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Editorial

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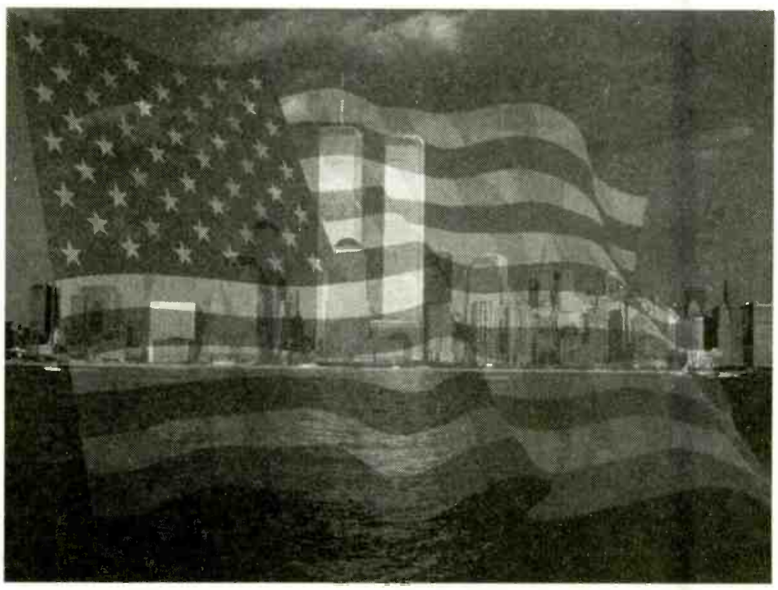
In Our Thoughts and Prayers

December's issue has been in production since September 8th. The disastrous destruction of the Twin Towers on September 11th has hit home, so to speak. The office of Gernsback Publications, Inc. is located on Long Island and is approximately forty miles from the island of Manhattan. The entire staff of **Poptronics** would like to offer their condolences for all those who have suffered—either directly or indirectly—from the tragedies in Pennsylvania, D.C., and Manhattan. Our hearts especially go out to fellow New Yorkers who are in the process of recovering from these acts of terror. No one shall ever succeed in tarnishing the magnificence and style that is New York City. Thank you for the letters of sympathy and support that have been arriving from our readers from across the globe.

Sincerely,

Chris La Morte
Managing Editor



MPX 2000 Correction

In a piece as complex as "The MPX 2000" article in the July issue, there are bound to be some errors. While looking over the schematic on page 30 (mainly to see how the authors implemented their PLL unlock detector), I noticed a few minor mistakes:

- There should be a ground connection at the junction of R112 and C47.
- Transistor symbols for Q6 and Q3 should be PNP types.
- Transistor Q9 is not labeled (2N3866 RF output transistor)

C47 needs no polarity indication, but C9 should have one.

Given the complexity of this circuit and publishing pressures, it is understandable that perfection isn't always possible. We hobbyists should all keep learning though, so when something is amiss in an article we can at least recognize that there is a problem and possibly be able to correct it as well.

I really enjoy ***Poptronics*** and have been a reader (including its predecessor magazines) since the 50s.
KEITH A. KUNDE, K8KK
Independence, OH
P.S. The scanned PCB images in that article are "el stinko"—don't you agree?

Thanks for your understanding and for taking the time to write about these corrections. Other corrections for this article have already been printed in the August issue. We appreciate your keen eye and your attitude; want to come work with us??—Editor

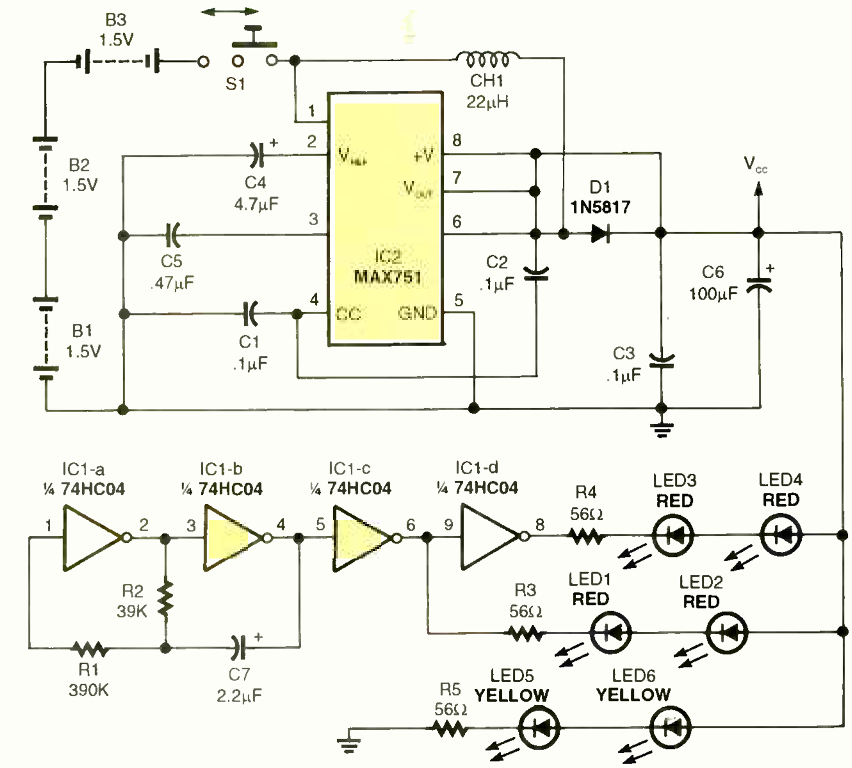


Fig. 1. Once again we bring you the schematic for the Pumpkin Safety Light. Note the changes to **IC1**-d and the connection of CH1.

Pumpkin Safety Light Correction

Fig. 1 shows the corrections to the schematic for "The Pumpkin Safety Light."The schematic has pins 6, 7, and 8 tied together with the anode and cathode of D1 shorted out. It should have CH1 going to the anode of D1 and pin 6 of µ1. Also, pins 7 and 8 of U2 are connected together and conected the the cathode of D1 and C2.

Also, the input to IC1-d is published as being pin 7, but pin 7 is the ground pin for the 74HC04. It shold read pin 9 as the input to IC1-d.

Reader Feedback

I read with interest the letter entitled "60-LED Watch" in the "Q&A" column in the July issue. I think the project referred to as the 60-LED clock was the same one I built around 1995. I've been having a problem with it lately and have tried getting in touch with the designer at his original address, but the letter was returned.

The name of the kit was a "hyper-clock" and it was designed by Leon Schmidt. His company was SkiTronix, P.O. Box 9685, Spokane, WA 99209. If any of your readers know of a more current address, I would appreciate it.

I like the new Poptronics, as I liked its predecessors. I suppose it is better having one magazine instead of two—instead of none at all. I would like to offer one suggestion to the writers of projects that you publish: Offer a parts kit or at least a PCB. I don't make my own PCBs and/or have time to hunt up a bunch of small parts, then drill a and print a case to put it all in. I've passed up some projects that I was quite interested in for this reason. I realize all of the designers don't wish to get into this, but it would be nice if they could at least make a PCB available.
RICHARD FLAWS
Oswego, IL

If I were asked "How to make **Poptronics** a better magazine," my answer would be to divide your isssues into three categories: basic, technical , and expert. Then, with each issue put in a 3×5 card for simple circuits such as power supplies, LEDs and so on.

No one is an expert in electronics, they're just simply good at what they have been exposed to.

My hobby is robotics and lasers. I attended an optical course in the US

Army in 1974, where my field was optical instrument repair. I then went on to lasers and thermal optical instruments. Your magazine has always been a tool and a technical manual for me, except during the past year where, I believe, it has fallen short of help.
FRANK L. PRITCHETT

Thanks for your comments and suggestions. In regard to your problem with contacting Leon Schmidt , this is the situation. The original article was published in .the February 1992 issue of **Radio Electronics**. *The address given was for the author's own P.O Box, which he probably used for that project. .Mr. Schmidt has not written for us lately, and we do not have a current address for him, unfortunately. Sorry that we cannot help you further.—Editor*

Canadian Parts

I am writing about the letter from G.D. Ransford in the September "Letters" column. In addition to those suggested by the editor, here are a few places in Canada itself where parts can be purchased. HVH Technologies, at *www.hvhtech.com*. This Calgary-based company specializes in microcontrollers. It is tailored to the hobbyist, as small orders and related books can all be bought online.

For local electronics parts stores, check out Active Electronics at *www.activestores.com*. This nationally based company has small order, individually packaged products. Their Web site is run by a different company, so you will have to go to the store to find what you are looking for. It has locations in these cities: Calgary, Edmonton, Mississauga, Montreal , Ottawa, Quebec City, Toronto, Vancouver, and Winnipeg.

I hope this will help your Canadian readers.
SEAN CLARK
via e-mail

Canadian Parts II (and Other Matters)

In response to the letter from G.D. Ransford in the September "Letters" column, I suggest you take a spin up to Ottawa and check out Future/Active's Active Components retail store. Pick up a catalogue and inquire about their mail-order service. While I can't vouch personally for either, I've been shopping at the Calgary outlet for years. They are "business-oriented" and tend not to suffer hobbyists' questions too well, but they really do retail an amazing amount of "neat stuff." Also try *www.future-active.com*.

I was happy to see from George Williamson's letter that he agrees with me, at least. If you did something for us "little guys" (say, reintroduce a "Reader's Circuits" column, f'rinstance), perhaps he'll do what I did, and hint to his relatives that he would rather get a gift subscription to ***Poptronics*** for the holidays, instead of the usual socks and ties. Worked for me.

Now for the major "reflections" in this letter, which are on "Radio Signals From The Great Pyramid." After a couple of paragraphs, I checked the cover to make sure you hadn't time-warped me next April's issue.

But, no. Like most electronics hobbyists, I like to think of myself as an amateur scientist (not mad, just grumpy. Thus, this coprolite is so offensive on so many levels that my first draft of this letter was over five pages. As you are no doubt deluged by "backfeed" on this piece (*Yes, see the November "Letters" column.—Editor*), I'll just note a few of the most glaring errors.

Yes, fieldlines will "freeze" in igneous rock, if it contains ferromagnetic minerals. However, it is rather tough to date by fieldline shifts—not only does the earth's magnetic field change polarity every few million years, but the poles themselves wander around like drunken astrologers in the meantime. About all the phenomenon proves is the "shift happens."

As to the "stone radio," I'd want to do a control experiment, hang that great iron bar from a nearby tree with a length of nylon sashcord, hammer the nail in the ground, and see if it doesn't work just as well as when hammered in some poor innocent rock.! Rock's got feelings too, ya know, ya newager, ya!

As to the main premise, fooey! Is it a vacuum or isn't it? How many megawatt-hours of pumping would it take to evacuate the Pyramid, considering that it will be effervescing CO_2 by the hogshead due to several railcars of H_2SO_4 that it has to contain? Not to mention them "open vents"…..aaaaaaargh!

Want to make electricity from a rock? Simple. Obtain some pyrolusite. Powder. Mix with sal ammoniac to form a thick paste. Glop into a galvanized bucket. Splork an inanimate carbon rod halfway in. Voila! You have a dry cell.

You can also get electric power from a model pyramid—with about \$200 worth of gold foil and other goodies , you can get a 14-incher to kick out ¾ volts @200 µA….cheaper to just buy batteries.

To sum up, with "hundreds" of manuscripts…a month" to choose from, why waste eight pages with some new-age pipedreams?

On a positive note, the FM transmitter in the same issue looks interesting.
GRANT DERMODY
Calgary, Alberta, Canada

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:

Letters
Poptronics
275-G Marcus Blvd.
Hauppauge, NY 11788

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Radio Signals And The Great Pyramid

Kudos for your September article, "Radio Signals and the Great Pyramid." While this fine article explored in detail the electrical properties of rock and described several electronic devices the Great Pyramid could have been used as, it gives scant insight into reasons the Ancient Egyptians, great inventors as they were (including plywood), might have had to necessitate these inventions.

I believe that I have solved the

(Continued on page 63)

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The *Guardian 1030 AC/DC/IR Hipot Tester* ($3495) allows technicians to perform dielectric withstand (hipot) tests safely and efficiently. Test voltages can be programmed in the range from 50 V_{DC} to 6k V_{DC} with a 1-volt resolution. The maximum current is limited to 10 mA. The infrared measurement range is from .1 MΩ to 50 GΩ, with test voltages from 50 to 1000 V_{DC}. The unit can be used to perform tests on transformers, electric motors, and a variety of electronic components.

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800-253-1230
www.quadtech.com

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TDL TECHNOLOGY, INC.
5260 Cochise Trail
Las Cruces, NM 88012
505-382-3173
www.zianet.com/tdl

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Placentia, CA 92870
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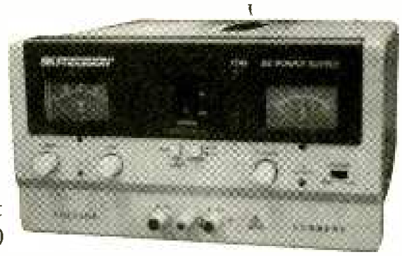

Offering a variable range from 0 V_{DC} to 35 V_{DC}, the *Model 1744 Analog DC Power Supply* ($645) also provides an output current ranging from 0 to 10 amps. Weighing in at only 25.8 lbs., this power supply has a front-panel-mounted analog voltmeter and ammeter that constantly monitor the output. A shorting button has been included for shorting the output while a current limit is set. Both noise characteristics and ripple are low for the power supply output, which provides excellent line and loads regulation.

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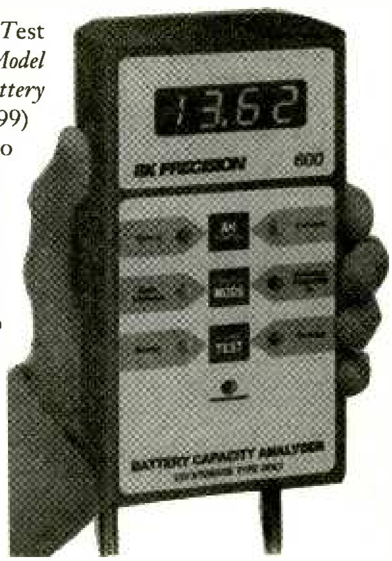
Measure Your BUT



*B*attery *U*nder *T*est (*BUT*)...that is. The *Model 600 Hand-Held Battery Capacity Analyzer* ($299) has been designed to measure both the capacity and no-load voltage of 12-volt lead-acid batteries, similar to the ones found in back-up lighting that is used in offices, hospitals, theaters, etc. No external power is needed—the device is powered by the BUT. Total analysis time is just about six seconds from the time the TEST switch is pressed. The analyzer can also be used for automotive applications, as well.

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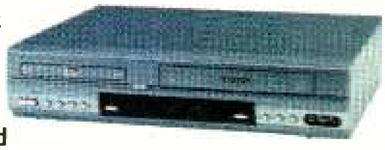

Want DVD, but aren't ready to ditch VHS just yet? The multi-format *DVD-V1000* ($349.99) plays and records to VHS and SVHS tapes, in addition to playing DVDs, CDs, CD-Rs, MP3-encoded CDs, and VCDs. With only one output jack for both DVD and VHS, hookup is a breeze.

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Measuring less than 3½-inches deep, the *Plasmavision SlimScreen PDS-4242* ($9999) offers a 42-inch widescreen plasma display. The 1024- × 1024-pixel panel and the digital video processor deliver high-definition images with exceptional brightness and color reproduction. Image-enhancing technologies include a line doubler and digital noise-reduction circuitry. Extensive inputs and outputs allow the display to be connected to a PC as well as to traditional home-theater gear.

Fujitsu General America, Inc., 353 Route 46W, Fairfield, NJ 07004; *www.plasmaTVnews.org*.

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Terk Technologies Corp., 63 Mall Drive, Commack, NY 11725; 631-543-1900; *www.terk.com*.

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Travel Planner

With the push of a button, you can download turn-by-turn travel directions for multiple trips from Rand McNally's Web site directly to the portable *TripLink* ($69.95). The five-ounce device also provides the exit number, direction of travel, and distance to more than 70,000 roadside services, including gas, food, lodging, hospitals, and rest areas.

Ultradata Systems, Inc., 9375 Dielman Industrial Drive, St. Louis, MO 63132; 800-747-2605; *www.randmcnally.com*.

CIRCLE 53 ON FREE INFORMATION CARD

Sovereign Rule

The *Sovereign DV-5900M* ($1500) is the first 400+3-disc DVD-Audio/DVD-Video/CD mega-changer. It is also the first to be equipped with Faroudja Laboratories' progressive-scan video and line-enhancement technologies. The player provides an RS-232 port for daisy-chaining up to two more units. Kenwood's disc-navigation system with graphical user interface lets you sort, manage, and store discs. Users can access them with cover art, title, track, artist, and genre information via online databases such as CDDB Music Recognition Service and OpenGlobe MovieDB.

Kenwood U.S.A. Corp., 2201 East Dominguez St., Long Beach, CA 90801; 800-KENWOOD; *www.kenwoodusa.com*.

CIRCLE 54 ON FREE INFORMATION CARD

You Can Take It With You

The *SD-P1500 portable DVD player* ($1199.99) boasts an 8-inch widescreen active-matrix LCD display. It has built-in stereo speakers as well as two headphone jacks (one for each kid in the back seat) that use Spatializer N-2-2 Virtual Surround Sound technology. The supplied lithium-ion battery provides more than three hours of movie playback; playing CDs uses much less power. The device can be connected to a TV and stereo for home—or vacation home—use.

Toshiba America Consumer Products, 82 Totowa Road, Wayne, NJ 07470-3191; 973-628-8000; *www.toshiba.com/tacp.*

CIRCLE 55 ON FREE INFORMATION CARD

MP3 Camera

The *ViviCam 2795* ($199.95) is a digital camera with a built-in MP3 player. Measuring just over 3½ × 3 × 1½ inches, the camera can store 29 VGA photos as JPEG images in its 2MB of flash memory, expandable with Compact Flash cards. It can also store 10 minutes of MP3 files in internal memory and up to 90 minutes with the addition of a 16-MB card. Audio clips can be recorded in WAV format as well, and the camera can take video clips at two pictures per second.

