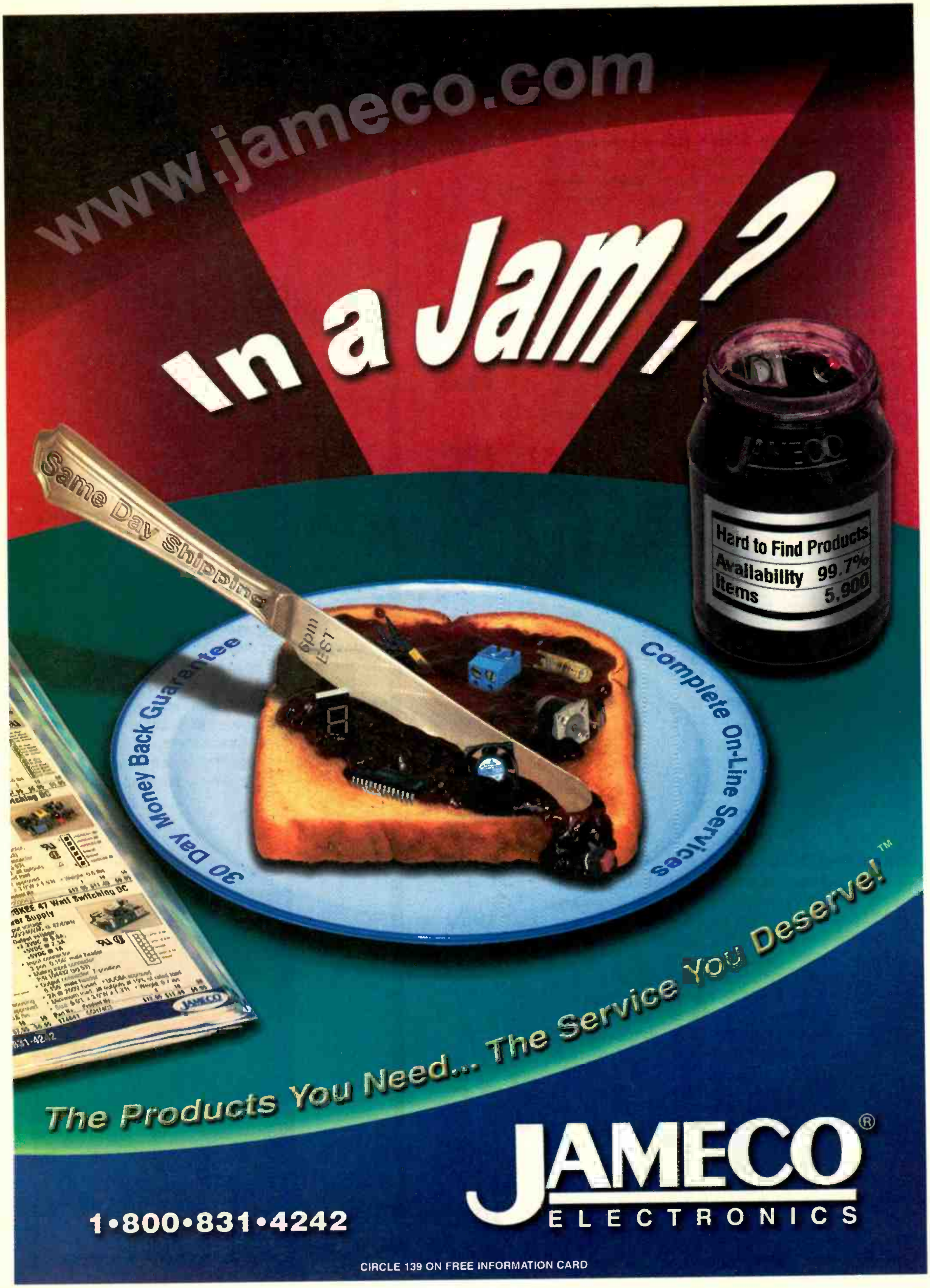
Prototype/Innovation and E-mail

In "Prototype," in the December issue of **Poptronics**, you discussed the Guardian Alert—an ultrasonic device. Its purpose is to determine distances behind large trucks as they back up.

When you use the word "prototype," it implies that the item under discussion is new. Well, this thing isn't. About six- or seven years ago, I bought the exact same device from a surplus dealer that advertises in your magazine. At first, I was going to use it in my robot, but then decided on another application. I used it as a "curb detector" for my car, because I kept hitting high curbs with the front valance (air dam).

Also, a few months ago in the same section, you had a story of an automated camera that took pictures of license plates when the driver didn't pay the right amount of money at a toll road. The implication was that this was some "new technology." For the last five or six years now, the local police have been using such a device coupled with radar to take pictures of those exceeding the speed limit. The proof is in all the speeding tickets I've obtained. That

(Continued on page 5)



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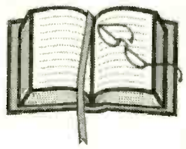


YESTERDAY'S NEWS

A PEEK INTO THE GERNSBACK ARCHIVES

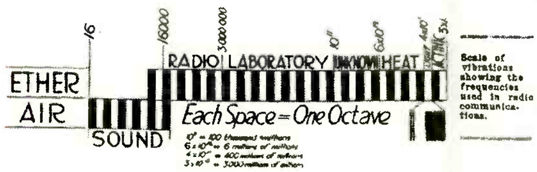
Dateline: July 1921 (80 years ago)

Yes, this is our *May* issue, but take a look at the accompanying scale taken from a **Radio News** reprint of a lecture given by Lt. Ellery W. Stone that was entitled "Radio Telefony."

Note the matter-of-fact representation of the ethereal plane and how it relates to the rest of the then-known electromagnetic spectrum. What is labeled as LABORATORY has since been classified as radio, and the bands that were once called UNKNOWN and HEAT are now combined and referred to as infrared. (*Popular scientific notions have changed, indeed! Today, there is a general consensus on what is beyond (visible)* LIGHT*—UV, X-ray, gamma, and cosmic bands. Who knows what bands will exist a hundred years from now!*)

Radio Telefony

By E. W. STONE



Dateline: May 1961 (40 years ago)

Radio-Electronics kept readers abreast of technological advances with feature articles such as "Communications On 450,000,000 MC"—an educational piece explaining the application and theory of ruby-rod masers. Only one year had passed since Ted Maiman had managed to construct the world's first operatable laser.

"...all the maser energy could be concentrated within single living cells and selective destruction of tissue (surgery) be performed." Those words explained some of the possible applications that maser technology could help unlock. Other advances such as fiber-optic communications and deep-space communications were also discussed in the article. (*It is staggering to see how rapidly science and technology have advanced in only forty years!*)

Dateline: May 1991 (10 years ago)

Radio Electronics featured "Personal Communication Networks" (PCNs)—a highly informative article that explained the then-cutting-edge digital-telephony network. The article thoroughly explained the theory and design of both digital and analog mobile phone networks and how those future networks would provide coverage areas and affordable services to subscribers. Advanced radio techniques—including frequency hopping and Time Division Multiple Access (TDMA)—were also discussed.

"PCN's are intended to provide mobile telephone service with quality and reliability equivalent to wireline...advantages can only come if there is a large number of subscribers." (*Looking back, it is amazing how fast portable digital-radio technology has developed into a hot commodity. Ten years have gone by, and, since then, companies—such as Sprint and Nortel among others—have dotted the landscape with tower stations that serve millions of digital mobile-phone subscribers.*)

LETTERS

(continued from page 2)

device is made in Sweden and is called the Multa-Nova. As I write this letter, a similar device is being installed at select traffic lights to take pictures of drivers going through red lights. Perhaps you should change the title of that section to "Innovation" rather than "Prototype."

BOB FOUND
Calgary, Canada

(You are correct that units such as Guardian Alert have been around for a while. It is not a first-of-its-kind device. Rather, it is the first available application of microwave technology to this commercial use. Of course, you are also right that photos have been taken for years of moving vehicles that are speeding etc. Again, the news here is that fiber-optic technology was being used for the cameras.

The main stories in "Prototype" are about new technology and research. Sometimes we highlight a commercial adaptation of new technology in a small box item. Thanks for your input. We appreciate the feedback that our readers give us.—Editor)

Thank you for your reply. All too often, we e-mailers write to corporations that don't take the time to reply (which makes me wonder why they bother putting an e-mail address on their Web site). It's refreshing to know that *someone* is actually reading this stuff.

BOB FOUND
(**Popular Electronics** subscriber since 72—I still have the first copy I received!)

Circuit Feedback

When **Poptronics** was **Popular Electronics**, I enjoyed the column "Circuit Circus," written by Charles D. Rakes, immensely. It was very much like the present "Basic Circuitry" column in the current **Poptronics**. As a novice electronics experimenter in high school, I usually don't have enough experience to build most of the projects in the feature articles. However, "Basic Circuitry" is sort of a safe haven that I can feel free to dive into. I must say that sticking to themes is very effective in that it introduces a type of circuit and then offers variations that gradually get more complex. Branching off into new directions, more circuits bloom which convey different aspects of the theme.

I also enjoy the brief explanations of how the circuits work, which help me to understand electronics theory. I would appreciate it if more theory were added, specifically in the field of engineering your own circuits. Could "Basic Circuitry" possibly have a theme about circuit engineering in the future?

One more request: I've noticed that some of the construction articles feature electronic kits that you can buy through the mail. One voice-stress analyzer kit manufactured by Vectronics that I've held off on ordering is from the *TechAmerica Catalog*. I suggest that you publish a feature article on this type of kit.

It's nothing fancier than a simple LED bargraph indicating the stress in someone's voice (revealing a lie). I've heard that you can hold it up to news broadcasts and get interesting results from the circuit. It sounds like it would be of wide interest to other readers.

KYLE O'BRIEN
Paso Robles, CA

Improve Your Bias

I like Gary McClellan's article, "Bias Checker" (**Poptronics**, November 2000). All of his articles have been useful to those of us working with musical electronics and with pro- and semi-pro audio, in general. There are several current-production tube amplifiers, as well as much interest in restoring classic guitar amplifiers from the 1940s, 50s, and 60s. Technicians often build needed equipment, which is either not on the market at all or is quite high in price. For example, the only item I know of that is similar to McClellan's Bias Checker is the Bias King (which only measures one tube at a time), listed in the 2001 *Antique Electronics Supply Catalog* at $115. (The Bias King Pro, which like the Bias Checker, measures two tubes at a time is $175). The cost of parts for the Bias Checker is much less!

I have a few suggestions for the Bias Checker. If 1% resistors are used for R1 and R2, the need for resistor matching and for calibration of the completed unit

(Continued on page 54)

KEEP IN TOUCH

We appreciate letters from our readers. Comments, suggestions, questions, bouquets, or brickbats ... we want to hear from you and find out what you like and what you dislike. If there are projects you want to see or articles you want to submit—we want to know about them.

You can write via snail mail to:

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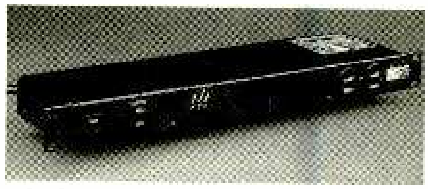

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There is a resettable overload circuit breaker, and the unit continues to provide power if surge protection is lost. LED diagnostic indicators display power, protection, and polarity/ground status. Models come with either 15- or 20-A receptacle ratings, with an optional ON/OFF switch, and a 12-foot line cord with either a straight-blade or locking plug.

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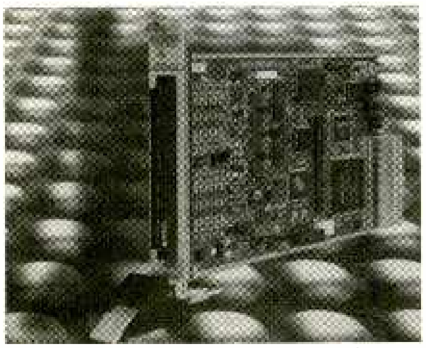

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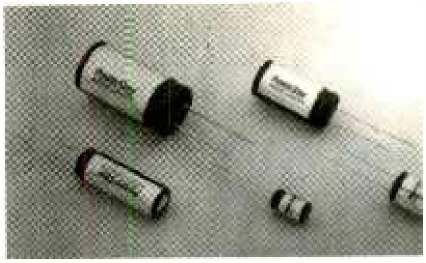

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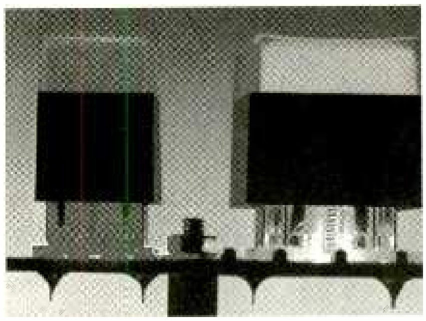

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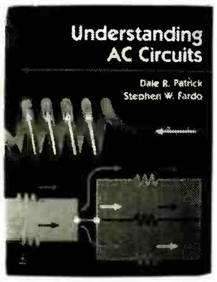
NEW LITERATURE



Understanding AC Circuits

by Dale R. Patrick and
Stephen W. Fardo
Newnes, Butterworth-Heinemann
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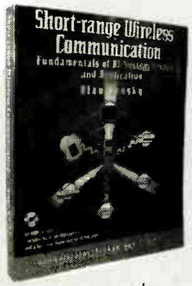
The second half of a basic electronic circuit theory course, this practical book exposes readers to systems built with AC circuits. The easy-to-read text includes graphics and electronic experiments that enable readers to build simple circuits and low-cost AC electronic projects. Among the topics covered are single- and three-phase AC electronics, the use of a multimeter and oscilloscope, troubleshooting and testing circuits, tools and equipment, all types of AC circuits, electronics symbols, and soldering techniques.

Focusing on the basics of electronics theory and mathematics, this book is a handy reference for electronics beginners, hobbyists, and experienced technicians.

Short-range Wireless Communication



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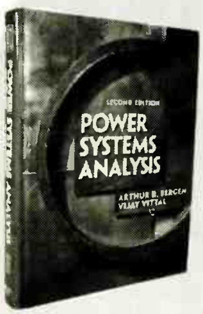
Short-range RF communication is undergoing a revolution—as a replacement for wiring in homes and offices. Designers in this field can find the detailed technical information and design guidelines they need in this book. It serves as a gateway to understanding the basics of all forms of RF communication, including satellite and cellular systems with an emphasis on short- or low-range power wireless applications.

In addition, the included CD-ROM contains Mathcad engineering worksheets integrated with the text and a complete searchable eBook version with hyperlinked references and bookmarks. A Web site covering new short-range RF developments at *www.shortrangewireless.net* also provides supplemental material and a reader forum.

Power Systems Analysis, Second Edition



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Designed as a college-level textbook, this updated edition reflects the changes in the U.S. electric utility industry since the original publication in 1986. New material includes a discussion of determining transmission-line parameters from the manufacturers' tables and a chapter on network matrices.

In this edition, a running design problem continues throughout the book, with variations tied to the concepts being presented. The problem is computer oriented; students may either use available software or may develop their own. Updates, information on available Web sites related to power system analysis and power issues, and additional resources can be found at the following Web site: *www.prenhall.com/bergen/vittal*.

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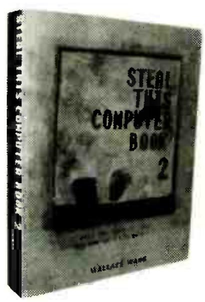


Computer viruses, Trojan Horses, electronic con games—how do they work, who's behind them, and how can you protect yourself? Taking an offbeat, non-technical look at computer security issues that affect everyone, this updated second edition keeps the irreverent tone of the first book. Readers learn how to: guard against these viruses and frauds, protect against security breaches, and encrypt data and recover deleted data.

True to the book's "Steal This" philosophy, everything found on the CD-ROM is either free or a cheap alternative to mainstream software. Programs include encryption tools, virus scanners, firewalls, intrusion-detection programs, and computer forensics tools.

2001 Communications Catalog

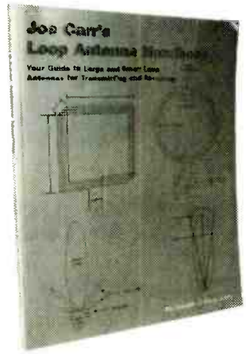
from Universal Radio, Inc.
6830 Americana Parkway
Reynoldsburg, OH 43068-4113
800-431-3939 or 614-866-4267
www.universal-radio.com

Free

This 104-page catalog covers equipment for the amateur radio, shortwave, and scanner enthusiast. A concise introduction to shortwave listening offers the beginner a helpful foundation for getting started in the hobby.

Among the new items featured are the AOR SDU-5500 Spectrum Display, the Yaesu VR-5000 Wideband Receiver, the Uniden Bearcat BC-780XLT Scanner, and the ICOM 910H Amateur Satellite Transceiver. Photos, full descriptions, specs, and price information accompany each device in the catalog. There is also an extensive selection of antennas, headphones, books, and accessories.

Joe Carr's Loop Antenna Handbook



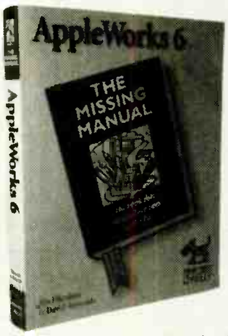
by Joseph J. Carr
Universal Radio, Inc.
6830 Americana Parkway
Reynoldsburg, OH 43068-4113
800-431-3939 or 614-866-4267
www.universal-radio.com

$19.95

Written by the late Joe Carr, a former **Popular Electronics** columnist, this handbook is a complete easy-to-read guide to understanding and building high-performance large and small loop antennas. Radio signals and reception, radio direction finding, and VLF and VHF are also discussed.

Readers learn how to build various antennas, from longwave to shortwave. Each antenna type is thoroughly covered from theory to construction. Clear diagrams illustrate each project.

AppleWorks 6: The Missing Manual



by Jim Elferdink
and David Reynolds
O'Reilly and Associates, Inc.
101 Morris St.
Sebastopol, CA 95472
800-998-9938 or
707-829-0515
www.oreilly.com

$19.95

This manual guides readers through the basics and the hidden aspects of *AppleWorks* 6, with special emphasis on its enhanced word processing, Internet, and presentation features. According to the authors, the bugs in the original release were fixed by an updated version, 6.3. It was released as the book was going to press, and some information about 6.3 was included.

The early chapters dig deeply into the six core modules, including 85 pages on the word processor alone. The text also covers such applications as exchanging documents with other programs, versions, and platforms. Troubleshooting is thoroughly discussed with workarounds given for the program's weaknesses.

MPLAB-Integrated Development Environment (IDE) "SE" CD-ROM, Special Edition

from Microchip Technology Inc.
2355 W. Chandler Blvd.
Chandler, AZ 85224-6199
480-792-7668
www.microchip.com

Free

This resource enables Microchip users to test-drive C compiler demos to determine which compiler options fit their needs, look up PIC micro components, and find Development Tool sources. The special edition CD-ROM also contains a complete copy of the most current release of Microchip's MPLAB-IDE software.

Allowing designers to write, debug, and optimize the PICmicro MCU applications, the program features users' guides and project tutorials. The software package includes a project manager, simulator, text editor, and an assembler for the PICmicros and other language products supporting MPLINK and MPLIB. PICmicro data sheets with the most current errata are easily referenced with the click of a button.

A LOOK AT
TOMORROW'S TECHNOLOGY

PROTO

Business Buzz

MINIATURE SWITCH
NEC Corporation announced the development of a 0.5-mm mechanical microswitch—a new type of miniature relay—made from single-crystal silicon that increases mechanical reliability. The switch is fabricated on a glass substrate, which unlike the substrates used in conventional switches can be easily extended over a wide area. Since a large number of microswitches can be integrated on a glass substrate, overall equipment costs are relatively low. One application is in a large-scale integrated circuit in the *R*adio *F*requency (RF) field, such as in high-gain, phased-array antennas.

THE PEN IS MIGHTIER
Thousands of ID Pens were donated by the manufacturer, Monico Products, to local San Diego police stations, businesses, and community watch groups. The ID Pens mark property for security purposes, using an invisible ink that is semi-permanent. It actually bonds molecularly to the surface written on. The pen's invisible ink can be seen under an ultraviolet lamp by police departments. According to Michael Senoff, president of Monico Products, the ID Pen is more useful than the vibrating engravers, which can imbed scratches and damage the property. For further information, check the company Web site: *www.monicoproducts.com.*

COMPUTER RECYCLING TIPS
The non-profit *S*ilicon *V*alley *T*oxics *C*oalition (SVTC) and Pax World Funds, a socially responsible mutual fund, issued a set of tips to help consumers recycle computers. Hundreds of materials in PCs—including chlorinated and brominated substances, metals, gases, acids, and plastic additives—are highly toxic. Even though 90 percent of computer contents can be reused, only about 6 percent of PCs abandoned during 1998 were recycled, according to SVTC. The National Safety Council projects that over 315 million computers will become obsolete by 2004, which would add an estimated 8.5 million tons to America's landfills. According to Pax World Director of Social Research Anita Green, the public needs to realize the dangers of old computers and that they still have value—to schools, community groups, and senior homes. To access the recycling tips on-line, go to *www.paxfund.com/pcrecycletips.htm.*

Brave New "Nanoworld"

Research into the "nanoworld" at the Georgia Institute of Technology includes experiments with silver nanoclusters and large-scale simulations of silicon nanowires just several atoms in diameter, among other areas of exploration. First, let's look at the recent successful demonstration of binary optical storage: writing and reading simple images recorded on thin films made up of silver oxide (Ag2O) nanoparticles.

Today's Letter is L

Led by Robert M. Dickson, assistant professor of chemistry and biochemistry, this research group, included Lynn A. Peyser, Amy E. Vinson, and Andrew P. Bartko. They were able to store images of simple geometric shapes and the letter "L."

"These nanomaterials have a remarkable new property: when you shine blue light with a wavelength of less than 520 nanometers onto them, you switch on their ability to fluoresce," said Dickson. "You can then read the fluorescence nondestructively by illuminating the clusters with longer-wavelength light." Fluorescence has previously been reported in silver clusters at low temperatures and in rare gas environments, but he believes this is the first time the phenomenon has been reported at room temperature.

Thin Films

The team began by producing extremely thin films (less than 20 nanometers thick) of silver-oxide nanoparticles on a glass slide. They then selectively exposed portions of the film to light in the blue spectrum. The light chemically reduces particles near the surface of the film, partially converting them to clusters of silver atoms. When these photoactivated silver clusters are then exposed to longer wavelength (greater than 520 nanometers) green light, the clusters fluoresce strongly, emitting red light easily visible to the naked eye. Silver-oxide particles not photoactivated by exposure to the blue light do not fluoresce.

Robert Dickson, Lynn Peyser, and Amy Vinson expose a silver nanoncluster sample to green laser light. Responses are shown on the computer monitor behind them. (*Photo by Gary Meek*)

Images stored on the silver-oxide film can be read nondestructively by green light for at least two days, the longest period of time they were left on the stage of their microscope. How long the effect will last will be studied further.

Understanding How It Works

Though they have been able to optically write and read information with the new system, the researchers do not yet know if the information can be optically erased and the film re-written. The current objective is to understand the fundamental issues governing the properties of the nanoclusters.

"We really want to understand the underlying physics and chemistry of this material," Dickson said. "While we have an eye toward developing applications, the issue now is understanding what gives rise to the fluorescence, understanding the size and geometry of these clusters, how to control the composition, and what factors are important for generating the fluorescence."

Dickson believes the phenomenon's cause relates to the quantum mechanical properties of atomic silver: "Interesting things happen when materials that behave in one way as bulk materials are reduced to the small scale," he added.

Future Developments

When studied under a microscope, the individual silver particles display an additional property that may ultimately prove useful for increasing the density of optical data storage. First, observers see green emission, then red emission, and then yellow emission—all from the same particle. "Not only are you generating fluorescence, but you presumably are also changing the size and/or geometry of the cluster, which causes it to emit different wavelengths," Dickson said.

By using the correct distribution of particle sizes, these multi-color emissions could allow storage of more than one bit of information per data point. If the particles could be distributed in a three-dimensional matrix, they could provide a very dense storage medium to be written and read in parallel.

Other potential applications for the fluorescent emissions from the clusters could be in biological labels and electroluminescent displays.

Predicting Behavior of Things Too Small To See

Another question being explored at Georgia Tech is how to predict the behavior of things that are too small to see—and too small to even fabricate yet. The issue is important as scientists consider building smaller and smaller electronic devices to boost speed and reduce energy use. Ultimately, these devices will be so small that they will use wires less than ten atoms in diameter.

In the researcher's hand is a silver nanoncluster sample that fluoresces when excited by laser light. (*Photo by Gary Meek*)

Using massive simulations, researchers from Georgia Tech and IBM have predicted some unusual behaviors for tiny wires—called "nanowires"—that would be made from silicon. These predictions, based on a science called molecular dynamics simulations, will help future device designers anticipate how current will flow through these wires.

"It's a much-discussed expectation that devices of this size will be different, but in what ways and by how much, remained unknown," said Uzi Landman, Regents' Professor of Physics and director of the Georgia Tech Center for Computational Materials Science. "In this study, we have explored certain unique properties of systems this small through first-principles quantum mechanical simulations. Such simulations, which are to the best of our knowledge the largest ones to date, are essential for gaining reliable and predictive information about these systems."

Prize-Winning Research

Landman won the 2000 Feynman Prize in Nanotechnology (Theoretical) for this pioneering work in computational materials science for nanostructures. Such computer modeling provides deep insights into the nature and properties of matter at the nanoscale.

Landman, Robert Barnett, and Andrew Scherbakov from Georgia Tech, and Phaedon Avouris from the IBM T.J. Watson Research Center simulated silicon nanowires etched from bulk silicon or self-assembled from clusters containing 24 atoms of silicon. In each case, hydrogen atoms were attached to unused bonds, and the wires were connected to aluminum leads. The simulations produced data on the nanowires' electrical conductance, the influence of

Research Notes

LIGHT ON QUANTUM COMPUTING

A functional quantum computer could solve large mathematical problems faster than today's fastest supercomputers. Scientists Emanuel Knill and Raymond Laflamme at the DoE's Los Alamos National Laboratory and Gerard Milburn from the University of Queensland's Centre for Quantum Computer Technology in Australia suggest using the high sensitivity of single photon detection and the detection results to simulate the effects of non-linear elements. They have used quantum error correction to prevent the apparently irreversible loss of the "quantumness" of the system. The proposed device can work at room temperature and is based on existing technology: beam splitters, phase shifters, and single photon sources and detectors.

TESTING, ONE, TWO, THREE

Comprehensive testing of the compatibility of *G*lobal *P*ositioning *S*ystems (GPS) with *U*ltra *W*ide*B*and (UWB) technology was conducted by the *A*pplied *R*esearch *L*aboratories: The *U*niversity of *T*exas at Austin (ARL:UT). UWB is a form of wireless communications technology that fuses three technologies: wireless, radar, and positioning. UWB, which operates without satellites, could extend the reach of GPS to underground, indoor, and urban environments. The independent tests examined several UWB emitters and several types of GPS receivers and their interactions. Test results were submitted in October to the FCC, who will evaluate the data. ARL:UT will make the data from the testing available to the public, without analysis or conclusions.

"VIRTUAL REALITY" SOFTWARE

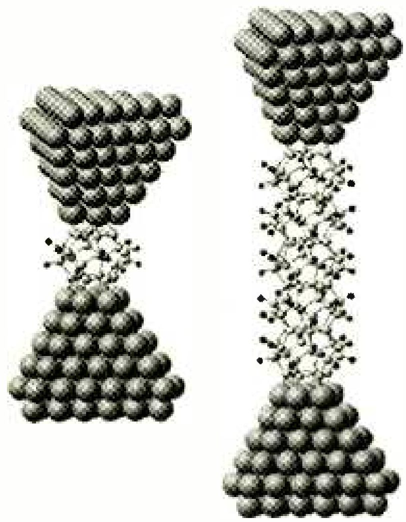
Sandia National Laboratories has released updated computer software that models the complex physical phenomena that occur as a nuclear power plant accident progresses through time. Distributed on a CD, the software synthesizes the results of nuclear power-plant safety research since the 1979 accident at Three Mile Island. MELCOR 1.8.5 models the whole power plant, from the plumbing and wiring to the physical interactions between nuclear fuel rods and their containment vessels. By using the latest experimental data, the program can help evaluate plant safety.

the silicon-metal interface, and the role that doping with aluminum atoms may play in changing materials properties. The work also suggests new ways of doping ultra-small transistor channels.

Simulation Results

Carried out on an IBM SP-2 computer at Georgia Tech, the simulations revealed that electronic states formed from a combination of the aluminum leads and the silicon wire atoms penetrate all the way through nanowires of less than about one nanometer in length, giving such silicon bridges a finite conductance. (In longer structures, these electronic states penetrate only partially into the nanowire, with the silicon retaining its semiconducting properties.)

They also showed that the height of Schottky barriers at nanoscale metal-to-semiconductor contacts might not be too different from those found at more familiar size scales. This barrier height depends on the nature of bonding and atomic arrangement at the contact itself for various nanowire configurations. It varies between 40 to 90 percent larger than values at the macroscale contact, indicating that device engineers won't have to apply dangerously large voltages across the barrier formed at nanoscale metal-to-silicon contacts.



A diagram of atomic configurations of silicon nanowires created through the assembly of silicon clusters connected to aluminum electrodes. The wire on the left is 0.6 nanometers long, and the one on the right is 3 nanometers.

The simulations also suggest a way that could overcome some of the anticipated problems involved in doping the silicon used in devices this small. Because the clusters form hollow cages, much like carbon fullerenes, they could be fabricated around a dopant atom. With each cluster then containing a dopant atom, device consistency may be achieved.

Another problem the study explored was that the wave-like nature of the electrons could cause interference effects in the electric conductance through the silicon nanowires. This behavior results, at certain electron wavelengths and wire configurations, in interference resonances that cause the nanoscale current channels to appear transparent, leading to spikes in the current flowing through them.

The next step is to actually fabricate and test devices this small.

Nanotubes, Nanojets, And Nanoparticles

In other nano-research at Georgia Tech, researchers led by Dr. Z.L. Wang, professor of materials science, measured the comparative bending strength of tiny carbon nanotubes, using oscillating electric voltages on nanotubes glued to tiny gold balls. They compared nanotubes produced by traditional high-temperature carbon-arc discharge to nanotubes grown through a lower-temperature catalyst-assisted pyrolysis process. There were dramatic strength differences in the catalytically-grown nanotubes, which were weaker than the carbon-arc tubes.