Vivitar USA, 1280 Rancho Conejo Blvd., Newbury Park, CA 91320; 805-498-7008; *www.vivitar.com.*

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Featuring both improvements and new elements, the *Signature 800* ($20,000/pair) replaces the Nautilus 801 as the flagship model in B&W's loudspeaker line. Instead of the Nautilus's 15-inch bass driver, the 800 uses two 10-inch woofers— each driven by the proven "motor" structure. In the midrange, the familiar spherical head enclosure houses an improved version of the trademark 6-inch FST Kevlar driver. The high-frequency driver's top-end limit has been extended to 50-kHz, in step with the ultra-wideband SACD and DVD-Audio formats. The speaker is finished in Tiger's Eye veneers and fine leather.

B&W Loudspeakers of America, 54 Concord St., North Reading, MA 01864-2699; 800-370-3740; *www.bwspeakers.com.*

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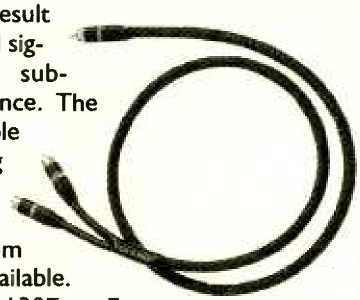

Tributaries, 1307 East Landstreet Road, Orlando, FL 32824-7926; 800-521-1596; *www.tributariescable.com.*

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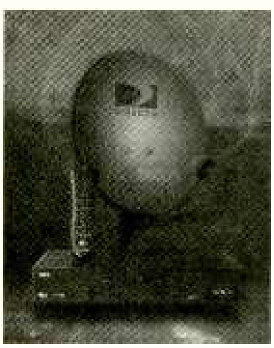
Satellite Web-Surfer

The *RCA DS 4290RE DirecTV Receiver* with UltimateTV service ($499) allows you to watch one show, record another, and surf the Net, all at the same time. It features two satellite tuners, a 35-hour digital recorder, and Internet access via a built-in modem. You can pause live TV and create instant replays. The receiver comes with an 18-inch dual-LNB antenna and a universal remote control. A wireless keyboard is optional.



Thomson Consumer Electronics, 10330 North Meridian St., Indianapolis, IN 46290; *www.rca.com.*

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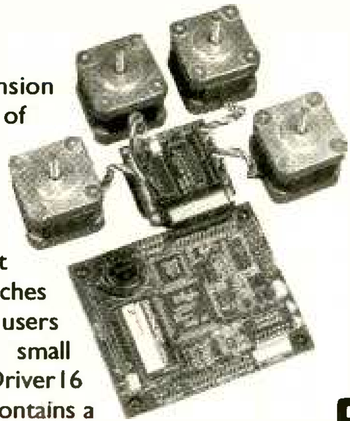
PC GIZMO®

Driver16



The *Driver16* expansion board ($29) allows many of JK microsystems' single-board computers to convert regular TTL-level I/O lines into as many as 16 high-current outputs. Less than two inches square, the board lets users drive relays, lamps, and small motors directly. The Driver16 Development Kit ($39) contains a Driver16 card and everything needed for integration with LogicFlex (pictured), Flashlite 386Ex, or V25 controllers.

JK microsystems, Inc.; 530-297-6073; *www.jkmicro.com.*

Power Protection

Aimed at SOHO PC users, the *Pulsar Esprit Power Cluster* 1.4-kVA uninterruptible power supply with external expandable battery modules can back up two computer servers for over 10 hours. Its suite of "Internet-grade" monitoring and communications features includes Windows 2000 integration and XML Web-based management. The modular system can be configured with power ratings from 1.4 kVA to 13.5 kVA, with prices starting at $1584. Both USB and RS 232 connections are provided.

MGE UPS Systems, Inc.; 714-557-1636; *www.mgeups.com.*

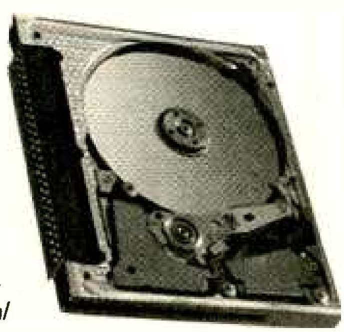
PC Movie Maker

The *Intel Play Digital Movie Creator* ($99) is an easy-to-use digital video camera and software package that lets kids use a PC to script and star in their own movies. As a standalone unit, the camera can capture up to four minutes of footage with audio or 1200 still shots; connected to the PC, its capacity is limited only by the size of the hard drive. Films can be enhanced with a library of titles, special effects, transitions, and sound files.

Intel Corp.; 502-696-8080; *www.intel.com.*

Mighty Micro

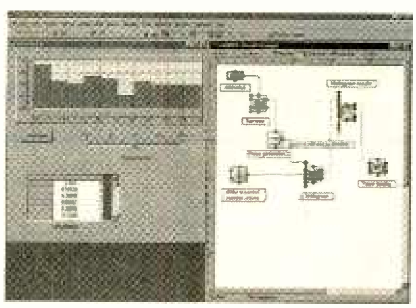
The *IBM Microdrives* provide high-capacity data storage to products, from cameras and PDAs to music players. About the size of a quarter, the 1-GB device can hold up to 1000 photos, 20,000 pages of text, or nearly 18 hours of digital audio music. Prices on the IBM Web site are $199 for 340 MB, $259 for 512 MB, and $379 for 1-GB.



IBM Corp., 888-426-5214; *www.ibm.com/storage/microdrive.*

Beyond Basic

SoftWIRE 3.0 ($495), a graphical programming extension to *Microsoft Visual Basic 6.0*, allows non-programmers to create powerful computer programs quickly, without having to write any code. A visual debugger makes it easy to find mistakes. ActiveX DLLs allow users to create common programming functions and store them in a large library, simplifying large project development.

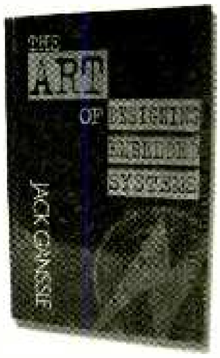


SoftWIRE Tech-nology, Inc.; 508-946-8900; *www.softwiretechnology.com.*

Gizmo is published by Gernsback Publications, Inc., 275-G Marcus Blvd., Hauppauge, NY 11788. Senior Writers: Christopher Scott and Teri Scaduto.

NEW LITERATURE

The Art of Designing Embedded Systems



by Jack Ganssle
Newnes, Butterworth-Heinemann
225 Wildwood Ave.
Woburn, MA 01801
800-366-2665
or 781-904-2500
www.newnespress.com
$39.95

Get better systems out faster, using the practical ideas discussed in this useful primer and handy reference. According to the author, hardware and software can't be designed in isolation. He shows readers how to get better, more integrated code and hardware designs and how to troubleshoot the inevitable bugs. This book presents a philosophy of development, instead of a cookbook of directions.

NOAX's Radio Puzzler

by H. Ward Silver, N0AX
ARRL
225 Main St.
Newington, CT 06661
888-277-5289
or 860-594-0200
www.arrl.org
$7.95

Take some time out with the lighter side of Ham radio, with this compilation of puzzles, word games, quizzes, humorous articles, and cartoons from the pages of *QST*. There is also some previously unpublished material. This is a good book to pick up when you want to tickle your brain cells and gain a little knowledge at the same time.

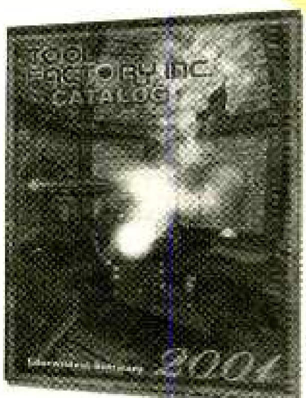
IMovie 2: The Missing Manual

by David Pogue
O'Reilly and Associates, Inc
101 Morris St.
Sebastopol, CA 95472
800-998-9938
or 707-829-0515
www.oreilly.com
$19.95

The companion to iMovie, this book covers every step of iMovie production, from choosing and using a digital camcorder to burning the finished work on CDs. In just under 400 pages, it takes neophytes from Spielberg wannabes to producers extraordinaire and shows them how to have fun doing it. A witty and entertaining read, it's packed with information and humor.

Educational Software Catalog 2001

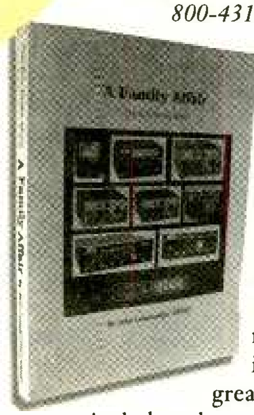
from Tool Factory, Inc.
1929 Dorset Hill Road
East Dorset, VT 05253
800-220-8396 or 802-366-8253
www.toolfactory.com
Free



Aimed at students and teachers alike, the software products in this catalog are a cornucopia from around the world. When necessary, products have been adapted to American conventions. This 50-page full color catalog is packed with over 100 CD-ROM products., in categories such as Language Arts, Math, Social Studies, Early Learning, and History.

A Family Affair—The R. L. Drake Story

by John Loughmiller, KB9AT
Universal Radio, Inc.
6830 Americana Parkway
Reynoldsburg, OH 43068-4113
800-431-3939 or 614-866-4267
www.universal-radio.com
$29.95



Here's the behind-the-scenes story of the famous R.L. Drake Company, focusing on the days when it was king in amateur radio. Weaving together stories of the people involved and the radios they made, the 300-page book is interesting to read and a great technical reference. It also includes a huge section of useful circuits and modifications for many Drake radios.

(Continued on page 20)

A LOOK AT TOMORROW'S TECHNOLOGY

PROTO

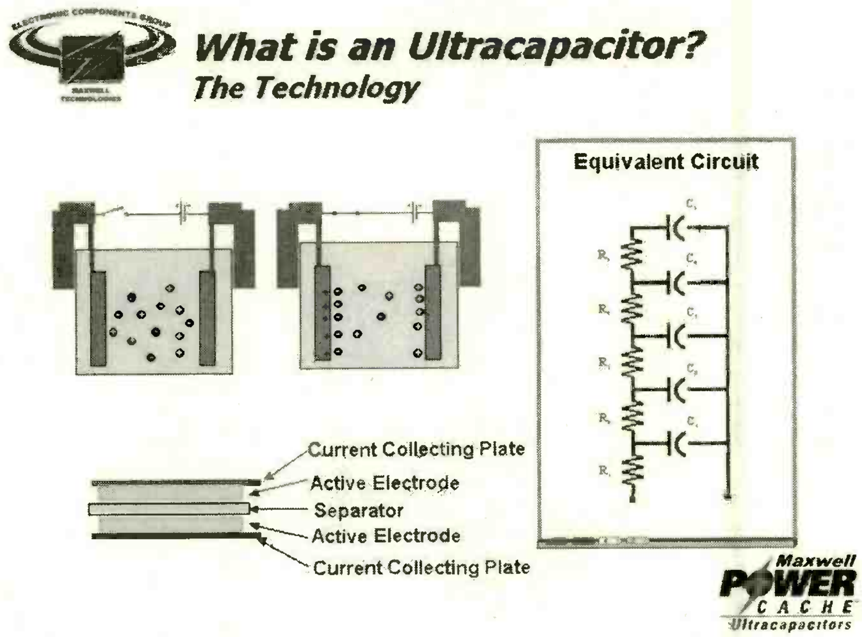
Business Buzz

IF YOU CAN'T BEAT 'EM ...
In an attempt to beat video pirates at their own game, five major Hollywood movie studios soon will begin providing video-on-demand over the Internet. AOL Time Warner, Sony, Viacom (Paramount Pictures), Universal, and MGM hope the move will also cut out costly middle men in video distribution and help the studios get in on the future of digital entertainment. The service will require a broadband connection, limiting its potential audience. Encryption software will let users download films to a PC's hard drive, where they will remain for up to 30 days. Once a film is accessed, however, the user will have just 24 hours to play it on the PC monitor; then it is automatically deleted. Prices for the service have yet to be announced.

HIGH-SPEED SEMICONDUCTOR
According to Motorola, its new semiconductor runs 35 times faster than current models. The secret lies in its fabrication. Gallium arsenide, which is fast but brittle, is bound together via a cushioning, spongy middle layer to silicon. The result is a semiconductor that boasts the durability and economy of silicon and the high speed of crystal components. The new semiconductor runs at 70 GHz, while today's fastest PC processors plod along at a mere 2 GHz. Motorola believes the device will lead to smaller, less expensive, and faster computers, cell phones, and telecommunications equipment.

32-BIT FLASH DSPs
Texas Instruments has unveiled the first 32-bit control digital signal processors (DSPs) with on-board Flash memory and performance up to 150 million instructions per second (MIPS). Aimed at industrial automation, optical networking, and automotive-control applications, the devices are said to deliver 12 times the performance of any existing programmable DSP controller and to reduce development time from hours to minutes. Offering a complete system-on-a-chip, the TMS320F2812 integrates 128 kilowords (kW) of Flash memory, and the TMS320F2810 includes 64 kW, for reprogramming during development and in-field software updates. Samples are scheduled for availability in the first quarter of 2002.

More Power, Mr. Sulu



An ultracapacitor consists of two non-reactive porous collecting plates suspended within an active electrolyte. When a voltage is applied across the plates, the positive plate attracts the negative ions in the electrolyte, while the potential on the negative plate attracts the positive ions. This effectively creates two layers of capacitive storage.

Batteries can store energy for extended periods of time, but have limitations when it comes to peak-power delivery, rapid charging/discharging, and the ability to be deep cycled repeatedly. On the other hand, ordinary capacitors are capable of repeatedly providing high levels of power, but cannot store much energy. Often capacitors cannot discharge their power for more than a few microseconds. Ultracapacitors lie somewhere between batteries and capacitors in their ability to store and release energy rapidly and repeatedly.

Capacitors and Ultracapacitors

Both capacitors and ultracapacitors, also known as "super capacitors," store energy in the form of a separated electrical charge. The greater the area for storing charge and the closer the separated charges, the greater the capacitance or ability to store the charge. A conventional capacitor uses a dielectric material, such as a plastic or paper film or a ceramic, to separate the charged plates. To obtain high capacitance, the flat, conductive material is wound in great lengths. Imprinting a texture on the material increases its surface area and thus its capacitance. Dielectric capacitors can be made only as thin as the available films or applied materials, thus limiting energy-storage capacity.

An ultracapacitor features a carbon-based electrode material, whose porous structure offers a much larger surface area than in a conventional capacitor—approaching 2000 square meters per gram. Its charge-separation distance is determined by the size of the ions in the electrolyte, which are attracted to the charged electrode. This provides separation distances of less than 10 angstroms, significantly smaller than with conventional dielectric materials. The combination of enormous surface area and extremely small charge separation provides the ability to deliver up to 100 times the energy of conventional capacitors and 10 times the power of ordinary batteries.

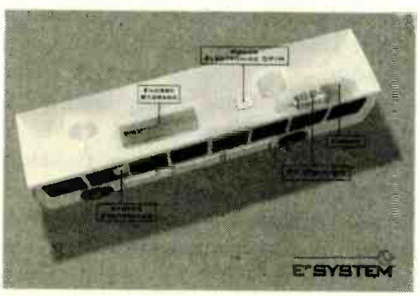
The Way It Works

The way an ultracapacitor stores energy electrostatically is by polarizing an electrolytic solution. Though it is an electrochemical device, a.k.a. an electrochemical double-layer capacitor, there are no chemical reactions involved in the energy-storage mechanism. This mechanism is highly reversible, allowing the ultracapacitor to be charged and discharged hundreds of thousands of times—compared to lifetimes of 500 to 1000 cycles for most batteries. Another advantage of an ultracapacitor is that it charges extremely quickly.

Applications

In applications where power determines the size of the energy-storage device, an ultracapacitor may do better. In other applications, they can be used with batteries to combine the ultracapacitor's unique characteristics with the greater energy storage of a battery. Unlike batteries, there are no caustic or toxic liquids to handle, and their shelf life is said to be almost infinite.

There is enormous potential for the use of ultracapacitors. Maxwell Technologies is one company exploring that potential. Their PowerCache ultracapacitors range in capacitance from the PC 5 with 4 farads that can deliver 1 ampere at a peak voltage of 2.7 volts up to the PC 2500, which is rated at 2700 farads with the ability to deliver 625 amperes at 2.7 volts.



Shown here is the Allison E^PSystem installed in a bus.

These units can be used as energy-storage systems in applications ranging from computer-memory backup devices to stationary power-generation facilities. They are ideal for quick-charge applications, such as power tools and toys, where they can be charged in seconds and then discharged over a few minutes. In uninterruptible power systems (UPS), ultracapacitors provide the power for short outages or until a generator set can come on line to provide continuous backup power. They can also be used for load-leveling with an energy-rich, power-poor energy source, such as a photovoltaic system. One interesting application is for back-up power in the "black box" recorders of airliners.

Developing Hybrids

Another possible focus for ultracapacitors is in hybrid electric vehicles (HEVs). Batteries may not be the best energy-storage devices for these HEVs because of the difference in duty cycle compared to electric vehicles. In an EV, energy is stored when the battery is charged, which is at most a few times a day; then the battery is discharged relatively slowly. Additionally, energy recouped during regenerative braking is used to keep batteries charged, but this charging is rather benign compared to the deep cycling that occurs as the battery is discharged and recharged. In a HEV, especially of the common parallel-configuration type, energy is constantly stored and used as the battery is charged by the internal combustion engine and from regenerative braking. It is then released as extra power is needed for acceleration and hill climbing. This frequent discharging and charging can be detrimental to battery life.

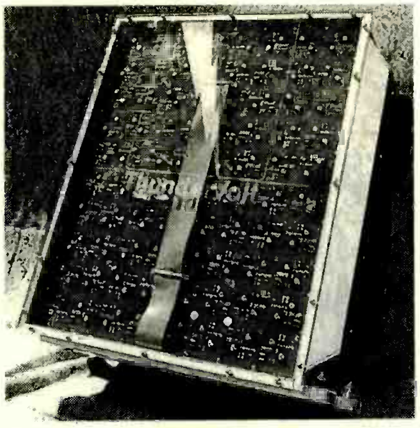
At this point, ultracapacitors such as PowerCache come in. These ultracapacitors are already used in General Motors' Allison Transmission Division's new E^P System parallel hybrid-electric system and the E^S System series hybrid system for trucks and buses. In the parallel E^P System, a diesel engine drives

Research Notes

SciDAC AWARDS
Under its Scientific Discovery through Advanced Computing (SciDAC) program, the U.S. Department of Energy has awarded $57 million for this fiscal year to 51 research projects in fields including fusion energy sciences, nuclear astrophysics, and high-performance computing. SciDAC is an integrated program that will help create a new generation of scientific simulation codes. It also includes research on mathematical and computer software to allow these codes to use modern parallel computers efficiently. Another goal is developing "collaboratory" software to enable far-flung scientists to work together better, to control scientific instruments remotely, and to share data more easily.