However, it is believed that the catalytically-grown nanotubes may have advantages in ultra-light-weight composites, where the point and volume defects could help interlock the tubes. On the flip side, though, these defects could produce problems in electronic applications such as field-emission electrodes where current flow could cause uneven heating in the narrow regions.

Research in nanojets involved liquid jets a few nanometers in diameter. To study jets this size, a Georgia Tech team, headed by Prof. Landman and Michael Moseler, used molecular dynamics simulations on the same IBM computer. They observed how 200,000 molecules of propane behaved when compressed within a tiny reservoir and then injected out of a narrow nozzle made of gold.

Such jets could one day be used for producing ever-smaller electronic circuitry, injecting genes into cells, etching tiny features, and even serving as fuel injectors for microscopic engines. As a next step, researchers would like to create nanojets experimentally and use them to apply patterns that could replace current lithographic processes for manufacturing nanoscale miniaturized circuits.

Another research team, under the leadership of Dr. John Zhang, learned how to precisely control the size and magnetic properties of one class of magnetic nanoparticles. The goal is a "recipe book" that other researchers could use to produce nanoparticles with exactly the right properties for different applications.

Because magnetic properties vary by size, the particles must all be about the same diameter to ensure consistency. This team developed a statistical model to predict and control the size of nanoparticles, producing them with size variations of less than 15 percent, and the hope is to reduce that even further.

Research into the "nanoworld" may be research into the world of the very small, but it is obvious that the possibilities resulting from this research are in the realm of the infinite. PT

Wireless RF Technology

Wave ID, a recently established startup company, will develop and sell wireless communication technology systems based on *R*adio-*F*requency (RF) identification technologies, developed at *P*acific *N*orthwest *N*ational *L*aboratory (PNNL). These systems will include RF tags—wireless communication devices that vary in size from a grain of rice to a credit card. Capable of tracking items ranging from honeybees to soldiers, they can be designed to identify, locate, or monitor items or people.

We previously covered this RF research in "Virtual Medical System" in "Prototype" in the November 2000 issue. That RF system was directed toward an embedded use in dog tags for the military. For those who might have missed this issue, here's a brief recap of the research.

The *Tactical Medical* Coordination System (TacMedCS) is a virtual medical system designed to save time and possibly lives. The system uses RF technology, electronics, and GPS to quickly store, record, and transmit information on an injured person's medical condition. The heart of TacMedCS is a rubber-encapsulated RF tag that's the same size as the familiar metal dog tag. Featuring a tiny silicon chip that holds up to 110 characters of information, the RF tag is an electronic medical chart that stores information on the person's medical condition, blood type, and allergies.

This data is uploaded almost instantaneously into a program stored on a miniaturized hand-held computer. A computer program automatically formats the patient's information onto a screen, where a corpsman simply points and clicks to indicate alertness, location, and type of injury. Information on the treatment can be programmed back into the RF dog tag for later use. Using GPS to pinpoint the location of the injured person, the corpsman can send the location of the wounded sailor or marine to a TacMedCS command center where medical personnel can coordinate transport of multiple patients according to severity of wounds.

"Now, back to our story." Since 1995, PNNL has received government funding to design RF wireless systems to be smaller and capable of communicating at unprecedented distances. Military projects have included tracking honeybees used in landmine detection, securing night-vision goggles against theft, and creating the electronic dog tags discussed above. Over this time period, PNNL engineers have enhanced the capabilities of RF tagging systems to meet the U.S. military's need for better and automated inventory management and security control, as well. Potential commercial markets include warehouse management, such as locating a pallet of goods.

"Wave ID will fill a void in the wireless communication technologies for applications where longer range but low power consumption is required. Our technology falls between short-range technologies such as bar code and long-term technologies that require significant battery power, such as cell phones," said Curt Carrender, Wave ID's chief technical officer and a former PNNL engineer. "Our wireless technology can provide information at a greater distance, yet uses very little power."

Wave ID will be partially financed by Batelle, which operates Pacific Northwest for the DoE. Batelle paid for commercialization activities associated with these technologies, including business planning and patent applications. In exchange for an exclusive license to the RF technology, Wave ID will pay Batelle royalties, of which 51% will be returned to PNNL for laboratory use.

More information on PNNL's RF technology development can be found at *www.pnl.gov/nsd/commercial/rftags*.—**Material was contributed to this story by Bill Siuru.** PT

GIZMO®

Video Triple Play

Perched on my kitchen counter, the 19-inch TV/VCR combination has been a favorite in a house filled with the latest-and-greatest electronics gear. It's just so easy to use; no unsightly wires connect it to anything else—and my son can snack and watch a favorite film without getting crumbs all over the living room. That's all fine, unless his favorite film is a DVD.

We might just have to upgrade to one of Panasonic's *Triple Play TV/DVD/VCR* combinations: the 20-inch *PV-DF2700* ($899.95) or the 27-inch *PV-DF2700* ($1299.95). Both feature a DVD/CD player, a four-head stereo VCR, an FM radio, built-in stereo speakers, an alarm clock, and the flat-screen Tau PureFlat picture tube—said to deliver a distortion-free image from corner to corner. The 27-inch model also includes the two-tuner picture-in-picture feature, allowing two TV programs—or a TV show and a DVD or videotape—to be viewed simultaneously. Both models include the V-chip parental guidance system, VCR Plus+ recording, and a lighted remote control.

It would be tempting to hook up a receiver or amp equipped with a Dolby Digital or DTS decoder and add a few more speakers to take advantage of DVD soundtracks. However, the Triple Plays provide built-in stereo speakers said to create realistic surround-sound effects.

Panasonic Company, One Panasonic Way, Secaucus, NJ 07094; 800-211-PANA; *www.panasonic.com.*

CIRCLE 50 ON FREE INFORMATION CARD

Hands on the Wheel

If you've managed to get a PlayStation 2 and want to add more realism to racing games, check out the *Blue Thunder Racing Wheel* ($69.95). The auto-centering steering wheel can be placed on a table or on a chair. Lifelike wheel tension, analog gas and brake pedals, and a digital stick shift provide an authentic driving experience.

The racing wheel offers eight analog fire buttons and an 8-way analog directional control pad. Its powerful vibration feedback technology enhances the sense of racing realism.

InterAct Accessories, Inc., 335 Clubhouse Lane, Hunt Valley, MD 21031; 410-785-5661; *www.InterActAccessories.com.*

CIRCLE 51 ON FREE INFORMATION CARD

Auto Pilot

Like its predecessors, the third-generation *StreetPilot III* portable automotive navigation system ($1272) features electronic map capabilities. However, it uses a 16-color, higher resolution display and adds turn-by-turn navigation directions and voice prompting. Users can directly download street-level mapsets onto a removable memory cartridge, insert the card, and simply mount the system on the dashboard.

The device uses a 12-channel GPS receiver claimed to provide accuracy within 30 feet. Vocal prompts alert the user to upcoming turns and announce distance and arrival information. Up to 25 routes from either the internal basemap or downloaded mapsets can be stored. The built-in basemap covers the United States, Canada, and South America, and includes major highways, roads, railways, waterways, and geopolitical borders. It even lets the user know what services—food, lodging, gas—are available at U.S. interstate highway exits.

The StreetPilot III comes with a USB data card programmer, a 32-MB datacard, and a PC interface cable. Available travel-related data includes residential maps and thousands of local attractions, such as restaurants, shopping centers, hotels, ATMs, and service stations.

Garmin International, Inc., 1200 East 151st St., Olathe, KS 66062; 913-397-8200; *www.garmin.com.*

CIRCLE 52 ON FREE INFORMATION CARD

Gizmo®

Wireless Meets USB

Now you can enjoy the freedom of wireless networking combined with the ease and versatility of USB. Lucent Technologies' ORiNOCO now offers both a Silver and Gold version of their new *USB Client.* The Silver USB lists at $199 and offers 64-bit encryption, while the Gold USB lists at $219 and offers 128-bit encryption. Both Wi-Fi certified units have a range of up to 1200 feet, as well as up to 11 Mbps of bandwidth. The Client is available for Windows 98, Windows ME, and Windows 2000.

Lucent Technologies Microelectronics Group; 800-928-3526; *www.lucent.com/orinoco.*

PDF Scanner

Microtek's *ScanMaker 5700* ($449.99) incorporates a PDF engine for better file compression. Documents larger than 30 MB can be scrunched down to a mere 1MB—with no sacrifice in quality. The 5700 offers both a FireWire port and a USB port. The dual-purpose lid can be used as a transparency adapter or as a light board for viewing 35-mm transparencies.

Microtek Lab, Inc.; 800-654-4160; *www.microtek.com.*

Multi-Function PDA

The *PA-100* ($399)—also known as *Cyberboy*—is an option-packed PDA incorporating a digital still camera, a full motion PC camera, a MP3 playback device, a digital audio recorder, and an FM receiver. Via its touch-sensitive screen and onboard buttons, the PA-100 registers data for use in various programs including a scheduler and address book.

Hotan Corporation; 925-829-5311; *cmc.taiwanet.com.*

Versatile Portable Desk

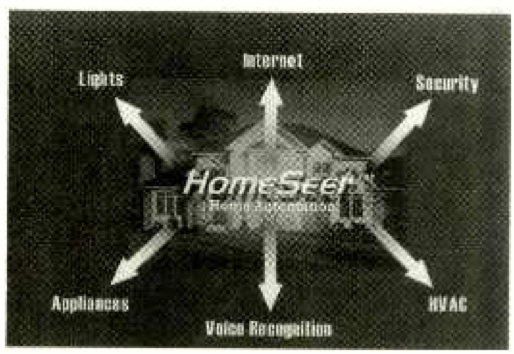
Originally designed to make reading easier for the disabled, the *Adapt-A-Lap* ($49.95) comes with adjustable straps to hold a book and transparent straps for keeping pages in place. Able to fold down to an inch and a half package, this portable desk complete with a telescoping leg is fully adjustable. Measuring 12 by 14 inches and weighing 22 ounces, inventor Ed Blum's creation can also support a laptop at the beach, in bed, or anywhere else a desk is needed.

Adapt-A-Lap, Inc.; 800-419-2354; *www.adaptalap.com.*

Home Automation From Afar

Imagine being able to control your home's appliances, lights, and security system from miles away. Using voice recognition, *HomeSeer Home Automation Software V1.5* ($99.95) allows the user to send commands directly to various devices via the Internet or phone. Time presets can also be used for delayed control of particular home systems. The software runs on Windows-based PCs and can interact with commercially available X10 switch modules.

HomeSeer Technologies, LLC; 603-471-2816; *www.homeseer.com.*



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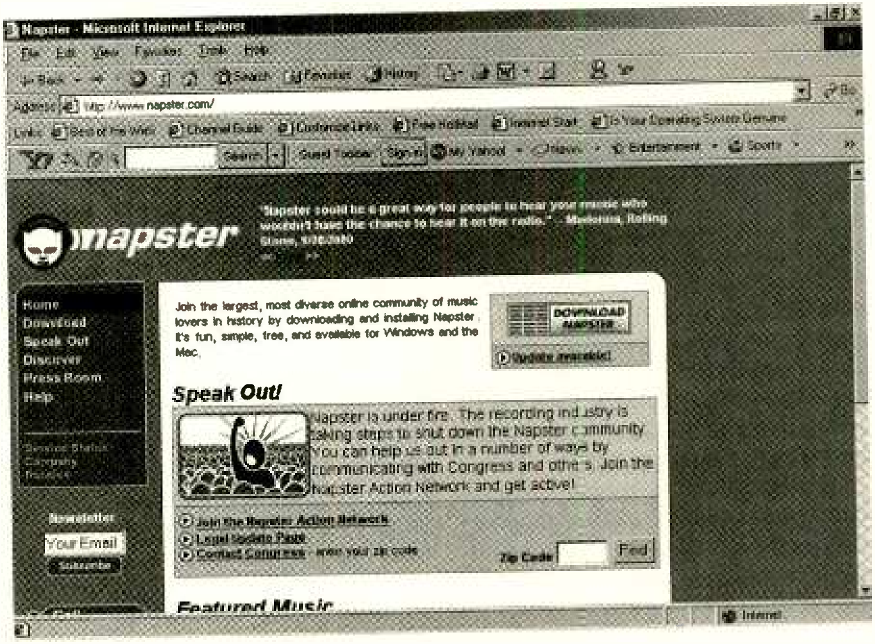
CHRIS LA MORTE

mailto: netwatch@gernsback.com

PIRATES OR PATRIOTS?

How often does technology *truly* affect society? Back in July 2000, proponents of Napster (*www.napster.com*) let out a collective sigh of relief when the company continued to operate. Following in the wake of an early February ruling, Napster is still operating as a central host for alleged copyright violators. Amazingly, a simple code that allows users to swap controversial packets of data managed to (gently) rock the halls of justice. Senator Hatch, who leads the Senate Judiciary Committee, fears that if Napster ceases to exist, then its users will drift away to decentralized file-sharing systems such as Gnutella and Freenet. Ah, Mr. Fanning—founder of Napster—did you have this scenario in mind when you were tinkering with your complier?



Napster seems bulletproof. After a court agreed that the organization promotes the violation of copyright laws, Napster continues to function as if nothing happened.

SWAPPING MUSIC

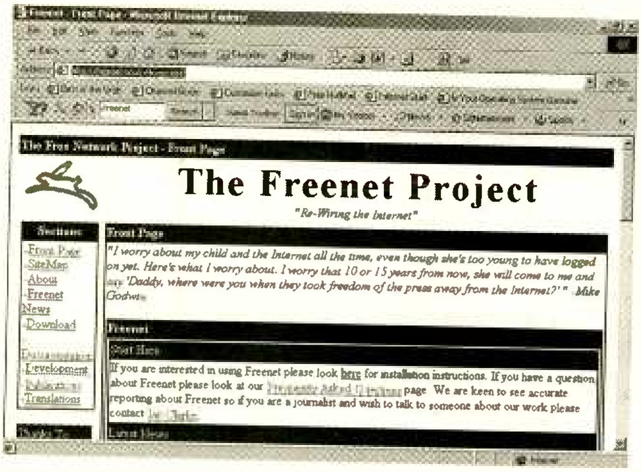
Think back before the age of cell phones and cheap personal computers—when K-Tel Records was king and 8-track decks were savvy. I remember, as a child, watching the *big* kids share their music collections. Friends would arrive carrying milk crates stuffed with albums (those big, round, plastic, black things) and a box of blank cassette tapes that cost a fortune in those days. Phonographs were patched into dual-cassette decks in order to dub select songs. Does this sound familiar?

The major difference with swapping music before the age of the Internet and swapping music via programs like Napster is that music fans couldn't instantly communicate and swap with thousands of other fans before. Of course, this is not the only difference. Record companies are making a lot of money these days, and certain companies feel that Napster is stealing right under the eyes of the law. In the days when swapping took place in living rooms between a handful of people, the practice was overlooked. Today, a server allows nearly 70,000 people to share millions of songs in a public forum. Napster is a "swap-meet" of global proportions—that's a lot of milk crates!

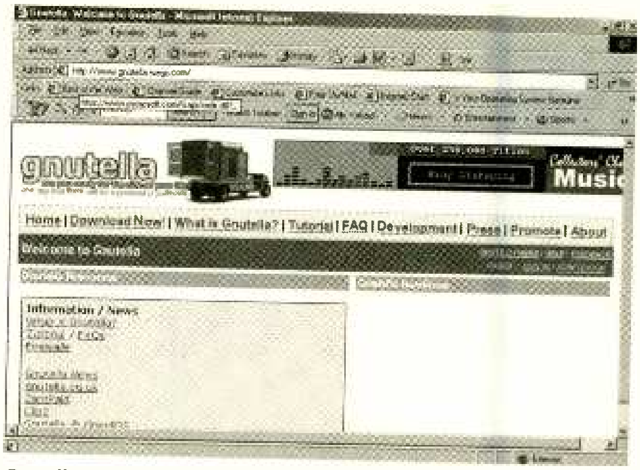
FIXING A DESIGN FLAW

Although Napster continues to be as limber as a wily coyote, doom is always around the corner. The truth is Napster uses a central server to manage the swapping of files between users. In reality, Sheriff So-and-so can walk into the office and pull the plug on Napster. It is because of this threat that a few crafty designers began to fiddle with a decentralized server or, more accurately, as Ian Clark of Freenet proposed, a Distributed Decentralized Information Storage and Retrieval System (*DDISRS*).

Freenet (*www.freenet.sourceforge.net*) is an open-source, Java-based server that boasts the absence of a central controlling hub. Clients donate either hard drive space or RAM to the system. Data is stored on the users' computers and actually moves about in a psuedo-random sort of way. Each data packet is published into the system and



Freenet picks up the ball and runs with it. Boasting a decentralized server and "floating" data, Freenet showcases cutting-edge peer-to-peer technology.



Gnutella is the unruly kid on the block. Humor combined with a simple-to-use platform has increased Gnutella's popularity. Why trade only songs when you can swap any format?

associated with a "key." In order to retrieve the packet, a user must insert the appropriate "key." This system also attempts to maintain a failsafe method of assuring anonymity for people who both post and retrieve information. The founders hope that Freenet can become a forum for global awareness and that "people under oppressive governments can use Freenet to describe their plight without retribution." So, it's not just for swapping $700 programs?

No matter how much the collaborative folks at Freenet want to wave a flag of liberty, they will surely be a topic of discussion among the courts. Politics aside, Freenet has helped broaden technology. The Internet has started to come full circle. Now, it is trendy to surf among Web rings and manipulate peer-to-peer applications. The Web of years gone by, when people depended on links between Bulletin Boards in order to surf the Net, has given way to a commercially-driven mesh of corporate portals.

SOMETHING GNU

Gnutella (*www.gnutella.wego.com*) is designed for the consumer, rather than the activist. That is to say, a minimum of computer expertise is needed in order to take advantage of this decentralized system. However, sacrifices are made for simplicity. Anonymity is by no way guaranteed for downloaders of information—legal or illegal—and unlike Freenet, the available files are searchable among the user "horizon." The "horizon" is a group of users (limited to 10,000 nodes) that the Gnutella program can access.

As promising as this system appears, it does have a mischievous bent, as can be seen on its Web page. The section entitled "What's Gnutella?" gives off a sense of smugness. The author uses a pie recipe analogy to represent the files downloaded. I am going out on a limb here, but who uses peer-to-peer file-transfer applications to swap pie recipes? Once again, Gnutella is an application that permits the transfer of virtually any file format—from ASCII recipes to whole .exe files waiting to be downloaded.

HUNGOVER ON FREEDOM

It seems that when the major "money-makers" are being wracked with losses that can be attributed to goods being pirated by means of technology, people can still manage to go about their day. After all, who cares when someone downloads a copy of *Office* for nothing—we are all too busy downloading the best of Barry Gibb's discography. "Free market" is a good theory, but there must be limits. Who knows when *your* product will be passed around free of charge with no reimbursements? Maybe one day a site will be designed to swap property deeds and mortgages for other people's homes. Golly, isn't freedom nice? Well, that's enough of me pounding my pulpit; I'm beginning to get blisters.

No matter what morals a person possesses, it cannot be denied that Napster, Gnutella, Freenet, and scores of lesser-known applications are revolutionizing the way people trade information and products. This new system of computer-based trade has only begun to challenge our legal system here in the United States. Looking beyond the U.S.—a country that epitomizes freedom—one can only guess at the global impact of the free exchange of data. P

HOT SITES

Freenet
www.freenet.sourceforge.net

Gnutella
www.gnutella.wego.com

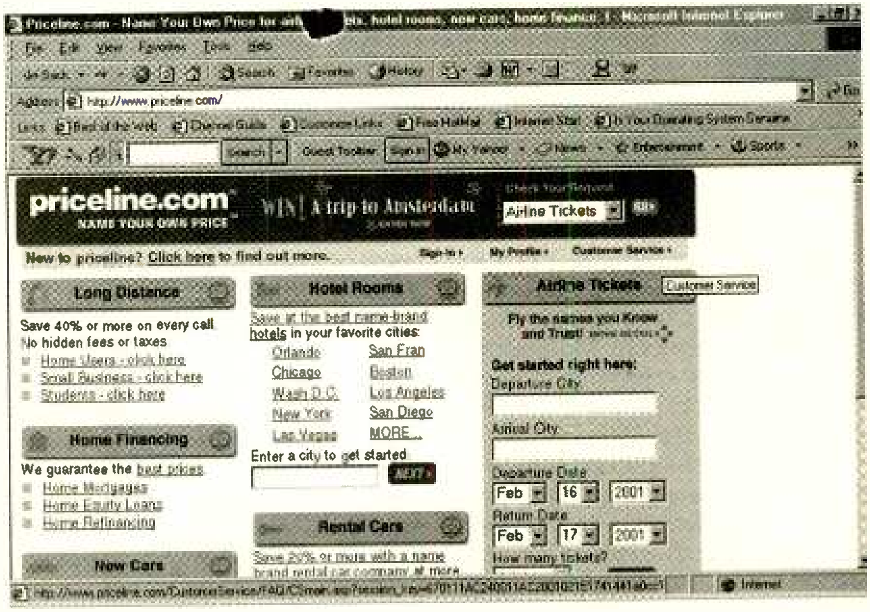
Napster
www.napster.com

REID GOLDSBOROUGH

mailto: digitaldomain@gernsback.com

START A NEW CAREER OR TAKE A VACATION

To some Net surfers, the Internet is a communication medium first and foremost—offering us the ability to talk to virtually anyone, anywhere. However, as far as most consumers are concerned, the Internet is a source of discount savings. Thanks to the competition in the Web-commerce environment, deals-a-plenty can be found with help from your browser. Now, job recruitment has been added to the mix. You can post a résumé for a job as a wireless technician in Antigua and book tickets for a flight all with the aid of your Internet connection. Let's take a look at how to change your career path and then celebrate the new job with an exotic excursion.



It has been a rough-and-tumble year for tech stocks, and no one caught more publicity during the catastrophe than the folks at PriceLine.com. After all the dust settled, though, PriceLine lives on—that's one crispy phoenix, indeed!

A PSEUDO-SOCIAL REVOLUTION

"Labor, if it were not necessary for the existence, would be indispensable for the happiness of man," wrote the eighteenth century English author Samuel Johnson. Sometimes, though, work can just make you miserable. Whether you're looking to change jobs, need to hire, or are just starting your career, the Internet can help. But, as with everything, the Net is no panacea.

Pounding the electronic pavement can save on shoe leather, not to mention postage and phone charges. More important, it can reveal possibilities you wouldn't find otherwise. Online recruitment is good for employers, too. It can save a company up to $8000 per person hired, according to a study by Creative Good, an e-commerce consulting firm in New York City. This figure breaks down into $2000 saved in advertising costs and $6000 saved in time spent looking for a new hire.

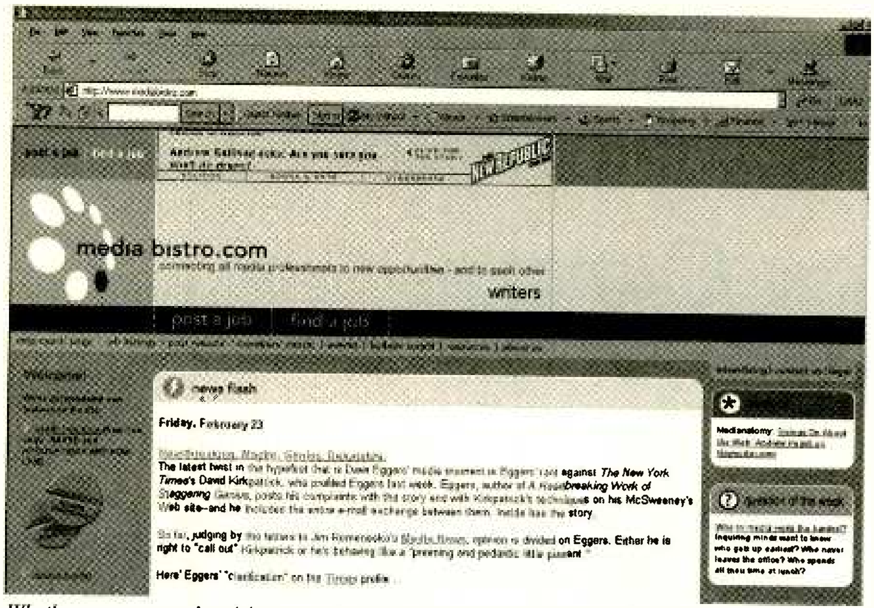
DIGITAL WANT ADS

"More companies are using the Web every day in their recruiting efforts," says Gary Resnikoff, president of National Career Search, which publishes *Career Magazine* at *www.careermag.com*. A study from an online recruiting firm, at *www.recruitsoft.com*, backs this up. Nearly 80 percent of the world's 500 largest companies use their Web sites for recruiting, up from 60 percent last year and 29 percent in 1998.

Online job seeking and recruitment, though, has its downside. It's better for entry- and mid-level jobs than executive positions. Applications as a result of job postings can overwhelm companies. Any given posting of your résumé may generate little or no response.

In a study involving interviews of 3000 online consumers, market research firm Forrester Research found that only 4 percent of respondents landed their last job using the Internet compared with 40 percent who got work from referrals and 23 percent from newspaper ads. You therefore have to be smart about how you use the Net to find work, says Pam Dixon, author of the book *Job Searching Online For Dummies*. Stick to the best job sites, she says.

Though the online recruitment industry has consolidated lately,



Whether you are an advertising executive, a writer, or a lay-out specialist, MediaBistro can help you land a job in the field of media.

there are still hundreds of job sites out there. Well-regarded examples include general-purpose domains such as Monster.com at *www.monster.com* and CareerPath.com at *www.careerpath.com*. MediaBistro.com, a publishing job URL at *www.mediabistro.com*, is a good example of a niche site.

Dixon includes a more extensive list of what she considers the best online job sites at her *www.thedixonreport.com address*, in the section called "The Online Job Search Companion." Another domain that recommends job sites is the Riley Guide at *www.rileyguide.com*. Created by Margaret F. Dikel (nee Riley) co-author of the book *The Guide to Internet Job Searching*, the site is also a good place to bone up on the basics of job seeking. It offers tutorials on preparing résumés, researching employers, interviewing, and salary negotiating.

A FEW TIPS OF THE TRADE

What's the biggest mistake people make when job hunting on the Net? "Being too informal," says Dikel. "Employers want to see a formal cover letter, even one sent by e-mail." Write in complete sentences and check your spelling and grammar, she advises. Another big mistake is not following directions, says Dixon. If a company accepts e-mailed résumés, for instance, it probably specifies that you should include your résumé as plain text within the body of the e-mail message, rather than as a Microsoft Word file attached to the message. Yet, many people still send attachments, which just causes your effort to be deleted unread out of fear that the attachment may contain a virus. If you already have a job, Dixon warns against posting your résumé to an online job site. She says she's talked to more than a dozen human-relations professionals who admit scanning résumé databases, looking for disgruntled employees. It's smarter to look for job leads and e-mail your résumé to specific companies.

For employers, the biggest mistake is assuming that only technical people search for work online, says Ward Christman, president of Jobnet.com, a regional job site at *www.jobnet.com*. Only 30 percent of the jobs advertised there are related to information technology, a percentage that has decreased every year since he became involved with the online career industry 1992. The most common jobs posted at his URL are those in customer service and in marketing and sales.

Now that you are on your way to finding the perfect career, let's take some time to learn how the Internet can make travel easy and affordable—whether the purpose is business or pleasure.

JUMPING ON THE BANDWAGON

The ability to send messages and retrieve information from virtually anywhere in the world is one of the benefits of the Internet. Lately, the Net has become increasingly useful in bridging the physical distance between you and any place in the world. Travel sites are growing in numbers. Their purposes range from researching vacations to cutting business travel costs.

Research conducted by various Internet consulting firms has shown growth in the Internet-travel market. The number of people booking travel online doubled last year over the year before. Now, over a third of the online population has participated in the Net travel boom. About 28 percent of business travelers (or their assistants) now regularly make airline reservations this way, compared with 33 percent who book using the telephone. Travel generates more revenue than any other online sector, having surpassed runner-up computer hardware and software last year.

Statistics such as these may delight Net travel industry insiders. However, travelers should be aware that the Net is better at some things than others. Due to the current instability in the dot-economy, you should be careful about Web travel companies that could head south at a moment's notice.

Nothing compares to the Internet for quickly gathering information or comparison-shopping, and both factors have fueled the online travel explosion. Top general-purpose travel sites such as Expedia.com, at *www.expedia.com*, and Travelocity.com, at *www.travelocity.com*, can help with every step of a trip. You can choose a vacation, research your destination, find the best airfare, book airline tickets, track frequent flier miles, reserve a hotel room, rent a car, get driving directions, check the weather forecast, and more.

Some sites specialize in business travel, such as Biztravel.com, at *www.biztravel.com*, which made a splash with its guarantee of cash compensation for mishaps from flight delays to slow responses to e-

(Continued on page 56)

TED NEEDLEMAN

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StarBand To The Max!

Last month, I explained how StarBand, a new two-way satellite Internet service, has brought my family into the "near" broadband world. I use the term "near" because the top speed that StarBand provides for downloads (about 500 Kbps) is a bit slower than most DSL or cable modem connections. Still, it's blazingly fast compared to the 26 Kbps we used to average.

Not surprisingly, the entire family has wanted to benefit from having the StarBand service installed. Initially, I thought my family would take turns using the new Dell OptiPlex PC that provides a gateway to StarBand (this would had been a simple solution for sharing high-speed Internet access). Well, I was wrong.

It turns out that getting four teenagers to share anything (even a meal) is nigh on impossible. This is something that should have occurred to me before obtaining the StarBand service. Although StarBand does not "officially" support networking the service, the Dell OptiPlex PC that holds the two satellite-communications cards has a built-in 10/100 Base-T Ethernet adapter.

We already have two complete 100 Base-T Ethernet networks running in the house, so it took only a two minutes to plug the Dell "StarBand" PC into the downstairs hub. After I tweaked some settings (mainly those of *Internet Explorer*), all of the PCs connected to the downstairs hub now have high-speed access.

A PIECE HERE, A PIECE THERE

If you've been reading this column for a while, you'll note that my home has gone through about three generations of networks in the last two or three years. Our home network is a bit of a hodge-podge as a result. Originally, there were 1-Mbps and 10-Mbps home phone-line networks, which were replaced last year with Ethernet. I haven't had the nerve to go up into the attic to draw wiring through the walls, so we have one 100 Base-T network running upstairs and another running on the main floor of our house. Connecting the two is a 75-foot long patch cable that runs from the upstairs hub to the main hub on the main floor.