"HYPER-THREADED" PROCESSORS
Intel's new processor design technique, named Hyper-Threading, is said to improve system performance by 30%. The multithreading design allows a single processor to manage data as if it were two processors, by handling data instructions in parallel. Hyper-Thread processors can manage incoming data from different software applications and continuously switch from one set of data instructions to the other, every few nanoseconds, without losing track of the status of each set. This technique can also significantly improve the number of Web transactions and users that Intel-based servers can handle at the same time. Hyper-Threading is first scheduled to be introduced in Intel Xeon processors for servers in 2002.

PATENTED METAL-OXIDE PROCESS
Scientists at Brookhaven National Laboratory received a patent for a unique way of making metal oxides, a class of compounds important in nanotechnology and commonly used in catalysts. The traditional method requires processing a molten metal at high temperature, while the new technology completely avoids the liquid phase. Instead, the metal is combined with graphite and heated to form an intermediate compound. When more heat is applied, the metal is released as a vapor, which can then be oxidized into a pure metal oxide powder. By controlling the heat, scientists can vary the vapor density. They have produced powders with uniform particle sizes from 5 to 500 nanometers. Other elements can also be added to alter the electrical, optical, and magnetic properties of the final products.



The ThunderPack ultracapacitor unit uses 149 Maxwell PowerCache ultracapacitors. A dual pack can meet the most demanding acceleration and peak power needs of large HE transit buses and trucks.

➤ Martian Airplane

NASA Ames Research Center's Kitty Hawk 3 project successfully completed a high-altitude test of a prototype Mars airplane. The NASA 731 glider, nicknamed "Orville," was dropped from a balloon at an altitude of 101,000 feet. (Its predecessor, dubbed "Wilbur," aced its own low-altitude trials.) The latest prototype is a conventional looking plane, with a long, straight wing and twin tails. The remote-controlled glider has a 4-foot-long fuselage and an 8-foot wingspan.

NASA731, *Orville*, is prepared for a 1000-foot low altitude test to check out aircraft and data systems.

In its future configuration, fully ready for Mars exploration, folding wings will allow it to be stored inside a spacecraft. The finished version is expected to have a propeller propulsion system capable of operating in the carbon-dioxide-laden Mars atmosphere. It will carry instruments to conduct experiments and an array of high-resolution cameras to provide close-up views of the planet's surface. "The images will be stunning," said Larry Lemke, an aerospace engineer NASA Ames who serves as Ames' project manager for advanced Mars mobility concepts. "During a Mars airplane mission, we will be able to view the planet at very close proximity, and this will convey to the public that there is a real planet out there, not just an abstract." PT

the Allison E^V Drive. This drive includes a split torque continuously variable transmission that supplies power to the wheels and a generator that supplies electricity to the PowerCache ultracapacitors. The PowerCache also stores energy from regenerative braking and rapidly releases energy when extra power is needed. In the E^S System series hybrid, the diesel engine is mated to a generator that powers the E^T Drive driving the rear wheels. Electricity is also sent to the energy-storage device.

Testing, One, Two, Three

Allison has demonstrated the E^P System in a 40-foot Gillig Phantom transit bus and a GMC C7500 TopKick truck. Future plans call for additional installations in suburban coaches, articulated buses, Class 8 trucks, and an Army Light Armored Vehicle. Two hybrid electric New Flyer buses using the E^S hybrid system are in service with the Orange County Transit Authority in Santa Ana, CA. While originally using batteries, they will be soon retrofitted with ultracapacitors. Allison expects a six-year lifetime from the Maxwell ultracapacitors. Compared to equivalent battery packs, the ultracapacitor storage device has one-third the weight and occupies one-half the volume.

Another company in this field that offers its ThunderVolt heavy-duty hybrid electric drive systems for buses, trucks, and tow tractors is ISE Research-ThunderVolt, Inc. This company also uses PowerCache ultracapacitors in its new ThunderPack. This electronically controlled energy-storage device consists of 149 Maxwell Technologies' PC2500 ultracapacitors in a fan-cooled aluminum enclosure. A single pack can store and release more than 150 kW, and a dual pack rated at 300 kW meets the acceleration and peak power needs of large HE transit buses and trucks.

Ultracapacitors may indeed be the answer to our need for efficient power storage and release.—**by Bill Siuru** PT

Z-Beamlet

Researchers at Sandia National Laboratories recently put to the test the third biggest laser on earth, known as the Z-Beamlet. In its trial run as a diagnostic tool, the laser was able to confirm that Sandia's Z machine—the world's most powerful laboratory producer of X-rays—spherically compressed a simulated fusion pellet during a firing, or "shot," of the giant accelerator. Being able to evenly compress a BB-sized pellet so that its atoms are forced to fuse is a crucial step in creating high-yield nuclear fusion.

Before the Z-Beamlet, Z researchers had to settle for electronic images of smoother and smoother Z pinches (the tool of compression). The pinch is a vertical magnetic cylinder that with increasing smoothness impels tungsten ions toward its vertical axis at a considerable fraction of the speed of light. In the past, scientists knew only that the tool was good and that its performance was improving, but they couldn't actually see the results.

Seeing Is Believing

Project leader John Porter likens the Z-Beamlet image to "a kind of giant dental X-ray." In a burst of energy lasting a fraction of a billionth of a second, it takes a snapshot by creating a shadow on a piece of X-ray film placed behind the pellet inside the central chamber of the firing Z machine. Like a picture taken of a tooth, the shadow accurately depicts what is happening in the "mouth" of Z. The laser's light is not used to create the image; higher frequencies of light are required. The beam travels horizontally for 75 yards before making a 90-degree turn down into Z's mouth, where it is focuses to a spot about the diameter of a human hair. The pulse lasts only 300 picoseconds, creating an extremely powerful beam. The beam strikes the metal plate, causing it

This shield protects the giant Z-Beamlet's final focusing lens from debris when the Z accelerator fires. The lens is square because the beam generates a footprint that's about one square foot, which is then focused down to about 100 microns.

to release X-rays. Those X-rays, as they emanate from a single point, have the accuracy and intensity to image the pellet.

Pulsed lasers are not new, but they normally produce mere millijoules of energy in university research labs. The Z-Beamlet, however, delivers kilojoules of laser energy for its diagnostic work. (When firing, Z delivers megajoules.) The beam starts out with picojoules of energy. Researchers use an assortment of small mirrors, lenses, beam splitters, and polarizers to amplify the little beam and smooth out any spatial nonuniformity. It is then passed through a vacuum changer in which it is focused into a point source from which it opens again. The entire system is run and monitored by an elaborate computer control system. After a final smoothing from an adaptive optics system, still more energy is added to the laser pulse by flash lamps resembling fluorescent tubes.

The Inside Story

"Instead of seeing the outside of Z science—the instabilities in the compressing magnetic field—we can now see the inside, the pellet at the center of the million-degree furnace — the interior of the sun, if you will—and we can accurately describe what's happening there," said Porter. "The beam compressed the pellet by a factor of 2 and demonstrated an encouraging uniformity. Our results show we're moving in the right direction."

Uniform 3-D compression, in which almost none of the X-ray energy delivered to the pellet is wasted, is essential to the creation of controlled nuclear fusion. Weapons simulation work (the alternative to nuclear testing) conducted on supercomputers by Sandia for the U.S. Department of Energy is expected to benefit from data from high-yield explosions. In the future, high-yield nuclear fusion will ultimately produce cheap electric power from sea water.

The Beamlet laser was originally built by Lawrence Livermore National Laboratory to serve as the scientific prototype of the National Ignition Facility (NIF). To make room for the NIF's lasers, the lab decided to remove the Beamlet. It took workers from both labs three years to reassemble the Beamlet at Sandia, at a cost of $12.875 million. PT

Harnessing Quantum Weirdness

Researchers at the Massachusetts Institute of Technology believe that taking advantage of the quirky nature of certain quantum pulses—a.k.a., "quantum weirdness"—could eventually lead to a dramatically more accurate global positioning system. They named the method QPS, for quantum positioning system. Eventually, as techniques for generating certain quantum pulses improve, the QPS will become viable for applications in which high accuracy and low power are important, such as satellite positioning.

GPS, radar, sonar, and lidar all use clock synchronization for locating objects in space and time. By bouncing pulses of light or sound between two places and determining the arrival time of the pulses at the reference point, users can track objects. Of course, the accuracy of the system depends on how precisely the arrival time of the pulses can be determined.

"Our work shows that by exploiting 'quantum weirdness' one can in principle dramatically enhance the precision of such pulse-timing methods," Seth Lloyd, associate professor of mechanical engineering at MIT's Research Laboratory of Electronics, said. "Counterintuitive features of quantum mechanics such as entanglement—quantum correlations that are 'excessive,' or greater than classical—and squeezing can be employed to overcome the classical limits in these procedures."

The accuracy with which the arrival time of a pulse of light can be determined depends on the bandwidth and the number of photons (which determines the power) in the pulse. The accuracy of conventional object-locator techniques is proportional to bandwidth of the pulse multiplied by the square root of the power in the pulse. Quantum mechanics allows accuracy to be enhanced based on how many photons can be prepared in a quantum pulse. One hundred photons gives a factor of 10 enhancement over the classical limit, while a million photons offer a thousand times better result.

It is difficult to prepare lots of photons in the requisite state. It is currently possible, however, to perform simple demonstrations of QPS using just a couple of photons. The researchers say that it might be possible to implement quantum cryptographic schemes that would block an eavesdropper from obtaining information on the position of the object in question. PT

Eye On The Storm

About 100 researchers from NASA, NOAA, and other agencies, assisted by Air Force "Hurricane Hunters," held a five-week study of Atlantic Ocean hurricanes this summer. Its primary goal is to produce more accurate predictions of when storms will hit land, which could decrease coastal evacuations and increase warning time. The study is expected to provide more accuracy in forecasting. Airborne researchers flew above, around, and through the storms; satellites, balloons, unmanned aircraft, and ground-based equipment were used, as well.

The study, dubbed CAMEX-4 for the Fourth Convection and Moisture Experiment, used NASA-funded aircraft and surface remote instruments to study hurricane development, tracking, intensification, and landfall impacts. Measurements were compared and validated with coincident observations from the QuikSCAT, Terra, and Tropical Rainfall Measuring Mission satellites. The resulting data, when analyzed within the context of more traditional aircraft, satellite, and ground-based radar observations, should provide additional insight to hurricane modelers and forecasters. PT

YESTERDAY'S NEWS

A PEEK INTO THE GERNSBACK ARCHIVES

1900

1910

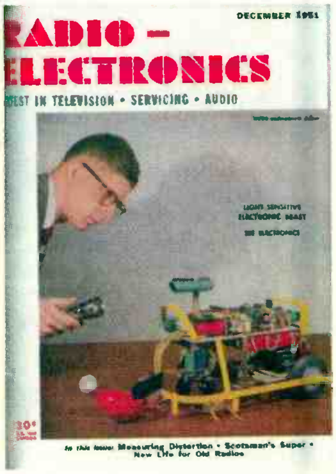
1930

1940

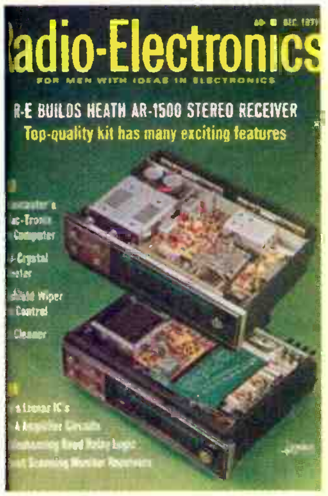
1951

Dateline: December 1951 (50 years ago)

Using a light-sensitive Robot Squirrel named Squee, **Radio-Electronics** illustrates a new design of circuits for mechanical brains and robots—a method called Boolean algebra. The two-part article emphasizes how to calculate with and put into process this new method. Other feature articles explain different means of measuring distortion, how to build a Scotsman's Superhet, and ways of reviving old radios.



1960



1971

Dateline: December 1971 (30 years ago)

Before Heathkits were retired from the market in the early 1990s, they had been the industry leader for an electronics era. Step-by-step, **Radio-Electronics** builds the latest Heathkit—the AR-1500 solid-state stereo receiver. Readers also learn how to build a liquid-crystal wattmeter, a sonic cleaner, and a windshield-wiper pause control. A second feature lists four more ways to use a tape recorder—in the kitchen, car, darkroom, and at a party.

1980

1991

Dateline: December 1991 (10 years ago)

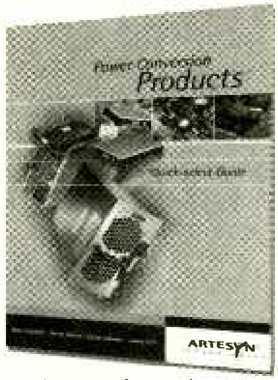
Just in time for the holidays, **Popular Electronics** helps those last-minute shoppers with a guide to the perfect gift for every electronics enthusiast—manufacturers and distributors list included for easy ordering. For those who really like to get into hearing the holiday cheer, watching the classics, and lighting up parties, there are articles on how to build a music-on-hold box, a dual-band loop antenna, and even a flashing lapel pin.

2000

NEW LITERATURE

(continued from page 11)

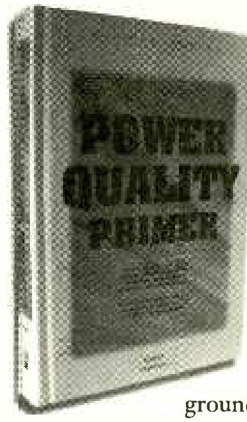
Power Conversion Products



from Artesyn Technologies.
125 Newbury St.
Framingham, MA 01701
800-769-7274
or 508-628-5600
www.artesyn.com
Free

This full color, 16-page quick-select guide details all of the company's latest-generation power-conversion products. An ideal reference for electronic design engineers and system integrators to find a suitable power source for their particular application, the guide covers both AC/DC power supplies and DC/DC converters. It includes more than 300 AC/DC power supplies and DC/DC converters, 70 of which are new.

Power Quality Primer



by Barry Kennedy
McGraw-Hill
2 Penn Plaza, 12th Floor
New York, NY 10121
800-2MCGRAW
www.books.mcgraw-hill.com
$75

Written in easy-to-understand language, this book explains how to prevent and solve power-quality problems. The first five chapters provide background information, followed by three chapters on diagnosing and solving power-quality problems. The last two chapters explain the economics of alternative power solutions and the latest research and development projects.

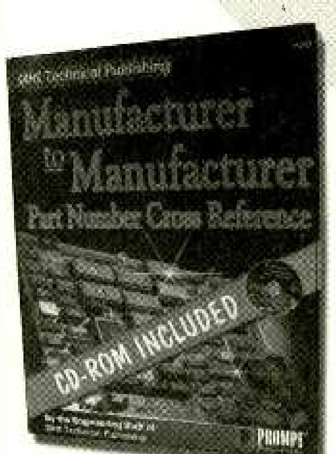
Embedded Controller Hardware Design

by Ken Arnold
Butterworth-Heinemann
225 Wildwood Ave.
Woburn, MA 01801
800-366-2665
or 781-904-2500
www.bbusa.com
$49.95

Embedded systems incorporate microcontrollers and microprocessors in various devices and provide a degree of computer control. Designing such a system requires a familiarity with both hardware and software aspects. This book introduces readers to the design of such systems in a readable way, with the latest application-oriented information.

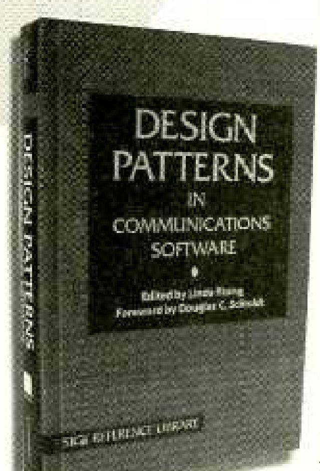
Manufacturer to Manufacturer Part Number Cross Reference

by the Engineering Staff of Sams Technical Publishing
5436 W. 78th St.
Indianapolis, IN 46268-4149
800-428-7267
www.samswebsite.com
$39.95



This complete reference allows users to find all the possible alternative replacement parts. Part numbers from various manufacturers are cross-referenced for use in many electronic devices. The included CD-ROM helps users quickly search the massive database of parts. It's a handy cross-reference guide that provides information on using electrically compatible parts already in stock and should be part of every technician's library.

Design Patterns In Communications Software



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www.cambridge.org
$59.95

A compendium of papers on patterns and pattern languages in communications software, this book covers everything from telecommunications to middleware distributed systems, multimedia networking, and Web technologies. Written by experts in their field, the papers thoroughly explore this subject and provide insight into factors shaping next-generation communications software.

ELIZABETH JAMISON

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Star Trek Technology Is Here... Sort Of

The captain orders, "Take it to warp-eight, shields up!" All hands are busy "making it so." The power-transfer conduits between the warp core and the warp-engine nacelles heat up. The verterium coils begin converting the core's energy into the propulsive warp fields. Within seconds, the galaxy-class starship blasts away at a speed faster than light, taking the crew to the furthest reaches of the universe.

Sounds convincing and familiar, right? In the past thirty years, the lexicon of *Star Trek* technology has become almost commonplace; with warp speed, transporter beam, jeffries tube, subspace converter, and space-time continuum taking their place among commonly known household terms. With computer technology racing ahead at warp-like speeds, it can sometimes be difficult to tell where the fantasy ends and reality begins.

So what role does *Star Trek* technology play in America today? "Every major space program starts with an idea, and with art. It's easy to think of ideas—science-fiction writers have been doing it for years. While our imagination is virtually boundless, it takes some effort to acquire the equipment needed to back up those ideas," says Rick Sternbach, one of the authors of *Star Trek: The Next Generation Technical Manual* and the *Star Trek: Deep Space Nine Technical Manual.*

If art and imagination were indeed the catalyst for such heady ideas as warp speed, holosuites, the Federation of Planets, NASA, the computer chip, and Apollo, how close are we to reaching the heights of technological innovation explored by the *Star Trek* series? To be sure, we are merely technological infants in the beginning stages of development.

Mr. Spock demonstrates the many uses of his Vulcan food processor/juicer to Kirk and Bones. Sci-Fi inspired technology has been showing up in homes across the globe.