The Xerox Phaser 1235 is a" big sucker" that sure can crank out pages! See how it dwarfs its Dell OptiPlex neighbor in my home-based network.

Both Marc's and Bryan's computers are attached to the upstairs hub, which is a 3Com Home-Connect 10/100 Base-T Ethernet hub. Karin's room is too far away for a patch cord. The downstairs hub originally was a 3Com Home-Connect, but it didn't have enough ports to support everything that is connected to the network. That hub has been replaced with a Kingston dual-speed 10/100 Base-T hub with 16 ports. Five PCs in my home office are plugged into the hub, one of which is the Dell OptiPlex that serves as the StarBand server.

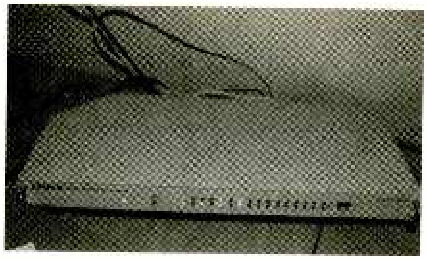
PURE PRINTING POWER

Our home network utilizes a Xerox Phaser 1235 color printer that is connected to the main hub and can be printed on from any of the five PCs attached to the network. This is a perfect printer for a network, though at about $3500, it's pricey for home use. However, it is one of the nicest color printers I've ever had the pleasure of using. Rather than a laser, the imaging system uses LED arrays that allows the printing stations for the four colors (Cyan, Magenta, Yellow, and Black) to be placed one after another. As a result, the printer prints a color (at 1200-dpi resolution) in one pass, rather than the four passes most color laser printers need.

Because everything is printed in one pass through the engine, the Phaser 1235 is FAST! When printing monochrome, it spits out pages at almost its full 20-ppm rated speed. Color pages also pop out quickly, with Xerox rating the print speed at 12 ppm. Lots of color lasers that I've tested in the past take quite a while to churn out that first page when you start printing. Not so with the Phaser 1235; it prints the first page within 45 seconds or so of when you click on PRINT.

WIRELESS INVESTMENTS

Home networking often presents challenging obstacles. A multi-level



The 16-port Kingston Dual-Speed 10/100Base-T Ethernet port is compact, with enough ports to accommodate our growing network.

dwelling means long cable runs. Home-based LAN designers must strike a balance between looks and practicality. In order to please my children, I use a hybrid of cable and wireless technology.

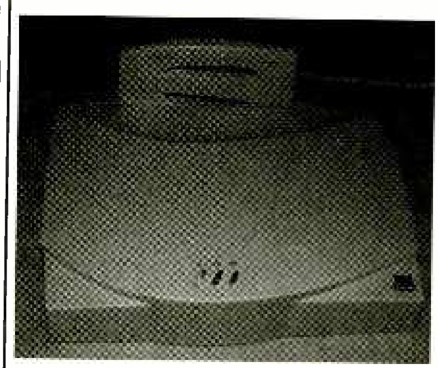
Scott's room is on the opposite side of the house. A long patch cable connects his PC to the network. When we get some time in the next few months, we'll run some Category 5 cabling in the basement to connect his room and the hub. If you want your network routing to be clean and professional, then the time must be taken to conceal the numerous cables. That's the case, unless the décor you are striving for resembles the inner workings of a communications center.

The current network solution left my daughter, Karin, without high-speed access on the PC in her room. A third network was created in the house—this one is wireless. The system is an 11-Mbps 3Com AirConnect wireless RF network. Conforming to both Wi-Fi and 802.11b High-Rate standards, it uses an AirConnect Hardware Access Point that's simply plugged into the Kingston hub downstairs and wireless Ethernet adapters. The AirConnect Network Starter Kit includes the Hardware Access Point and three wireless adapters in PC Card (PCMCIA) format. Karin's PC has one of the optional PCI card adapters in it, as does a Micron loaner system in the basement. The AirConnect Network Starter Kit is expensive ($1795); however, it does provide excellent coverage, and it worked right out of the box without an extensive setup. We also have several laptops that all can now connect to the StarBand service, via AirConnect, as well.

A WORK IN PROGRESS

While StarBand doesn't yet "officially" support multiple users over a network, it "un-officially" recommends the *WinProxy* software for those who are attempting to network. We haven't needed it yet. Instead, we set up the Dell OptiPlex as a proxy server, assigning it an IP address and the Gateway setting of 255.255.255.0. Each PC on the network also has an IP address, which is the same as the proxy server except for the last digit.

Setting up *Internet Explorer* to connect to the Internet through a LAN and supplying the IP settings of the



The 3Com AirConnect Hardware Access Point lets us access the rest of the network without wire. It's perfect for those hard-to-reach PCs and laptops.

SOURCE INFORMATION

3Com Corp.
5400 Bayfront Plaza
Santa Clara, CA 95052
800-NET-3Com
www.3com.com
CIRCLE 100 ON FREE INFORMATION CARD

Kingston Technology Company
17600 Newhope St.
Fountain Valley, CA 92708
877-KINGSTON
www.kingston.com
CIRCLE 101 ON FREE INFORMATION CARD

Xerox Office Printing Business
26600 Southwest Parkway Ave.
Wilsonville, OR 97070
800-835-6100
www.xerox.com
CIRCLE 102 ON FREE INFORMATION CARD

Proxy Server (i.e. the Dell) allows the browser to go to the Proxy Server and connect via StarBand—which is always accessible. At the moment, AOL doesn't run through StarBand, though I can check my AOL account using *Internet Explorer* and AOL Anywhere. The network is not sophisticated, but it was quick and easy (and so far, has worked well).

There are two things that are still in the experimental stage. The first of these is e-mail. StarBand provides up to ten e-mail accounts for each installation. So far, I have had only marginal success trying to use my MSN e-mail account. Most of the time, I have to go to MSN though a telephone connection to read or send mail from this account.

The second experiment involves firewalls. Now that we have "always on" Internet service, I'm kind of worried about being hacked. We're going back and forth right now between Zone Alarm (which is a terrific free application available from ZoneLabs at *www.zonelabs.com*) and Black Ice Defender. We haven't made up our minds whether to stay with a software firewall or to give one of the new generations of hardware firewall/routers a try.

That's all grist for another column. If you've had experience with either type of firewall—good or bad—I'd appreciate an e-mail message. Contact me through the address given at the top of this column.

TED NEEDLEMAN

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Going To The Ball

While the almost ubiquitous mouse is the primary way to move a cursor around the screen, it's certainly not the only choice you have these days. For example, laptops pass the mouse up for a fingertip-sensitive piece of conductive plastic called a touch pad or, perhaps, a tiny joystick-like pointing stick. For Apple Macs or most PCs running Windows or other graphical-user interface, the standard cursor control choice still falls to the rodent-named device. Mice have gotten better, with a new generation of optical mice hitting the streets that provides better resolution than their mechanical cousins. And optical mice don't usually need to be cleaned as frequently as a mechanical mouse.

SYNTHETIC MOUSE GUTS

From a design standpoint, a mouse is a fairly simple device. A small ball in the base rolls over the surface of a mouse pad. Two sensors in the mouse—one for the X-Axis and the other for the Y-Axis—feel movement in these axes. They then generate a signal that is sent to the PC and decoded to drive the cursor in a vertical/horizontal direction on the screen.

An optical mouse works pretty much the same way, except that it doesn't need a special surface that provides the traction required to turn a ball in the base. Instead, two beams of light are bounced off any surface the mouse is moved on, with photoelectric sensors tracking X and Y-Axis movement. The biggest problem with the mouse is that it requires a fair amount of desk space to operate.

The Marble Mouse is affordable and easy to use—whether you are left- or right-handed.

Even if you have one of the new optical mice, you'll still need the better part of a square foot of clear desk space to move it in.

DÉJÀ VU

With recurring bouts of "Tennis Elbow" caused by excessive keyboard and mouse use, I've been searching for ways to reduce the *RSI* (Repetitive Stress Injuries). There are lots of helpful accessories available, including wrist supports for keyboards and special mouse pads with a support that places your wrist in a less vulnerable position. With the growing amount of computer use these days, that cute-sounding little input device is causing more distress than its namesake in the form of RSI. It seems like even mechanical mice can be somewhat harmful to your health.

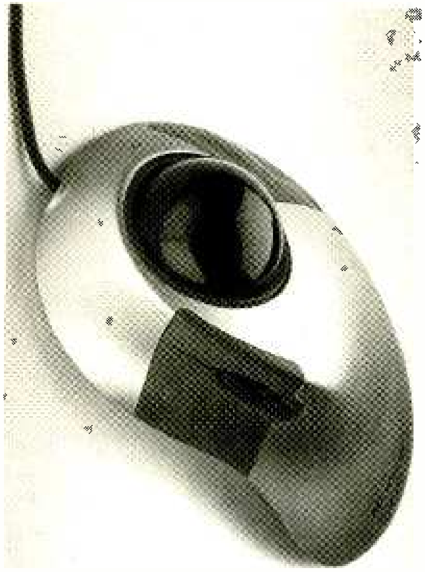
Perhaps one of the best ways to cut down on wrist strain, however, is a mouse alternative that's been available all along—the trackball. Actually, the trackball (a small device with a ball sticking out of it that moves a screen cursor when rolled) was in use as a cursor-control device long before the mouse was even thought of. With the original air-traffic-control computers and those computers originally used in missile tracking and defense, the preferred input device was either a light pen or a trackball.

It wasn't until Doug Engelbart (a scientist at the Stanford Research Institute in Menlo Park, California during the 1960s) turned the trackball upside down, that the mouse was born. Engelbart's re-thinking of the trackball was adopted for use in an office computer system being developed at Xerox's Palo Alto Research Center. This system featured a graphical-user interface. While it never saw commercial sales, it did inspire Steve Jobs over at Apple Computer to adopt this type of interface, and controller, for Apple's LISA and Macintosh computers. The LISA, priced at $10,000, was not a huge success. But the Mac and its mouse both were.

Still, trackballs never quite disappeared from the scene, though they proved much less popular with users than the mouse. For one thing, they were somewhat clunky, with most mice offering considerably more precision in positioning the cursor. For another, they were not quite as intuitive to use. With a mouse, when you move your hand, the cursor moves. With a trackball, you move the ball with your fingertips or thumb—it's a much more subtle correspondence.

SCOUTING OUT TRACKS

The latest generation of trackballs improves on the precision,



Microsoft's Trackball Explorer looks great and operates smoothly.

though the correspondence difference still remains. Given the proliferation of alternate cursor-control devices such as the touch pad, making the switch to a trackball these days is much easier than it was previously.

The recent resurgence in trackballs is largely the result of new products introduced by two giants—Microsoft and Logitech. Both of these companies have re-engineered the trackball using optical technology and a specially printed ball. The designs from both vendors bounce beams of light off the ball. These beams track both fore and aft movements, as well as side-to-side movement, to derive the actual direction that you are trying to move the cursor on the screen. Resolution is very fine, in fact much greater than most mice.

Microsoft produces a pair of optical trackballs, the $49 Trackball Optical and the $79 Trackball Explorer. Both use the same optical-tracking system and the same scroll wheel that Microsoft now offers in its IntelliMouse. The largest difference is in the placement of the large ball. The less expensive Trackball Optical is designed to put the ball under your right thumb. The two buttons are pretty much in the same place that they are placed on a standard mouse, so the learning curve in coming up to speed on this particular design is very short.

The more expensive $70 Trackball Explorer has a ritzy silver case, but the major difference is the placement of the trackball in the center of the device. This means that you need to move it with tips of your middle and index fingers, which takes a bit of getting used to. On the plus side, someone who is left-handed can use this trackball as easily as someone who is right-handed. Action on both trackballs is smooth as silk, and both models offer a dual-use connector so you can plug the trackball into a standard PS/2 type mouse connector or USB port. Software is included for both Windows and the Mac OS.

Logitech has three new models, the Cordless TrackMan FX, Cordless TrackMan Wheel, and Marble Mouse USB. As you might infer from their names, the two "Cordless" models use a radio-frequency transmitter to eliminate the cord. A small receiver plugs into the USB port on a PC or Mac, and batteries in the trackball will power the unit for months. The major differences between the $79 TrackMan FX and $59 TrackMan Wheel are the placement of the large trackball. As with the two Microsoft models, the more expensive TrackMan FX places the ball in the center of the unit, where both left- and right-handers can use it easily. The less expensive TrackMan Wheel is designed very much like a standard mouse, with the trackball under the thumb of a right-handed user.

If you're a lefty, you don't necessarily have to go for the more expensive model in each of the lines. Logitech also offers a very reasonably priced $29 Marble Mouse. Almost exactly the same size as a standard mouse, the Marble Mouse is a wired controller that plugs into a USB port on a PC or Mac. The trackball is slightly smaller than on the other two Logitech models, but it sits smack in the center of the unit, where both lefties and "righties" can use it with equal aplomb. I've found that the Marble Mouse also makes an excellent replacement for that track pad on my laptop. Now that I'm finally getting used to the trackball, it's much more accurate than the track pad and much easier on my wrist than a standard mouse. It also has the added benefit of not needing any desk space to be moved around in.

FREEDOM OF CHOICE

Not everyone will appreciate the trackball. However if you're starting to hate your mouse, give it a try. Even die-hard fans of mice might want to see how the "other half" has been living. With today's ever-changing technologies, there is a strong possibility of both the mouse and track ball dissolving into folklore. Only our imaginations can limit the possible designs for user interfaces of the future. Who knows what's cooking in the cauldrons of the tech industry? **P**

SOURCE INFORMATION

Logitech
6505 Kaiser Drive
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Microsoft Corporation
One Microsoft Way
Redmond, WA 98052
425-882-8080
www.microsoft.com
CIRCLE 111 ON FREE INFORMATION CARD

You've Got Mail!

BOB ZILLER

Don't run through bad weather only to find that the mail hasn't been delivered yet—have this simple audio annunciator tell you when "The mail's in!"

We take mail delivery for granted when it is put in the mailbox outside the front door. What if your rural delivery is to a mailbox 100 feet from the house? How about a situation where your driveway winds behind some trees? Suppose your driveway is a tad long—on the order of a quarter mile? It's tiresome checking on the mail during a winter storm and finding that it is not yet delivered. Some form of delivery announcement would be helpful.

To that end, we present the *Remote Mail Announcer*. This project takes the approach that should be almost obvious to the average electronics hobbyist. This "no-brainer" arrangement makes for a simple weekend task—installing a magnetic-reed switch for sensing when the mailbox door opens and closes and connecting it to a sensing circuit in the house. Now, you've got a reliable system to alert you when (to use that dreaded phrase made popular by a certain on-line computer service) "You've got mail!"

How It Works. Let's take a look at the all solid-state circuit (except for the switch, of course) and discuss the obvious and not so obvious features.

The schematic diagram for the Remote Mail Announcer is shown in Fig. 1. A "thumbnail" description might read something like: "A magnetic-reed switch, S3, is mounted in the mailbox. That reed switch is a normally-closed type that is held open when the magnet mounted in the door is in close proximity. It

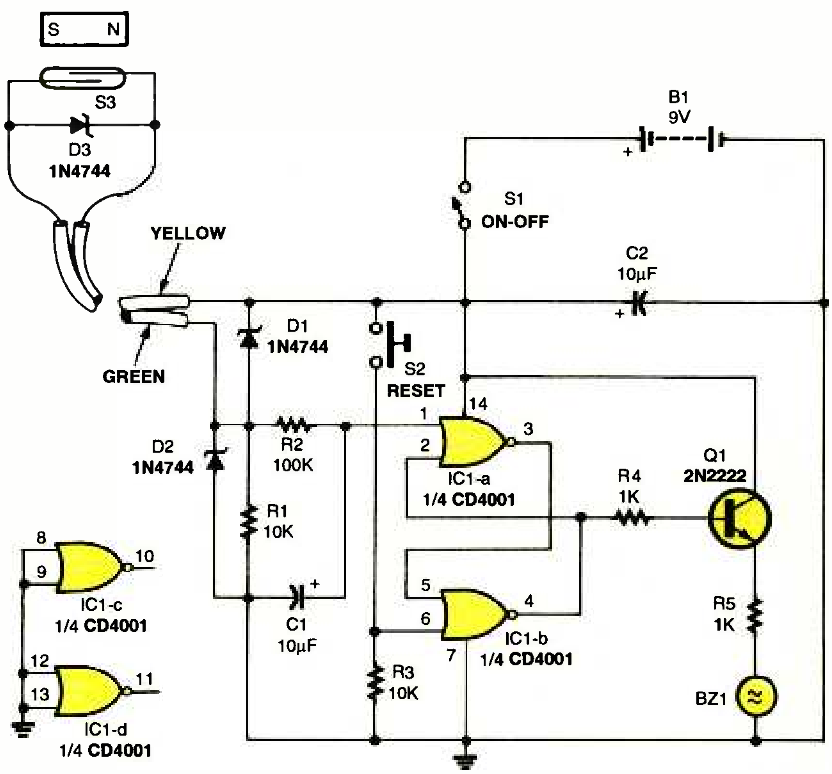
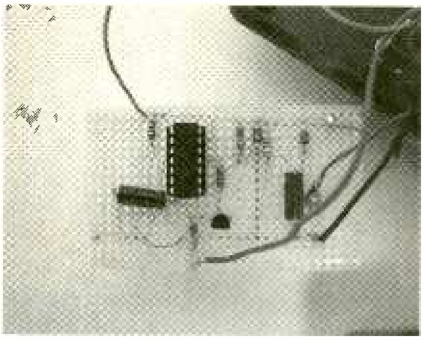


Fig. 1. The Remote Mail Announcer uses a simple flip-flop circuit. When the mailbox door opens, S3 triggers the flip-flop. Transistor Q1, in turn, powers the alarm.

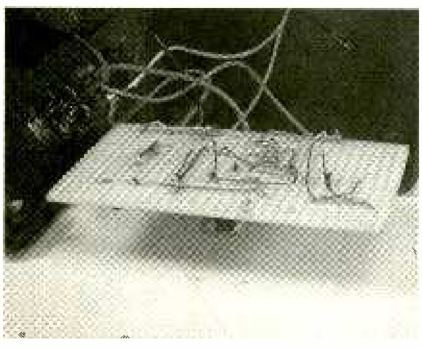


The circuit fits on a small piece of perfboard. Cut to the right size, the board can fit in the retention slots of an experimenter's project box.

operates a flip-flop made from two CMOS NOR gates. The flip-flop output drives a 2N2222 transistor that activates a piezoelectric buzzer. Once activated, the reset switch is pushed to reset the flip-flop and turn off the buzzer."

Let's go back and look at the circuit in greater detail. This time, I'll point out some of the not-so- obvious design details.

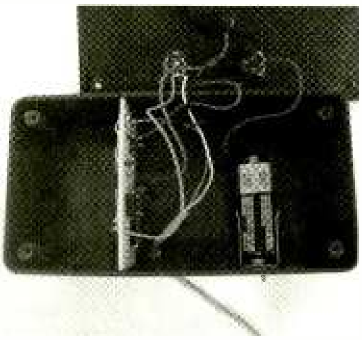
We'll start with the use of Zener diodes. Reed switches are almost as sensitive as transistors when it comes to violating their parameters of voltage, current, and wattage. In my installation, the mailbox was 100 feet from the house. A wire that long is begging to conduct a static charge for the sole purpose of destroying S3 or IC1—possibly both at the same time. After all, both conductors going to the mailbox are easy prey to static electricity from storms. Ground isn't ground when sleet and lightning currents discharge throughout the area. To protect the reed switch, a 15-volt Zener diode (D3) is placed directly across the switch terminals. Additional diodes (D1 and D2) protect IC1.



By carefully placing the components, you can use their leads as circuit traces without having to cut, trim, or use additional wire.

Capacitor C2, obviously not needed to smooth out the 9-volt battery voltage, helps keep static-induced voltage fluctuations picked up by the long conductors from entering pin 14 of IC1 and tripping the flip-flop into the opposite state.

A low-pass filter, made from C1 and R2, serves two purposes. First, it prevents very high frequencies from triggering the flip-flop. Second, it gives a ¾-second delay when the mail-box door is opened. Knowing this, one can throw in a piece of mail and close the door before the buzzer is activated—handy when depositing mail for pickup.

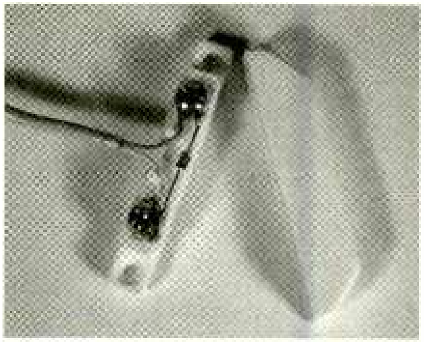


The Remote Mail Announcer fits in a RadioShack project box with room to spare.

During my development of the Remote Mail Announcer, the single most important requirement I had was to minimize battery load. Only the quiescent wattage (0.01 microwatt) of IC1 and the leakage current from Q1 draw current from the battery while waiting for the mail to arrive. When the buzzer (again, selected for its power-sipping properties) is activated, the circuit draws about 1 mA intermittently as it switches on and off at one-second intervals.

Initial designs had an LED in parallel with the buzzer, but experience showed that the flashing light is ignored unless accompanied by an audio signal. So much for Man being a "visual-centric" creature. Well, maybe just a bit inattentive at times...

Construction. Building the Remote Mail Announcer is simple and straightforward. I used a piece of perfboard measuring about 1½ by 3 inches and standard construction techniques. In fact, if you choose



The reed switch at the mailbox has convenient solder tabs for connecting D3 where it's needed most—to protect the reed switch.

component placement carefully, you can simply bend the leads over and shape them as needed to act as "copper traces."

Of course, you can design and fabricate a printed-circuit board to hold the components. That task is beyond the scope of this article and is left up to the ambitious reader.

Choose a suitable plastic enclosure to hold the board, a battery, the buzzer, and two panel-mounted switches. I chose a RadioShack enclosure measuring 3 inches wide on the inside. That particular enclosure has ribbed guides on the inside that are perfect for holding a 3-inch-wide circuit board.

Mount a 9-volt-battery clip inside the case. Switches S1 (a toggle switch) and S2 (a momentary- contact push switch) are mounted to the enclosure's front panel. I drilled an additional ⅜-inch hole centered where the buzzer will be glued. if you wish, you may drill a fancy pattern of holes to create a "speaker grille" of your own design. Feel free to let your "creative juices" flow! On my unit, I found that the buzzer was uncomfortably loud to the point where I placed a small piece of electrical

The completed Remote Mail Announcer is ready to tell you when to trek out in the snow, rain, or cold, because "You've got mail!"

The author's mailbox installation. At this point, the Remote Mail Announcer is beeping like mad!

tape over my single-hole grille.

While the adhesive on BZ1 is drying, head outside and start playing "lineman." Although only two conductors are required, I used the indoor/outdoor variety of four-conductor telephone wire. I chose that type of wire because it was the cheapest wire I could find that's rated for outdoor burial.

Since only two conductors are needed, speaker cable might be cheaper, but I have not seen specifications on how the insulation deteriorates (or doesn't) in the ground. While it might work just fine, I don't feel like experimenting; would *you* like to dig up several hundred feet of wire for the sake of saving a few bucks? I know I don't.

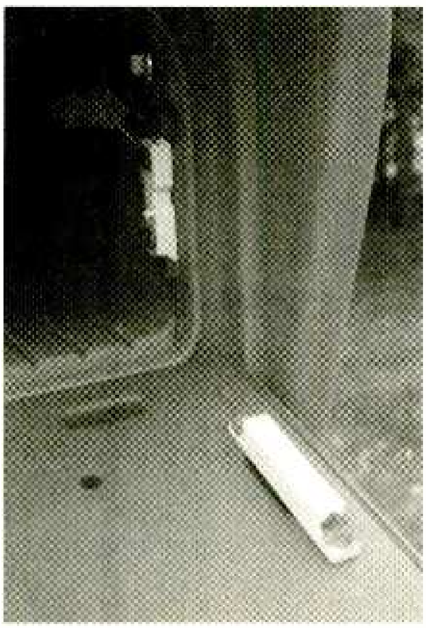
When selecting the reed switch, make sure that it is the normally-closed variety. I used switches from RadioShack. They carry both normally open and normally closed types in identical packaging. Be careful to select the right version; I found the instructions printed on the back of the package to be confusing.

Solder D3 to the tabs provided on S3. Keep everything neat and close to the switch assembly so you can replace the switch assembly cover without interference. Mount the magnetic reed switch and magnet in your mailbox so that they trigger as the mailbox door is opened and closed. Whatever method you use to secure the switch assembly, make sure that it's *secure*. You wouldn't want your switch torn from its location if a lot of mail is thrust in.

Make note of the wire colors you're going to use. This is important because of D3's polarity. When you wrap the wires around the contact screws of S3, note which wires connect to D3's anode and cathode (banded side).

Run the wire from your mailbox to your house, burying it about two or three inches below ground. Route the wire to a convenient place in the house—mine is in the kitchen—where the on-off and reset switches can be easily reached and where the buzzer can be heard. When you connect the other end of the wire to the circuit board, double-check that you're not reversing D3 (out at the mailbox) by accident. If you get it backwards, the system won't work properly.

Operation. With the mailbox door closed, connect a fresh battery. Turn the unit on with S1; all should be quiet. When the mailbox is opened, the alarm should sound. It should continue to sound either until power is removed or S2 is pressed. Obviously, having an assistant makes doing that test easier.



This closeup of the reed switch installation shows the liberal use of two-part epoxy to secure the switch and magnet in place.

PARTS LIST FOR THE REMOTE MAIL ANNOUNCER

SEMICONDUCTORS

IC1—CD4001B quad two-input NOR gate, integrated circuit
Q1—MPS2222A NPN silicon transistor
D1–D3—1N4744 12-volt Zener diode

RESISTORS

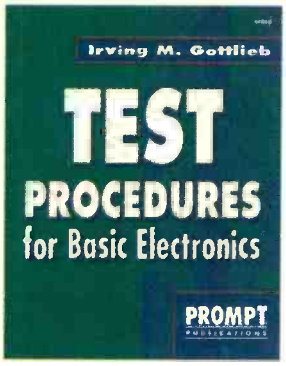
(All resistors are ¼-watt, 5% units.)
R1, R3—10,000-ohm
R2—100,000-ohm
R4, R5—1000-ohm

ADDITIONAL PARTS AND MATERIALS

B1—9-volt battery
BZ1—Piezo buzzer (RadioShack 273-066 or similar)
C1, C2—10-µF, 35-WVDC electrolytic capacitor
S1—Single-pole, single-throw toggle switch
S2—Single-pole, single-throw momentary-contact push switch
S3—Single-pole, single-throw, normally closed reed switch with magnet (RadioShack 49-533 or similar)
Battery connector, battery holder, enclosure, outdoor-grade two-conductor wire, hookup wire, hardware, etc.

Battery life should be several months unless the buzzer is left on for many hours. The on-off switch is used to disable the circuit during vacations.

This circuit has been used throughout one Wisconsin winter. It's nice to know that no useless trips are necessary during a 20° below zero blizzard.



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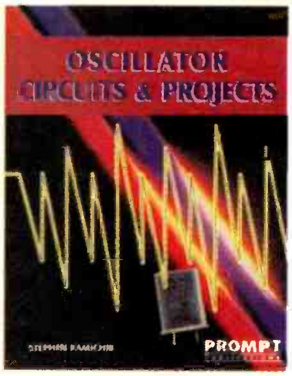

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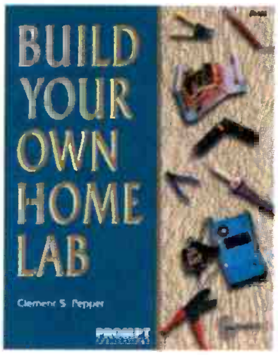

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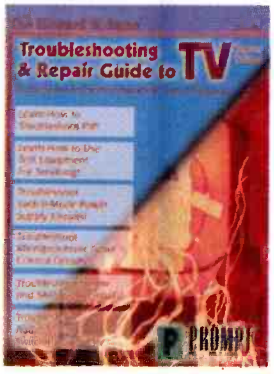

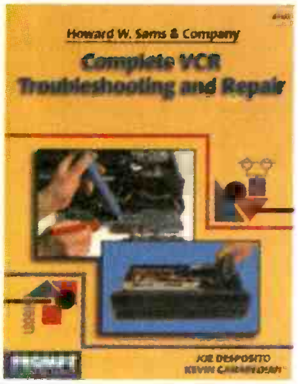

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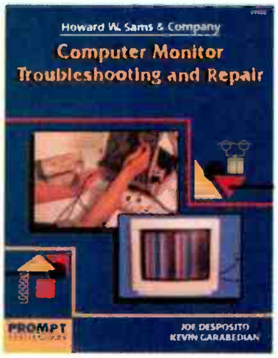

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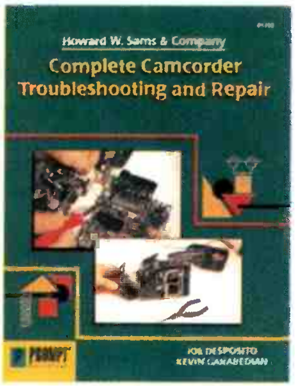

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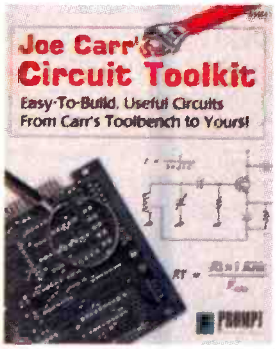

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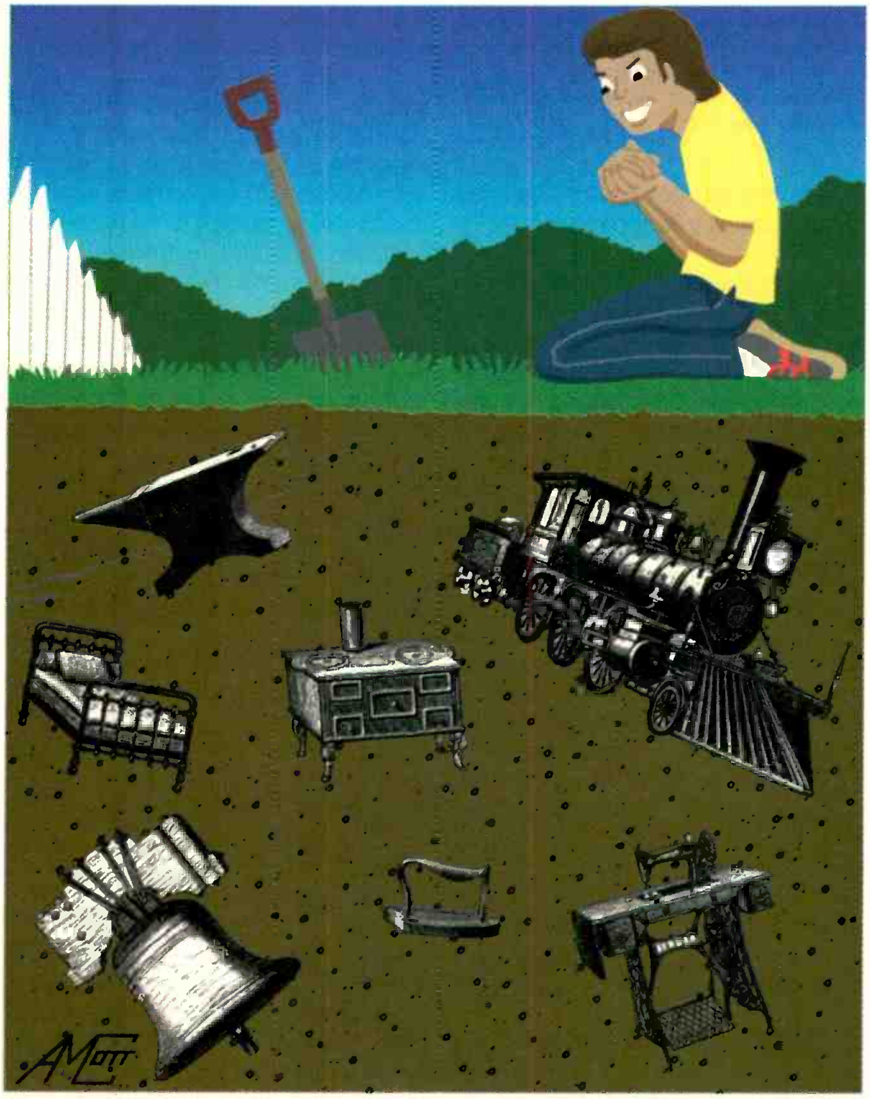
CL04

Search for ferrous objects with a Fluxgate Magnetometer

There be iron in "them thar" buried treasures!

CARL MORELAND



The instrument of choice for the modern treasure hunter is, no doubt, the *metal detector*. Those "minesweeper lookalikes" have the capability of not only finding precious metals; but most can also provide some level of discrimination against unwanted targets such as pull tabs, foil, and other trash. The metal detector operates by generating a dynamic electromagnetic field and looking for disturbances in the field due to conductive objects. Another instrument, called a *magnetometer*, looks only at static magnetic fields (namely, the Earth's) for changes. Not all metals affect magnetic fields in an easily measurable way; the magnetometer is sensitive only to ferrous targets such as iron and nickel.

In most cases, the treasure hunter is trying to *eliminate* ferrous targets—or at least those that contain iron (such as nails)—and detect only gold, silver, copper, and their alloys. So why would anyone want a magnetometer that can only locate iron while totally ignoring gold? The answer lies in the things that sometimes accompany treasure. For example, a cache might be buried in a steel or iron container; placer gold is often found in highly magnetic black sand; and sunken treasure is often accompanied by iron artifacts. In fact, most of the sunken treasure ships found in the last 30 years were pinpointed with a magnetometer; and the "mag" is an obvious choice in detecting steel-hulled ships. So while the mag is not the sort of instrument a weekend coin hunter might use, it is certainly a valuable tool for other treasure hunters. Such a useful tool is the *Fluxgate Magnetometer* presented here. However, we're getting a bit ahead of ourselves. Let's start by looking at how magnetometers work in general.

The Basic Mag. The basic magnetometer consists of a sensor that produces a signal that is proportional to the strength of the magnetic field around it. The *proton-precession magnetometer* uses a sensor consisting of a bottle of distilled water or a hydrocarbon such as kerosene around which a coil of wire is wound. The coil is periodically energized to produce a strong magnetic field that aligns the "spin" of the hydrogen protons and effectively magnetizes the liquid. When the coil field is removed, the protons *precess*—an atomic "wobble" that occurs with a frequency

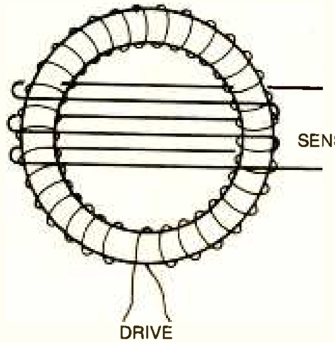


Fig. 1. In a fluxgate sensor, a donut-shaped core is pulsed with a field to saturate it. When the field collapses, the sense windings generate a current based on how much an external magnetic field rushes in to fill the void created by the collapsing drive field.

that is dependent on the strength of the surrounding ambient magnetic field.

Another type of magnetometer uses a device called a *fluxgate sensor*. The fluxgate consists of a magnetic core that is periodically hard saturated by a first coil (much like the proton liquid), while a second coil senses the resulting electromagnetic field. Figure 1 shows one such device: a toroid core with the energizing coil wound toroidally (spiralling around the donut) and the sense coil wound flat around the outside. Under normal conditions, the sense coil will not detect the field that is generated by the toroid because it will be balanced, assuming that the sense coil is symmetrically wound. However, an additional external magnetic field can cause an imbalance in the toroid's *hysteresis*, resulting in a net field that is detected by the sense coil. In this particular configuration, the sensitivity to the external field responds to the orientation of the sense coil with respect to the field.

Fig. 2. These fluxgate sensors, manufactured by Speake & Co., make using such devices a simple "plug and play" task.

A Cheap And Easy Sensor. A fluxgate sensor is a little tedious to construct; the sensing circuitry is rather difficult and requires an oscilloscope for proper adjustment. Fortunately, a ready-made fluxgate sensor (Fig. 2) that is incredibly easy to use is made by Speake & Co. in the UK and distributed by Fat Quarters Software on this side of the Atlantic. See the sidebar for contact information.

This FGM (*f*lux*g*ate *m*agnetometer) sensor is small—about 2½ × ⅝ inches—and has four 100-mil-spaced (0.1-inch) pins at one end. It can operate over a range of ±50 microteslas (μT) with a resolution on the order of about 10 nT (nanoteslas). This makes it extremely sensitive to very small field anomalies.

The pinout of this device, shown in Fig. 3, includes a feedback connection—useful for making linearity corrections to the device. Although that is an impressive feature to have, we don't need such scientific accuracy in our project. We only need to detect the *presence* of field anomalies, not to accurately measure their value. Therefore, we'll be using the Speake device as a true three-terminal device: 5-volt supply, ground, and output.

The output of the sensor is an easy-to-use 5-volt pulse whose frequency varies with the strength of the surrounding magnetic field, generally from about 50 kHz to 120 kHz. As with the nature of fluxgate sensors, the device is highly directional, meaning that it responds differently as it is rotated in free space. This poses a problem because directional variations with respect to the earth's magnetic field can easily swamp out any small anomalies that we might be looking for. One possible solution is to use two fluxgate sensors that are aligned in the same direction. They will both "see" the same absolute magnetic field regardless of orientation as long as they remain aligned to each other. If there is a local anomaly present, it will affect the closer sensor by a greater amount. Technically, this type of arrangement is known as a *gradiometer* because it detects magnetic-field gradients, but we will still refer to it by the more general term *magnetometer*.

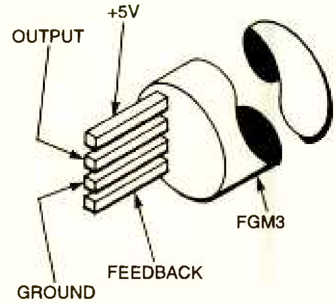


Fig. 3. The FGM-3 has four pins for connecting to an outside circuit.

Recall that the output of the FGM sensor is a pulse train in the 100-kHz range. Using two sensors, we can mix the two sets of output pulses to obtain a low-frequency difference signal. This type of arrangement is reminiscent of a BFO (*b*eat-*f*requency *o*scillator) metal detector, where two oscillators are mixed together and the method is to look for a shift in one of the frequencies caused by a metal target. In the same manner, we can directly mix the output frequencies of the two fluxgate sensors to produce an audible indication of a target. Figure 4 shows the schematic for such a digital "mixer". However, there is a better way.

The Circuit. Speake & Co. also makes a chip called the SCL007 gradiometer. It accepts the outputs from two fluxgate sensors and does the digital mixing for us. The output of the gradiometer chip is an 8-bit byte that corresponds to the mix frequency. A zero output means

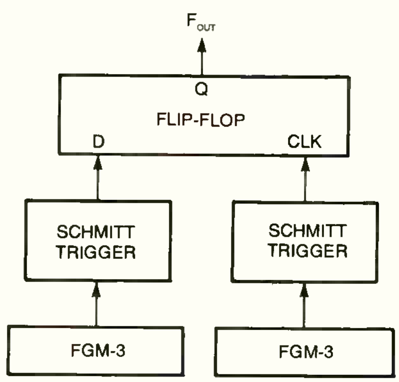


Fig. 4. A digital mixer takes the outputs of two fluxgate sensors and combines them into a difference signal.

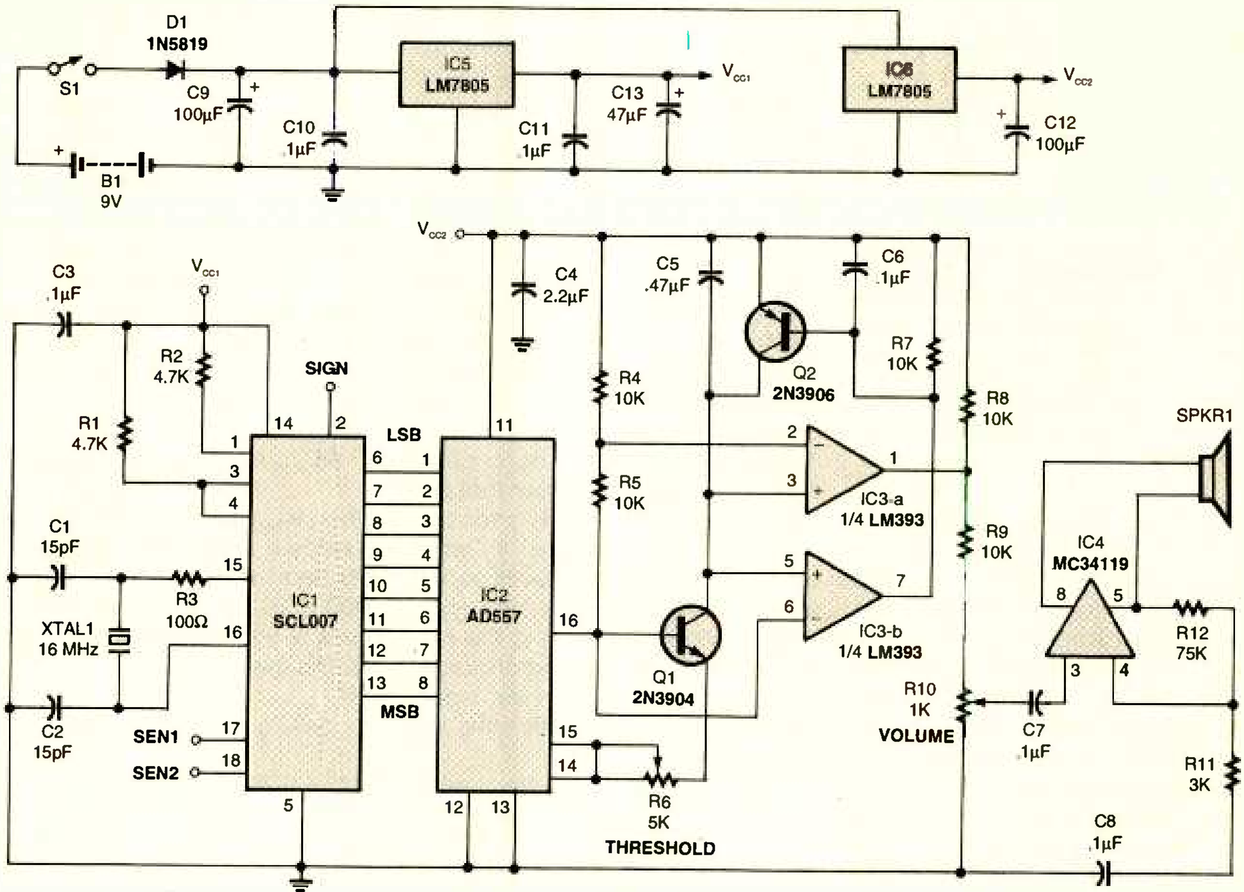


Fig. 5. The Fluxgate Magnetometer is a simple circuit, thanks to a sophisticated interface chip from Speake that handles all the messy "behind-the-scenes" work when dealing with fluxgate sensors.

that the sensors see the same field; a full-scale output means there is a large difference. The SCL007 also has a "sign" bit that can tell us which of the two sensors is detecting an increase in the magnetic field, making the total output a true offset-binary 9-bit word. We are not particularly concerned with the sign bit, although it could be used to determine which sensor is closer to the target.

To make immediate use of the 8-bit digital output, we must use a digital-to-analog converter (DAC) to produce an analog signal; and then we will use this voltage to produce an audible or visual signal. Since direct digital mixing will produce an audio-frequency signal without all of the intermediate mess, why bother using the gradiometer chip? Because it also provides a power-up calibration of the two sensors, improving sensitivity and making the sensors easier to use. The DAC can also directly drive a voltmeter, and the 8-bit output is useful for data logging to a computer.

Figure 5 shows the complete schematic for the final design. The gradiometer chip is basically connected according to the Speake & Co. data sheet. The Analog Devices AD557 DAC converts the 8-bit word to an analog voltage with a range of 0–2.5 volts. This voltage is then used to drive a voltage-controlled oscillator (VCO), which produces an audible tone that drives a speaker. Note that the sensors and gradiometer chip are powered by one regulator, while the DAC, VCO, and audio output have a separate regulator. This is an absolute necessity; any supply fluctuations that get to the sensors will cause them to misbehave. Further isolation is provided at each sensor with an LC (inductor/capacitor) filter on the supply line.

VCO. The VCO is the only part of the circuit that requires any further explanation. While there are integrated-circuit VCOs available, it is difficult to locate any that are very low power (below 1 mA) and readily available from hobbyist-friendly sources, such as mail-order houses. Thus, a simple—but effective—VCO was designed around the LM393 dual comparator.

Figure 6 shows a simplified diagram of the VCO. Transistor Q1 is inserted into the feedback path of

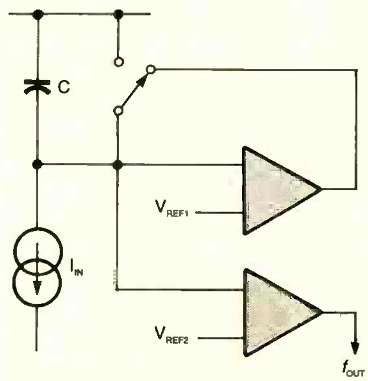


Fig. 6. This simplified model of a voltage-controlled oscillator (VCO) illustrates the principles behind the circuit built around IC3.

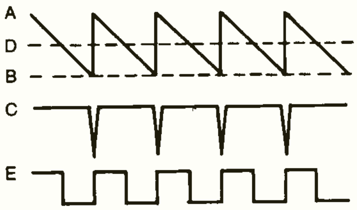


Fig. 7. The waveforms generated by the VCO include the ramp signal created by charging and discharging the capacitor (A). When the ramp falls to its lowest point (B), a series of spikes are generated by the first comparator (C), which control the discharge control on the capacitor. At a mid-voltage level (D), an approximate squarewave (E) appears at the output of the second comparator.

the DAC's output amplifier so that, with the DAC feedback resistors (about 1600 ohms total), it performs a voltage-to-current conversion for driving integrator capacitor C5. Therefore, the current drive from Q1 is directly proportional to the DAC's output voltage. Interestingly, the true DAC output voltage is not seen at the output pin (pin 16), but at the feedback pins (pins 14 and 15). This signal is brought out to a separate pad on the PC board (with an adjacent ground pad) so that it can be used as a true analog output. However, with the addition of threshold adjustment (R6), this voltage is not low impedance and should be buffered with an op-amp.

Integrating capacitor C5 generates a descending ramp voltage that is sensed by comparator IC3-b. See Fig. 7 for the relationship of the various waveforms about to be described. When the ramp voltage (A) falls below the reference on the negative input (B), the comparator output (C) goes low and turns on Q2. When Q2 short-circuits C5, the voltage at A pulls back up to V_{CC2}. The transistor shuts off, and the ramp starts all over again. Comparator IC3-a compares the resulting sawtooth waveform at A with a midpoint level (D) to generate an approximate squarewave (E).

The minimum output voltage of the DAC is zero volts when the sensors are balanced, which should result in a silent VCO. In reality, the sensors are never perfectly balanced, so the VCO is always running at some low frequency. It is actually desirable to have the VCO idle at a very low frequency. The reason for that is partly why the old *b*eat-*f*requency *o*scillators (BFOs) were tuned to run at a slow "putt-putt" frequency: the human ear is very sensitive to frequency changes. By running them at a very low rate, we are able to discern very minute changes. If we run it too low, we risk getting a rate change that is actually too low to distinguish. A nominal rate of 5–10 Hz is a good operating point. Obviously, this is below the frequency range of average human hearing (about 20 Hz on a good day). However, remember that the speaker waveform (E) is a squarewave, not a single tone, so what we hear are "clicks." Because the squarewave is rich in harmonic energy, slight variations in the fundamental frequency mean larger variations in the harmonics, resulting in an even more effective frequency change.

The resulting VCO frequency depends on the integrator current and capacitor value, according to the following equation:

$$f=I/\Delta V \times C$$

where ΔV is the full excursion of the ramp voltage and, as already mentioned, I is V_{DAC}/R_{DAC}. The reference to IC3-a is derived from a level-shifted version of V_{DAC}, so ΔV ends up being roughly equal to V_{CC}-V_{DAC}-0.7. Ignoring R6, we find that the frequency is:

$$f=V_{DAC}/(4.3-V_{DAC}) \times R_{DAC} \times C$$

When V_{DAC} is zero, the minimum frequency is zero. When the DAC is 1 LSB (*l*east-*s*ignificant *b*it) from zero (00000001 or 2.5 volts/256), we want a very low frequency, say 5 Hz. This means that

$$5=9.76 \text{ mV}/4.29 \times 1600 \times C$$

or C = 0.28 µF. The design uses 0.47 µF for C5, so the LSB frequency is actually 3 Hz. Again, you will probably find that the DAC output nominally runs a few LSBs above zero. The maximum frequency occurs when V_{DAC} is about 2.5 volts and is

$$f = 2.5/1.8 \times 1600 \times 0.47 \text{ µF}$$

or 1850 Hz. We end up with a full frequency range from DC to nearly 2 kHz, which corresponds to the strength of the detected gradient.

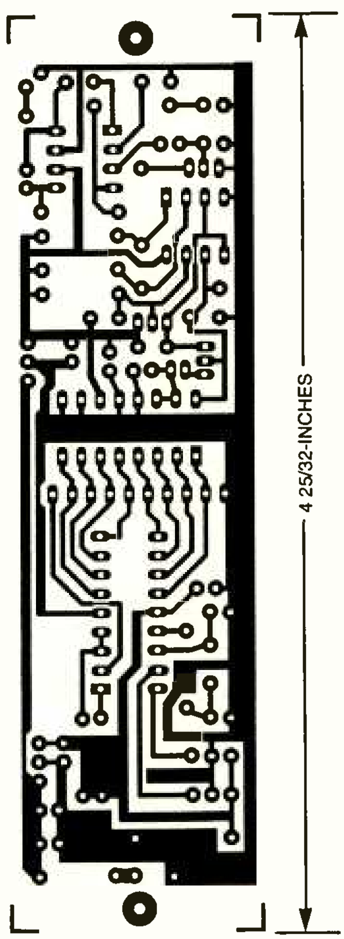


Fig. 8. The Fluxgate Magnetometer circuit fits neatly on a single-sided PC board.

Construction. Building the Fluxgate Magnetometer is easiest with a printed-circuit board. A foil pattern for a single-sided board is shown in Fig. 8. If you don't wish to etch your own board, one is available from the source given in the Parts List.

If you use a purchased board or one etched from the foil pattern, use the parts-placement diagram shown in Fig. 9 as a guide when installing components.

There is absolutely nothing difficult about the circuit portion of this project for an experienced hobbyist—just solder everything in place and you're done! Well...at least with the circuit portion of the project. You may use IC sockets if you wish (I do whenever possible) and 100-mil headers for plugging in the

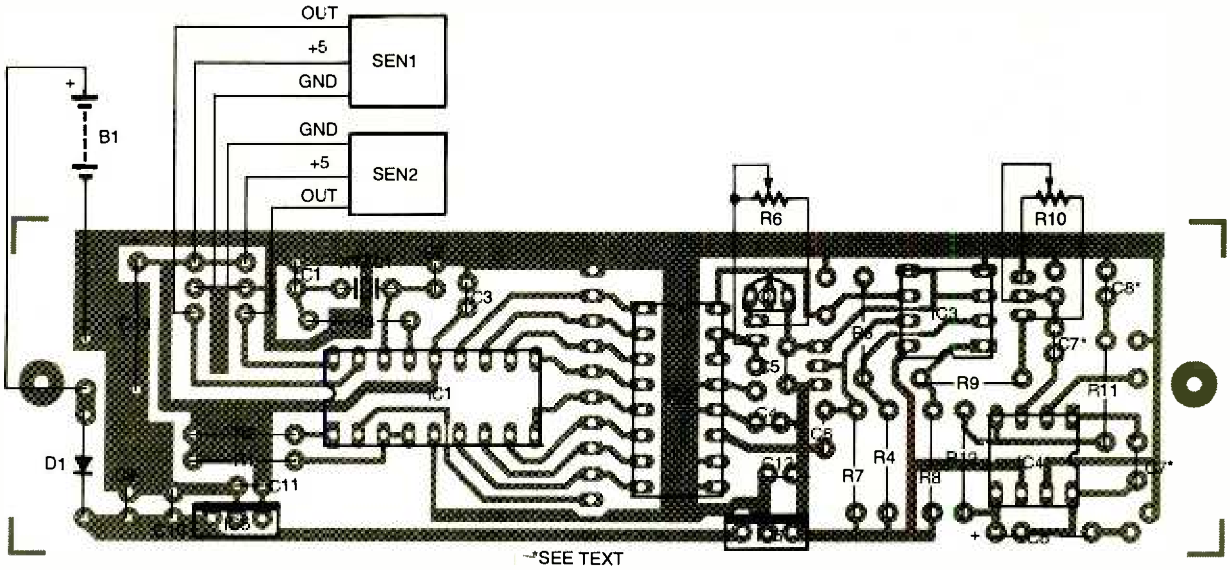


Fig. 9. Most of the components are soldered to the board. Only a few devices are connected by external wiring.

sensors leads. Those two little tricks will make assembly and disassembly (if ever necessary) a bit easier.

Note that the board includes pads for directly taking off the 9-bit data word (including the sign and a ground reference) and the DAC analog output for interfacing to other circuitry.

The Motorola MC34119 used for IC4 is a little difficult to find, so the PC board has been laid out to accommodate the more popular (and slightly higher power) LM386. Figure 10 shows the schematic for this variation. Note that you need to clip pin 7 off the LM386 and add a ground short for pins 2 and 4; pads are provided on the board. Furthermore, you need to select the correct values and locations for C7 and C8. The larger values are used with the LM386. There are also two sets of pads for connecting SPKR1; the LM386 variant uses the two pads at the very corner of the board.

The "Magic Wand." Building up the enclosure and the tube is not difficult either, but it does require more time and effort. You will need to obtain some 1½-inch PVC pipe from a local home-improvement center along with two end caps and a few other PVC components for the sensor modules. The length of the PVC will roughly determine sensitivity (up to a point), and 5–6 feet is a very practical length. You do not want it so long that the tube flexes; it is very important to maintain rigidity!

For the main circuit box, I used an almost perfectly sized plastic case from RadioShack (see the Parts List). You will want to avoid the use of any ferrous material in the construction of the Fluxgate Magnetometer, and the main tube should not be metal of any kind as eddy currents will be generated and seriously degrade performance.

Fasten the box to the center of the tube with two aluminum sheet-metal screws. Drill a ½-inch hole in the center through the bottom of circuit box and into PVC tube. Next, cut a three-wire cable for each of the sensors; I peeled off 3 leads of a ribbon cable. The cables need to be about 12 inches longer than half the tube length. Thread the cables from the circuit box out to each end of the tubes and temporarily tape them in place.

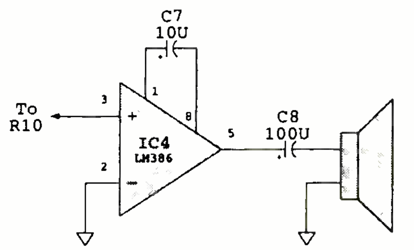


Fig. 10. If you can't find the suggested audio amplifier IC, you can substitute an LM386—cheaper and widely available.

With the three-lead cables pulled into the circuit box, finish the hookups to the board, including the panel-mounted controls and other components that mount off the board (battery, speaker, etc.). You may want to trim off some of the excess sensor leads, but leave them long enough so they project at least 8 to 12 inches from the tube. You should also mark on the sensor end which wire is supply, ground, and signal. Mount everything according to your preferences; my non-ideal solution is pictured in Fig. 11.

Magnetometer Mounts. The final step—the most difficult of the whole project—is to install the sensors in a way that they can be mechanically aligned. Sensor alignment consists of adjusting one of the sensors until it is perfectly on-axis with the other sensor. The method described by the Speake & Co. literature is to fix one sensor into the tube with "O-rings" and to mount the other sensor with an adjustment mechanism, as shown in Fig. 12. The "O-ring" provides a pivot point, and four external non-magnetic (nylon, aluminum, or brass) screws are used to make the necessary adjustments. I found this approach to be unsightly with the screws sticking out of an otherwise sleek-looking tube, as well as being

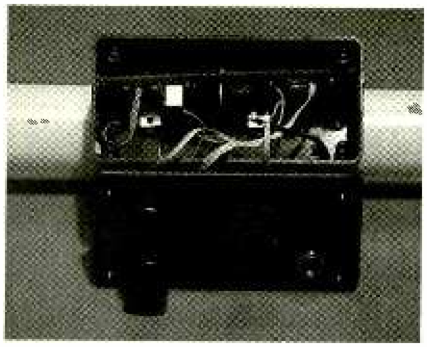


Fig. 11. Here's the author's completed control box mounted on the PVC pipe.

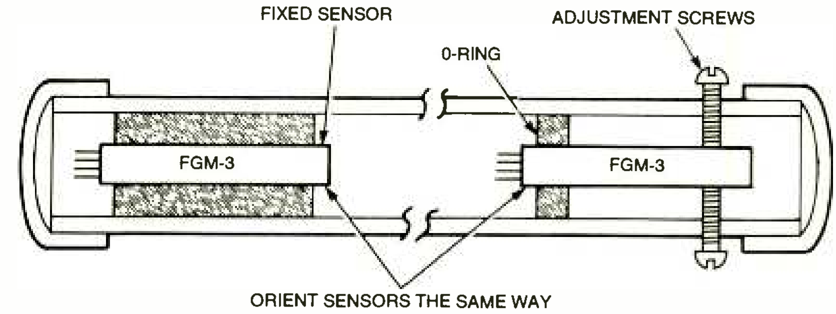


Fig. 12. Speake & Co.'s adjustment method, while functional, is not very practical.

subject to damage.

A better method is to place the adjustment mechanism entirely inside the tube. It just so happens that a 1-inch PVC coupler will very nearly slide into the inside of 1½-inch PVC pipe. Of course, that might vary slightly among manufacturers and production runs. Two modules, one fixed and one adjustable, can be made from couplers that are reduced to slide into the pipe. A cross-sectional diagram of that arrangement is shown in Fig. 13. One advantage of the sensor-module approach is that you can easily switch between tubes of different lengths.

To reduce the coupler diameters, several methods can be used depending on the facilities at hand. They can be turned in a lathe, sanded in a drill press, or shaved with a Sur-Form rasp. Just make sure that they fit snugly and remember that turning or sanding will warm the PVC coupler and cause it to expand slightly; let it cool before checking the fit.

For the fixed module, 1- × ½-inch bushings are inserted into both ends of a coupler; and short pieces of ½-inch PVC pipe are inserted into each bushing so they are flush. The FGM sensor will now slide into the assembly with a slight amount of clearance to the inside of the ½-inch PVC. One or two wraps of electrical tape around the FGM sensor will result in a snug fit. One potential problem with the FGM sensors is that the plastic covers eventually loosen (probably due to thermal expansion cycles) and the expoxied sensors slide out, so you should watch for this and apply some glue if necessary. Figure 14 shows the pieces of the fixed module disassembled, but properly aligned for assembly.

The adjustable module is made in a similar manner. One end of the module pivots, so it uses a bushing and ½-inch PVC just like the fixed module. One minor difference is that this module will be installed with the connecting pins pointing out of the tube, so we need to provide a path through the module for the wiring. Cut a lengthwise notch in the ½-inch PVC pipe for the wire to run past the sensor. When using electrical tape to shim the pivot end of the sensor, keep the width of the tape narrow (3/16 inch or so) so that the sensor will easily pivot.

The other end of the sensor needs some room for movement in the module. Use a 1- × ½-inch bushing, but not a piece of ½-inch PVC pipe. The bushing is drilled and tapped to accept two non-magnetic screws at 90° angles to each other. I used 6-32 nylon screws cut to length with the heads removed and new screwdriver slots melted in with a hot screwdriver. The screws look like nylon set screws. Opposite each screw is a piece of high-density foam to keep the sensor pushed against the screws. Figure 15 shows the adjustable module from the end with the adjustment screws. Note the notches that were cut in the coupler for accessing the screws.

The final step is to connect the sensors to the wires and slide the sensor modules into the tube. The wires are connected to the sensors through an L-C filter (L1-C14 and L2-C15, as shown in Fig. 16). I used a 100-mil header socket as a "plug" that slips over the sensor pins. Again, note the correct order of wires—that's why you labeled them before you put the wires in the tube, right? If you're not sure, use an ohmmeter to check the connections from board to sensor before power-up.