SPACE TRAVEL

"The concept of space travel goes back to the 17th century—people have been telling stories about flying to the moon since the days of Isaac Newton," says Sternbach. While the idea of space travel has existed in the dreams of visionaries for centuries, the actual progress we have made is minuscule compared to that realized by the fantastic, yet fantasy-based United Federation of Planets.

NASA is well on its way, though. In the last half of the 20th century, NASA has taken us to the moon and back, provided us with photos of planets throughout our solar system, launched the Space Shuttle, and brought us a magnificent telescopic platform from which to view deep space—the Hubble Space Telescope.

Why has NASA so diligently researched and expanded its reach into the unknown depths of space? The Human Exploration and Development of Space program (HEDS), a subsidiary of NASA, seeks to, "bring the frontiers of space fully within the sphere of human activity to build a better future for all humankind."—NASA Web site.

The following goals of HEDS, which "...bring people and machines together to overcome the challenges of distance, time and environment," are significant:

- Send human missions to planetary and other bodies within the Solar System
- Extend scientific knowledge using the environment of space
- Provide safe and affordable human access to space
- Establish a human presence in space

Source: NASA Web site at *www.nasa.gov*

We feel an unquenchable desire to explore deeper into the unknown, just as early American settlers felt compelled to discover, conquer, and claim all land from coast to coast. Each year, NASA reaches a little farther into the depths of space, hoping one day to uncover its infinite mysteries.

OTHER LIFE FORMS

Perhaps one of the most commonly asked questions in space travel is "Are there other life forms?" Are there other "beings" out there, and if so, where are they? According to

Sternbach, "The question is not where are they, but *when*." Sternbach says that in all likelihood, there have been other life forms, but they could have come and gone—evolved throughout numerous civilizations and countless millennia, without our even being aware of their existence. "Based on what we see out there, there is a good chance that other life forms have evolved up to our level. How we find out about them is the hard part," Sternbach reflects.

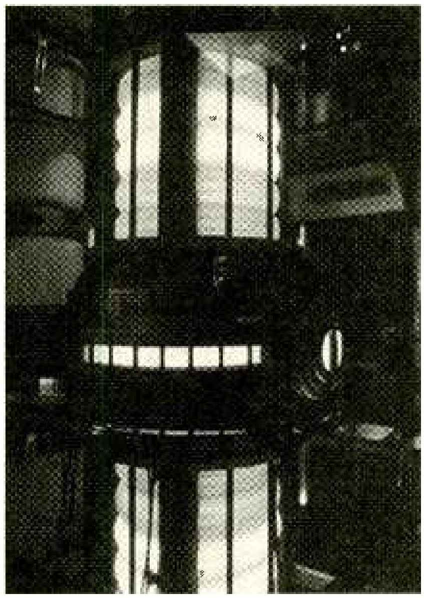
Consider two strangers passing on a busy street, narrowly missing each other in the process and never being aware of the other's existence. The odds are favorable that our planet will "narrowly miss" an infinite number of other beings. Will we ever make contact? "It is one of my fondest hopes that *Star Trek* may help people see the importance of our present-day exploration of space. Not just the possibility of contact with alien intelligence—although I am confident that this will indeed eventually happen—but in a myriad of benefits closer to home."—Gene Roddenberry, *Star Trek: The Next Generation Technical Manual.*

SPACESHIP DEVELOPMENT

Before extended journeys far into the universe can take place, you need a spacecraft that will overcome the problems of galactic travel—time, materials, and funding,of course. In the world created by Gene Roddenberry, such a ship does indeed exist. With the Galaxy-Class Starship, it becomes possible to travel the universe. While the Federation made space travel look easy, NASA has quite a long way to go on its quest for a starship.

"Today, we are limited not by ideas but by available materials to build with," says Sternbach. The *Enterprise* is an ingenious invention created with fictional materials. The tritanium and duranium that comprise the skeletal structure, the subspace radio antennas, deflection shield grid, and crystalfoam stringer—all help to maintain the ship's physical integrity and exist solely in the minds of the show's creators.

When asked about the fictional materials Sternbach helped develop for the *Star Trek* series, he replied, "The U.S. is coming up with new materials every day—we already have aluminum, titanium, and magnesium."



This is an image of a warp-core reactor from Star Trek: The Next Generation. *Technology such as this may one day make deep space travel a possibility.*

(Note the similarities to the fictional tritanium, duranium and aluminum crystalfoam.) "For the 24th century, we just gave new names to similar materials we thought might eventually be discovered."

NASA is pursuing a technological thrust in the development of new materials, hoping to create "lightweight airframes, tanks, and micro-components using nanotechnology (atomically precise manipulation of matter) and ultrahigh temperature ceramics."— NASA Web site. We have three hundred years to come up with some of the ground-breaking developments that have helped propel *Star Trek* to the top of television ratings. Based on current research, it might not take that long.

During powered flight, the Galaxy Class Starship maintains its structural integrity with a series of forcefields that reinforce the physical framework. This structural energy field is then distributed through a network of molybdenum jacketed waveguides, which distribute this energy throughout the spaceframe.—*Star Trek: The Next Generation Technical Manual.*

Sounds reasonable, or at least believable, right? In a fictional world 300 years in the future, this technology may very well come into existence. However, "...you can't really compare the Space Shuttle to the *Enterprise*," says Sternbach, "It just doesn't take you very far."

The Space Shuttle is also not as strong as the *Enterprise*. "Although the Space Shuttle is protected from thermal energy during re-entry (into the Earth's atmosphere), it is actually a very fragile spacecraft," reveals Sternbach.

Although much of the latest technological development is in the conceptual stage, NASA is currently working on new types of spacecraft. According to the NASA Web site, it is the goal of the space program to "...within ten years, integrate revolutionary technologies to explore fundamentally new aerospace system capabilities and missions; and within twenty-five years, demonstrate new aerospace capabilities and new mission concepts in flight."

NASA also plans to "...aggressively explore fields with a high potential for creating advanced performance characteristics...information technology, biologically-inspired technology and nanotechnology." NASA will investigate new ways to build space vehicles, starting from the ground up by constructing them atom by atom.

WARP SPEED

Have you ever wished your car had a warp button? Think of the time you would save! According to the *Star Trek Technical Manual*, warp speed (faster than light travel) centers around the basic mechanism of continuum distortion propulsion. In the original warp-drive theories, single shaped fields, created at tremendous energy expenditure, could distort the space/time continuum enough to drive a starship.

This warp-propulsion system, the most complex component of the *Enterprise*, consists of three major assemblies:

- **The Matter/Anti-Matter Reaction Assembly—**The heart of the warp-propulsion system, also called the warp-core reactor, warp-engine core, or main engine core

- **Power-Transfer Conduit—**Constructed to constrain the plasma to the center of each nacelle and peristaltically force the plasma toward the warp-engine nacelles, where the warp-field coils use the energy for propulsion

- **Warp-Engine Nacelles—**The termination point, where the actual propulsion work is done

This system has two functions: to

A BRIEF HISTORY OF NASA	
1958	NASA (National Aeronautics and Space Administration) is formed as a result of the Sputnik Crisis in October, 1957.
1961-3	Human Space Flight Initiatives—Mercury's single astronaut program developed to see if a human could survive in space.
1969	Apollo-11 fulfilled President Kennedy's challenge by successfully landing Astronauts Neal Armstrong and "Buzz" Aldrin on the moon.
1981	Development of the Space Shuttle proceeds.
1986	The Space Shuttle *Challenger* explodes, causing a two-year grounding of NASA's shuttle program.
1988-98	NASA successfully launches 65 shuttle missions.
Future Shuttle Plans	
11/ 29/ 01	Endeavor—10-day mission
01/17/02	Columbia—11-day mission
02/28/02	Atlantis—9-day mission

provide enough energy for the shop's propulsion throughout space and to power the high-capacity systems, including the defense shields, phaser arrays, tractor beam, main deflector, and computer cores—*Star Trek Technical Manual*. The technical writers of *Star Trek* came up with quite an impressive model for warp technology.

How close are we to actually attaining speeds that are faster than light? NASA is currently working to "extend their reach with faster space travel." By 2015, NASA plans on reducing the time for planetary missions by a factor of two. This objective is to "...develop light, rapid space propulsion systems that will reduce travel time. Technology focus areas include small systems to travel to other planets and 'breakthrough' propulsion technologies to allow missions to reach other stars within a human life span."—NASA Web site.

Sternbach has doubts. He explains that our knowledge of physics is still extremely limited. "From what we do understand, it may take much more of an effort (to achieve warp speeds) than humanity can muster." Sternbach also reflected that there might never be a real need to go that fast.

COMPUTERS

If there is one area of technology we have explored that has the potential to meet and even exceed that of the Federation, it is in the field of computers. In fact, according the Sternbach, we may be further ahead today than the first writers of *Star Trek* ever anticipated. "We could have gone further with our *Star Trek* computer technology, when you compare it to the present day computer capabilities."

Similar to computer servers and central software-controlled hubs of today, the computer aboard the *Enterprise* is responsible for the operation of virtually every other aspect of the ship. The crew can interface with the computer via an easy-to-understand graphics display board or through voice activation. Similar technology is in existence today. The highly developed graphics of today's software is just as impressive as that aboard the *Enterprise.* Voice-activation programs, originally for the visually impaired, have also been developed.

COMMUNICATIONS

Remember Captain Kirk's old communicator in the first episodes of the *Star Trek* series? Take a look at a typical flip-top cell phone and notice the similarities. Technology has also begun to close the gap on the video-phone, more commonly used in the *Star Trek's Next Generation* series. "It's not there yet, but it's coming. It is not quite as polished, and the video quality isn't as clear as the *Star Trek* series, but give us another five to seven years," Sternbach promises.

With today's incredible satellite systems, fiber optics, and the Internet, we are able to communicate with anyone on the planet or even in Earth's orbit. Bring in a subspace transceiver and a personal communicator, and we'll be right there with the members of Star Fleet.

TRANSPORTERS

The act of transporting the matter of a living being from one place to another may seem far off, but scientists think they have already figured out how to transport one atom. If we can transfer one, perhaps we'll soon be able to do two, and so on. The time when we can "beam up" may seem a long way off, but the goal might very well be achieved within this century.

So what does all this mean for the future of space travel? According to Sternbach, "Apollo took us to the moon—that's as far as we've gotten. We may never attain the speed of light; it will take years and years of hard work to do it. The present day space crafts are just the beginning."

Well, until the day comes that people can take a weekend vacation to Saturn, I think I'll stick to watching the latest *Star Trek* episode. After all, "...in a fictional world, we can do anything," says Sternbach.

SURVEYING THE **DIGITAL** DOMAIN

REID GOLDSBOROUGH

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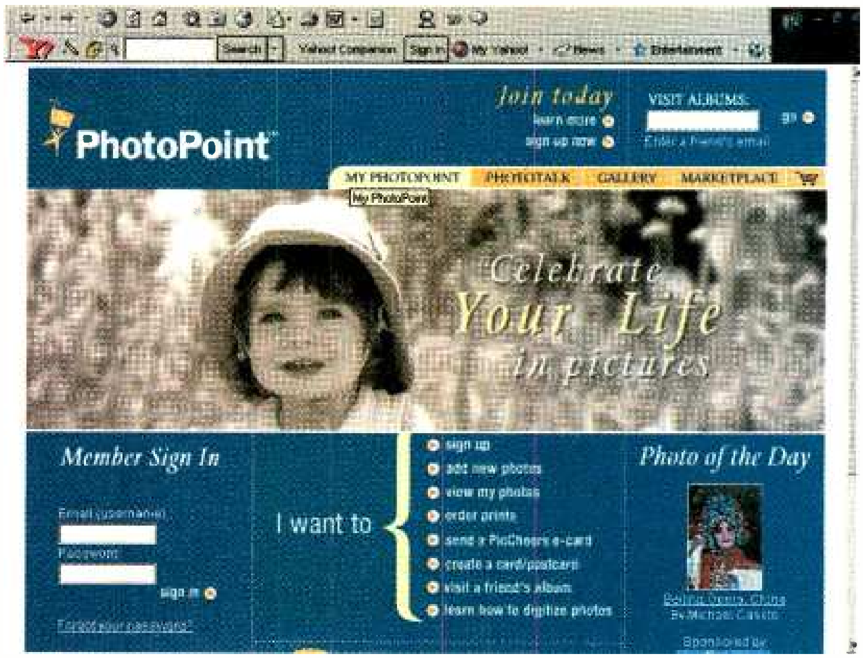
The Golden Age Of The Web Is Over. Or Is It?

Sad, but true, the Internet is showing signs of change that aren't quite positive. The collapse of hordes of global dot-com ventures has rattled the market and affected the pockets of a large percentage of consumers and shareholders, both here and abroad. Now that the initial glitter has dulled, companies that once provided free services to Web-surfers are now hurting in the advertising revenue department. The result has been the implementation of fees and charges. Along with this financial dilemma, there also lurk the scams, hoaxes, false information, and general abuses of the medium. The Internet has become infested with pirates, con-artists, and the like. Let's see what Mr. Goldsborough has to say.—Editor



Sites, such as Photopoint, have been forced to start charging for services that were once offered for free. It seems as if ad revenue is falling in the Internet market. When was the last time you clicked on a banner ad?

THE RISING COST OF FREE LUNCHES ON THE WEB

The ongoing tumble in the value of technology stocks and the subsequent drying up of venture capital for dot-coms has had dramatic repercussions for Web-empowered consumers and businesses: Many Web services that were once free now charge fees.

The formerly free Britannica.com, for instance, just began charging subscription rates of $5 per month or $50 per year for full access.

Britannica.com, the online version of *Encyclopædia Britannica* and other reference material at *www.britannica.com*, understands the Web mindset that holds to the adage "Information wants to be free." The service still provides some free information, though there are caveats.

Without subscribing, you can still access the articles in the encyclopedia—though you can read only the first two paragraphs—and all the pictures, as well, though you can see only small thumbnail versions.

Going the free route, you can still read the full text of articles about the subject you're searching for from popular magazines and the most recent 30 days of articles from the Reuters news service. However, you'll be bombarded with pop-up ads, whereas subscribing eliminates this distraction.

Britannica.com isn't alone. The list of other one-time Web freebies whose backers now want you to open your wallet is long and includes top photo site Photopoint at *www.photopoint.com*, the excellent remote storage service Xdrive at *www.xdrive.com*, the versatile voice-mail service eVoice at *www.evoice.com*, the popular online payment service PayPal at *www.paypal.com*, and the well-regarded stock

The Internet is an excellent tool for would-be scam-artists and alarmists. About.com's "Urban Legends" site is a useful tool for weeding out "digital-bologna."

tracker Company Sleuth at *www.companysleuth.com*.

COPING WITH CHANGE

This sea change from free to pay wasn't unexpected, but can be painful nonetheless. Who likes forking over hard-earned dollars when you were previously subsidized by start-ups looking to build market share?

Without adequate revenue, many of these start-ups have gone away. It can be hugely expensive to run a Web-based service. Some photo Web sites, for instance, burn through $500,000 to $1 million a month to maintain their sites. There are costs that advertising alone can't cover, according to market research firm, ARS.

The harsh reality is if you're using and benefiting from a service and want it to be around in the future, you're better off paying for it than expecting a sustained free ride. When a service you or your business depends on goes under, you have to pay the occasionally large cost or undergo the often great inconvenience of switching to another service.

Many people in fact are willing to pay for information on the Web. A recent survey by the market research firm, Lyra Research, showed that 20 million people have already paid for Web content. According to the survey, 27 percent have paid for industry-specific business material, 18 percent for online database services, and 10 percent for premium music and news services. The most popular type of pay service is for adult material.

Some people argue that fee-based Web services will create a digital divide separating society into those who can afford information and those who cannot. What will likely emerge in the online world are the same kinds of tiered services that exist in the offline world.

Offline, you can choose offerings ranging from pricey ad-free newsletters to free high-quality, controlled-circulation business publications. Otherwise, you can read newsstand and subscription newspapers and magazines for free at your local library, albeit less conveniently. Similarly, you can opt for free broadcast television; or you can pay for the extra channels of cable or satellite TV.

YGWYPF

Likewise, a number of basic-level online services will undoubtedly remain free, with the only charge being greater inconvenience. You'll have to put up with distracting Web ads, and you may be inundated with annoying e-mail promotions. Some high-quality services may remain free. However, more and more frequently, such services will cost you.

The cost may be worth it. More so than in the past, on the Web today and particularly on the Web of the future, you'll get what you pay for.

For businesses, it may be worth it to risk losing visitors by going from free to fee. Granted, it can be maddeningly difficult to persuade someone to pay for something they currently receive for free. Yet, it's better to find yourself less popular than out of cash and out of business.

On the other hand, with more and more services going under or going pay, if your service remains free, you'll stand out more. Then, you just may attract enough visitors for the ad-only model to work.

HOAXES AND SCAMS

Speaking of fees, did you know that under Bill 602P, the federal government will levy an "alternative postage fee" of five cents for every e-mail message you send? The legislation, currently pending, would compensate the U.S. Postal Service for lost business from the growing popularity of e-mail. The government would bill your Internet Service provider, which would in turn bill you.

This was the essence of an e-mail alert I recently received, with the sender urging me to write my congressman in protest and to forward the alert to everyone in my e-mail address book. Sure, it's all bogus, an Internet hoax and urban legend that's been circulating for years. These kinds of info scams do snag their victims, wasting time and draining productivity.

This is just one way that the Internet is abused as an information medium. The e-mail with the "inside" information about a stock, the Web site with "unbiased" medical advice that's silently sponsored by a pharmaceutical or herbal company, the Internet discussion group "troll" who deliberately posts inflammatory opinions to start arguments—all are examples of information abuse.

The Internet is not unique here. People, businesses, and governments have all been abusing information delivery channels. Microsoft Corp., combining elements of both old and new, embarrassed itself when it was revealed last month that a group it funded had orchestrated a nationwide campaign of "citizen" letters to government officials urging them to end their antitrust actions against the company.

Dead people, according to the *Los Angeles Times*, purportedly wrote

(Continued on page 35)

TED NEEDLEMAN

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MP3s For Home Or The Road

For a while, it seemed like Napster, the music file-sharing service, was a prime reason for sales of MP3 players. With copyright infringement issues settled, Napster has pretty much waned in popularity. Even with other file-sharing peer-to-peer offerings, the focus of MP3 and other digital music formats has shifted. Now the focus is on encoding legitimately owned music to digital format, a process refered to as "ripping," or on downloading the growing amount of "non-brand-name" music that's becoming available on the Internet.