When you have the sensors connected to the wires, carefully insert them into their respective modules. The fixed sensor should be snug and secure with the lead connections pointing inward toward the control box as in Fig. 13. The adjustable module will be installed so both the lead connections and the adjustment screws are toward the outside end of the tube. The sensor wiring folds back through the module between the screws and through the slot in the pivot end. Slide both modules into the tube, making sure that the adjustable module protrudes just enough to access the screws. Both modules should have a fairly tight

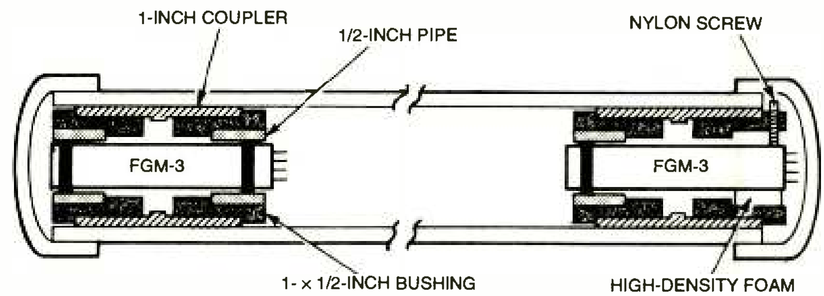


Fig. 13. While this method of mounting the sensors is a bit more complex, it does protect the sensitive mechanical adjustments from being accidentally "knocked out of whack."

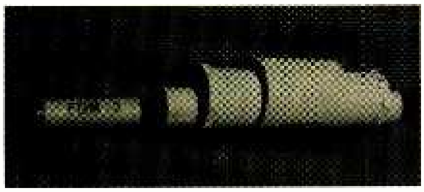


Fig. 14. The individual parts of the fixed module are ready for final assembly.

fit in the tube so they do not slide easily. If there is any looseness, apply some non-permanent adhesive before sliding the modules into the tube.

We are now ready for power-up and test.

Adjustment and Calibration. At this point, you could run off and start using the mag; but for optimal performance we need to make one easy mechanical adjustment. Recall that a single sensor is sensitive to its orientation within the magnetic field. For the two-sensor arrangement, the mixed-frequency output is sensitive to their misalignment to each other. If they are perfectly aligned, then each sensor will detect the exact same magnetic field (in the absence of a target); and the gradient will be zero even if the whole tube is rotated. If they are not aligned, then one sensor could detect a slightly different field. Worse, that will change with the movement and orientation of the tube. All calibration and alignment procedures should be done well away from undesirable magnetic fields, including iron targets and electrical (AC) lines.

Before we can align the sensors, we first need to allow the SCL007 to perform a sensor calibration. According to the Speake literature, the calibration is done during the first ten seconds or so after power-up, during which time it expects the sensors to see a minimum and maximum earth field. The described method is to hold the tube in a North-South orientation, pointing the north end upwards at the angle of the field's inclination. For example, the magnetic inclination in the UK is about 67° to the horizontal. In parts of the US, being somewhat south with respect to Great Britian, that figure is a bit less. Naturally, the figure is close to 0° at or near the Earth's equator. You'll have to search out that information for your particular location.

Switch on the power and slowly rotate the tube, head over heels, through 360° during the first ten seconds. That's all there is to it; this procedure should be done every time the mag is turned on for use.

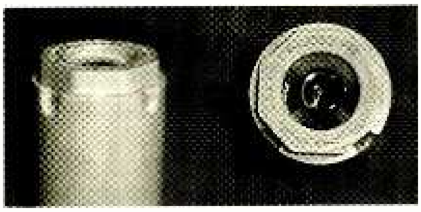


Fig. 15. Note how the adjustable-sensor assembly has notches cut for the adjustment screws.

To align the sensors, turn on the unit and go through the sensor calibration described above. Place the tube in an east-west orientation (and level) in a way that you can rotate or roll the tube. I built a simple wooden U-shaped stand with V-shaped notches cut in the uprights. With the tube in a starting position, listen to the output frequency. If there is no output sound or the frequency is less than 10 Hz, you may need to adjust the VCO to get an appropriate frequency. Slowly rotate the tube by about 180° and listen for a frequency change. If there is one, it indicates that the sensors are misaligned. I found an effective method is to rotate the tube to find the highest output frequency. With the tube held at that position, adjust the sensor to reduce the frequency. Continue until you can rotate the tube with little or no frequency change.

SOURCE INFORMATION

The fluxgate sensors and gradiometer chip are manufactured by:

Speake & Co. Ltd.
Elvicta Estate
Crickhowell, Powys
NP8 1DF
United Kingdom
Tel: 01873 811 281
Fax: 01873 810 958

Only the sensors and SCL007 are available from Speake; please call for pricing. For all customers in North and South America, the distributor for Speake & Co. products is:

Fat Quarters Software
24774 Shoshonee Dr.
Murrieta, CA 92562
909-698-7950
fqs.dconn.com
ekern@dconn.com

For the latest version of this article and discussion forum, please see the author's Web page at *tthn.com/geotech*.

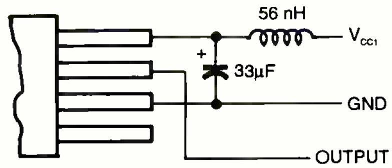


Fig. 16. A simple LC filter needs to be connected at the sensors themselves.

Options. The Fluxgate Magnetometer has only two knobs: "Volume" (R10) and "Threshold" (R6). The threshold knob can be used to reduce the minimum frequency at idle for better sensitivity. Doing that creates non-linearities in the DAC-voltage-to-VCO-current translation and reduces the maximum frequency somewhat, but neither effect is important for an audio magnetometer. You may choose to omit R6 and put a short (jumper wire) in its place.

As mentioned before, the PC board includes extra solder pads at the digital outputs of IC1 for interfacing to a computer. This permits use of the Fluxgate Magnetometer for more accurate mapping with appropriate software. That type of use is beyond the scope of this article, but the feature is available to the ambitious reader.

The analog output of the DAC also has convenient solder pads for driving another analog indicator. However, it is important to use a high-input-impedance buffer for this signal as any current drawn from this node will get applied directly to the VCO capacitor and cause large frequency errors.

The fluxgate sensors are extremely sensitive to magnetic fields, and the use of a moving-coil speaker for SPKR1 caused initial concern. However, I've found that the dynamic electromagnetic field of the speaker does not seem to affect the sensors. You may choose

PARTS LIST FOR THE FLUXGATE MAGNETOMETER

SEMICONDUCTORS

IC1—SCL007 gradiometer, integrated circuit
IC2—AD557 digital-to-analog converter, integrated circuit
IC3—LM393 quad comparator, integrated circuit
IC4—MC34119 or LM386 audio amplifier, integrated circuit (see text)
IC5, IC6—LM7805 5-volt fixed voltage regulator, integrated circuit
Q1—2N3904 NPN silicon transistor
Q2—2N3906 PNP silicon transistor
D1—1N5819 silicon diode

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1, R2—4700-ohm
R3—100-ohm
R4, R5, R7–R9—10,000-ohm
R6—5000-ohm potentiometer, linear taper
R10—1000-ohm potentiometer, linear taper
R11—3000-ohm (see text)
R12—75,000-ohm (see text)

CAPACITORS

C1, C2—15-pF, ceramic disc
C3, C6, C10, C11—0.1-µF, monolithic
C4—2.2-µF, 10-WVDC, tantalum electrolytic
C5—0.47-µF, monolithic
C7—0.1-µF, monolithic or 10-µF, 16-WVDC, electrolytic (see text)
C8—0.1-µF, monolithic or 100-µF, 16-WVDC, electrolytic (see text)
C9, C12—100-µF, 25-WVDC, electrolytic
C13—47-µF, 10-WVDC, tantalum electrolytic
C14, C15—33-µF, 10-WVDC, tantalum electrolytic

ADDITIONAL PARTS AND MATERIALS

B1—9-volt battery
L1, L2—56-µH inductor
S1—Single-pole, single-throw toggle switch
SPKR1—8-ohm speaker
XTAL1—16-MHz crystal
FGM-3 fluxgate sensors, battery clip, optional headphone jack (in place of SPKR1), enclosure (RadioShack 270-1803 or similar), 1½-inch PVC pipe, 5-foot length, 1½-inch PVC end caps, 1-inch slip couplers, 1- × ½-inch SxS bushings, ½-inch PVC pipe, IC sockets, pin headers, wire.

Note: The following items are available through Fat Quarters Software, 24774 Shoshonee Dr., Murrieta, CA 92562; 909-698-7950; *fqs.dconn.com; ekern@dconn.com*: Blank PC board, $7.75; FGM-3 sensor, $37.50; SCL007 interface IC, $24.50; AD557 A/D converter chip, $6.75; parts kit of all PC board components and IC sockets (does not contain potentiometers, above-mentioned ICs, or externally-mounted devices or hardware), $12.75. Checks and money orders only. Please add $5.50 for priority mail postage and handling. CA residents must add 7.75% sales tax.

to use headphones instead of or in addition to the speaker, or a piezo-based audio device, or a meter driven from the DAC analog output.

Using The Fluxgate Magnetometer. You can carry the Fluxgate Magnetometer in one of two ways: horizontal or vertical. Vertical orientation seems to be more sensitive, while horizontal can allow you to cover more ground by making a wider swath. In the vertical position, the sensor with the wires coming out towards the end cap (the adjustable module) is more sensitive and should be the one nearest the ground. When using the Fluxgate Magnetometer in the horizontal position, remember that a target signal could be coming from either of the two sensors. You will either have to determine this by moving the unit around, or you can use the sign bit from IC1 to drive an LED to distinguish the sensors. With a little practice, you should be proficient in no time. The Fluxgate Magnetometer is extremely easy to use and will make a nice (and inexpensive!) addition to your treasure-hunting arsenal.

One final piece of advice: don't forget your shovel, rakes, and other "implements of destruction" when you locate the mother lode! P

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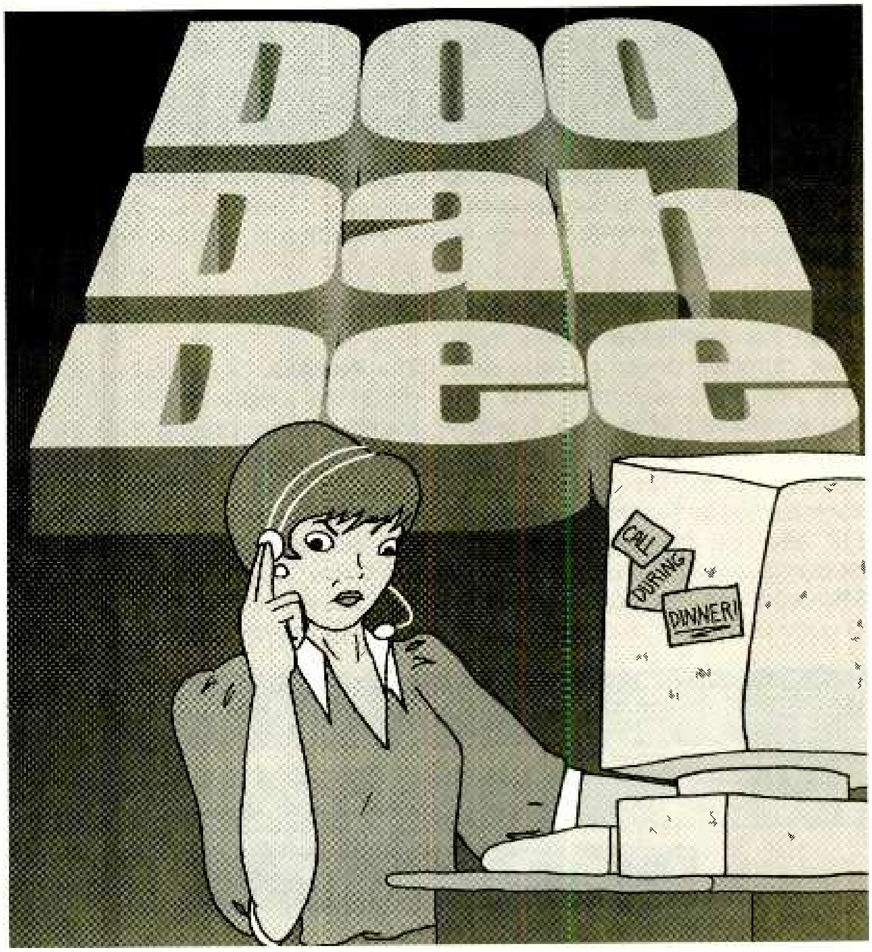
Telemarketers' Nightmare!

Find out how you can create a digital "shield" to protect yourself from those pesky telemarketers by using one of Ma Bell's built-in defenses.

JOHN CARTER

It never seems to fail. You're just sitting down for an evening meal, and the phone rings. Another one of those unwanted telemarketing "boiler rooms" is trying to sell you something—anything from soup to nuts! It's happening more and more frequently, and it will continue to grow as long as enough people bite. If you are sufficiently disturbed by this type of call, read on and discover a way to fight back using a dose of automated technology.

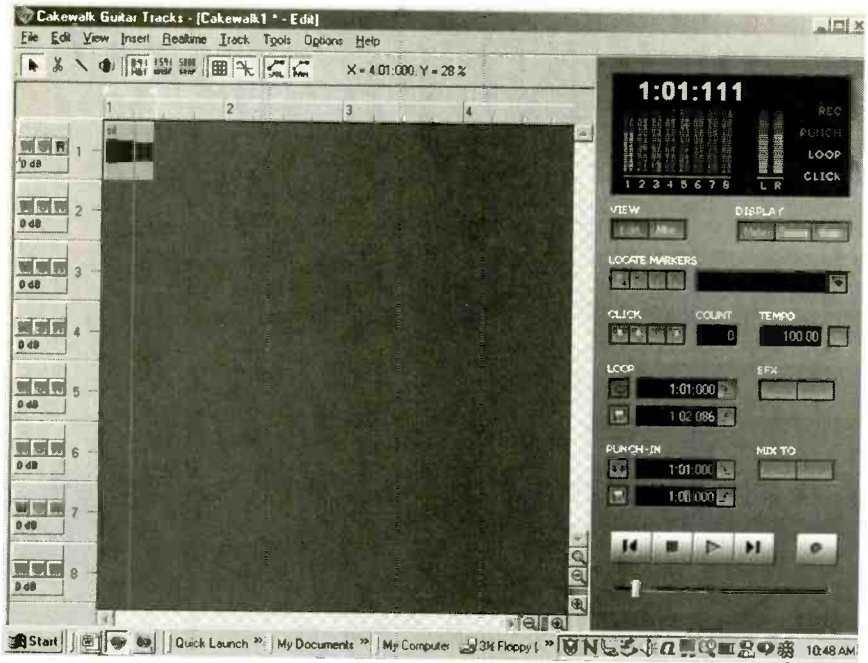


The Problem. Most telemarketers use predictive dialers. It's nothing more than a computer set up to automatically dial phone numbers on their lists. Once the computer determines that it has a live person on the line, the call is switched to an operator. Your name and number may appear on their screen, so the caller sometimes starts with asking for "Elmo" or "Gertrude" or whatever name your telephone is registered under. This switch to a live operator takes a second or so to happen. That's why you sometimes hear a pause after you answer a call. That pause is a dead giveaway that it's a telemarketer. Some even have the nerve to play a recording asking you to wait! Yeah, right!

Here's how the system works. When a telemarketer calls and you answer, their predictive dialer software monitors the audio. If it hears a short burst of audio—usually "Hello"—then a pause, it knows it probably has a live person on the line and routes the call to one of their operators. If it hears a longer message—like "Hello...you have reached the Jones residence," then it thinks it is an answering machine and hangs up the call. It also notes that this is a working number and to retry it later during a different time frame in hopes that it will catch you at home.

The Solution. Ma Bell has graciously provided us with a series of tones (doo...dah...dee) called Special Information Tones when you call a non-working number (see sidebar for more information on applications). Most predictive dialers recognize these tones and hang up right away since they don't want to waste their time on a non-productive call. As a side benefit, most predictive dialer software automatically removes the number from their list. Again, they do not want to waste their operator's or system time on non-working numbers.

By simply adding these tones as the first part of your outgoing



Here is screenshot of the Special Information Tone as seen in Cakewalk's "Guitar Tracks" sound-editor. The tones are descending in volume, but ascending in frequency. The tones are: 985.2 Hz, 1370.6 Hz, and 1776.7 Hz.

WHAT YOU'LL NEED

There is no need for semiconductors or solder for this project—instead you'll need some audio-editing equipment. Here is a short list of required items:

- A computer equipped with a sound card, speakers, and a microphone.
- Any audio-editing software (Windows *Sound Recorder* or the Mac's sound-control taskbar)
- An answering machine

If you have any difficulties when attempting to edit your greeting, you can e-mail your greeting via a .wav file attachment or send your greeting on an audio-cassette (this option requires a $3.00 return shipment cost). I will gladly blend the SIT tones with your greeting. The address is below.

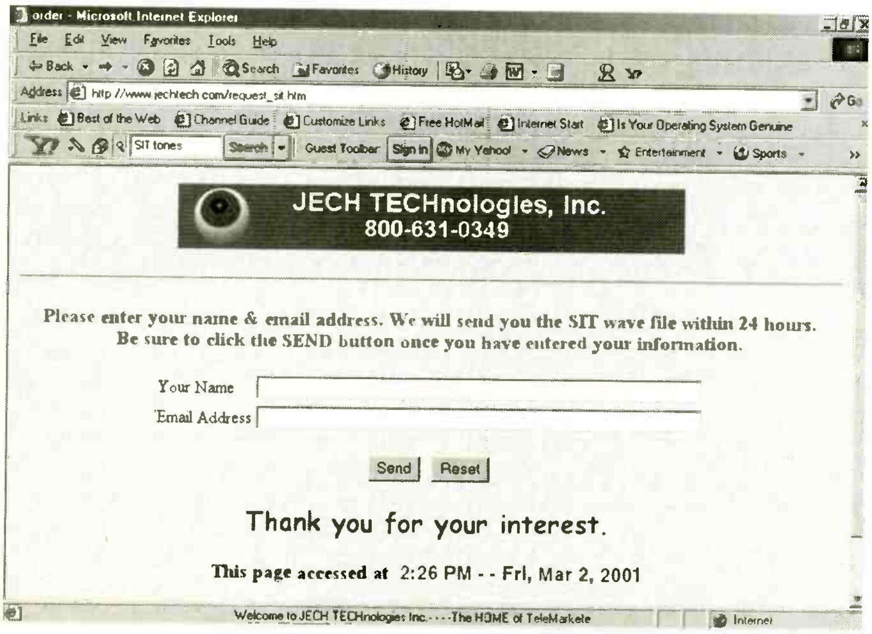
John Carter
JECH TECHnologies, Inc.
13962 Olde Post Rd.
Pickerington, OH 43147
800-631-0349

answering machine message you make the predictive dialers think your number doesn't exist, and they will remove it from their list. You've started your own "cleaning" process without lifting a finger! You can get the Special Information Tone audio file from the Gernsback FTP site at *ftp.gernsback.com/pub/pop/sit.wav*. That file, in the Microsoft .wav format, is playable on any computer or operating system with the appropriate software.

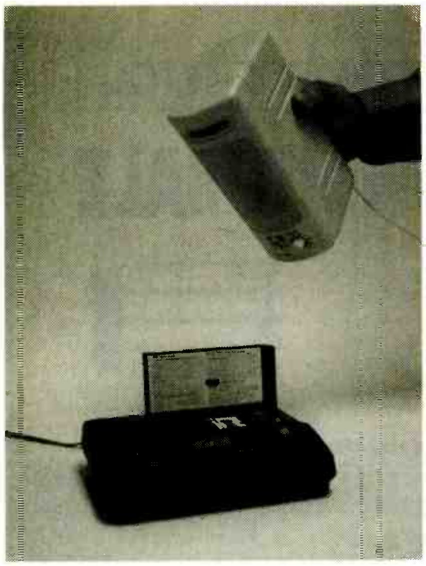
The Process. Once you've got the audio file, load it into your favorite sound-editing program, such as Windows *Sound Recorder* on systems running a version of the Windows operating system. Using the editor's browser, locate and load the file "sit.wav" that has been downloaded.

Next, play the file through to the end. The slide bar of the *Sound Recorder* program should move from left to right indicating that it's at the end of the file. You should have heard the audio file as it plays "doo-dah-dee." After the file stops, record your personal outgoing message by clicking once on the red RECORD button. You will need a microphone attached to your sound card to record your voice. Click on the STOP button when you're done recording. Typically, your message would be something like "Hello, you have reached the Smith residence." Save this file to your hard drive so you can access it later. It is a good idea to save the new recording under a different name. That way, you still have the original tones available without having to re-download them. You now have an audio file that can be used to re-program your answering machine's outgoing message.

To do that, you will need to position your answering machine near your computer's speakers. Set the answering machine to record your outgoing message and play the .wav file that you've just created back through your computer speakers. Hold the answering machine microphone about six inches away from your speaker while recording. The resulting recording will sound



You can download these audio tones free of charge from www.jechtech.com. *Once you capture the tone, you are ready to duke it out with telemarketers.*



Hold your computer's speaker approximately six inches from your answering machine's microphone while recording your new improved greeting.

like "doo...dah...dee...Hello. You have reached the Smith Residence." It may take several tries to get the level just right, but the results should be well worth the effort!

Final Words. Even if you don't have access to a computer, these tones can be pulled from your phone using a suction-cup microphone (designed to stick to the back of a handset) and a tape recorder. Simply dial a number that you know has been changed recently and record the Special Information Tone with the microphone. Of course the quality will not compare to a digital .wav file, but it will do. Those days of annoying telemarketers' calls will be numbered once you upgrade your answering machine's greeting with this tone.

TELEMARKETERS VS. THE FCC

This project should also work in Canada, since their system is very similar to the system used in the United States. Keep in mind that anyone reaching your answering machine will now hear the Special Information Tones before your message, so be prepared to answer a lot of "What was that I heard on your answering machine?" questions. The actual values of the three tones are: 985.2 Hz, 1370.6 Hz, and 1776.7 Hz. More importantly, all of the predictive dialers will hear it as well and, hopefully, won't be bothering you again!

The predictive dialers also recognize fax and modem tones as well. They hang up on them too, but add the number to their "Valid Fax Number" or "Valid Modem Number" lists! They then sell these lists to companies doing fax marketing! That's why you get those mysterious faxes offering discount trips to Florida, etc. The Special Information Tones take care of those as well, since it *removes* your number from all their lists!

Unfortunately, those tones on your answering machine will not stop a live telemarketing person from disturbing you. There are literally thousands of these smaller manual telemarketing firms that conduct local telemarketing plans for all types of businesses. You know, "We're in the area.... Blah...blah...blah." The trend for these small-time operations is to "go automated," since the predictive dialer never calls in sick or needs a coffee break, working 24/7 (24 hours a day, 7 days a week) for the same money. Don't worry, the live person telemarketers are still around.

The FCC has given the consumer a "hammer" to use on these types of telemarketing calls. The *1991 Telephone Consumer Protection Act* allows consumers to block solicitations by simply asking to be placed on their "do not call" list. Note that you must ask to be placed on the "do not call" list. "Take me off of your list" is not the right phrase to use. You must say you want to be placed on their "do not call" list It's a kind of a reverse logic thing. So, if you answer the phone and it's a live telemarketer, tell them politely "Please add me to your 'do not call' list"...then hang up.

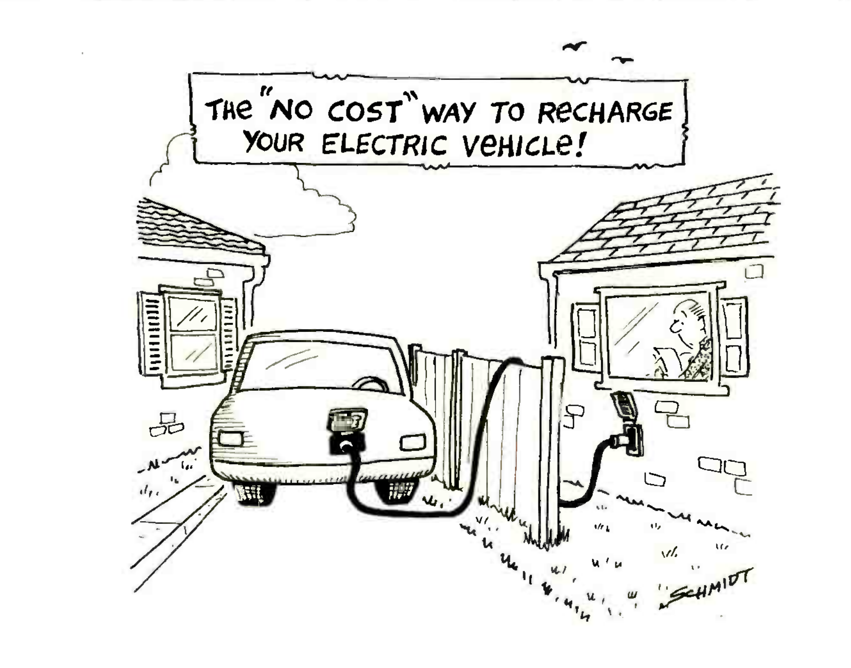
If you feel that you are still getting repeat calls from those same telemarketers, get the name of the company and call the FBI at 202-324-3000. They will then discuss your options with you. Typically, asking to be added to their "do not call" list will work effectively since they are subjecting themselves to substantial fines for non-compliance. I recently heard of a fellow in Arizona making a considerable sum by suing telemarketers who did not comply with this regulation.

SPECIAL INFORMATION TONE APPLICATIONS

Special Information Tones can be used for a variety of digital-signaling applications. The most common use is to indicate the status of a particular line. The standard Special Information Tone consists of three tones. The first two tones can vary as high or low binary codes, but the final tone is always the same high tone. Note that high and low refer to the binary status and not necessarily the frequency of a signal. The tones provide a binary encoding to represent the four meanings. Tone 1 can either be low at 913.8 Hz or high at 985.2 Hz. Tone 2 can either be low at 1370.6 Hz or high at 1428.5 Hz. Tone 3 will always be 1776.7 Hz—a high indication. A low tone's duration is 274 ms and a high tone's duration is 380 ms.

Here are the four line-status codes and their corresponding tones.

- Reorder—Low High High
- Vacant—High Low High
- No Circuits—High High High
- Intercept—Low Low High



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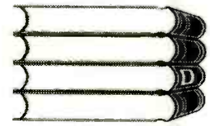

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ET11

Oops!

Well, my first column (February 2001) did not quite make it through without some typographical errors; I caught two when I first opened the magazine. In Fig. 1 (page 45), select input "C" of IC3 (pin 3) should be marked "2^2" rather than "2^3." Also, in the "Internet Resources for Manuals" sidebar on page 46, the fifth URL should end with "heath.htm" rather than "hewath.htm." The URL error was definitely the fault of my clumsy fingers, not the editors'.

While we're on the subject of corrections—it won't come out until two months after I write this—the April column, under the question titled "Which Oscilloscope Probe?," mentioned a Tek 5110 oscilloscope. To those still new to electronics, "Tek" is short for Tektronix, the most recognized name in oscilloscopes in the world. I was remiss in not mentioning that fact.

Antique Radio "Pot Lube"

Q *What is the best lubricant for a 1950s-vintage wirewound potentiometer? I understand modern potentiometer and switch lubricants might not be the best choice in this case, because something with a greater viscosity might be called for in the older wire-wound devices. Also, some basic information would be appreciated as to how electrically conductive (or non-conductive) are common petroleum products such as Vaseline.—M. L., Warwick, RI*

A Petroleum products straight from Texaco, Shell, or Cheseborough-Pond are effectively non-conductive. However, I'd venture to say that used motor oil, especially from a diesel engine (besides being carcinogenic) might have enough carbon mixed in it to alter its electrical properties. However, in terms of potentiometer lubricants, read on, and you'll find that it won't matter.

I had some preconceived ideas about potentiometers myself. I'd frequently clean them with a shot of GC's Spra-Kleen or—in hard-core cases—actually open up the mechanism and use a Spra-Kleen-soaked cotton swab to get the gunk out. Of course, that was just a "seat-of-the-pants" notion that wasn't backed up by an authoritative source, so I went looking for the "straight dope." Although I didn't go as far as sending a letter to the venerable Chicago columnist Cecil Adams, I did end up with a technical spanking after gaining some knowledge.

Linda Hampson, a technical-support specialist with Bourns Sensors and Controls, responded to my question, in which I had noted the use of GC's Spra-Kleen. I'll quote her here:

"Carbon elements have a self-lubricating effect and should not be lubricated. A small piece of sponge rubber and rubbing alcohol can be used for cleaning, using only a few light strokes. Carbon resistance elements can be easily damaged. Cotton swabs might leave fibers, which cause noise. No stronger chemicals should be used.

"Wirewound elements can also be cleaned with rubbing alcohol and foam rubber. The lubricants used on these elements by the manufacturers are specialized and not readily available to the public. No test data by the potentiometer manufacturers is available on the GC material referred to, so a recommendation regarding its use cannot be made. *[To GC's credit, this is not to say that there's anything wrong with Spra-Kleen; it just hasn't been tested and approved.—Dean]* Formulation of the lubricants for resistance elements is a very specialized art, and many otherwise good lubricants can cause problems on resistance elements. Without a recommendation from the potentiometer manufacturer on the specific materials involved, it is best to leave the element unlubricated. On wirewound elements, this will result in a shorter life than with the appropriate lubrication, but an inappropriate lubricant might result in an even shorter useful life. When many antique radios were manufactured, the specialized lubricants used today were not available anyway. The most important thing to do is to remove all of the wear debris from the potentiometer.

"After cleaning with rubbing alcohol, most good bearing greases can be used on the bushing and shaft. It should be applied sparingly. Particular care should be taken to keep the lubricant away from the resistance element and contacts. Many lubricants will creep over long distances. Lubricants containing silicone or fluorocarbons should not be used.

"If the potentiometer is noisy after cleaning, it probably cannot be reclaimed and would have to be replaced."

Well, I guess that I've been found guilty of "pot abuse." We're grateful to Linda for her enlightening information on this subject. Now, if we can just talk Bourns out of that special modern "pot lube" that we can't get down at the local auto-parts store...

Desperately Seeking Transformer, Part Deux

Reader Ronald Smith of Bolton, Ontario wrote in regarding a question in the December 2000 "Q&A" column about an open primary in an old GE C445g stereo.

Ronald suggested that running out and buying an expensive replacement transformer was not the first thing to do. The original power transformer should be removed, opened up, and checked for an internal thermal fuse that most of those transformers had, which might be open. If open, the fuse should be replaced with another with the same current and temperature ratings. Carefully insulate the connections and check the primary for continuity at the connecting leads.