MP3 isn't the only digital music format, though it is still the most popular. Developed by the same Motion Picture Experts Group (MPEG) that developed the MPEG-1, MPEG-2, and MPEG-4 standards for encoding digital video, MP3 stands for MPEG audio Layer-3—a part of the MPEG compression system that specifically deals with audio compression. MP3 enables a single audio track in the form of a WAV file, which takes up about 32 MB of space on an audio CD, to be compressed to a digital MP3 format file of about 3 MB. This is done using a sampling rate of about 44K samples per second, and it maintains almost all of the original piece's fidelity. Lowering the sample rate reduces the ultimate file size even further. Another technique—called variable bit-rate sampling—adjusts the sampling rate dynamically according to the musical characteristics of the piece, generally increasing storage requirements a bit. It also improves the overall depth (or dynamics) of the playback in most cases.

Evergreen Technologies' Portable MP3 CD Player offers basic MP3/CD performance for the low price of $99. An optional car adapter kit is also available.

Microsoft has its own format, promulgated through the Windows operating system. Not surprisingly, this approach is called WMA, or Windows Media Audio. Actually, WMA provides a more compact digital file as a result of compression in comparison to MP3. A new encoding protocol from the MPEG Group, (MP3 Pro) raises the stakes again, providing better playback fidelity and a tighter compression ratio than MP3 or WMA.

Most users think of the small pocket-sized digital music players when they hear the term MP3. While these are the most popular and affordable players, with more than a dozen vendors producing several dozen models, there are some interesting alternatives. Here's a look at three of them.

YOU WILL BE ASSIMILATED

One problem with portable MP3/WMA players is that they only play digital music files. After all, that's what they were designed to do. Another approach to digital music players takes a more inclusive path. These are CD players that not only play standard audio CDs, but can also play CD-Rs that contain MP3 files. With a capacity of 650 MB, a standard CD-R disc can hold an awful lot of 3-MB and 4-MB MP3 tracks. With CD-RW drives becoming almost ubiquitous and prices on CD-R discs down to between 25 and 40 cents each, these players provide an excellent way to take a lot of listening along on a walk or trip.

One such model is available from Evergreen Technologies. The $99 Portable MP3 CD Player looks pretty much like every other CD Player, with a small LCD screen and a set of controls to let you select what tracks to play. It comes with a set of rechargeable batteries and an AC power supply/charger. Operating the player with a regular audio CD installed is simply a matter of choosing what track you want to play.

With a CD-R containing MP3 files, the process is just a touch more complex. For organizational neatness, it makes sense to put your MP3 files into directories. You can use the LCD panel and controls to navigate to the desired directory and select the MP3 files you wish to play. An even easier way is to use an MP3 ripper such as *MusicMatch Jukebox* to create playlists and then to simply select the desired playlist using the LCD panel and controls. In our testing, ripping an audio CD into MP3 format at CD quality sampling rate produced about 79 MB of

Compaq pushes forward into the MP3 stereo component marketplace with its latest release—the IPAQ Music Center. This unit is priced at $799 and is geared to hard-core audiophiles who prefer multi-component systems.

SOURCE INFORMATION

Compaq Computer Corp.
20555 SH 249
Houston, TX 77070
800-888-0220
www.compaq.com

Evergreen Technologies
808 NW Buchanan Ave.
Corvallis, OR 97330
541-757-0934
www.evertech.com

IOMagic Corp.
1300 East Wakeham Ave.
Santa Ana, CA 92705
714-953-3000
www.iomagic.com

MP3 files. Using variable-bit-rate encoding bumped this up to a bit over 94 MB. With a 650-MB CD-R, you can fit about five complete albums on a disc. That's a lot of music.

The Portable MP3 CD Player does have a few down sides. For one thing, it does not recognize the WMA digital music file format, only the MP3 format. Also, you can't mix WAV analog files on a disc with MP3 digital files. In addition, the disc must be a CD-R, not a CD-RW; and the player will read only the first 650 MB, so using the new 700-MB capacity discs is a waste of money.

Still, for the price, the Portable MP3 CD Player, and similar units such as the Rio Volt, provide an excellent alternative to the typical portable digital music player.

MORE MUSIC!

Assuming that even the MP3/CD player doesn't satisfy your musical hunger, the newest breed of digital music jukeboxes should. Creative Labs came out with the first of these, the Nomad Jukebox, last year. With its 6-GB hard disk, it could hold over 100 hours of music and was an instant hit.

The new Neo Jukebox 2200, from IOMagic, raises the ante. This compact 5.5- × 4.75- × 1-inch portable contains a 20-GB hard disk drive to hold music files. You can store an incredible 600 albums on the Neo Jukebox 2200, more than many of us have in their entire music collections!

Using the Neo Jukebox 2200 is easy. Connect it to your PC with the included USB cable, and your PC sees the Jukebox as just another hard disk. That means you can simply drag and drop MP3 files, directories, and playlists from your PC's hard disk to the drive in the Neo Jukebox 2200. IOMagic includes a copy of *MusicMatch Jukebox* so you can rip and organize files, but you can actually use any MP3 encoder for this purpose. As with the Portable MP3 CD Player above, the Neo Jukebox 2200 only plays back MP3 files. The firmware is flash upgradeable, however, so it's likely that WMA and future file compatibility will be added.

At $399, the Neo Jukebox 2200 is a lot more expensive than your typical MP3 player. With its humungous capacity and the ability to be hooked up to your car or home stereo, it's a worthwhile purchase.

MP3 PHONE HOME

The digital music players discussed to this point have all been more or less portable. They are all light enough and small enough to carry with you in a pocket, on a belt loop, or in your car.

The IPAQ Music Center from Compaq is a whole different story. It is not meant to be used in a portable mode and doesn't operate from batteries, only from an AC power cord. It's also much larger, at 17- × 12- × 3.7-inches, than any of the other units reviewed—designed to fit in as a component of your home audio setup.

Priced at $799, it's also considerably more expensive than the other digital music players reviewed in this column. That additional expense, however, is justified in view of what the IPAQ Music Center offers. Compaq has positioned the IPAQ Music Center as a high-end stereo component, just like a CD changer or other audio add-on. It presupposes that you already have a receiver or other home-theater-type amplifier, existing speaker system, and a television—all within arms length of each other. The television isn't necessary for the operation of the IPAQ Music Center, but it is required for the initial setup. Also required, if you want to be able to correctly label the tracks as you convert them from a CD to MP3 file, is a connection to the Internet. The IPAQ Music Center has a built-in HomePNA phoneline network adapter so that you can network the unit with a PC that's hooked up to the Internet through a dial-up or broadband connection. The HomePNA network is the one fault that we found with the IPAQ Music Center, considering that garden-variety Ethernet, either wired or wireless, is much more widely used than HomePNA for home networks.

Setup is also a bit more complex than either of the other devices reviewed here. There are an intimidating number and variety of inputs and outputs on the rear panel, with both analog and optical I/O available. As mentioned earlier, you'll need a TV set and an Internet connection available before you start. Still, 15-year old Bryan had the Music Center up and running in less than a half hour.

MP3 stereo components are starting to appear slowly in the market. In addition to Compaq's IPAQ Music Center, Dell is also selling a unit manufactured for them by SONICblue, which sells the same unit under its own Rio brand.

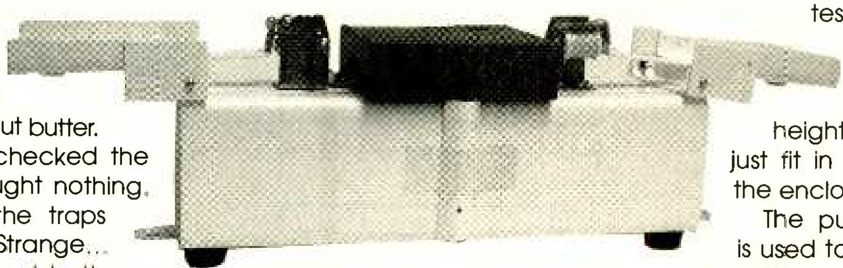
It's too soon to tell if this type of device will become as popular as cassette and CD players have been in the past. Still, if you are heavily into MP3 music, you'll find the IPAQ Music Center well worth looking at.

P

The Electronic Mouse Trap

JURGEN F. BAUER

I was sitting and watching my favorite Friday night movie when out of the corner of my eye I saw something scurrying in a dark corner of the living room. I got up to have a look, but the little beastie was faster and got away. I live on a farm; and, as is the norm, field mice and shrews are a constant intrusion. I set out the spring-loaded mouse traps baited with appealing mounds of peanut butter.



The next day I checked the traps, but had caught nothing. Three days later the traps were still empty. Strange... the mound of peanut butter on one of the traps was diminishing. Looking closely at the trap, I could see teeth marks on the peanut butter. It seemed that a shrew (a very small mouse-like creature) was eating the bait without setting off the trap. The shrew obviously didn't weigh enough to set it off.

I decided to design an *Electric Mouse Trap (EMT)* that did not require weight to trigger it. The design uses easily found, square, plastic eaves, trough downspout, and glue for almost all of the assembly. Since my research showed that rodents in general will follow a wall rather than moving across open spaces, I knew where to set the traps.

Building a better mousetrap with the help of optical sensors

Circuit Description. The prototype circuit board was hand-wired. Figure 4 is the schematic for the basic EMT. A PIC microcontroller does most of the work. An ultra-bright light-emitting diode (LED1) is pulsed by Q4, which is controlled by pin GP4 of the PIC. LED1 is current limited by R1, a 47-ohm resistor. The light output of LED1 is seen by PD1 (a large-surface photovoltaic detector) that biases Q1 to conduct. The sensitivity of PD1 is adjusted by way of R15, a 50,000-ohm trimpot. When Q1 turns ON, the base of Q2—an inverting buffer amplifier—goes low. This reaction brings the collector of Q2 and PIC pin GP3 high.

When PIC pin GP2 (which is held low) comes high, the MOSFET (Q3) turns ON. It activates the door solenoids (SOL1 and SOL2) for .4 seconds, thus dropping the doors (more on this later).

A standard red light-emitting diode, LED2, is used to indicate if the CPU has started properly and what mode is activated—either trap-enabled, test, or count-display. This LED is soldered to the circuit board at a height that allows it to just fit in a hole drilled into the enclosure cover.

The pushbutton (TEST/S1) is used to navigate through the different modes. The whole circuit is powered from a 12-volt wall wart that directly supplies power to the solenoids. A 5-volt despiked fixed regulator supplies power for the rest of the electronics. Rather than using a frequency-modulated IR LED and a frequency-demodulating circuit, I opted for simplicity due to the short distance between LED1 and PD1.

The newer high-powered LEDs on the market today are so bright that they are almost laser-like. **WARNING: Do not stare directly into LED1 when it is working.**

Construction. The circuit is simple enough to hand-wire. Whether you use a printed circuit board or do hand-wiring, I strongly suggest using a socket for the PIC. See Fig. 6 for the parts placement. All the electronic parts (except for LED1, PD1, D1, and D2) are mounted to the circuit board. Be careful when you handle the PIC and Q3. These parts are more static sensitive than the rest. Before applying power to your board, double-check that all the parts are oriented in the proper direction; that no solder bridges, cold joints, or missing solder joints are present; and that a short-circuit test has been performed across the power supply.

A second version (MTRAP18) of the EMT that uses a PIC16C620 with a crystal oscillator and an LCD display,

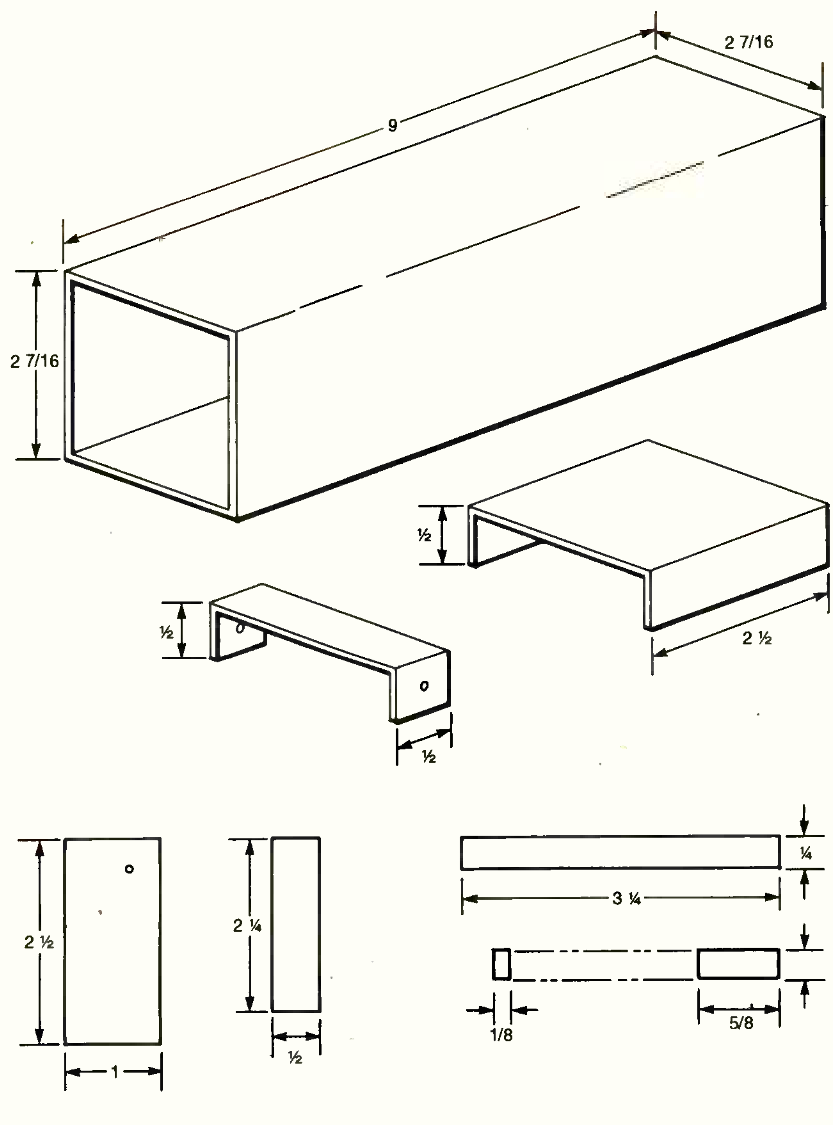


Fig. 1. The Electronic Mouse Trap consists of a rectangular corridor with a spring-loaded door at each end. An LED/photodetector circuit acts as a trigger. The dimensions for each plastic piece are given above.

providing a better visual feedback of the mode currently in operation, is shown in Fig. 5. This version also includes a subroutine that more easily aligns LED1 to PD1.

We will concentrate on the PIC12C671 version (MTRAP8). This PIC uses its own internal RC timing clocked at 4MHz, so no external RC or crystal oscillator is required. Figures 7 and 8 are foil patterns for the component side and solder side, respectively.

Solenoids—Part 1. The solenoids are actually 30-amp, 12-volt relays that have been modified. Take your time to modify the relays. Start by using very small side cutters—the type used for circuit boards—and start nubbling one of the corners of the plastic casing. Continue until a small hole appears, and then you can use small needle-nose pliers to gently break off more and more of the casing. Once you have the relay coil and contacts free of the black casing, start removing the contacts. Carefully trim the plastic that holds the contacts in place. The common contact that is riveted to the moving armature must be cut off using sheet metal snips. Be very careful not to damage the coil or armature spring. Figure 3 shows what the solenoids should look like when the modification is all done.

The solenoids must be attached to a mounting bracket. Fashion two mounting brackets from .025-inch brass stock and drill all the holes shown in Fig. 3. Clean the burrs and sharp edges from the holes and bracket. The solenoids must be soldered to the brackets using a soldering gun or a very hot iron. If you use fast, high heat, you will be less likely to damage the coil or plastic parts of the solenoids. Place heat shrink or some type of insulation on the coil wires so that they can't create a short on the bracket. Set the solenoids aside for now. They will be mounted later.

Housing And Doors. If you follow Figs. 1 and 2, constructing the main housing doors and latch springs is not difficult. Figure 1 shows the dimensions of the main housing, main hinges, doors, latch springs, door hinges, and relay latch bars. All of the parts are cut from a piece of 2½- × 2½-inch square eaves, trough down-spout, about 16-inches long. This down-spout and the special adhesive to glue the parts together are available at any well-stocked hardware store.

I used a table saw to cut the main pieces for the 9- × 2 7/16- × 2 7/16-inches corridor. The piece that is left over is used for all the other parts, like the latch springs and relay-latch bars. I used a pair of sheet metal shears to cut the parts out. You can use any method that works for you. Once all the parts are cut to the proper dimensions, sand off any rough edges that may be present.

Glue the relay latches and the door hinges to the doors, as shown in Fig. 2. Use the glue sparingly, because it doesn't take much to weld the parts together. The parts will have a much better fit and move more freely if large gobs of glue are not produced. Next, glue the main hinges to the main housing as shown. The last part to glue is the latch springs. Follow the expanded view of Fig. 2.

Let these parts dry for at least two hours. The glue melts the plastic material of the two parts and then sets after evaporating the solvent. It takes at least two hours. Be sure to use the glue in a well-ventilated area.