He noted that one of two things might have caused such an open in the fuse: (1) a shorted primary, in which case the transformer needs replacement; or (2) a power surge, which might have opened the primary as well as the fuse. If the primary is still open, visually check for a melted primary winding and reconnect as necessary. A primary or secondary short might exist, in which case the failure will occur again when the transformer is energized after repair. Often, on older equipment, an attempt to repair the transformer is worth a try, especially if a replacement is difficult or impossible to find. Thanks, Ronald, for that insight.

In any case, if the stereo did not have a primary fuse, I would definitely install one.

A 2-amp fast-blow fuse should be a good match for this particular model.

Recycling Computer Parts

Q *I have enough old computer parts to build another computer, and I ask myself if there is something else to build. For example, there's a Sound Blaster card with its generic I/O connections. I was wondering if, instead of microphone and speakers, I could hook up an IR (infrared) detector and an IR LED (infrared light-emitting diode) to make an interesting "learning universal remote control." Any suggestions or schematics?—S.V., Bensalem, PA*

A I've disposed of at least 75 computers myself, ranging from three late-1960s and early-1970s minicomputers to all sorts of PCs and XTs, as well as their monitors, keyboards, printers, and stand-alone backup tape drives. Using the internal boards apart from a computer would be a nightmare, at best, considering all the data, address, interrupt, and timing signals with which you must deal. Making that universal remote means a cumbersome, non-battery-operated mess that you'd have to hide behind the sofa with a pendant connected to the Sound Blaster and the keyboard connectors. At least you wouldn't have to turn the sofa upside-down every couple of months to extract the remote.

Alas, from my point of view, you either "deep-six" the computer parts or run them through your component-recycling chain, which is what I'm currently doing myself. I'm harvesting a treasure trove of SMT (surface-mount technology) components and sorting them as I have done with my through-hole-component collection, albeit in a smaller space. In addition, the boards are supplying me with a lot of current through-hole chips to upgrade and flesh out my logic stash.

I end up discarding unreprogrammable ICs and other specialty components. Circuit boards, when I'm through stripping them, are recycled for soldering practice by my students. If you're not going to use the boards or parts yourself, why not give them away to a hobbyist who's willing to desolder them for parts?

We're at the point in electronics history where you can't reuse most assembled items, since they won't easily interface to current technology. What am I going to do with external 1200- baud modems other than use them for slower communications in dedicated in-house systems, such as some Stamp applications? Hence, in the landfills, we have building-high stacks of monochrome, CGA, and EGA monitors, huge desktop-computer cases, and keyboards. I harvest the components that I can use, and the rest adds to mankind's future waste-disposal problem, unfortunately.

HOW TO GET INFORMATION ABOUT ELECTRONICS

On the Internet: See our Web site at *www.poptronics.com* for information and files relating to **Poptronics** and our former magazines (**Electronics Now** and **Popular Electronics**) and links to other useful sites.

To discuss electronics with your fellow enthusiasts, visit the newsgroups *sci.electronics.repair, sci.electronics.components, sci.electronics.design*, and *rec.radio.amateur.homebrew*. "For sale" messages are permitted only in *rec.radio.swap* and *misc.industry.electronics.marketplace*.

Many electronic component manufacturers have Web pages; see the directory at *www.hitex.com/chipdir/*, or try addresses such as *www.ti.com* and *www.motorola.com* (substituting any company's name or abbreviation as appropriate). Many IC data sheets can be viewed online: *www.questlink.com* features IC data sheets and gives you the ability to buy many of the ICs in small quantities using a credit card. You can also get detailed IC information from *www.icmaster.com*, which is now free of charge although it formerly required a subscription. Extensive information about how to repair consumer electronic devices and computers can be found at *www.repair faq.org*

Books: Several good introductory electronics books are available at RadioShack, including one on building power supplies.

An excellent general electronics textbook is *The Art of Electronics*, by Paul Horowitz and Winfield Hill, available from the publisher (Cambridge University Press, 800-872-7423) or on special order through any bookstore. Its 1125 pages are full of information on how to build working circuits, with a minimum of mathematics.

Also indispensable is *The ARRL Handbook for Radio Amateurs*, comprising over 1000 pages of theory, radio circuits, and ready-to-build projects, available from the American Radio Relay League, Newington, CT 06111, and from ham-radio equipment dealers.

Back issues: Copies of back issues of and past articles in **Electronics Now**, **Popular Electronics**, and **Poptronics** can be ordered on an "as available basis" from Claggk, Inc., Reprint Department, P.O. Box 12162, Hauppauge, NY 11788; Tel: 631-592-6721. To ensure receipt of the correct material, readers must supply complete information on the article or issue that they wish to buy.

Poptronics and many other magazines are indexed in the *Reader's Guide to Periodical Literature*, available at your public library. Copies of articles in other magazines can be obtained through your public library's interlibrary loan service; expect to pay about 30 cents a page.

Service manuals: Manuals for radios, TVs, VCRs, audio equipment, and some computers are available from Howard W. Sams & Co., Indianapolis, IN 46214; (800-428-7267). The free Sams catalog also lists addresses of manufacturers and parts dealers. Even if an item isn't listed in the catalog, it pays to call Sams; they may have a schematic on file which they can copy for you.

Manuals for older test equipment and ham radio gear are available from Hi Manuals, PO Box 802, Council Bluffs, IA 51502, and Manuals Plus, 130 N. Cutler Dr., N. Salt Lake, UT 84054.

Replacement semiconductors: Replacement transistors, ICs, and other semiconductors, marketed by Philips ECG, NTE, and Thomson (SK), are available through most parts dealers (including RadioShack on special order). The ECG, NTE, and SK lines contain a few hundred parts that substitute for many thousands of others; a directory (supplied as a large book and on diskette) tells you which one to use. NTE numbers usually match ECG; SK numbers are different.

Remember that the "2S" in a Japanese type number is usually omitted; a transistor marked D945 is actually a 2SD945.

Hamfests (swap meets) and local organizations: These can be located by writing to the American Radio Relay League, Newington, CT 06111; (*www.arrl.org*). A hamfest is an excellent place to pick up used test equipment, older parts, and other items at bargain prices, as well as to meet your fellow electronics enthusiasts—both amateur and professional.

Voice Recognition for Lighting Control

Q *Is there some way to turn on a light in a room using voice-recognition technology?—K.R., Kansas City, MO*

A That technology is an analog system that's as old as the hills, and I used to have just such a system. It took me about six years to perfect it, and the overall design required a lot of feedback, both positive and negative. Unfortunately, as the system aged, it became progressively unstable until it finally began going totally non-linear on me at times. My attempts at adjustment often failed.

The kid who was to become my son-in-law thought that I had a really nice-looking system and wanted it for himself. So one Saturday, I gave the entire thing to him. Now that he has it, he finds that it doesn't work very well for him either unless he says "Honey," "please," and "thank you" a lot—and then he sounds whiney.

Joseph Suda, our editorial kingpin, observed that electronic solutions for lighting control are considerably cheaper than the estimated $250,000 to $300,000 maintenance-per-unit over an 18-year period for the biological system. Perhaps only 10 or 12 years are actually useful, subtracting the pre-verbal (birth—2 years old), pre-reach (2—5), and post-verbal/highly-unstable (12—17) periods. Of course, if you already own one or more systems, you might as well put them to use.

On a more serious note, check John Iovine's "Amazing Science" column in the October 2000 issue of **Poptronics**. For about 50 clams and a handful of interfacing components, you can have a stand-alone system that will control up to 15 functions *(For around $100, there's also "home-automation software" reviewed in this month's "Gizmo."—Editor).*

Of Bomb Shelters and Reception

Q *I'm writing to find out more about "amplified" antennas. I recently bought a "GE Omptima" amplified antenna to improve the reception of my AM/FM Walkman, and it does basically nothing. It clearly states on the box that the antenna will improve FM reception. I have tried everything to get it to work right to no avail. You might say that the tons of concrete and steel that comprise my building could cause antenna interference. However, I hooked up a pie tin and it outperforms any antenna I've ever seen. Unfortunately, that solution is not viable.*

Also, where can I get circuitry schematics and information on how to decode resistor color bands?—E.M., Pittsburgh, PA

A Well, the concrete and steel are certainly the enemy here, and I can understand your plight. Radio signals just don't like going through that stuff. I remember as a kid in the late 1950s seeing radios on the plans and lists of stuff to have in your home bomb shelter but never saw mention of an external antenna!

Amplified antennas have been around for a long time. Their big drawback, whether used on the roof of a travel trailer or on the end of a Walkman, is that they have to have a signal with which to work so that the signal-to-noise ratio is high. Otherwise, the amplifier will be amplifying as much noise as it does signal, and the net result is lousy reception. One possible solution, if you're allowed to have hook-up wire, is to run as much wire around your dorm room as possible and connect the little amplifier to that and then to the Walkman. But you'll have to experiment a lot there.

As soon as you start wrapping the wire around the perimeter, depending on the station frequency, you may have a signal in one leg that's induced out-of-phase in the other leg and will cancel or reduce the antenna output. You'll just have to experiment by using the entire perimeter or just part of the room.

I can't explain why the pie tin worked better for you, other than the fact that it might have had more surface area and better pickup than the amplified antenna's antenna. Since, as you said, that's not a viable solution, we can't add it to the amplified antenna's configuration. Can you get at the bed springs for an antenna or are they grounded? In the February 2001 "Q & A," a reader in a similar situation had radio reception problems, also. You might see if that answer might be helpful to you.

I suggest procuring some basic books from RadioShack. The *Engineer's Mini Notebook* series by Forrest Mims should be a lot of help with your circuit and resistor color-code questions.

Battery Capacities

Q *I have several unmarked nickel-cadmium (NiCd) batteries in sub-C, C, and AA sizes. Is there any way to determine the amp-hour capacity so that I can charge and use them?—R.S., Monessen, PA*

A All manufacturers have their own method of battery construction; and similarly-sized batteries don't always have the same power capabilities, even within the same chemistry. In fact, some manufacturers get downright underhanded in some cases. A trip to your local Super-Mart to scout out NiCd "D" and "C" cells will likely show you that they both have the same amp-hour (A-H) rating. This is because the manufacturer has actually put a "C" cell into a "D" case. Heft the two of them, and you'll notice that they're not that much different in weight. The better manufacturers will have "D" cells that are much higher-power than their "C" cells, and the "D" cell version will be a lot heavier than the "C" cell. So, it's difficult to compare one to another.

Consulting an electronics catalog from a distributor like Newark, Allied, or Digi-Key will guide you into the approximate ratings for the batteries. Good "D" cells will be about 4000 mA-H, "C" cells about 2400 mA-H, "sub-C" about 1000 mA-H, "AA" cells about 1500 mA-H, and "AAA" cells about 550 mA-H. Again, figures do vary somewhat, but the ones that I've just provided are close enough for most needs.

Homebrew Surge Suppressors

Q *I had a modem destroyed by a lightning strike and decided to build a surge suppressor. I wanted to avoid metal-oxide varistor (MOV) devices because they wear out, so I built a circuit that uses spark gaps instead (see Fig. 1). It costs almost nothing. The spark gaps are made from bus wire, bent so that the spacing is the thickness of a sheet of paper, corresponding to about a 300-volt breakdown.—D. H., Rindge Center, NH*

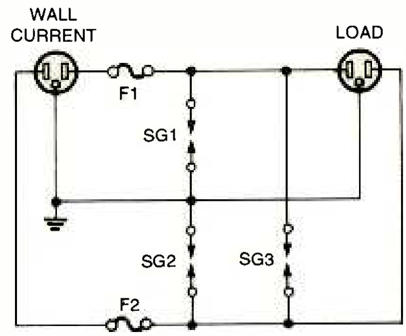


Fig. 1. A surge protector using homemade spark gaps will be slow to react and unpredictable in operation.

A Since you didn't phrase your response in the form of a question, I'll assume that you're inviting comments. Spark gaps that are used for specific voltage breakdowns should always be devices that are hermetically sealed. Humidity, air pressure and contaminants affect an unprotected gap's arc-over voltage, so I wouldn't trust that 300-volt calculation from day to day. In addition, a spark gap is slower to respond to a transient than a MOV, typically in the microsecond range while MOVs are rated in the nanosecond category.

MOVs are semiconductor devices and, like any other semiconductor device, they don't "wear out" in the same way vacuum tubes do. However, like any other semiconductor device, they can be damaged if improperly designed into a circuit. The MOV's maximum continuous rms or DC-voltage rating should be higher than that being continuously applied in the circuit. A MOV, while conducting during a transient "event," should be rated to dissipate the transient power and protected against over dissipation and subsequent shorting, opening, or explosive destruction. Fuses in series with the input line and/or in series with the MOV are mandatory.

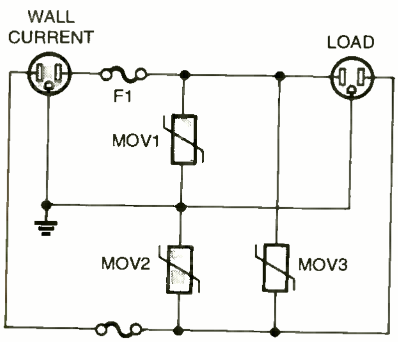


Fig. 2. A surge protector using voltage-clamping metal-oxide varistors (MOVs) will react quickly and reliably, protecting the load from damaging transients.

When used in a properly-designed circuit, such as that shown in Fig. 2, a MOV should have the long life expected of any semiconductor without fear of failure or degradation of performance.

My suggestion is to buy one of those higher-dollar surge protectors for your entire computer system. They run around $40 to $60 and come with a manufacturer's guarantee to replace any computing equipment that's destroyed by a surge while connected to the protector. That guarantee doesn't come with your spark-gap circuit—or any home-built surge protector—no matter how well-designed or well-built it is.

Besides, there are few surge protectors, save some of those used on the antenna system of a television- broadcast station, that will protect your equipment from a direct lightning strike.

A Good Samaritan

Reader Kenneth Roby came to the rescue of B.L. of Kent, WA, who had a dead PS/2 mouse port (see the December 2000 column). Kenneth was ready to ship a Microsoft InPort at no cost, but, in the meantime, B.L. had solved his problem. Our thanks to Ken for his generous offer. Readers like him make the "Q&A" column, ***Poptronics****, and the hobby of electronics really worthwhile.*

Differential Temperature Ceiling-Fan Control

Q *My house has cathedral ceilings—excellent heat collectors. I am looking for an automatic switch or circuit to turn on my ceiling fans when the temperature difference between ceiling and floor exceeds a certain value—say, 20° F—and turn them off when the difference is down to 5° F. Can this circuit be hooked up in parallel with the normal on/off switch?—P.K., via e-mail*

A A pair of thermistors, R2 and R5, and a simple comparator, IC1, should do the trick, as shown in Fig, 3. At 25° C, the two thermistors have a value of 10,000 ohms, so I chose a 10,000-ohm resistor to go in series with each to create a voltage divider with six volts nominal fed to each comparator input.

A 2000-ohm potentiometer serves to set the temperature differential at which the two circuits will trip the comparator. If you assume the potentiometer to be set so that the R1 = R3 + R4 with both thermistors in the same location, the comparator will be on the verge of either switching on or off. In other words, barely touching R2 will turn the fan on, and barely touching R5 will turn it off.

The ambient temperature will raise the resistance of both thermistors at the same rate, and the comparator will still be on the verge of switching on or off.

If you increase the value of R4, you will increase the differential so that R2 will have to get even warmer than R5 before the fan will turn on. This differential stays pretty much the same whether the room temperature is set warm or cool. You can increase the value of R4 if you want a larger differential. I didn't actually check the maximum differential that this circuit would provide.

The output of IC1 drives a Darlington power transistor, Q2, which turns on RY1. Diode D1 protects Q1 from the reverse voltage created when the RY1 field collapses as it turns off.

Resistors R4 and R5 should be mounted near the floor, away from any sources of heat. I'd suggest running both sensor circuits through a two-conductor shielded cable. Using shielded wire, such as instrumentation or balanced-microphone cable, will minimize stray AC pickup, which would really mess up the comparator. Capacitors C1 and C2 will help by bypassing any stray AC to ground. I used a RadioShack 271-110A for the two thermistors.

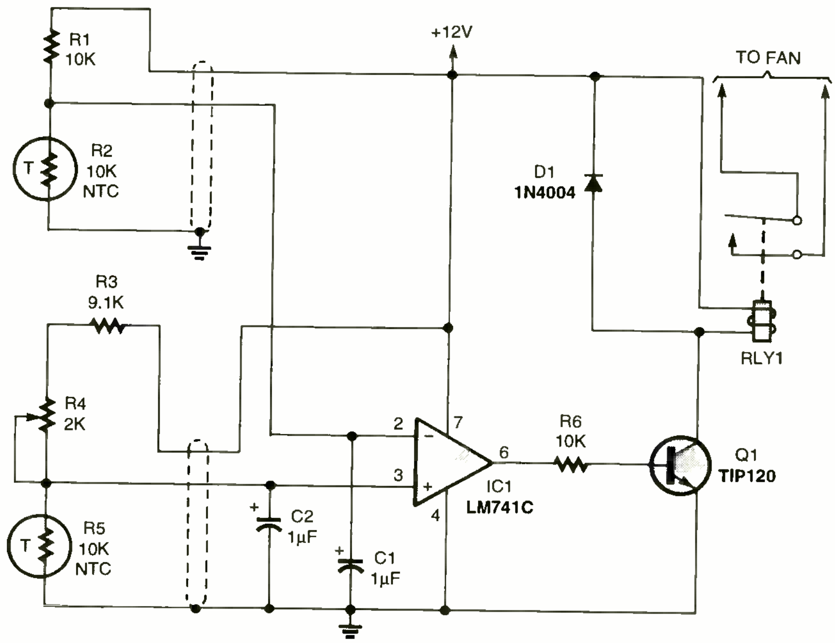


Fig. 3. A control circuit for keeping room temperatures between ceiling and floor more even uses a simple comparator to control a ceiling fan.

Relay RY1 needs to have a 12-volt

(Continued on page 60)

mailto: amazingscience@gernsback.com

JOHN IOVINE

Back To The Fuel Cell: Part II

Now that the turtle robot sidetrack is done, let's get back to our previous discussion on fuel cells. For those who don't recall, we had started this series in the February issue with an overall discussion of the history and basic technology behind these potentially compact and powerful devices. Until we can buy a Mr. Fusion kit for mounting on the back of our DeLorean, let's sit back and take a look at how different types of fuel cells are constructed.

Fuel cells are typically categorized by the type of electrolyte. The following is a short list of the more common types of fuel cells:

Alkaline—Used by NASA on space missions, the alkaline variety was the first fuel cell to capture the public's attention. NASA has been able to push the efficiency of these cells to 70 percent. As an experiment, we will be building this type of fuel cell using potassium hydroxide as the electrolyte.

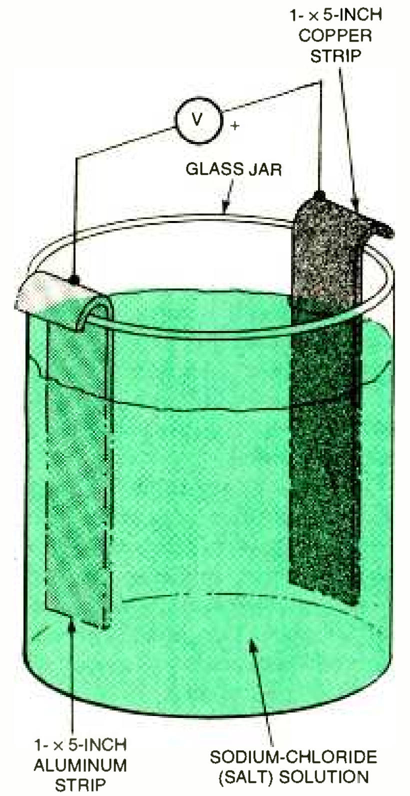


Fig. 1. An aluminum battery is a simple variation of the more familiar lead-acid "wet cell" battery found in cars.

PEM—The acronym for this fuel cell has developed two similar meanings: *P*roton *E*xchange *M*embrane or *P*olymer *E*lectrolyte *M*embrane. The PEM material is an organic polymer. DuPont sells a commercial PEM material under the trade name Nafion. Currently, these fuel cells are on the fast track for development and use in many electric vehicles.

Phosphoric Acid—These fuel cells are used commercially. They are deployed as power plants in hospitals, hotels, office buildings, and other similar environments. Efficiency of this fuel cell approaches 40 percent. However, higher efficiencies are possible if the steam generated from this fuel cell is used for electrical cogeneration.

Molten Carbonate—This fuel cell has the ability to consume coal-based fuels. Its operating temperature is 1200° F.

Solid Oxide—The solid-oxide fuel cell is a hard ceramic material (Zirconium Oxide) running at a temperature of 1800° F.

Regenerative—This is an interesting closed-loop, regenerative-cycle fuel cell. During the daytime, photovoltaic cells (or other primary electric power source) perform electrolysis on water in the cell, storing the separated hydrogen and oxygen gases in individual tanks. At night (or during a high electric demand), the hydrogen and oxygen are consumed in the fuel cell to produce electric power and water. The water "ash" produced by the fuel cell is stored in a tank for subsequent electrolysis.

Direct Alcohol Fuel Cells—This is a new type of fuel cell that converts alcohol (a hydrogen-dense compound) directly to electric power. Adding microorganisms that convert sugar to alcohol (like yeast) forms a "bug" battery.

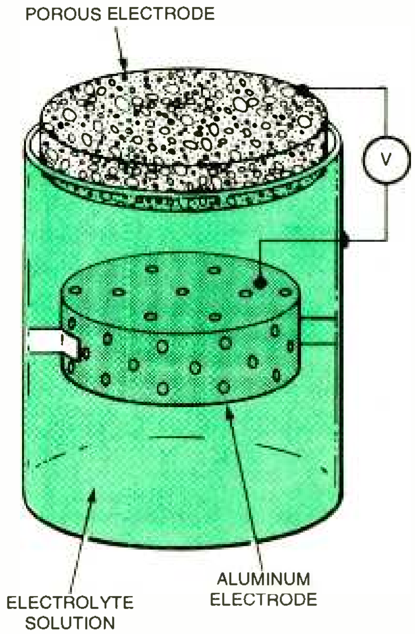


Fig. 2. An aluminum-air battery absorbs oxygen from the air through a porous electrode to enhance the chemical reaction and, therefore, the power output.

Some of those types of fuel cells are not the easiest to build from a hobbyist point of view. We'll start with something easy. This month, we will build a methyl-alcohol fuel cell and save the bug battery for next month.

Before Building

Building fuel cells involves working with and handling corrosive and poisonous chemical compounds. Cleanliness and precaution must be exercised throughout the construction of the fuel cell and subsequent experiments. If you are uncomfortable handling chemicals, then this is not a project for you.

Here are a few general guidelines: First, never handle chemicals or allow chemicals to come into direct contact

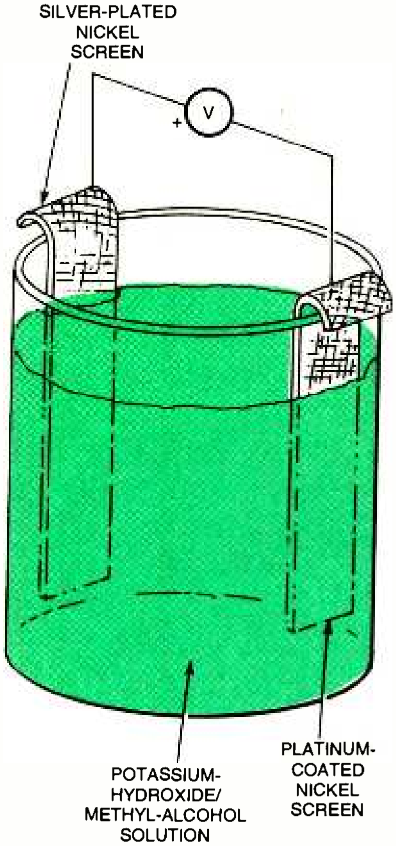


Fig. 3. Although our methyl-alcohol fuel cell looks similar to a wet-cell battery, the fluid is based on potassium hydroxide (commonly referred to as "lye")—at the extreme opposite end of the acidity scale from sulfuric acid used in car batteries.

with your skin, eyes, mouth, etc. Do not breathe in any vapors or dust from any compound. Depending upon your experience, you should wear rubber gloves and goggles whenever working with the chemicals. Actually, if you are experienced, you already know to wear protective gear. Finally, always clean up spills and messes quickly and completely.

Aluminum Battery

As I said back in February, fuel cells and batteries are both electrochemical devices that produce electric power. Batteries, for the most part, are simpler in construction, so before we build a fuel cell, let's first build a simple battery.

The electrolyte that may be used in an aluminum battery is fairly flexible. One may use a NaCl (sodium chloride—table salt) solution (that's a fancy way to say "salt water!") or an alkali solution like potassium hydroxide.

To build the aluminum battery, simply place strips of aluminum and copper (about 1 × 4 inches, 0.032 thick) in a solution of table salt. This salt battery will generate about 0.5 volts at a current between 1 and 3 mA. See Fig. 1 for the basic arrangement.

When properly made, aluminum batteries have a very high energy density and are used commercially as emergency power supplies. In an emergency, the electrolyte (salt water) is dumped into the battery. The battery then immediately supplies electrical power. In its dry state, before any electrolyte is added, the batteries have an extremely long shelf life, without any degradation in power density when used.

A variation of the aluminum battery—the aluminum-air battery—is similar in construction, as shown in Fig. 2. In the aluminum-air battery, one electrode is porous, allowing oxygen (air) into the cell. The aluminum reacts with the OH- ions to form aluminum hydroxide and three electrons. At the porous electrode, oxygen and electrons are absorbed. The electrons produced at the aluminum electrode travel to the porous electrode through an external load circuit. Reactions continue until the aluminum is depleted.

FUEL CELL SHOPPING LIST

Nickel screens, 150-200 mesh, 1 × 5 inches
Platinic chloride, 1 gram
Silver nitrate, 5 grams
Isopropyl alcohol (rubbing alcohol), 1 pint
Methyl alcohol, 100 milliliters
Glass vessel
Potassium hydroxide, 500 grams
Distilled water, 2 liters

Boosting Output

What separates the aluminum-air battery and the aluminum battery is—obviously—air or, more precisely, oxygen. It stands to reason that if we could inject some oxygen into the cell we could boost its output. Although that sounds too simplistic to be true, it does turn out to be the case. The current output (not voltage) of our simple aluminum battery can be temporarily boosted by adding a little hydrogen peroxide to the salt-water solution. Hydrogen peroxide (H_2O_2)—yes. that's the same hydrogen-peroxide antiseptic found in many medicine cabinets—adds oxygen into the solution. The current in my aluminum battery increased from 1–3 mA to upwards of 50 mA.

Aluminum Alloys

How well your aluminum battery works may depend upon the alloy of aluminum you use. The alloy used in my aluminum battery is relatively pure (1100 alloy) aluminum. The aluminum containers used for soft drinks do not work. This is due to a protective film coating the inside of the container.

SOURCE INFORMATION

If you are "stuck" trying to find sources for the various items needed this month, here are some suggestions:

Nickel screen:
Newark Wire Cloth Company
351 Verona Ave.
Newark, NJ 07104
800-221-0392

Distilled water
Isopropyl (rubbing) alcohol
Hydrogen peroxide:
Local drug store

Platinic chloride
Silver nitrate
Methyl alcohol
Potassium hydroxide:
Local chemical company

Aluminum and copper sheet metal:
Local hardware store

Methyl-Alcohol Fuel Cell

The first fuel cell we will build is similar to the aluminum-air battery. To build the cell, start by gathering the items listed in the "Shopping List" sidebar.

First, clean the nickel screens in isopropyl alcohol to remove any grease and dirt. After they are clean, handle them with tweezers or tongs so as not get any fingerprints on them. We need to plate one nickel screen with platinum and the other with silver. The platinum acts as a catalyst and moves the reaction along at room temperature. After plating, I repeat, do not touch the screens or you will contaminate them with fingerprints. Always handle them with tweezers or tongs.

To plate one screen with platinum, make up a solution of platinic chloride by mixing 1 gram of acid into 100 milliliters of water. Immerse the nickel screen into the platinic-chloride solution for about one hour. The nickel screen will turn black as platinum metal becomes deposited on it.

To plate the other nickel screen with silver, make up a solution of silver nitrate. Mix 5 grams of silver nitrate in 100 milliliters of distilled water. Immerse the nickel screen into the silver-nitrate solution until the screen turns silver-black (2–5 seconds). Silver quickly deposits onto the nickel. If you leave the screen in for any amount of time, the silver will "form" and flake off the screen.

Make up a solution of potassium hydroxide (a.k.a. lye or caustic potash). The ratios are approximately 100 grams of KOH in 300 milliliters of distilled water. When mixing the potassium hydroxide, bear in mind that this reaction is exothermic (it generates heat). Always add the potassium hydroxide to the water and not the other way around.

The finished fuel cell is shown in Fig. 3. The potassium-hydroxide solution is placed in an open glass vessel. The electrodes are draped inside the vessel, with about ½ inch on the outside to connect alligator-clip leads. The leads connect to a volt-ohmmeter. Add 10 milliliters of methyl alcohol to the potassium hydroxide solution. My fuel cell developed about 0.25 volts at 30 mA. The current quickly drops as the silver electrode becomes covered with a fine mist of bubbles caused by the reaction. After disrupting the bubbles, the voltage and current will resume.

To disrupt the fine mist of bubbles, you can use a plastic straw to gently tap the silver electrode. As the bubbles become disrupted, the current resumes at its highest level.

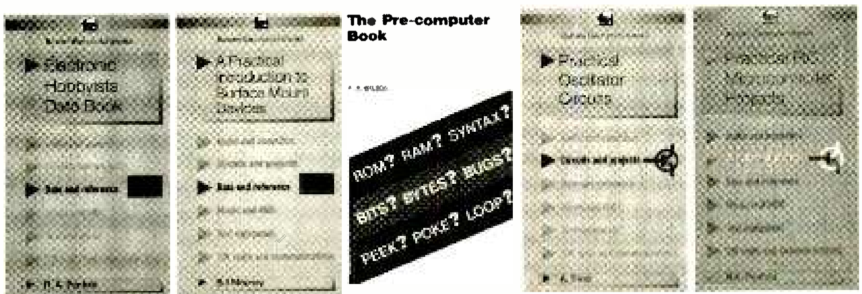
Commercial Applications

I have read a lot of news on this type (methyl alcohol) of fuel cell. It is being developed for use in cellular phones and laptops. The commercial fuel cells last around 20–50 hours and are recharged for another 20 hours by injecting a little more alcohol into the fuel cell. These cells are expected to hit the market in 2001.

Next Month

Next month, we will finish our fuel-cell series (I promise, no more side-tracks!) by building two additional fuel cells: the hydrogen-oxygen fuel cell (made famous by NASA) and a bug battery. To build the hydrogen-oxygen fuel cell, we will be using a few of the solutions and components used in making the methyl-alcohol fuel cells. Primarily, you will use the platonic chloride solution again, a little more 200-mesh nickel screen, and potassium hydroxide.

However, that's for next month. Until then, keep your suggestions and comments coming. P



BP396 BP411 BP115 BP393 BP444

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Tucson, AZ 85713

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Van Nuys, CA 91411

California Electronics
221 N. Johnson Ave.
El Cajon, CA 90202

Electronics Plus, Inc.
823 4th St.
San Rafael, CA 94901

Electronics Warehouse
2691 Main Street
Riverside, CA 92501

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Buena Park, CA 90621

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4837 Amber Lane
Sacramento, CA 95841

Halted Specialties Co.
3500 Ryder Street
Santa Clara, CA 95051

Inland Electronic Suppliers
1012 N. Carpenter Rd.
Modesto, CA 95351

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Bakersfield, CA 93301

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Costa Mesa, CA 92627

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Mar Vac Electronics
4747 Holt Blvd.
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Santa Barbara, CA 93111

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2537 Del Paso Blvd.
Sacramento, CA 95815

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Oxnard, CA 93030

Mar Vac Electronics
12453 Washington Blvd.
Los Angeles, CA 90066

Metro Electronics
1831 J Street
Sacramento, CA 95814

Orvac Electronics
1645 E Orangethorpe Ave.
Fullerton, CA 92631

Sav-On Electronics
13225 Harbor Blvd.
Garden Grove, CA 92643

Colorado

Centennial Elec. Inc.
2324 E. Bijon
Colorado Springs, CO
80909

Connecticut

Cables & Connectors
2198 Berlin Turnpike
Newington, CT 06111

Illinois

BB&W Inc.
2137 S. Euclid Ave.
Berwyn, IL 60402

Tri State Elex
200 W. Northwest Hwy.
Mt. Prospect, IL 60056

Indiana

King of the Road Elec.
409 E. Center Rd.
Kokomo, IN 46902

Maryland

Mark Elec. Supply Inc.
11215 Old Baltimore Pike
Beltsville, MD 20705

Massachusetts

Electronic Hook-Up
104 Main St.
Milford, MA 01757

"You-Do-It" Electronics
40 Franklin Street
Neeham, MA 02494

Michigan

Norwest Electronics
33760 Plymouth Rd.
Livonia, MI 48150

Purchase Radio Supply
327 East Hoover Avenue
Ann Arbor, MI 48104

The Elec. Connection
37387 Ford Road
Westland, MI 48185

Minnesota

Acme Electronics
224 Washington Avenue N.
Minneapolis, MN 55401

Missouri

Gateway Electronics
8123-25 Page Blvd.
St. Louis, MO 63130

New Jersey

Lashen Electronics Inc.
21 Broadway
Denville, NJ 07834

New York

LNL Distributing Corp.
235 Robbins Lane
Syosset, NY 11791

T&M Elec. Supply, Inc.
472 East Main Street
Patchogue, NY 11772

Unicorn Electronics
Valley Plaza
Johnson City, NY 13790

Ohio

Parts Express
725 Pleasant Valley Drive
Springboro, OH 45066

Oregon

Norvac Electronics
7940 SW Nimbus Avenue
Beaverton, OR 97005

Texas

Computers Electronics Etc.
110 E. Medical Center Blvd.
Webster, TX 77598

Electronic Parts Outlet
3753 B Fondren
Houston, TX 77063

Tanner Electronics
1301 W Beltine
Carrollton, TX 75006

Washington

Supertronix Inc.
16550 W. Valley Hwy.
Tukwila, WA 98188

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mailto: serviceclinic@gernsback.com

SAM GOLDWASSER

To Repair Or Not To Repair?

Rather than continuing with the VCR repair guide saga—which by now must seem like something from a never-ending story—I'd like to step back and discuss some issues that were raised by readers on the "Service Clinic" series. Over the next few months, we'll try a variety of different approaches. It would be very helpful if you, the reader, could provide feedback via e-mail to the address above or directly to the publisher by snail- or e-mail about your preferences for this series. Don't worry; if you are clipping and saving the VCR series, the grand wrap-up is coming next month.

Justifying Repair Effort

One of the frequent questions in reader feedback is:

"Why bother with repair of VCRs (or anything else) when I can buy an inexpensive replacement model?"

or there's the comment:

"This stuff may have been useful five years ago, but now some/much of the material doesn't apply to newer VCRs."

While both deal with VCRs, it should be understood that they apply equally well to many other consumer electronics. Depending on your background and interests, those statements may have some validity. Clearly, there is a need for some objective (if possible) way of making a decision whether to bother with repairing at all, and especially whether to attempt the repair yourself. When does it make sense to attempt *any* repair yourself rather than to toss the item in the trash or take it to a professional?

People do this sort of stuff for several reasons:

- For the challenge and rewards associated with success.
- To save money.
- For the unique features or controls of the equipment.
- To avoid cluttering landfills.

The first of these is likely most relevant to the readers of **Poptronics**. It's quite difficult to suggest an approach in deciding when something is worth repairing. You have to decide how much the equipment is worth to you in terms of monetary, sentimental, or other value; how much time you are willing to put into a repair; and whether the failure represents a good excuse to upgrade! To what extent each of the factors is significant will also be determined by how much you enjoy troubleshooting and tinkering. On the other hand, if you can't spare the time or could use it more profitably, then perhaps you should be doing something else. The sidebars accompanying this column offer various examples of repairs that I have conducted throughout the years.

However, it is easier to identify specific situations where equipment probably *isn't* worth attempting to repair on your own (or possibly at all). If serious damage is due to water (especially salt water), fire or smoke, then repair is often in vain. Even if the obvious faults can be found and corrected, there are likely to be latent failures just waiting to strike in a few weeks or months. In case of a direct strike, lightning is like the 900-pound gorilla—it can go anywhere it wants. Even if you can repair the obvious damage and get the equipment working, there could be hidden problems waiting to appear at a later time due to components that aren't totally fried but just weakened. Another problem is extremely high electrical power surge, like a 13,000-volt feeder line falling across the 115-volt wiring to your house, which can wreak havoc on all appliances.

If any appliance is covered by insurance, then dealing with the insurance policy would be the best option (as long as the settlement is reasonable). If the insurance company allows you to keep the damaged equipment, there is nothing to stop you from attempting repairs as a challenge—you might get lucky. However, it could also be a long, drawn-out, expensive frustration. It may be impossible to replace broken parts. Twisted metal can be straightened, but there is a good chance there will still be erratic behavior. Prior attempts at repair may have resulted in an undetermined number of new unidentified problems within electronic equipment. At least when something breaks on its own, your only opposition is the device itself. If another person attempts a repair and is a novice or just plain incompetent, the dumpster may be the best solution.

GE TV Dropped—This TV had taken a nosedive off a 4-foot shelf onto an unknown surface. Of course, someone had probably attempted to use it after this with possible additional damage. While the exterior didn't show any major abuse, it was obvious that there was severe trauma as soon as the back was removed. The main circuit board was broken near the (heavy) flyback transformer. Several dozen traces were severed including some to surface-mount parts.

A repair shop would be unlikely to want to tackle this for several reasons: (1) The obvious repairs to circuit board traces would take at least a couple of hours; (2) There could be unseen damage to the CRT in the form of a distorted shadow mask, and this wouldn't be known until the circuit board was fixed; and (3) Any repair might not catch everything so future problems could develop. As it turned out, the only damage was to the circuit board. After two or three hours of soldering—and then finding additional traces to solder—I fixed the set, and it has continued to work reliably for several years. (Taken from: *Repair Brief #69: GE Portable Color TV—Dropped*)

GE TV With "Rivlets"—In the early 1980s, some brilliant manufacturing engineer working for GE decided that a good way to save money on circuit boards would be to use what were dubbed "rivlets" instead of actual plated-through holes to connect top and bottom. A rivlet is basically a rivet that (the theory goes) is then soldered to the copper traces. That's the theory. In practice, due to the thermal mass of the rivet, soldering was never reliable. As a result of thermal cycling, cracks developed between the rivet and traces over time. Problems ranged from a dead set to loss of color depending on which rivlet was unhappy on any given day.

Attempting to repair just the problem rivlets was impossible because as soon as you found a bad one and soldered it, another in its vicinity would decide to fail. The only approach that worked was to reheat every one that could be located using a soldering gun. Since there were many dozens of these on the circuit board, this took quite a while and it was easy to miss some. In fact, the only truly reliable repair would be to remove the solder from each rivlet, snake a bare wire through it, and solder the wire directly to the traces top and bottom. This repair would also take a couple of hours and would likely be too expensive for a small TV; if the same chassis were used on a 27-incher, repair might be worth it. (Taken from: *Repair Brief #59: GE 13AC1504W Color TV—Dead (with Other Problems)*

Equipment with known design or manufacturing problems often cannot be repaired. When we undertake a repair, one assumption is that the equipment originally worked correctly and/or that the fault isn't something that was designed in before the name went on. For most things, this is a valid assumption. Even the famous RCA/GE/Proscan and Sony TV solder problems, while no doubt resulting in hundreds of thousands of sets ending up in the trash, are repairable with modest effort at low cost. The result is a well-performing reliable TV. However, some computer monitors may die when fed a particular scan rate or during boot when mated with a particular video card—a design flaw which may not have a (known) solution.

I can pretty much guarantee that a $39.95 VCR isn't worth any effort unless the problem is obvious. This junk is built as cheaply as possible with a lot of plastic parts, no thought given to access for testing or repair, and with attention only to the short-term bottom line. In fact, there has been no miraculous invention to reduce construction cost of the relatively complex VCR mechanism—it comes out of reliability.

How about other equipment: cell phones, pagers, and other modern wireless devices such as cordless phones; PC main boards, peripheral boards, and disk drives; TV set-top and cable boxes, satellite receivers, etc. It is basically impossible to obtain service information on any of these so unless the problem is an obvious broken connector or broken trace on the printed circuit board, or possibly a dead power supply, forget it. You don't have the documentation, test equipment, rework equipment, or any chance of buying many of the repair parts in any case.

Any situation where safety would be compromised by your repair should be avoided. For example, do not attempt to reconstruct a smashed microwave oven door or "rig" a flyback transformer that has serious arcing. One must very carefully inspect for any possible safety-related damage (like charred insulation in hidden areas) that may not have affected operation. If you really don't know what you are doing, leave it to a professional! Not only is it dangerous to be poking around inside many types of equipment if you don't even know what not to touch, there is a strong likelihood that such attempts will cause additional, possibly fatal, damage to the circuitry. Even if the equipment can be repaired, the ultimate cost will end up being much greater than if you had not done anything in the first place—both in terms of labor (troubleshooting and repair) and parts. If you can't justify a professional repair, just set it aside until you have more experience and can deal with the equipment safely (for you and it).

Finally, don't attempt to repair a piece of equipment for which you do not have the proper tools or test equipment. Attempting to remove a part from a multi-layer printed circuit board without proper desoldering equipment will just make an unsalvageable mess. Guessing at a replacement part ("I heard that the flyback transformer is a likely cause for a dead monitor.") will just end up being frustrating and expensive (unless you've won the Lottery recently, in which case maybe your luck is still holding).

What About Older Equipment?

The basic technology of TVs and VCRs hasn't changed significantly in 10 or 15 years. Yes, there are convenience features like "auto clock set." They are supposed to make life easier but often don't (If the station transmitting the clock information has their clocks set wrong or uses a feed from source in a different time zone!). But as far as picture and sound quality, that VCR from ten years ago will be just as good or better than one purchased today. It will almost certainly be better constructed and more maintainable. For example, Panasonic VCRs from the mid- to late-80s were solid machines that could be kept in shape with a bit of periodic maintenance (cleaning, rubber parts replacement) and repair of known problems (failed electrolytic capacitors in the power supply after years or so). One could not expect that $39.95 special to provide such service. If it lasts through the warranty period, you're probably ahead of the game. I'd still take a middle-aged Panasonic over any new low- to medium-priced model. Even the high-end VCRs may be based on a flimsy chassis.

In the good old days when life and electronics were simpler and you could count the total number of transistors in a TV on your hands and feet, service information was included with the equipment or was readily available

CD Player Restoration—Here is a case of a piece of equipment being partially destroyed by previous repair attempts. The Pioneer PD5100 is a basic solid CD player, but this one had broken parts in the loading mechanism and was in unknown operational condition. If it were taken to a repair shop, the response would probably be something along the lines of: "Well, that certainly looks like a delayer." It simply wouldn't be worth the time and effort to repair what was obviously broken with the possibility of finding more serious electronic problems after that.

I had nothing better to do (!!), so I decided to try to restore it to something usable. After repairing the mechanical damage, I found there was indeed a servo problem that ultimately required the replacement of a motor-driver chip—for which I got lucky. The player would read the disc directory, but it was unable to seek to any track, even #1. One of the chips was getting hot. So, I replaced it and after servo alignment, the play problems were cured. If that hadn't worked, there was probably little more I could have done. Very likely, the servo chip was the original problem, and the previous repair attempt created the mechanical mess. (Taken from: *Repair Brief #10: Pioneer PD5100 CD Player Trashed)*

Sony TV With Badly Butchered Soldering—Our final example is a Sony TV that had the infamous tuner/IF box solder problems. This is normally a fairly easy repair, especially for this particular model where the IF box (which was faulty in this case) is readily accessible. Once repaired, like the RCA/GE/Proscan TVs with similar solder problems, the result is a solid, reliable TV. However, the friend of a friend who had attempted to replace it apparently used a Weller soldering gun to do the fine soldering, leaving nearly every pad detached or missing. Fortunately, only the pads appeared to have suffered; and after 20 minutes and several new jumper wires, this one was healthy again. (Taken from: *Repair Brief #81: Sony KV-19TR20 Color TV—No Reception*)

either from the manufacturer or Howard Sams at *Sams' Photofacts* (no relation to me). There are still *Sams' Photofacts* for many TVs at least; but, for anything else, obtaining schematics may be impossible or the cost may be excessive if they are available. Paying $100 for a mediocre copy of a service manual for a computer monitor that can be replaced for $250 may not be justified.

One way to get an idea of your chances of success with repairs of popular brands and models is to search the archives of the Usenet newsgroup sci.electronics.repair. If others have experienced—and repaired—similar problems, your chances of success are greatly increased. Asking for suggestions on that newsgroup may also be beneficial, especially if you have already done some initial testing.

Repairs For The Novice

It would be way too easy to poison your future outlook on servicing by attempting repairs multiple times and failing or making things worse. Equipment that is good to learn on because of immediate or ultimate gratification might include: small appliances, power tools, remote controls, and basic audio equipment like tape decks and low power amplifiers (not big power amps!). While electronic troubleshooting of CD players and VCRs is definitely for the advanced, they often have problems that can be easily remedied by a proper cleaning and/or general maintenance. Electronic problems are tough to diagnose, but most problems are mechanical and easier to fix. Microwave ovens are generally easy to repair, but because of the very serious safety issues, I'd suggest holding off on these unless you are experienced in dealing with high-voltage high-power equipment.

With reasonable care, PC troubleshooting involving basic swapping of components can also be rewarding. Don't expect to repair a main board with a peculiar failure of IRQ2 (unless you find a lock washer that ate through to some PCB traces!). Intermediate level troubleshooting and repair would include TVs, since service information in the form of *Sams' Photofacts* is available for the majority of popular models. Video (not computer) monitors are also straightforward to deal with. Perhaps it is also best to leave audio-amplifier and -receiver repairs to more seasoned technicians.

For those just starting out, there are some types of equipment to avoid (beyond those mentioned above). One in particular is a modern computer monitor. With their wide scan-rate range, microprocessor control, need for decent test equipment, dangerous voltages, and the difficulty in obtaining service information, even professionals will stay away from many of these—particularly no-name or non-major brand models. Except for obvious problems like bad solder connections, a blown fuse (replace *once* only, might have been a power surge), or the need for degaussing, they may not be worth the frustration, certainly not as your first project. TVs are not only much simpler than computer monitors, but, as noted, complete service information is usually available.

Wrap-Up

I hope that this discussion of some of the considerations for when to attempt repair has been useful. As always, please send feedback via e-mail. In particular, I'd like to know what you want to see covered in "Service Clinic." If you have some suggestions for general short topics, please pass them along. I think the days of the feature-length Service Clinic series are behind us, but we could have some Q&A, detailed treatment of a particular patient (like the Repair Briefs at my Web site—*repairfaq.org*), specific techniques for component testing, and so forth. See you next time. **P**

LETTERS

(continued from page 5)

is eliminated. The problem is that most parts suppliers do not stock 1.0-ohm, 1-watt, 1% resistors. I have found two solutions. Mouser Electronics stocks Vishay 1% 3-watt resistors in values down to 0.005 ohm (the stock number for 1.0 ohm is 71-RS2B-1.0). The other solution is that ten 10-ohm 1% resistors can be connected in parallel to make 1 ohm. Using the 10-ohm resistors costs less, as *MCM Electronics 2001 Catalog* lists them at ten for 30 cents (stock numbers 652-10, 662-10, or 352-10).

For those who would only need the Bias Checker occasionally, the cost can be reduced by replacing DISP1 with two tip jacks, for connection of the probe tips of a Digital Multimeter. (Nearly all DMMs have a 200 millivolt range). I plan to use this method, but I will use a plastic cabinet large enough to allow later installation of a digital panel meter. I also plan to use 18-gauge speaker wire or zip cord to connect the tube plugs and sockets to the cabinet; and I'll run the wires through holes in the case, eliminating PL3 and J1.

For those using the digital panel meter, I find most of them specify a factory calibration to 0.5%. Even when 1% resistors are used, it probably would be advisable to check that calibration, using the method described in the article. The use of D1 and D2 to protect against burnout of R1 and R2 in case of a shorted tube is good, but the hobbyist should make sure their polarity is correct. I saw one amplifier that had 1-ohm resistors installed in it for measuring the bias, and one of them had been burned out by a shorted tube. Also, there are a few amplifiers that have odd-ball cathode circuits in which the Balance position of S1 will not be useable.

BILL STILES
Hillsboro, MO

More Detail

I have been an avid reader of **Poptronics** magazine for the last two years. I am also an electrical engineering student about to graduate. I read your magazine in an attempt to get a better understanding of circuitry and to get an idea of the different types of ICs available these days.

Your projects are enjoyable to read and learn from. However, I often struggle with a lot of your articles in trying to fully understand the concept of the project. Your articles seem to be written primarily to give a basic idea of how the project works, but they do not seem to fully explain the project's operation—at least for someone at my level. Mostly, they only show how to build a project.

I realize that to write an article that would fully describe each function of the circuit, as well as to fully describe the theory behind the project, would be nearly impossible. The space alone to write such an article would be a magazine in itself.

However, I would like to ask that you publish some articles that would allow those readers who like to fully understand a project, both in theory as well as circuitry, to have that opportunity. Too many times, the authors take for granted that readers know more than they do. For example, they often use acronyms that never get defined within the article. The articles also talk about circuits as though everyone fully understands their operation.

I realize that writing for a broad audience requires such assumptions, but please realize that your audience may not all be at that level of understanding. I would rather read an article that insults my intelligence by writing more than I need to know about a subject than to be left feeling angry because there is not enough information presented.

I would also like to request articles on simple basic circuits and concepts. For instance, I have been trying to learn about phase-locked loops for some time, and I have yet to find a simple circuit that I can simulate to gain a good understanding of how they work.

TERRY LEE CALIENDO
via e-mail

Tubes and Antiques

I've enjoyed **Popular Electronics** for years, and I like the look of your new magazine, **Poptronics**. In fact, I've just started a new two-year subscription.

I'd like to see a tube-amp project that wouldn't break the bank to build and isn't overly complicated. I'm from the generation that thinks "tubes sound best," and I think some of your younger readers might agree if they had a chance to listen to the output from a "glass amp!"

The only suggestion that I have for **Poptronics** is the return of some form of the "Antique Radio" Department. I do enjoy building add-ons for my computer and all things solid-state, but I still find "vacuum-tube logic" charming!

ROBERT EATON
via e-mail

Haves & Needs

I am in need of a Heathkit manual for a model AR-1302 Stereo Receiver. I will be happy to pay for a manual or copying, shipping, and handling.

ROBERT L. LINDSEY
3 Johns Drive
Mechanicsburg, PA 17050
rlindsey@pa.net

BUDGET PROJECT AND COMPUTER BOOKS

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☐ **BP368—Practical Electronics Musical Effect Units $6.99.** There is a constant hullabaloo for musical effects projects by the hobbyist community. This book provides practical circuits for several projects that range in complexity and are sure to work. All the circuits are easy to build and use readily-available parts.

☐ **BP385—Easy PC Interfacing $6.99.** The built-in ports in your PC provide an easy and hassle-free way of interfacing your circuits. This book provides useful PC add-on circuits including the following: Digital input/output ports; analog-to-digital and digital-to-analog converters; voltage and current measurement circuits; resistance and capacitance meters, temperature measurement interface, biofeedback monitor, and many other useful interfaces.

☐ **BP396—Electronic Hobbyists Data Book $7.99.** This book contains details of a modern five-band resistor code or an old color code for a ceramic capacitor, the formula for parallel resistance, and basic data on an NE5534AN operational amplifier.

☐ **BP343—A Concise Introduction to Microsoft Works for Windows $7.99.** This book explains how the Works for Windows package fits into the general Microsoft Windows environment; how to use the word processor to your advantage; how to use Microsoft Draw to create and edit graphics and place them in your documents; how to build up simple spreadsheet examples; and how single, and multiple charts, or graphs, of differnet types can be generated. And there's much more!

☐ **BP282—Understanding PC Specifications $5.99.** This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, 80486, Pentium etc.); math co-processors; input devices (keyboards, mice, and digitizers); memory, including both expanded (EMS) and extended RAM; RAM disks and disk caches; floppy disk drive formats and compatibility; hard disk drives; and display adapters (CGA, Hercules, super VGA, etc.).

☐ **BP298—Concise Intro to the Macintosh System and Finder $5.99.** This book explains: The System and Finder, what they are and what they do; how to use the System and Finder to manipulate disks, files and folders; configuring and printing files from the Finder; getting the most from the system utility programs; and running MultiFinder.

☐ **BP316—Practical Electric Design Data $7.99.** A comprehensive ready-reference manual for electronic enthusiasts with over 150 practical circuits. It covers the main kinds of components (from pig-tail leads to surface mount), pinouts, specs and type selection. Basic units are defined and most used formulae explained. Five additional sections are devoted to circuit design, covering analog, digital, display, radio and power supply circuits.

☐ **BP345—Getting Started In Practical Electronics $6.99.** This book provides basic essentials for the builder and 30 easy-to-build fun projects with which every experimenter should toy. Printed-circuits designs are included to give your project the professional touch.

☐ **BP451—Troubleshooting Your PC Printer $8.99.** Explains the different printer types, their suitability for different tasks, the costs of running them, how to connect them and get the driver software running and, of course, what is most likely to go wrong and what you can do for yourself. Most important of all, it warns you of what you should quite definitely NOT try to do for yourself.

☐ **PCP112—Digital Electronics Projects $10.99.** Contains 12 digital electronics projects suitable for the beginner to build with the minimum of equipment—from instrumentation to home security, and a few "fun" projects too. With one exception, all projects are battery powered, and therefore, are completely safe for the beginner or young constructor.

☐ **PCP107—Digital Logic Gates and Flip-Flops $10.99.** This book seeks to establish a firm foundation in digital electronics. It is for the user who wants to design and troubleshoot digital circuitry with full understanding of the principles. No background other than a basic knowledge of electronics is assumed.

☐ **BP317—Practical Electronic Timing $6.99.** This book provides the time measurement theory and backs it with a wide range of practical construction projects. Each project has how-it-works theory and how to check it for correct operation.

☐ **BP325—A concise User's Guide to Windows 3.1 $6.99.** Understand what hardware specification you need to run Windows 3.1 successfully, and how to install, customize, fine-tune and optimize your system. Get into understanding the Program Manager, File Manager and Print Manager. Tips on the word processor, plus how to use Paintbrush. More on the Cardfile database with its auto-dial feature, Windows Calendar, Terminal, Notepad, etc.

☐ **BP327—DOS: One Step at a Time $5.99.** There will be times when you absolutely need to use DOS to carry out 'housekeeping' functions. This book starts with an overview of DOS, and later chapters cover the commands for handling disks, directories and files.

☐ **PCP120—Multimedia on the PC! $14.95.** Multimedia can do lots of nice things! This 184-page book helps you create your own multimedia presentation. Multimedia applications by people like you can revolutionize educational and business applications as well bring more fun, fun, fun into your leisure computer activities.

☐ **BP404—How To Create Pages for the Web Using HTML $7.99.** HTML is the language used to create documents for Web browsers such as Mosaic, Netscape and Internet Explorer. These programs recognize this language as the method used to format the text, insert images, create hypertext and fill-in forms. HTML is easy to learn and use. This book explains the main features of the language and suggests some principles of style and design. Within a few hours, you can create a personal Home Page, research paper, company profile, questionnaire, etc., for world-wide publication on the Web.

☐ **BP411—A Practical Introduction to Surface Mount Devices $6.99.** This book takes you from the simplest possible starting point to a high level of competence in working with Surface Moint Devices (SMD's). Surface mount hobby-type construction is ideal for constructing small projects. Subjects such as PCB design, chip control, soldering techniques and specialist tools for SMD are fully explained. Some useful constructional projects are included.

☐ **BP379—30 Simple IC Terminal Block Projects $6.99.** Here are 30 easy-to-build IC projects almost anyone can build. Requiring an IC and a few additional components, the book's 'blackbox' building technique enables and encourages the constructor to progress to more advanced projects. Some of which are: timer projects, op-amp projects, counter projects, NAND-gate projects, and more.

☐ **BP401—Transistor Data Tables $7.99.** The tables in this book contain information about the package shape, pin connections and basic electrical data for each of the many thousands of transistors listed. The data includes maximum reverse voltage, forward current and power dissipation, current gain and forward transadmittance and resistance, cut-off frequency and details of applications.

☐ **ETT1—Wireless & Electrical Cyclopeia $4.99.** Step back to the 1920's with this reprinted catalog from the Electro Importing Company. Antiquity displayed on every page with items priced as low as 3 cents. Product descriptions include: Radio components, kits, motors and dynamos, Leyden jars, hot-wire meters, carbon mikes and more.

☐ **BP76—Power Supply Projects $3.99.** Presents a number of power-supply designs including simpled unbiased types, fixed voltage-regulated types and variable voltage stabilized designs. All are low-voltage types intended for use with semiconductor circuits. Apart from presenting a variety of designs that will satisfy most applications, the data in this book should help the reader to design his own power supplies. An essential addition to the experimenters electronics library.

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ET12

DIGITAL DOMAIN

(continued from page 20

mail. It can also automatically send last-minute flight updates to your pager, and it provides tools to help businesses stay within their travel budget.

For larger organizations, "managed travel" sites such as GetThere, at *www.getthere.com*, handle group rates you've negotiated with airlines, hotel chains, and car rental agencies. GetThere can build a travel intranet that employees can use to book their own travel. Some managed travel sites are beginning to offer their services to smaller businesses.

NOT SO SMOOTH SAILING

With any given trip, the time and cost savings you expect from going online may fail to materialize. Web pages may load slowly or crash, turning the process into a time-consuming headache. The least expensive itinerary from a discount site may be more expensive than from other sites or from a local travel agent.

Sometimes the advice you get is flat-out wrong. Mapping services, for instance, often provide driving directions that get you there via a slow, indirect route. Computer algorithms may be more sophisticated than ever, but most computers are no match for a human being when it comes to decision making, even with something as mundane as whether to turn right or left.

Some high visibility travel sites might not be around much longer. The investment firm Bear Stearns predicts that in two years, even though online travel revenue will increase fourfold, 80 percent of travel Web sites will fold, particularly discount sites.

The biggest name in discount travel, Priceline.com, at *www.priceline.com*, is currently in trouble, despite the efforts of former pitchman William Shatner. The company recently laid off workers and plans to lay off more as it shuts down its grocery and gasoline operations.

The value of its stock has tumbled more than 90 percent over the past year and a half, and the company is under investigation by the attorney general's office in Connecticut, where the company is headquartered, because of complaints from consumers.

Priceline.com's reverse auction format has attracted a lot of bargain hunters, particularly in the travel area. You specify what you're willing to pay for an airline ticket, hotel room, or rental car and hope it's accepted. But the reality doesn't always live up to the hype. Low bids are often rejected and when they are accepted, you have to accept terms that frequently include inconvenient departure and arrival times and out-of-the-way airports and hotels. Priceline.com, which unlike a lot of dot-coms generates significant revenue, could still survive the predicted industry shakeout. As with everything else about the Internet, the only constant is change.

SEARCHING FOR A CONSTANT

It is hard to predict trends in a volatile environment such as the Internet. One thing is for certain, though—there will always be options. When a consumer plugs a product name into the search engine, nine out of ten times there will be a reasonable list of merchants' Web sites. Consumers love to haggle, and whether it is a commercial transaction or negotiations about a job, the capabilities of the Internet are useful tools.

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CHARLES D. RAKES

The 4017 Saga Continues!

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This visit, we're going back for yet another look at a number of CD4017-driven LED-matrix circuits. The electronic matrix, in our application, can be defined as the results of two electronic circuits combining to form a new selected output common to both inputs. The most common electronic-matrix circuit consists of vertical circuits crossing horizontal circuits. Any of the crossing points can be a selected output. This can best be explained by taking a look at the simple five-by-five matrix circuit shown in Fig. 1.

The "X" circuits are on the five horizontal lines, and the "Y" circuits are on the five vertical lines. With the switches in Position 1 as shown, the crossing point of both circuits occurs at junction "A." Leaving "X" in Position 1 and moving the "Y" switch to Position 2 moves the output to junction "B." As the "Y" switch moves through Positions 3, 4, and 5, the selected output moves sequentially to junction "C," "D," and "E."