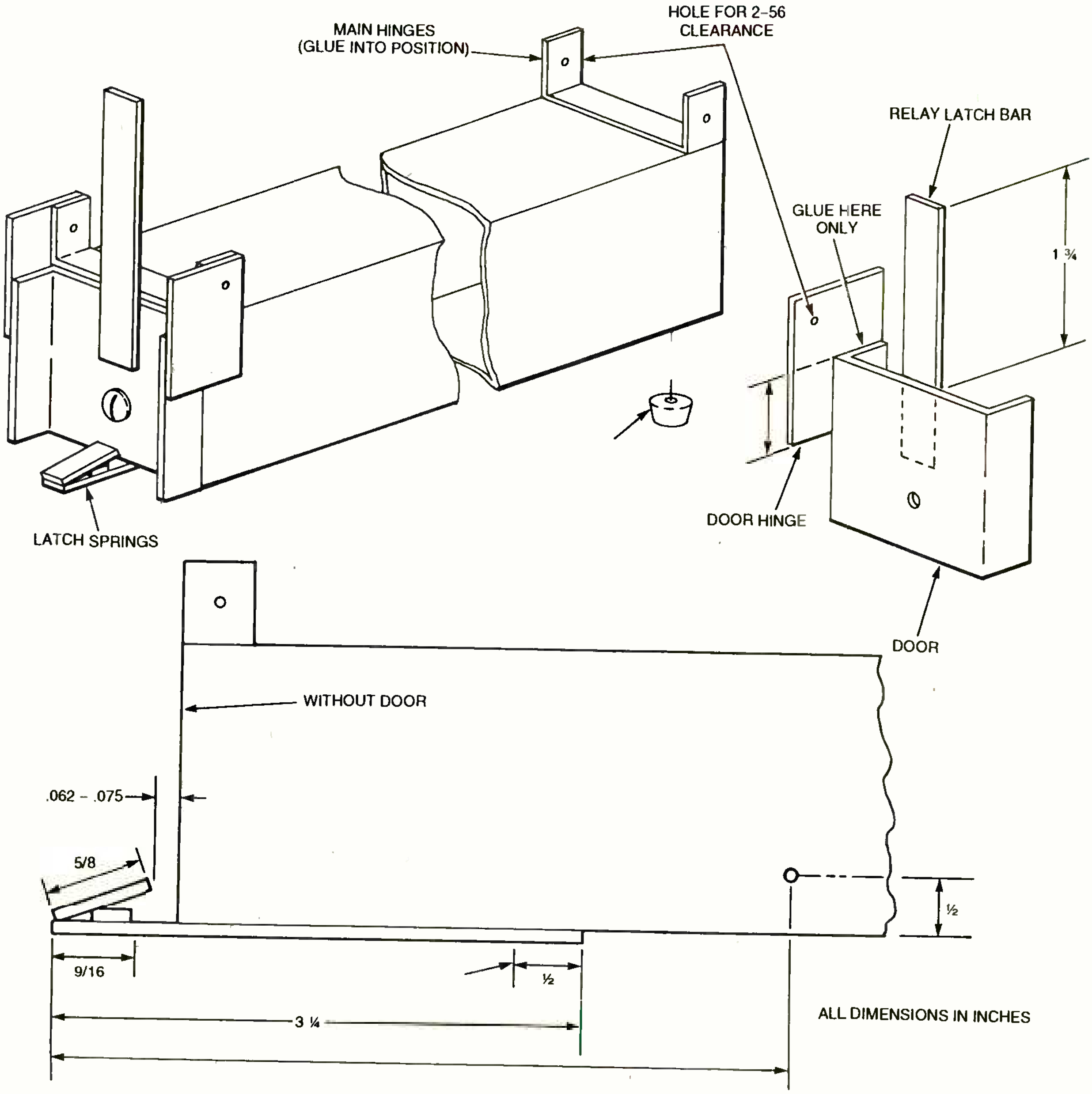


Fig 2. This figure shows how all the pieces fit together, as well as the various points where glue is needed. Be sure to follow all directions and heed all warnings related to the glue.

Read the instructions on the box and tube of glue before using.

When the glue has dried, take the assembled latch springs and glue them to the main housing. See Fig. 2. Be careful to only glue ½-inch on one end. Follow Fig. 2 for spacing the latch part of the spring properly. Use a piece of tape to hold the springs in place—flush against the bottom of the main housing—until dry (two hours).

Attach the ⅜-inch thick rubber feet to the bottom four corners of the main housing. The thickness of the rubber feet assures the proper functioning of the latch springs.

Figure 2 also shows the correct position of the doors on the main housing. Hold them in this position, and drill a clearance hole for a 2-56 machine screw through the center of the main hinges at all four main hinge locations. Clean the burrs from the holes, and install four 2-56 screws and nuts to hold the doors in place. Be careful not to tighten the nuts in a way that leaves the doors free-swinging. When you let the doors fall shut, the latch springs must hold the door locked until released. If the doors do not fall quickly and easily, you may have to add more weight to them. Add a 1-32X, ¼-inch machine screw and nut near the center bottom of the doors. Make sure that these screws do not interfere with the latch-spring operations.

Solenoids—Part 2. Now that the doors function without binding, it is time to install the solenoids on to the main housing. Start by opening one of the doors. Hold one of the solenoids in place, while referring to Fig. 3. Line up the relay latch bar just under the solenoid-moving armature, and mark the holes of the solenoid bracket onto the main housing.

Drill two 4-40 machine screw

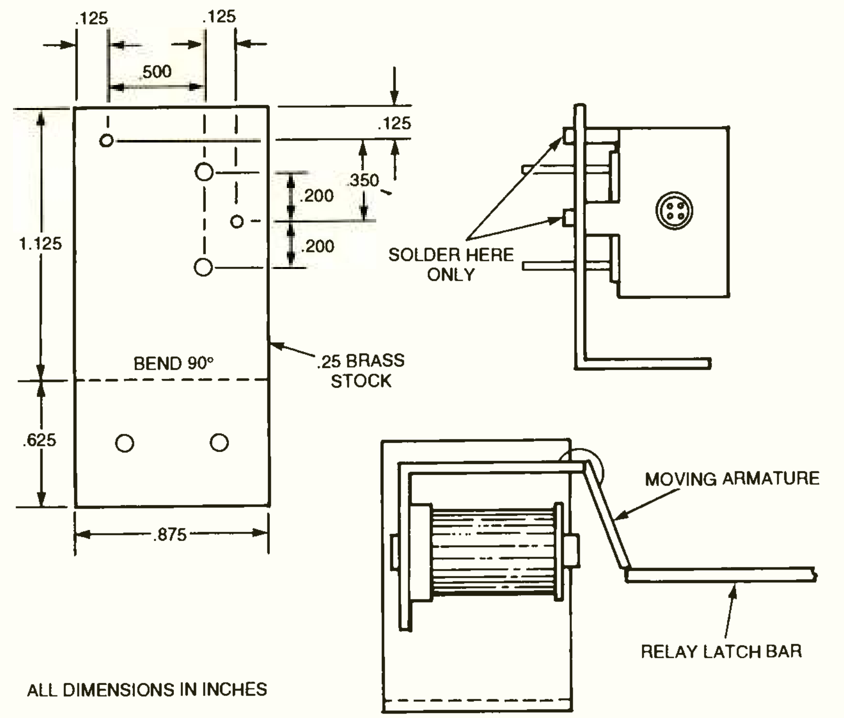


Fig. 3. Solenoids provide the control for the spring-loaded doors. This figure shows how to properly mount the two solenoids required.

clearances holes where marked, and attach the solenoid bracket. Install the nuts on the outside of the main housing. Check the operation of the solenoid by manually moving the armature to release the door. You may need to adjust the position of the solenoid or perhaps trim the relay latch bar to get the desired result. If the solenoid release works well, then install the other solenoid for the other door in the same way.

Final Assembly. Take the circuit board enclosure, and glue it centered to the top of the main housing. Let the glue dry.

At the exact center of one side of the main housing, exactly ½-inch from the bottom, drill a 3/16-inch diameter hole to mount LED1 (see Fig. 2). LED1 press fits into this hole from the outside of the main housing. Do not push it all the way in. This will allow you to adjust the alignment of LED1 later, if required.

On the opposite side of the main housing, at the exact center and exactly ⅜-inch from the bottom, drill a 1/32-inch hole. At .2-inch higher, drill another 1/32-inch hole for PD1. PD1 must be installed from the inside of the main housing through the two 1/32-inch holes, with the leads outside of the housing. Note which direction the red dot on PD1 is facing.

Attach two wires to PD1 and two wires to LED1 that are long enough to be wired into the enclosure. Drill two 3/32-inch holes into the enclosure where these wires will enter.

Solder these eight incoming wires to the circuit board, following Fig. 4 (or Fig. 5 for the PIC1C620). Solder the wires from the 12-volt wall wart to the circuit board. You can install an ON/OFF switch in series with the supply, if you like. Make sure you check the polarity of the wall wart before soldering it to the circuit board.

After all the connections have

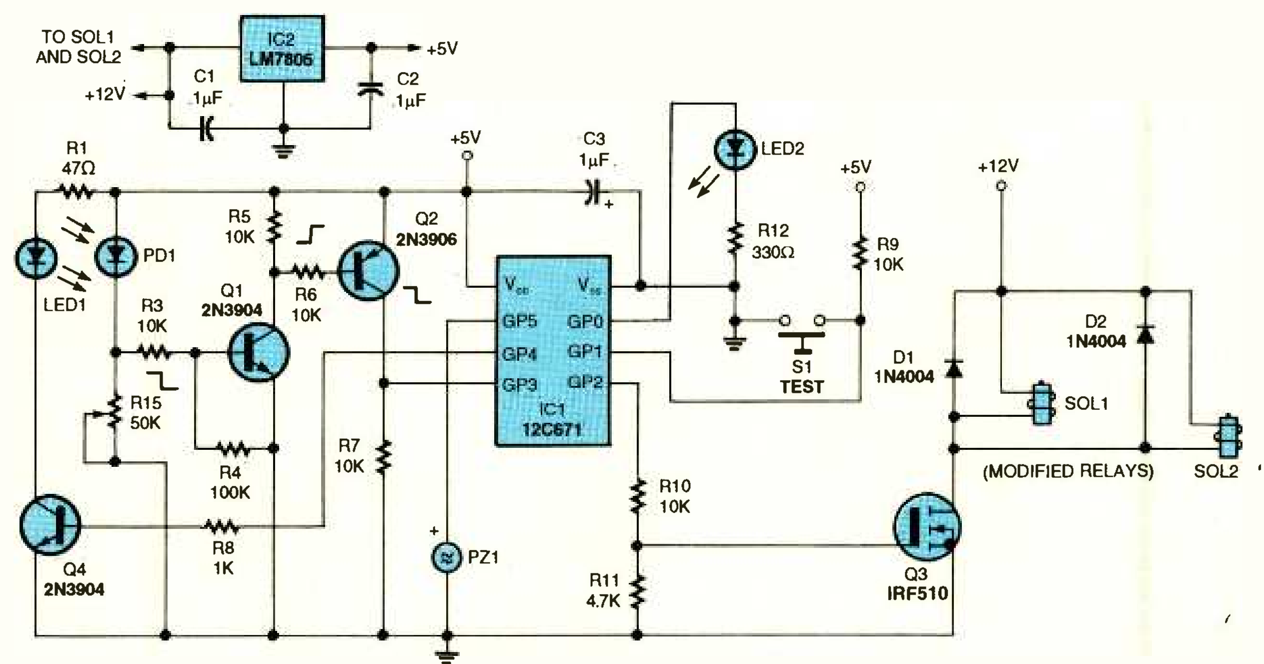


Fig. 4. The schematic above shows the circuit for the Electronic Mouse Trap. The circuit is controlled by a PIC12C761 microcontroller. Note the locations of LED1 and PD1. When an object blocks LED1's light from hitting PD1, the solenoids activate and release the doors.

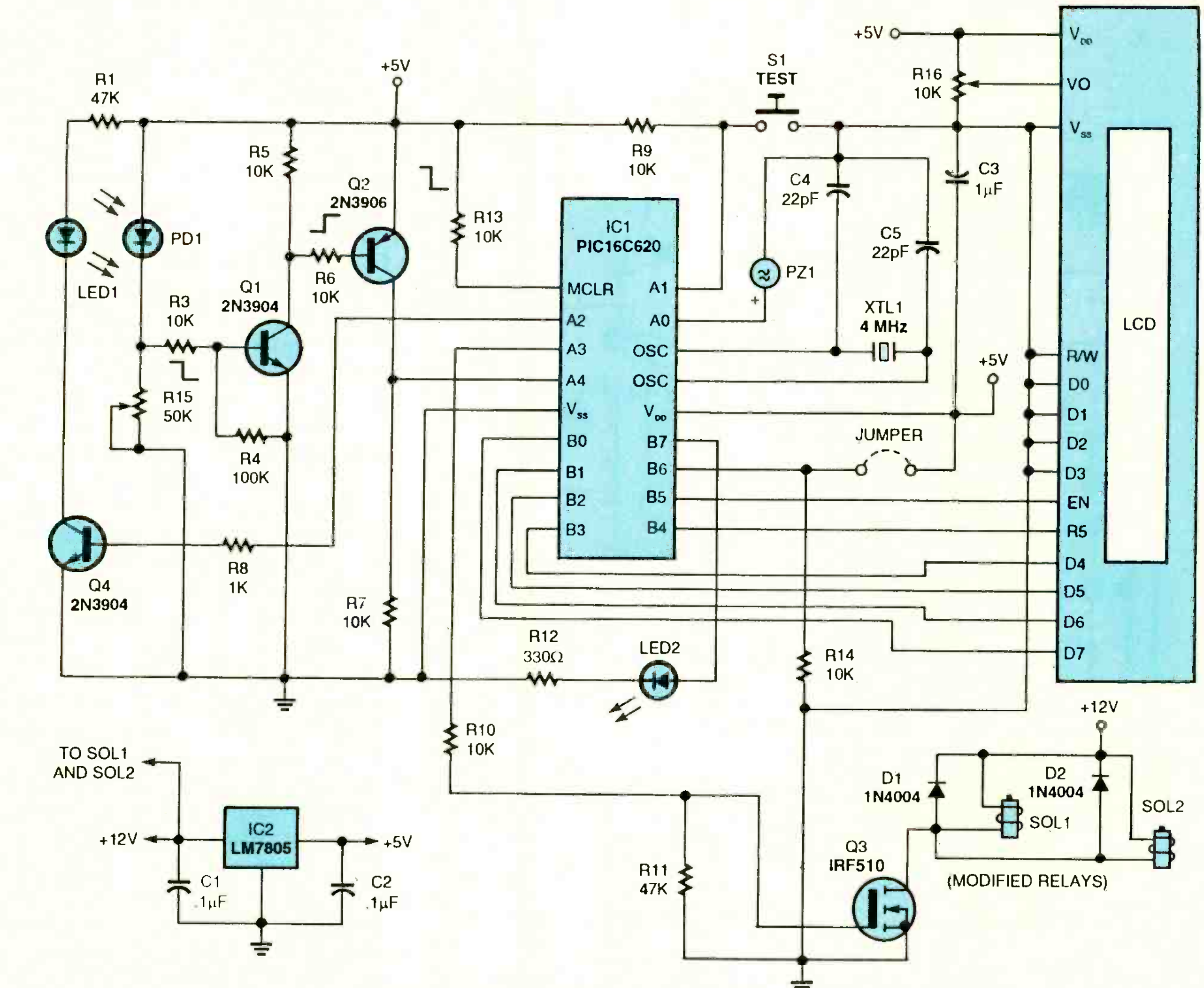


Fig. 5. This is the schematic for the upgraded Electronic Mouse Trap (MTRAP18). The modified version employs a PIC16C620 with a crystal oscillator. Another addition is an LCD display that gives a visual indicator of the trap's performance.

PARTS LIST FOR THE ELECTRONIC MOUSETRAP

SEMICONDUCTORS

IC1—Pre-programmed PIC12C761 microcontroller
IC2—LM7805, voltage regulator, 5-volt/1-amp
Q1, Q4—2N3904 silicon transistor
Q2—2N3906 silicon transistor
Q3—IRF510 N-channel MOSFET transistor
D1, D2—1N4004 diode, general purpose rectifier
PD1—Photodetector (Jameco #PDB-V113-ND)
LED1— Light-emitting diode, T1-¾, ultra-bright
LED2— Light-emitting diode, T1, red
PZ1—Piezo beeper, 5-volt (Jameco #76064)

RESISTORS

(All resistors are ¼-watt, 5% carbon-film units, unless otherwise noted.)
R1—47 ohms
R2—not used
R3, R5, R6, R7, R9, R10, R13, R14—10,000 ohms
R4—100,000 ohms
R8—1000 ohms
R11—4700 ohms
R12—330 ohms
R15—50,000 ohms potentiometer
R16—10,000 ohms potentiometer
(R13, R14, and R16 are used only for MTRAP18)

CAPACITORS

C1, C2—0.1µF, ceramic-disc
C3—1µF, tantalum

ADDITIONAL PARTS AND MATERIALS

SOL1, SOL2—(2) 12-volt relays (Jameco 129349)
S1—Pushbutton test-switch (B G Micro SWT1002)
Enclosure (All Electronics MB73), ⅜-inch rubber feet (Jameco 126981), (4) 4-40 machine screws, (4) 4-40 nuts, (4) 2-56 machine screws, (4) 2-56 nuts, PVC glue, brass stock ⅛- × 4- × .025-inches

NOTE: The following items are available from BAUER Electronics, Inc., 1805 Rte 340, St. Telesphore, Quebec, Canada, J0P 1Y0, *www.bauer-electron.com*: Kit of all PCB mounted parts, including pre-programmed PIC12C671, ultra-bright LED, and photo detector (no PCB, enclosure or relays), $28.50; Pre-programmed PIC12C671 or PIC16C620; $9.95; Ultra-bright LED, $2.95. Please add $5 for shipping and handling in Canada or $10 outside of Canada. Canadian residents add appropriate PST and GST. Money orders only accepted. No credit cards, please. All prices are in US currency.