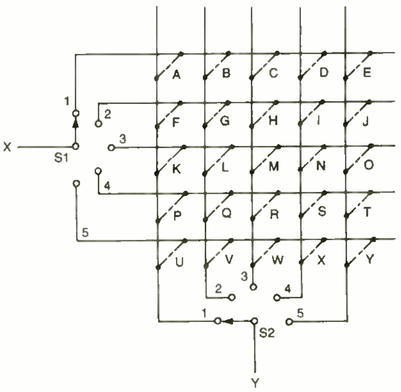

Fig. 1. A simple set of rotary switches makes it easy to select a particular intersection in a matrix.

PARTS LIST FOR MECHANICAL SWITCHING MATRIX (FIG. 1)

S1, S2—Single-pole, five-position rotary switch
Bus wire, etc.

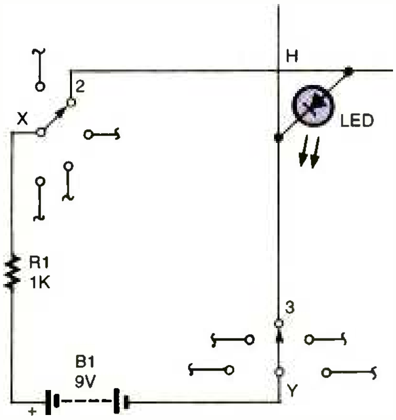

Fig. 2. The switches from Fig. 1 can power an LED connected at the matrix cross-over points.

PARTS LIST FOR CONNECTING AN LED TO MATRIX (FIG. 2)

B1—9-volt transistor battery
LED1—Light-emitting diode, any color
R1—1000-ohm, ¼-watt, 5% resistor

Any junction from "A" to "Y" may be selected as an output by simply setting the "X" and "Y" switches to the positions that cross over the desired letter junction. The number of output positions is equal to the number of "X" circuits multiplied by the number of "Y" circuits. In Fig. 1, there are five circuits in each group with a combination of 25 outputs. A matrix with ten vertical and ten horizontal rows would produce a combination of 100 outputs. It's easy to see how a very large matrix can be made with a limited number of input circuits.

Let The Light Shine

What can we do with such a matrix circuit? Well, let's look at some of the neat projects that can be built around Fig. 1. An LED can be connected at any cross-over junction and lit by setting the "X" and "Y" switches to the selected cross-over junction. See Fig. 2. Actually, an LED can be connected to all of the junctions. Each LED is then selected by the settings of the two input switches.

All that's needed to complete the circuit is a 9-volt battery and a 1000-ohm current-limiting resistor. The mechanical switching version of the matrix circuit is probably not one that you would run to your junk box to gather up parts for, but in its simplest form it can be turned into a game of sorts by rotating the switches and chasing the lit LED around the matrix.

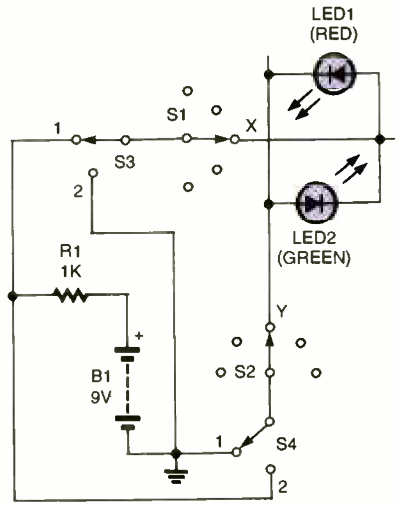

Fig. 3. By adding an additional pair of switches, you can reverse the current polarity, lighting a second LED.

PARTS LIST FOR THE SWITCHING COLOR CIRCUIT (FIG. 3)

B1—9-volt transistor battery
LED1, LED2—Light-emitting diode, any color
R1—1000-ohm, ¼-watt, 5% resistor
S1, S2—Single-pole, five-position rotary switch
S3, S4—Single-pole, double-throw rotary switch

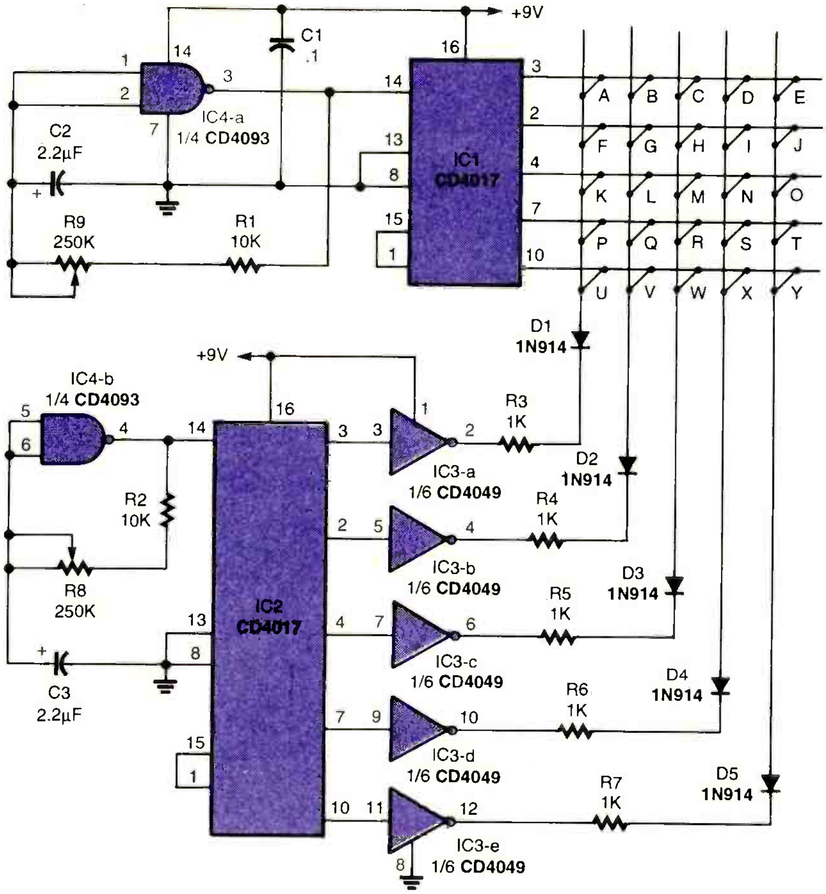

Fig. 4. A "random" flashing pattern results from clocking two CD4017s with independent oscillators.

PARTS LIST FOR THE AUTOMATED MATRIX (FIG. 4)

SEMICONDUCTORS

IC1, IC2—CD4017 CMOS decade decoder, integrated circuit
IC3—CD4049 CMOS hex-inverting buffer, integrated circuit
IC4—CD4093 CMOS quad Schmitt trigger NAND gate, integrated circuit
D1–D5—1N914 silicon diode.

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1, R2—10,000-ohm
R3–R7—1000-ohm
R8, R9—250,000-ohm potentiometer

ADDITIONAL PARTS AND MATERIALS

C1—0.1-µF, ceramic-disc capacitor
C2, C3—2.2-µF, 25-WVDC, electrolytic capacitor
IC sockets, potentiometer knobs, etc.

Red Or Green?

Following the dual-polarity circuit in Fig. 3 can easily double the matrix's output. Two different colored LEDs are connected back-to-back in parallel across each cross-over point. One LED will light when the "X" input is positive and the "Y" is negative, and the other LED will light when the polarity is reversed. The added switches, S3 and S4, allow for the polarity reversal. With the switches in the position shown in Fig. 3, the positive polarity is connected to the "X" circuit and the negative (ground) is connected to the "Y" circuit. This places the positive supply to the anode of LED1 (red) and the negative supply to its cathode, lighting the LED.

Switching S3 and S4 to Position 2 reverses the output polarity and the green LED lights. Adding the doubling circuitry to our mechanically-switched matrix circuit in Fig. 1 changes the 25-output matrix into a 50-output matrix.

The LED Matrix Wave

Our next entry, shown in Fig. 4, converts the basic matrix circuit into a fully automated LED matrix wave machine. The versatile CD4017 (I bet you were wondering when we were going to slip in a reference to this month's featured chip!) comes to the rescue to replace the two mechanical switches. Control of the "X" and "Y" circuits is handled by IC1 and IC2, respectively. A CD4093 Schmitt-trigger NAND gate, IC4-a, is connected as a simple low-frequency squarewave oscillator, which supplies the clock signal to IC1. A duplicate circuit using IC4-b supplies the clock input for IC2.

The CD4017 produces a positive

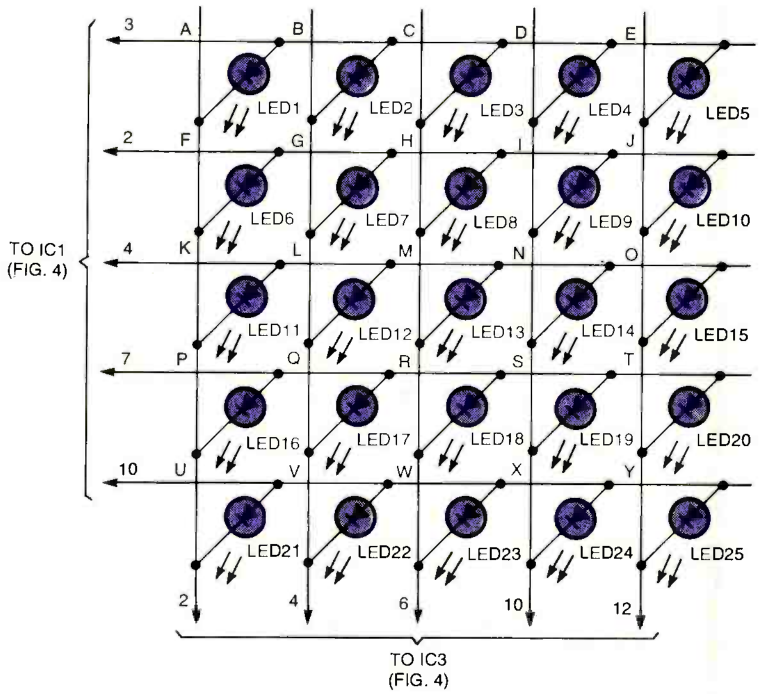

Fig. 5. Here's the details on connecting 25 LEDs in an addressable matrix.

PARTS LIST FOR CONNECTING LEDs TO MATRIX (FIG. 5)

LED1–LED25—Light-emitting diodes, any color
Tinned copper wire bus bars, etc.

voltage at the active output position, while the remaining nine outputs stay at ground. This makes it simple to add an LED to any or all outputs. The LED's anode connects to the desired CD4017's output; the LED's cathode goes to ground. This simple scheme works great when only one CD4017 is used.

Grounding Out The Other End

The outputs on IC2 must be inverted from a positive output to a grounding output for all of the vertical circuits. This is necessary for an electrical path to appear at the cross-over points. A CD4049 hex-inverting buffer connected between each of IC2's outputs turns the output signal upside-down, producing a grounded output for the vertical matrix circuits. The five 1N914 diodes, D1–D5, keep the voltage at the cross-over point from reversing and damaging the LEDs.

Hooking 'Em Up

Connecting the 25 LEDs to the matrix circuit is easily accomplished by following the drawing in Fig. 5. The anodes connect to the "X" circuits and the cathodes to the "Y" circuits. Let your imagination run wild in choosing the size and color of LEDs used. Mixing the colors in a random manner can only enhance the matrix-wave performance.

Run LED, Run

Let's look at a few scenarios that might occur with our matrix-wave circuit. Both the clock oscillators are free running and independent of each other. Each oscillator's frequency can be adjusted from about 1 Hz to over 100 Hz. The frequency range can easily be changed by either increasing the value of

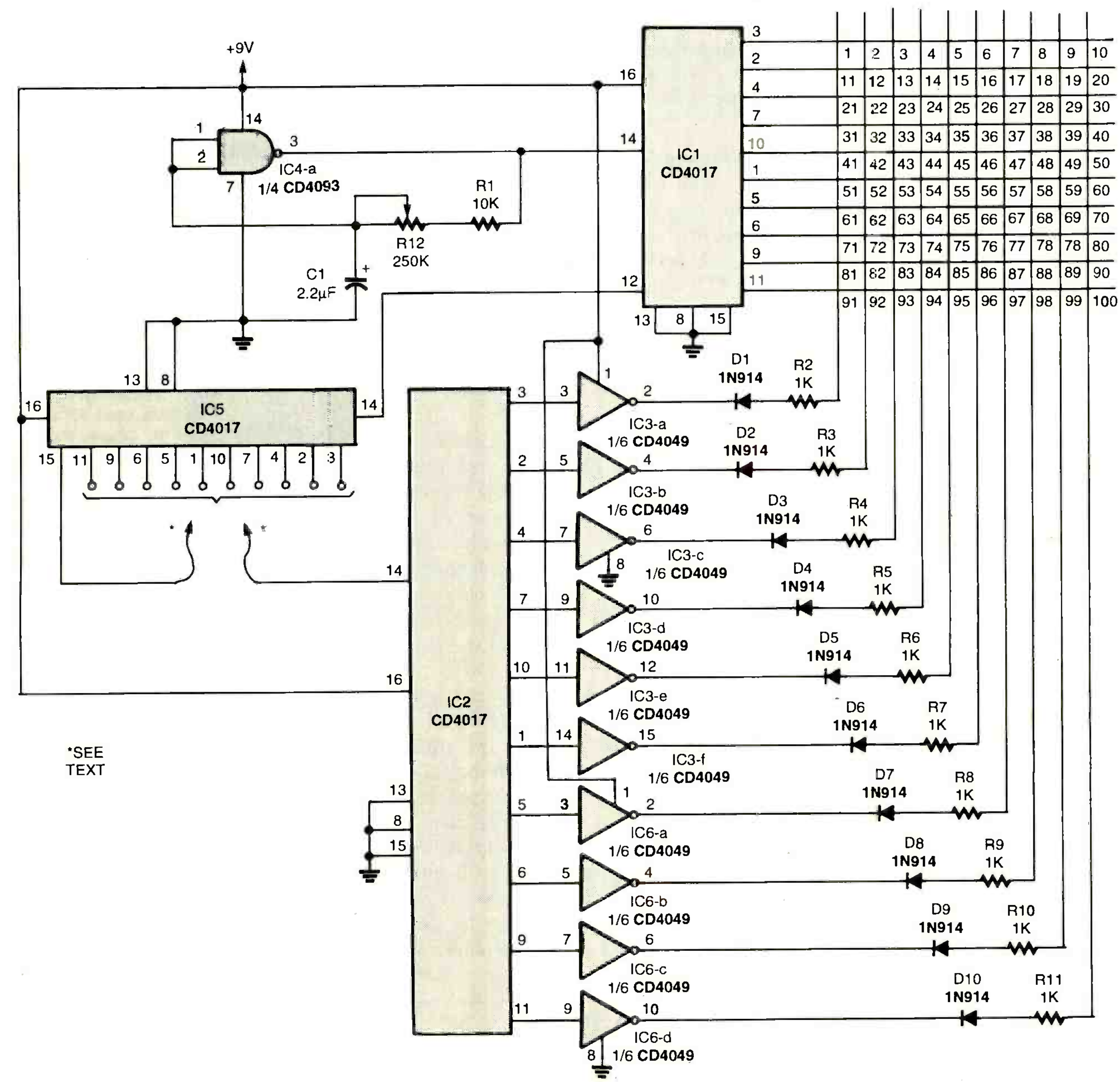

Fig. 6. This CD4017-based display circuit can access up to 100 LEDs.

C2 or C3 to lower the frequency range or decreasing the capacitor value to increase the range.

The clock oscillators can be adjusted for a ratio of 10:1 with IC4-a operating at about 1 Hz and oscillator IC4-b at 10 Hz. The matrix's output will count down ten vertically and over one row at a time until all LEDs have been lit sequentially. If the procession starts at cross-over point "A" (see Fig. 5), LEDs at junctions A, F, K, P, and U will light sequentially. Then the second row, starting with B, will follow the same sequence. Reversing the clock oscillators with IC4-b operating at 1 Hz and IC4-a at 10 Hz will cause the LED string to move in a horizontal direction.

The possibilities are almost endless in creating various LED waves. Play with the controls and see what you can create.

100-LED Wave

Our next entry, see Fig. 6, bumps the matrix-wave output to 100 LEDs. The circuit includes another feature, which allows vertical rows to move at a selectable rate of 10:1, 20:1, 30:1, and on up to 100:1. This simply means that the lit LED moves vertically through each column from top to bottom, advancing to the next column when the set number of cycles through the column has been completed. Once all columns have been selected, the sequence repeats.

How Did It Do That?

We're using IC5 as a divide-by-and-repeat circuit, with its output supplying the clock pulse for IC2, which drives the vertical circuits. Which output pin is connected to pin 15 of IC5 determines the division factor, which forms the selectable rate feature. The clock input at pin 14 of IC2 is connected to the desired output of IC5.

Dividing by 10 is an easy task. Connect pin 15 of IC5 to pin 2 of IC5, and connect pin 14 of IC2 to pin 2 of IC5. The wave will move across the matrix vertically one LED at a time and then step down to the next row and repeat until all 100 LEDs have been lit sequentially. Dividing by 50 is just as easily done by connecting pin 15 of IC5 to pin 1, and pin 14 of IC2 to pin 10 of IC5. Just follow the same scheme to divide by any number from 20, 30, 40, 60, 70, 80, 90, or 100. The LEDs connect to the cross-over junctions of 1 to 100 in the same manner as shown in Fig. 5.

PARTS LIST FOR THE BIG 100-LED MATRIX (FIG. 6)

SEMICONDUCTORS
IC1, IC2, IC5—CD4017 decade decoder, integrated circuit
IC3, IC6—CD4049 CMOS hex-inverting buffer, integrated circuit
IC4—CD4093 CMOS quad Schmitt trigger NAND gate, integrated circuit
LED1–LED100—Light-emitting diodes, any color
D1–D10—1N914 silicon diode

RESISTORS
(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1—10,000-ohm
R2–R11—1000-ohm
R12—250,000-ohm potentiometer

ADDITIONAL PARTS AND METERIALS
C1—0.1-µF, ceramic-disc capacitor
Bus wire, IC sockets, knobs, etc.

Winding Down

The clock is chiming, my head is spinning from watching all of the LED activity, and the dog needs to go out; until next month, enjoy chasing the LEDs through the matrix maze. ■

Q&A

(continued from page 44)

coil with contacts rated to handle the load of the fan. The power supply can be made in a similar way to the regulator circuits that were described in last month's "Q&A." The circuit doesn't need a high degree of regulation, but make sure that the relay coil doesn't draw much over 500 mA. You might have to heatsink Q1 if it's expected to pass much relay current.

The relay contacts can be put in parallel with the switch that controls the fan. The closure of either the original switch or the relay will turn the fan on. Turning power off to the control circuit will de-energize the relay so that the original switch has the only fan control.

Be sure to build the circuit into a closed box so it cannot be touched accidentally. There also may be some municipal codes you must comply with when you work on your house wiring.

Writing to Q&A

As always, we welcome your questions. Please be sure to include:

(1) plenty of background material,
(2) your full name and address on the letter (not just the envelope),
(3) and a complete diagram, if asking about a circuit; and
(4) type your letter or write neatly.

Send questions to Q&A, **Poptronics**, 275-G Marcus Blvd., Hauppauge, NY 11788 or to *q&a@gernsback.com*, but do not expect an immediate reply in these pages (because of our backlog). We regret that we cannot give personal replies. Please no graphics files larger than 100K. ■

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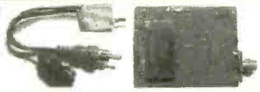

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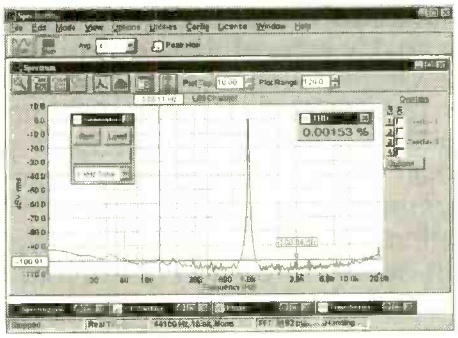

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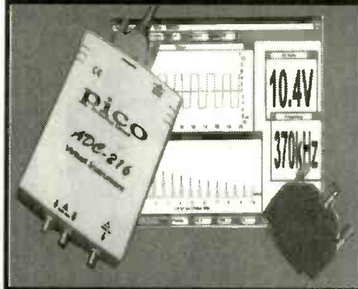

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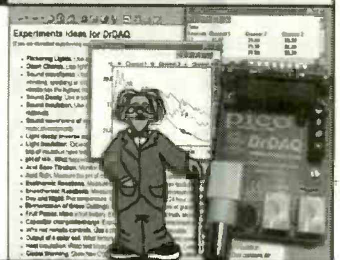

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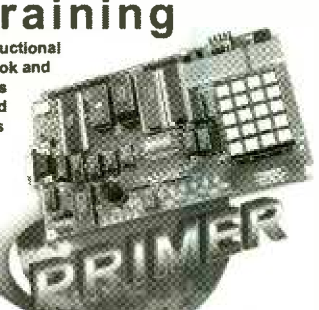

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The PRIMER can be purchased as an unassembled kit ($120) or as an assembled/tested kit ($170). Upgrades provide battery-backed RAM and PC connectivity via an RS232 serial port (shown in picture). Additional options include a heavy-duty keypad (shown in picture) and a 9V power supply -- see our website. Quantity discounts are available. Satisfaction guaranteed.

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DDF-1, Doppler Direction Finder Kit $149.95

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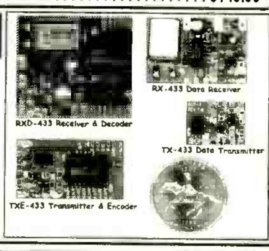
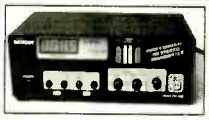


RF link boards are perfect for any wireless control application; alarms, data transmission, electronic monitoring...you name it. Very stable SAW resonator transmitter, crystal controlled receiver - no frequency drift! Range up to 600 feet, license free 433 MHz band. Encoder/decoder units have 12 bit Holtek HT-12 series chips allowing multiple units all individually addressable, see web site for full details. Super small size - that's a quarter in the picture! Run on 3-12 VDC. Fully wired and tested, ready to go and easy to use!

RX-433 Data Receiver............ $16.95 TX-433 Data Transmitter............. $14.95
RXD-433 Receiver/Decoder..... $21.95 TXE-433 Transmitter/Encoder..... $19.95

Super Pro FM Stereo Transmitter



Professional synthesized FM Stereo station in easy to use, handsome cabinet. Most radio stations require a whole equipment rack to hold all the features we've packed into the FM-100. Set freq with Up/Down buttons, big LED display. Input low pass filter gives great sound (no more squeals or swishing from cheap CD inputs!) Limiters for max 'punch' in audio - without over mod, LED meters to easily set audio levels, built-in mixer with mike, line level inputs. Churches, drive-ins, schools, colleges find the FM-100 the answer to their transmitting needs, you will too. Great features, great price! Kit includes cabinet, whip antenna, 120 VAC supply. *We also offer a high power export version of the FM-100 fully assembled with one watt of RF power, for miles of program coverage. The export version can only be shipped if accompanied by a signed statement that the unit will be exported.*

FM-100, Pro FM Stereo Transmitter Kit $249.95
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C-2000, Basic Video Transmitter.............. $89.95 C-2001, High Power Video Transmitter...$179.95

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CCDWA-2, B&W CCD Camera, wide-angle lens $69.95
CCDPH-2, B&W CCD Camera, slim fit pin-hole lens.. $69.95
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IR-1, IR Illuminator Kit for B&W cameras $24.95
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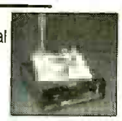
AM-25, Professional AM Transmitter Kit..... $129.95
AM-1, Entry level AM Radio Transmitter Kit... $29.95
CAM, Matching Case Set for AM-1.......... $14.95

FM Stereo Radio Transmitters

No drift, microprocessor synthesized! Great audio quality, connect to CD player, tape deck or mike mixer and you're on-the-air. Strapable for high or low power! Runs on 12 VDC or 120 VAC. Kit includes snazzy case, whip antenna, 120 VAC power adapter - easy one evening assembly.

FM-25, Synthesized Stereo Transmitter Kit $129.95



Lower cost alternative to our high performance transmitters. Great value, easily tunable, fun to build. Manual goes into great detail about antennas, range and FCC rules. Handy for sending music thru house and yard, ideal for school projects too - you'll be amazed at the exceptional audio quality! Runs on 9V battery or 5 to 15 VDC. Add matching case and whip antenna set for nice 'pro' look.

FM-10A, Tunable FM Stereo Transmitter Kit................ $34.95
CFM, Matching Case and Antenna Set $14.95
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Mini Radio Receivers

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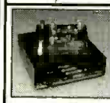
SCA-1 SCA Subcarrier Adapter kit for FM radio.... $27.95
FR-6, 6 Meter FM Ham Band Kit $34.95
FR-10, 10 Meter FM Ham Band Kit.......... $34.95
FR-146, 2 Meter FM Ham Band Kit.......... $34.95
FR-220, 220 MHz FM Ham Band Kit......... $34.95
Matching Case Set (specify for which kit) $14.95

RF Power Booster



Add muscle to your signal, boost power up to 1 watt over a freq range of 100 KHz to over 1000 MHz! Use as a lab amp for signal generators, plus many foreign users employ the LPA-1 to boost the power of their FM transmitters, providing radio service through an entire town. Runs on 12 VDC. For a neat finished look, add the nice matching case set. Outdoor unit attaches right at the antenna for best signal - receiving or transmitting, weatherproof, too!

LPA-1, Power Booster Amplifier Kit....................... $39.95
CLPA, Matching Case Set for LPA-1 Kit.................. $14.95
LPA-1WT, Fully Wired LPA-1 with Case $99.95
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TM-100, FM Antenna Kit.................. $39.95
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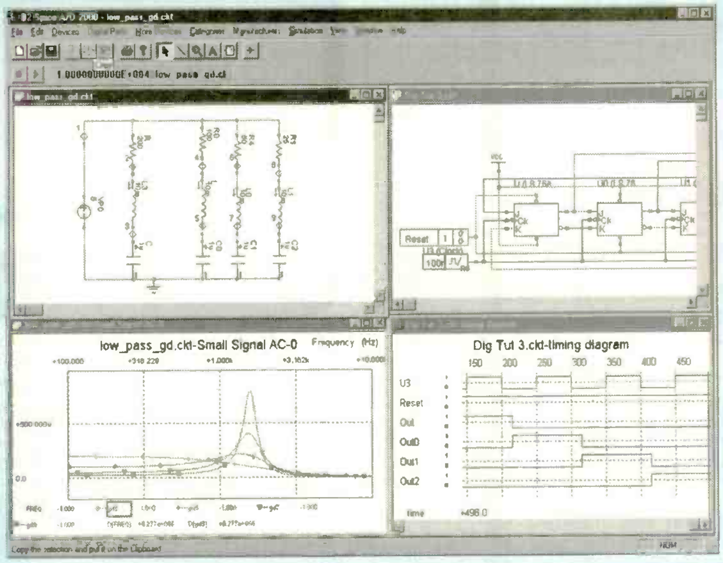

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Transfer function	X	-
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Distortion	X	X
Noise	X	X
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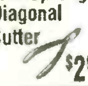

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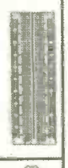

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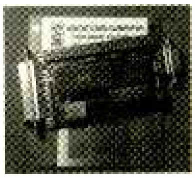

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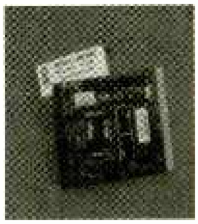

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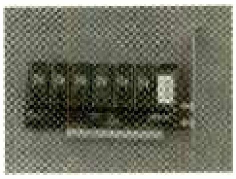

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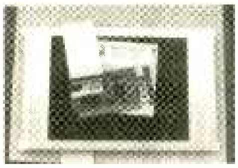

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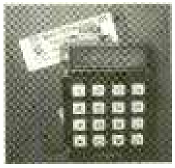

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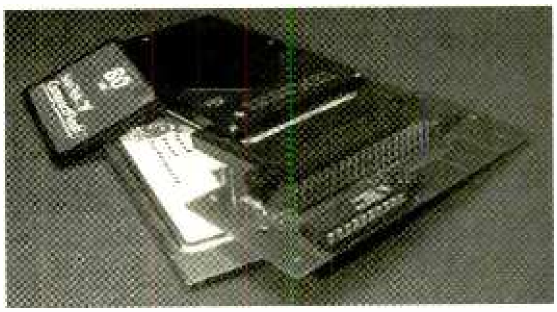

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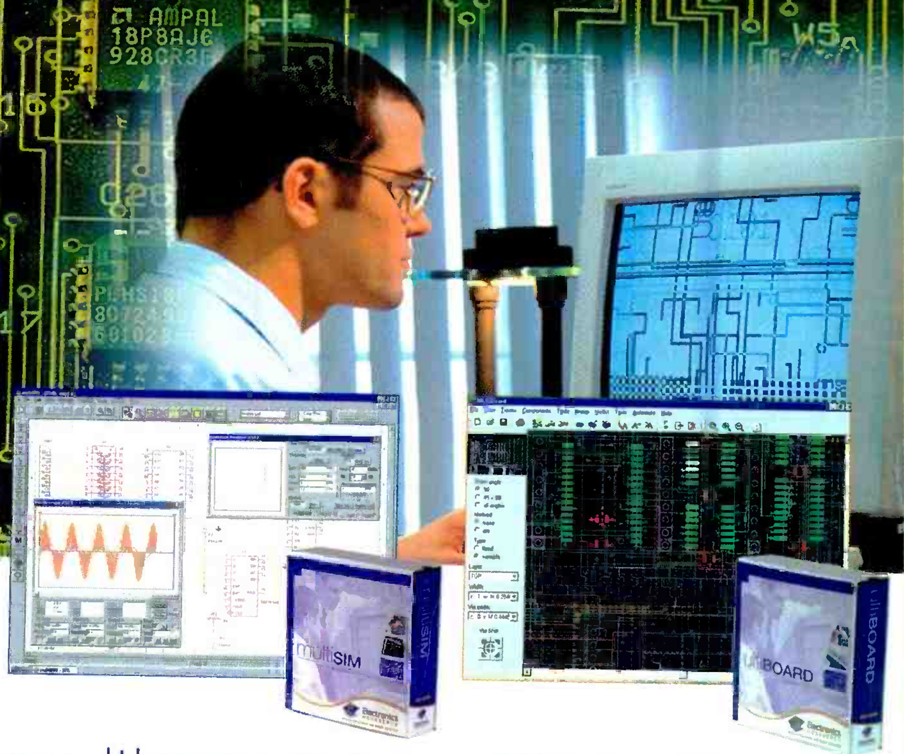

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