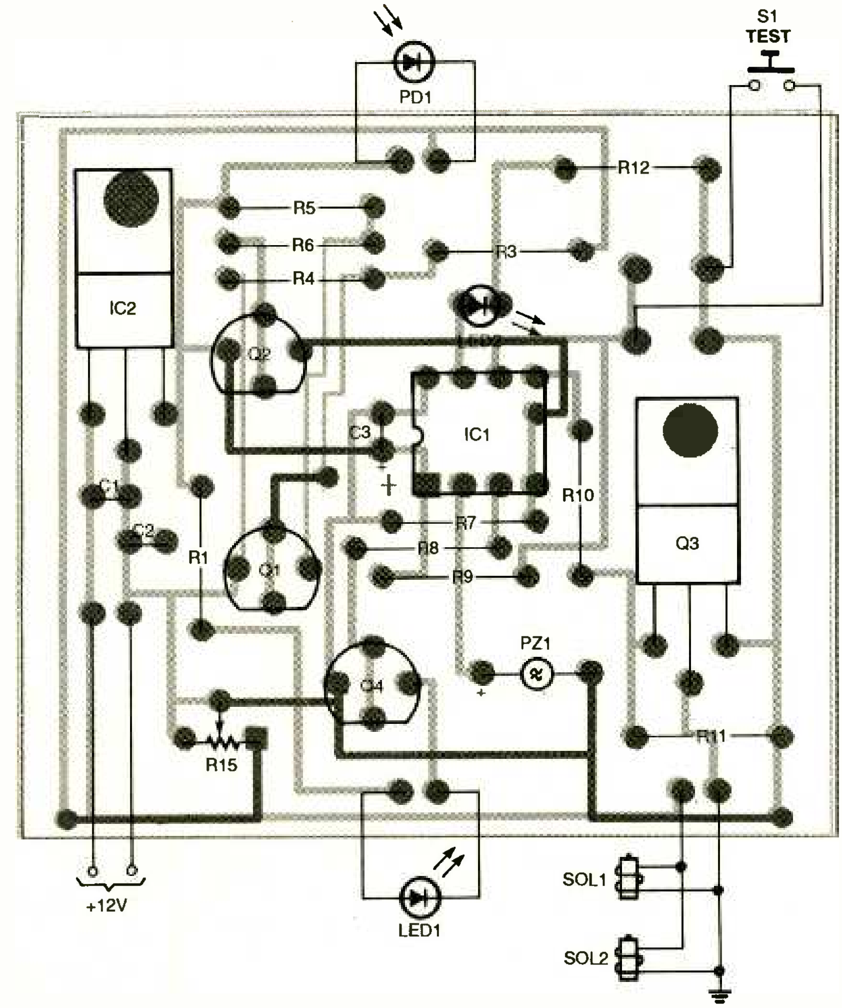


Fig. 6. Use the parts placement diagram above as a reference for constructing the Electronic Mouse Trap. Make sure to observe capacitor polarity.

been made, drill a 3/16-inch diameter hole in the enclosure cover for LED2 to show though. Drill a ½-inch diameter hole to access the pushbutton through the cover.

By cutting two corner pieces from the leftover down-spout parts, you can fashion a cover to go over the wires coming up the two sides of the main housing from LED1 and PD1.

Testing. Once you have double-checked everything, it's time for the smoke test. First, set R15 to its maximum resistance (most sensitive). Plug the wall wart into the wall and watch LED2. It should flash three times and stay ON. LED1 should also be flashing.

If LED2 flashes three times and turns OFF, LED1 is not flashing, and the beeper PZ1 is sounding every eight seconds, check the polarity of LED1. If the polarity is correct, then press and hold the pushbutton down. LED2 will flash three times and go OFF. You are now in the COUNT?TEST mode. LED1 will be flashing either rapidly or once in a while. If LED1 is flashing once in a while, you have to align LED1 to PD1. When LED1 is properly aligned, it will flash rapidly.

When LED1 is aligned, unplug the wall wart for five seconds to reset the PIC. Plug the wall wart back in. LED2 will flash three times and stay ON. LED1 will also be flashing. Lift the doors by unlatching the latch springs and latching the doors to the solenoids. Use a ping-pong ball or similar object and let it roll through the EMT. Do not throw the object. The EMT was designed so that it wouldn't detect a flying insect crossing the light beam (I live on a farm). Since rodents don't move at very high speeds, the PIC software timing is set for rodents and the like.

The last thing to do is to put the EMT in the area it is to be used and shut off all the lights. For the 8-pin PIC or 18-pin PIC circuits, put the EMT into TEST mode by holding the TEST button until LED2 stops flashing. Now adjust R15 until LED1 stops flashing rapidly, and then slowly adjust R15 until LED1 just starts flashing rapidly again.

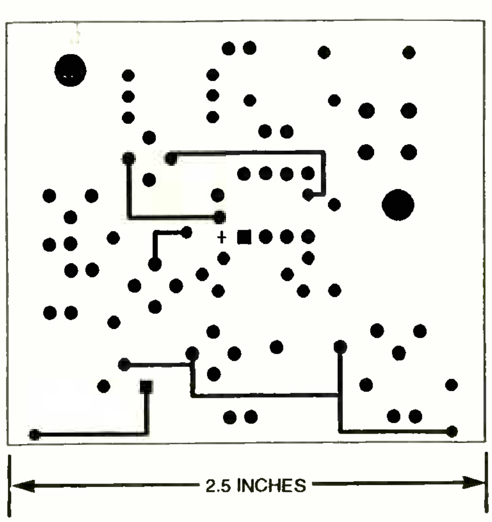


Fig. 7. This foil pattern represents the component-side copper trace.

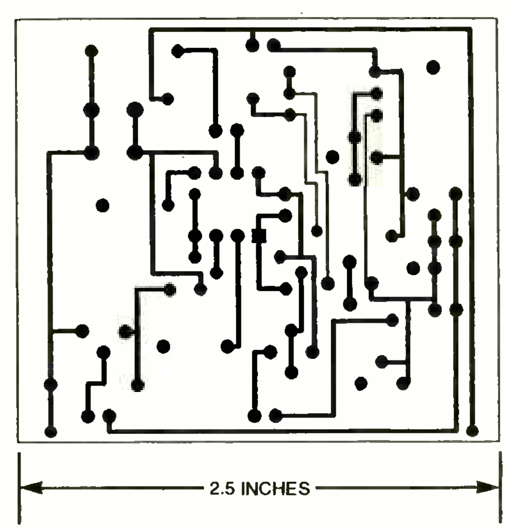
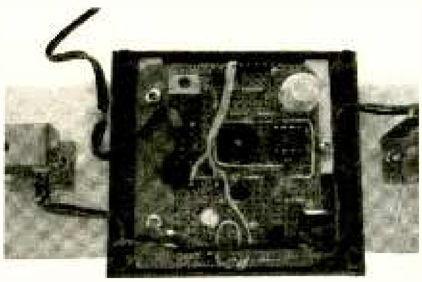


Fig. 8. Here is the solder-side foil pattern for the main PCB module.

Using The EMT. Using the EMT requires little human intervention. For the TRAP ENABLED mode, plug the wall wart into the wall, lift the two doors until they latch open on the solenoids, and wait for the beep indicating a trap event.

For the TEST mode, from the TRAP ENABLED mode, press the TEST button until LED2 stops flashing. The TEST mode allows you to monitor the rodent traffic through the EMT without activating the solenoids. If you are using the 8-pin PIC circuit, pressing the TEST button will flash LED2 the number of times an LED1 beam break was detected. If you are using the 18-pin PIC circuit, the number of beam breaks will be seen on the LCD display.



Here is a close-up view of the circuit used in the author's prototype. The voltage regulator is seen in the upper left corner, while the piezo tweeter is nearly dead center, and to its right is the PIC microcontroller that is mounted in a socket. Notice that the two servos can be seen to either side of the control box.

Conclusion. I have used the EMT for about seven months and have caught my share of field mice and shrews. I let my friends use the EMT with great success. Just remember that most of the time the critters stay parallel to a wall and, if you know where they are coming out of a hole, you can direct them through the trap by temporary cardboard barricades and walls.

The biggest problem my friends had was what to do with the rodent once it was trapped. By the way, the flashing ultra-bright LED1 does not seem to hinder or frighten away the rodents.

For the squeamish and the animal lover, I suppose you could take the creature outside and let it go far away from your property. Release it too close to your home, and the rodent will find its way in again very quickly.

DIGITAL DOMAIN

(continued from page 26)

some of the letters. All of the letters were made to appear to be spontaneous expressions of ordinary people.

Though the Internet is not unique, it is special. As the greatest boon to information dissemination since the invention of the printing press, it's also the greatest boon to info scams. Because it's so easy to put information on the Net, it's equally easy to find false information as well.

HONING YOUR "WEB-SMARTS"

How can you protect yourself? How should you ferret out good information on the Net from bad? How do you find truth? First, don't overreact. There is much information of value to be found everywhere on the Net. You just need to think critically about what you come across. Also, check out some of the sources listed in the sidebar.

Think about the source of information. Is it a news organization, professional or trade group, government agency, nonprofit organization, company, educational institution, advocacy group, student, or hobbyist? Different sources employ different levels of thoroughness in research and fact-checking and different levels of objectivity.

Think about why the person or organization is presenting the information. Individuals and organizations often have agendas—sometimes explicit, sometimes hidden. If you uncover the agenda and keep it in mind when evaluating the information, you'll be better able to filter out any bias.

Think about whether or not the information is paid for. Some Internet search engines place sites at the top of their listings not because of their usefulness or popularity, but because these sites have paid for top billing. Some book review sites accept payments from publishers for endorsing books without notifying readers. When in doubt, send the site an e-mail message asking about its policies.

Think about if, or how widely, the information diverges from your current understanding. If it diverges widely and may affect an important business, health, or family decision, try to verify the same information with at least two other sources. Information scientists call this the "principle of triangulation of data."

Think about whether the information is new or old. A lot of deadwood data is floating around in cyberspace at Web sites that haven't been updated in several years. If the site doesn't include a "Last updated" line or otherwise date its content, check out some of its links. If more than a couple are no longer working, the information at the site may no longer be up to date either.

Think about substance. Don't judge a Web site by its appearance alone. Looks can and do deceive, although appearance does count. A site that looks slopped together may include information that's been sloppily researched and presented.

In short, be skeptical, not cynical, about the Internet as an information resource. The watchword is "Caveat lector" —Let the reader beware.

Reid Goldsborough is a syndicated columnist and author of the book *Straight Talk About the Information Superhighway*. He can be reached at reidgold@netaxs.com or *http://members.home.net/reidgold.*

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Thinking Critically About World Wide Web Resources
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vMyths.com
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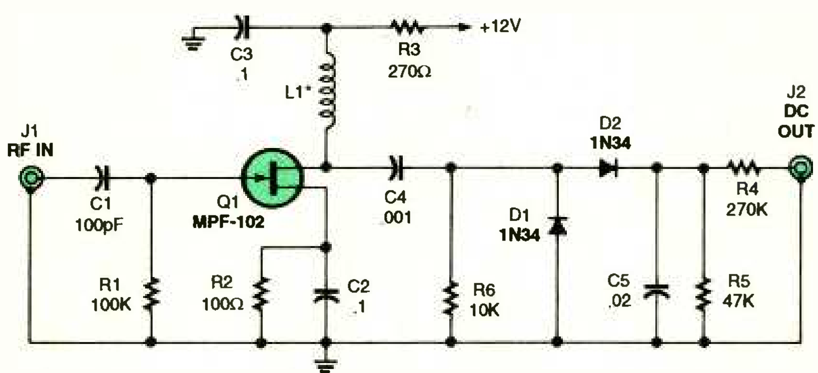
Xdrive
www.xdrive.com

mailto: shortcircuits@gernsback.com

CHRIS LA MORTE

What Could Be Made From This?

Time to get out your breadboards and VOMs. This month we have five circuits for your experimenting pleasure. I wonder if there is a forward-thinking hobbyist who could incorporate all of these circuits into one wonder device. What device would contain an RF probe, a logic probe, an AM radio, a metronome, and an IR detector? It would either be the next Mars rover or the latest gadget from *Ronco*. And now, with no further flash, here are the circuits.



TRY THIS ACTIVE RF DETECTOR

Depending on L1's value, this circuit could detect up to 100-MHz signals. Try using a 100-µH choke for 30–100 MHz, a 1000-µH choke for 2–30 MHz, or a 2.5-µH choke for signals less than 3 MHz. The FET operates as a wideband amplifier in the circuit.

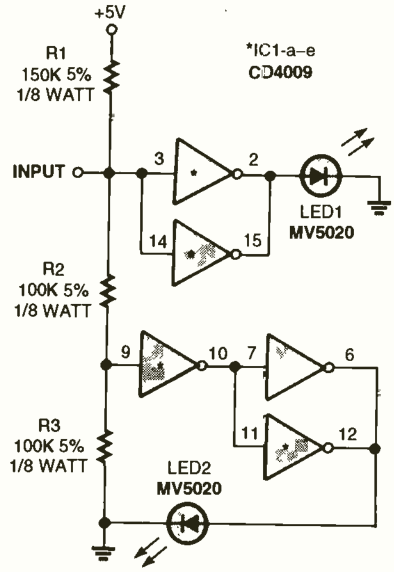
Nikola Tesla (1856-1943)

The debatable father of television, radio, wireless remote control, and holder of many other patents, Tesla has captivated the minds of many. No other scientist seems to be surrounded by so much controversy and intrigue. In his time, he was often regarded as mad (in the old sense) and eccentric.

One thing is for sure; we can all thank him for his persistence in incorporating AC into our power production grid. Until Tesla came along, scientists like Edison were trying to power cities with DC. Tesla's patent for AC power was sold to George Westinghouse in 1888. Tesla may have won the battle, but as time passed, Nikola's name was obscured and Edison's fame grew.

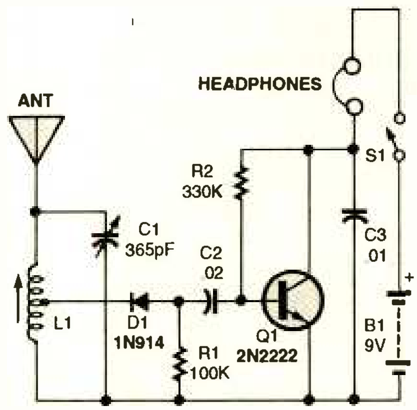
Nikola Tesla's most famous invention was, no doubt, the Tesla Coil. To this day, backyard inventors try to improve on the original spark-gap design. Tesla's largest coil once stood at his lab at Wardenclyffe, located in Shoreham, NY.

Our founder, Hugo Gernsback, had developed an amicable rapport with the scientific genius, Tesla.



SINGLE-IC LOGIC PROBE

Using a CMOS hex-inverter chip, you can build this handy logic probe. When the probe is touched to a logic low, LED1 lights. If the probe touches logic high, then LED2 lights. Inputs less than 2 volts will have the same effect as an open; no lights will be lit.



AM RADIO RECEIVER

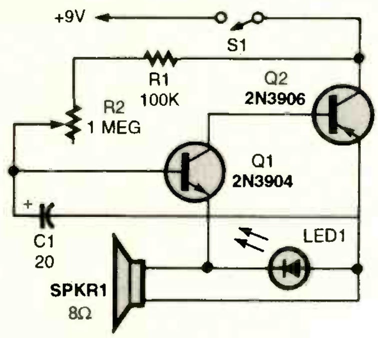
All you need to receive AM broadcasts is a diode detector, an audio amp, and a small amount of supporting components. Inductor L1 is a variable inductor, similar to those found in a transistor radio. In this circuit, the diode strips the intelligence from the carrier; and the audio signal is amplified by transistor Q1. This is a good example of a diode used as a rectifier. In this case, the rectified signal is the AM broadcast.

Thomas Alva Edison (1847-1931)

At the age of 12, Edison built his own printing press and was producing a daily newspaper from his home, which he sold to commuters at a nearby train station. His entire life would be marked by ingenuity and creative genius. By the time of his death in 1931, he would lay claim to over a thousand patents.

Some of his accomplishments include the discovery of radio waves in 1875, the invention of both the carbon transmitter and the phonograph in 1877, the invention of a carbon-filament lamp and DC generator for incandescent electrical light in 1879, and a radio transmission method in 1855 (that he later sold to Marconi).

In 1888, Edison tried his hardest to convince George Westinghouse that AC electrical systems are both dangerous and impractical. This old-fashioned mud slinging would not work against his target—Nikola Tesla. To say these two men disliked one another is a massive understatement.



METRONOME

This oscillator circuit powers both an 8-ohm speaker and an LED. The frequency can be adjusted by varying resistor R2. The result is a thumping and flashing metronome that's perfect for any musician or even for a timer on an exercise bike. Of course, the speaker and the LED can be removed; and the variable oscillator would be ready for insertion into any circuit requiring a variable output frequency above .5Hz and below 10Hz.

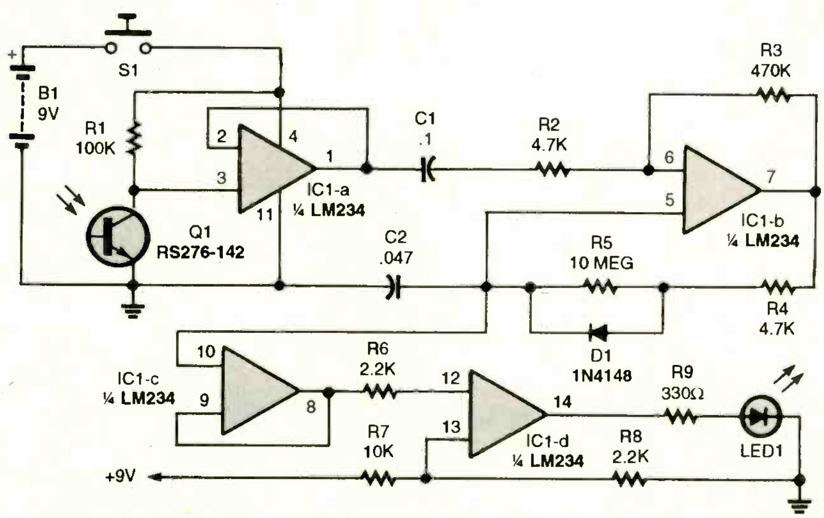
Guglielmo Marconi (1874-1937)

Known as the "Father of Radio," Marconi would later share this title with none other than Nikola Tesla. Ironically, Marconi's famous trans-Atlantic broadcasts used seventeen patented Tesla devices. Regardless, Marconi was a pioneer of radio communications.

Prior to the twentieth century, Marconi had successfully engineered a wireless system capable of broadcasting from ship to shore and back again. Marconi opened the world's first radio factory, which was based in Chelmsford, England. In 1898 he founded Wireless Telegraph and Signal Company, Ltd. This company has evolved into Marconi Corp., today. Marconi spent the final years of the nineteenth century perfecting his ship-to-shore radio systems.

In 1902, while onboard the US liner, *Philadelphia*, Marconi demonstrated the effects of reflection on radio waves. He showed that the range of transmission is better at night by transmitting 2000 miles, as opposed to only 700 miles by day.

Marconi's equipment managed to transmit from England to Australia in 1918. This monumental accomplishment only hinted at the possibility of today's global communications.



IR DETECTOR

Do you want to know if your TV remote is operational? This circuit will turn on LED1 for 2 seconds when it detects IR light pulses. Component Q1 is a phototransistor detector, and it works. It feeds the voltage-follower amp that charges C2. Capacitor C2 supplies a sample to another voltage-follower amp that powers the LED.

N.C.O.s

Q *In the October 2000 issue of* **Poptronics**, *there is an article on numerically-controlled oscillators (NCOs) that talks about how to build them. The article by Tom Napier makes mention of NCO chips. I was wondering if you know what these chips are and who their manufacturers are.—S. G., Trafford, PA*

A It's odd how NCOs, UPSs and ATMs are altogether different in modern electronics compared to their old meaning in the military, shipping industry, and banking. NCOs are the darling of the communications world. As Tom's article explains, they use a large digital word to set the frequency of a sine wave that is digitally-generated. Frequency-agile technology is the term often used to describe devices that can change their frequency at a very high rate of speed. Applications for this technology are found in spread-spectrum telephony and secure communications for military personnel. NCOs can easily frequency- or phase-modulate the output signal. In fact, Harris, the big manufacturer of broadcast transmitters, uses NCOs for their FM transmitters. They are the heart of direct digital synthesizers.

NCOs are manufactured by several companies including Intersil (HSP45102, HSP45106) and Analog Devices (AD9830, AD9832). You might be interested to know that Tom also wrote an NCO article in the October 1998 issue of *Circuit Cellar* magazine.

Conar, The Barbarian?

I've received responses from several of you kind folks regarding my plea for test equipment manuals for correspondence school kits—brands such as Conar, Bell & Howell, and Ameco (but not Heathkit). A special thanks to Jeffrey Lawrence, John Christensen, and Ralph Dominguez for their kind offers and contributions.

S-Video Jack Pins

Q *I am in need of the pin-connections on an S-Video jack. Can you help me with this?—D. K., Boonton, NJ*

A The S-Video standard separates the luminance and chrominance signals into two lines to reduce crosstalk and increase bandwidth and is incompatible with standard line-level video. The connector pinout, as seen from the solder lug side, is shown in Fig. 1. Pin 1 is the luminance ground; pin 2 is the chrominance ground; pin 3 is the luminance/sync signal; and pin 4 is the chrominance signal

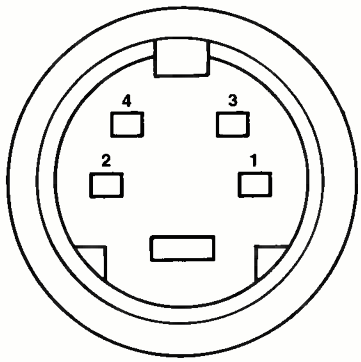


Fig. 1. The S-Video plug as viewed from the "solder tab" end, illustrating the pin locations as described in the text, is a 4-pin "mini-DIN" type of connector.

More Capacitors?

Q *I was sorting components. When I got to the film and ceramic capacitors, I wasn't sure what those capacitance codes stood for. Here are the codes from four film capacitors that I wasn't sure about: "0.01K400," "0.1K400," "1.0K400," and "10K400." The next one is a two-line code: "1/10" on top and then "100 MKT" under it. I also have some capacitors that don't have a voltage rating where the first two have a two-line marking and the third is one line: "103" and then "M3E," "474M" and then "3 D," and then "224" and nothing else. The last one is three lines: ITT 7329 T, 15630V6-14, and .1UF100VDC. Do you have a guide for identifying capacitors and a guide for reading those stamped codes?—M.J., Surrey, British Columbia*

A Different versions of the basic "How do I read capacitor values" question come up frequently, and this will be the fourth installment in the last two years in the "Q & A" column. Each time, we have a new wrinkle. Perhaps we could find a way to post this information on the Gernsback Web site at *www.gernsback.com*.

The first four caps mentioned are 0.01, 0.1, 1 and 10 microfarads in that order, each rated at 400 volts. The "K" means a tolerance of 10%. See the March 2001 "Q & A" column for more information on tolerance letter codes. If a capacitor value is in decimal form with a value less than 1, it is ALWAYS in microfarads. If the value is in whole numbers, you have to watch the capacitor construction and the style. If it's obviously an electrolytic, the value is usually in microfarads; if not, it's in picofarads.

I'd have to actually see the next cap to determine its value, and even then, I might resort to a digital capacitor meter to make the final determination. I'll admit defeat before making an incorrect choice. My preferred guess would be that "1/10" means 1 microfarad at 10 volts while the "100MKT" is a general style number that will be found on all caps of this type regardless of the value. If you choose "100MKT" as meaning 100 volts and "M" as 20%, then you have to deal with "1/10" somehow as well as the remaining "KT". Again, the meter would be used to verify my choice. If the meter said 1.2 microfarads, I'd still put the cap in with my 1 microfarad units, going by the marked value rather than the actual reading.

The next three caps are read as shown in the previously cited columns and will be 0.01 microfarads at 20% ("M" is a bit of an educated guess here), 0.47 microfarads at 20%, and 0.22 microfarads. With that last one, I'd assume a "Z" tolerance since no other was shown, which would be -20%/+80%, typical for "bulk" capacitance used in decoupling circuits. M.J. had photos attached of these three, asking what type they were. Since the photos would not have reproduced well here, I'll describe them. All three are radial-lead, conformal-coated ("dipped") capacitors, yellowish-beige in color with the imprinting in black or red ink. These are ceramic capacitors and might be monolythic or multilayer ceramics to get a lot of capacitance into a small volume.

The last cap, as shown in the photo, is a rectangular-shaped thing, black in color with white imprinting and radial leads. It's likely a plastic dielectric, most probably polyester. The lettering on the photo was a little fuzzy, but the top line, "ITT 7329 T" likely indicates that the cap was made for ITT (International Telephone & Telegraph), maybe in week 29 of 1973. The next line is probably the ITT internal part number, a "house number" for which you'll never find out anything unless you have some company-confidential material in hand. The last line is the value and voltage rating, 0.1 microfarads at 100 volts.

Muscle Wires?

Q *I have been looking for circuit diagrams for an electronic muscle stimulator (similar to a TENS unit) and can't find anything anywhere. Do you have any idea where I could get schematics for these devices? They are used for muscle development and are especially helpful for people who can't exercise because of arthritis (which I have) or other ailments.—W.H., via e-mail*

A One reason that you can't find a schematic like that is that the companies that manufacture such units closely guard the guts of their products because of liability issues. They don't want anyone but bonded/insured, authorized/licensed BMETs (biomedical electronic technicians) repairing any unit that connects to the body, especially if that device is connected to the electrical mains and/or puts out a current such as the device you describe.

As much as I'd like to help in that regard, the publisher and I are bound by the same code to avoid publishing information for circuits that have the potential of failing or which may be constructed of inferior or incorrect parts and could end up jeopardizing human life. Neither do we want to condone the use of non-prescribed treatments, which could be dangerous to the individual. A manufacturer's desire for profit doesn't drive up the cost of electronic medical devices as much as the liability insurance and bonding they must have to produce such things.

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.

Find A 2-mA LED

Q *In the July 2001 issue of* **Poptronics**, *the "In-Circuit Capacitor Tester" calls for a 2-mA light emitting diode (LED). I have not been able to locate a 2-mA LED; the best I have been able to find is 15 mA. Could you advise me where I might find one?—T.R., via e-mail*

A It is a little tough to find LEDs that are rated for less than 10 mA. However, don't forget that this is the absolute MAXIMUM forward current rating, and the LED will operate on much less current, albeit sacrificing light intensity. The cap tester circuit has 3.3 mA flowing through the LED. In this light, a "2-mA low current" diode is really a little bit stressed. I'd try whatever LED you have on hand, for you won't hurt anything in the circuit if you do. I used one rated at 20 mA in a mock-up of that portion of the circuit, and it worked just fine. The Digi-Key catalog (*www.digikey.com*) does have low-current LEDs from Chicago Miniature, some of which are surface-mount technology that are rated at currents as low as 1.8 mA.

Luminous Intensity And The 'mcd'

Q *What does M.C.D. stand for? Is there a simple way to test the luminous intensity* *of a light emitting diode (LED)?—E.L., via e-mail*

A The abbreviation "cd" stands for candela, which is the standard unit of measure of luminous intensity. The mcd is therefore a millicandela or 0.001 cd. You'll see this unit of measure used to compare the light output of one LED versus another. It's a measure of the overall brightness of any light source. To get more complicated, one candela produces one lumen per square meter at a distance of one meter from the source. I'm not a physicist, so this is as far as I go with these definitions!

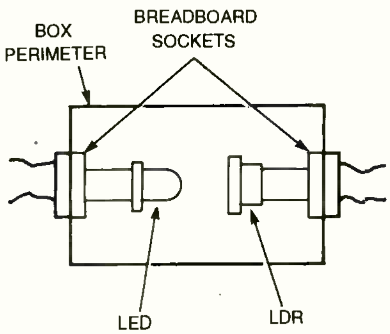


Fig. 2. This drawing shows how the solderless breadboard connectors are located on opposing sides of a light-tight box.

As far as testing for the luminous intensity, that's no problem. With a simple circuit, you can compare LEDs of the same color or check LEDs of the same size and color to match them for intensity. You can't build a simple circuit to provide you with the actual luminous intensity because things like calibration, standards, and light wavelength make a device too complicated for this column.

Build a light-tight box into which you can mount both the LED under test and a light-dependent resistor (LDR), otherwise known as a resistive photocell. LDRs are very sensitive to changes in light and have a huge dynamic range. I made a box of opaque black plastic. If I were to do it again, I'd use unetched printed circuit board material and solder the pieces together. Mount two little solderless breadboard connectors inside the box on opposing walls, facing each other. You can make these little connectors by sawing up an old breadboard so that you have two or more adjacent contact strips on each piece. The wires to the connectors come out through holes in the sides. Actually, I mounted two more of the solderless connectors on the outside of the box connected to those two wires so that I had a light-tight-box breadboarding component. Light-seal everything with flat-black model paint and coat the inside of the box with the paint. The tiniest bit of light leaking in can be seen by the LDR. An "inside" view of the box is shown in Fig. 2.

Connect the LED in series with a 100-ohm, ½-watt current-limiting resistor and a variable power supply. Set the LED current for the same value for each test, e.g., 10 milliamps, by using a digital multimeter (DMM) to measure the voltage across the resistor on the 2-volt range. Current will be the measured voltage divided by the 100 ohms. With the LED directly facing the LDR and the lid on the box, measure the LDR resistance with a digital multimeter and jot the reading down. Switch to another LED and repeat the test as many times as you need. Make sure that the distance and orientation between the LED and the LDR always remains the same for each test. A width of cardboard or popsicle stick may help as a gauge.

At this point, you don't have a glimmer of an idea what these readings mean. After you have tested ten or more LEDs, especially if they vary a lot in resistance of the LDR, you should be able to line them all up in a series circuit with a current-limiting resistor so that they have the same 10 milliamps going through each of them. Note the differences in intensity and see how far the resistance has to move to be able to see a difference. Probably your first test should be with a batch of "surplus" LEDs, since they tend to be "floor sweepings" that vary a lot in intensity and will give you a wider range of values than will a set of new prime LEDs.

Google Groups Are Active

In the July 2001 column, I had mentioned that Deja's Usenet Archive and forum that posted to the Usenet news groups went dormant after being acquired by Google. I'm happy to report that Google Groups is alive and well and is now taking posts. It is an extremely active forum. Be forewarned that if you're used to the Gernsback or Twisted Pair forums, you need to prepare for the possibility of ruffled feathers if you post there, because of the increased amount of "flaming" that goes on. The URL is *http://groups.google.com*.

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. **P**

mailto: amazingscience@gernsback.com

JOHN IOVINE

Hexapod Walker Robot

Walkers are a class of robots that imitate the locomotion of animals and insects. Walker robots have the potential to transverse rough terrain impassable by standard-wheel vehicles. It is with this in mind that robotists are developing walker robots.

Imitation Of Life

Sophisticated walkers imitate insects, crabs, and sometimes humans. Biped walkers are still a little rare, requiring balance and a good deal of engineering science. In this article we will build a six-legged walker robot.

6 Legs—Tripod Gait

Using a six-legged model, we can demonstrate the famous tripod gait used by the majority of legged creatures. In the following drawings, a dark circle means the foot is firmly planted on the ground and supporting the weight of the creature. A light circle means the foot is up and moveable.

Figure 1A shows our creature at rest. All feet are on the ground. From the resting position our creature decides to move forward. As shown in Fig. 1B, to step forward, the hexapod lifts three of its legs (represented by the white circles), leaving its weight on the remaining

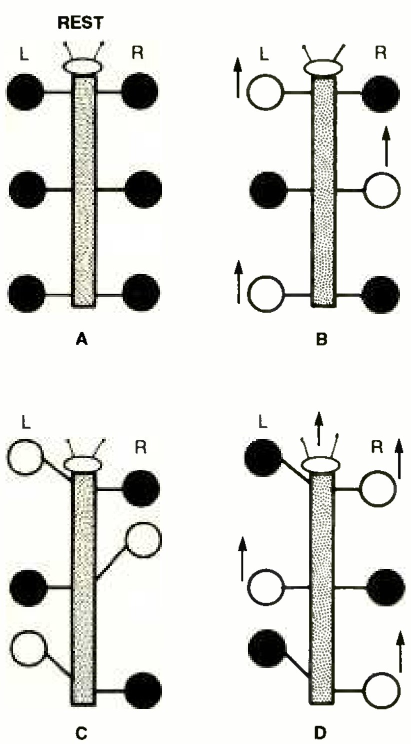


Fig. 1. The above diagram shows the tripod gait of a hexapod. There are always three feet on the ground at any given time.

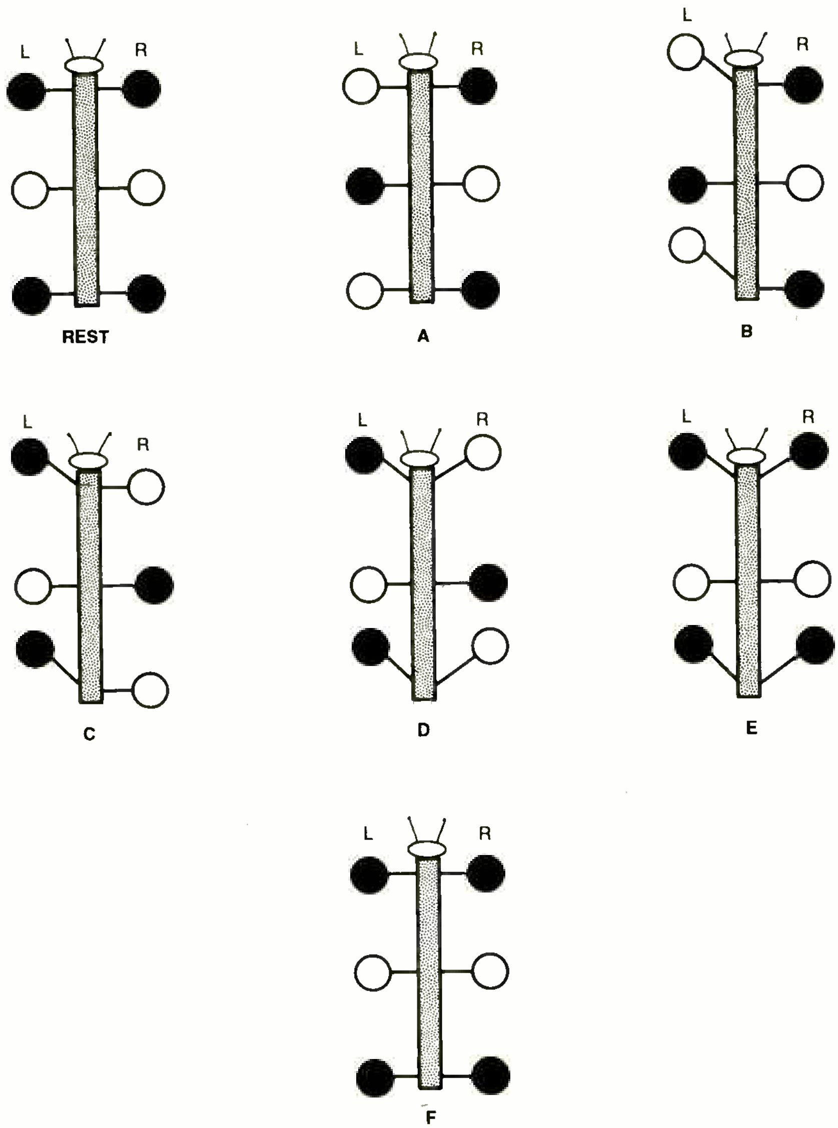


Fig. 2. Here is the walking pattern of a hexapod powered by three servos. Notice that, at rest, the center legs do not support any weight.

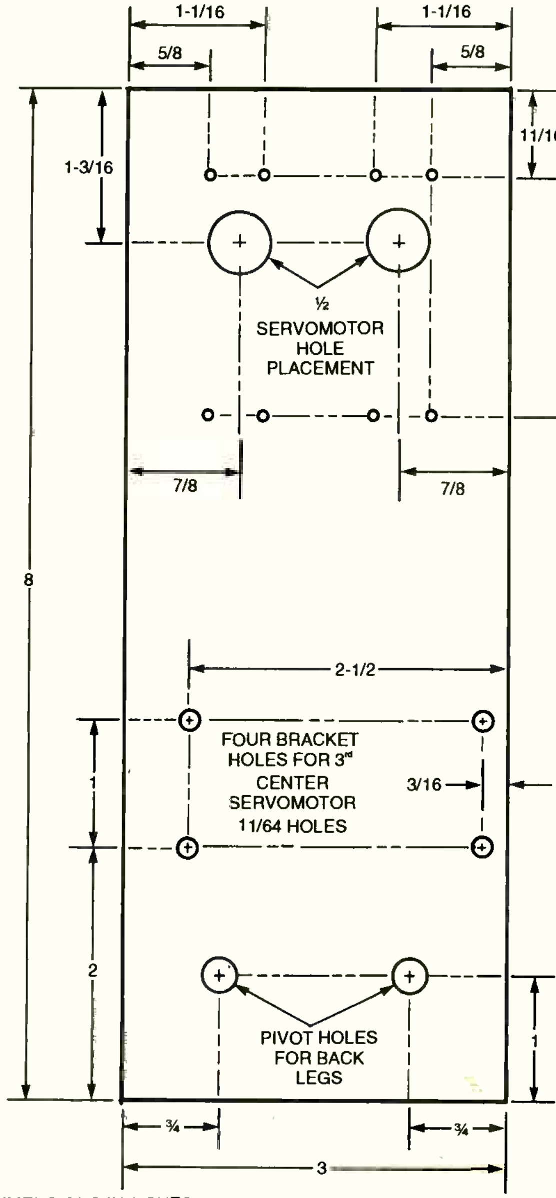


Fig. 3. The above figure can be used as a template for constructing the hexapod's body.

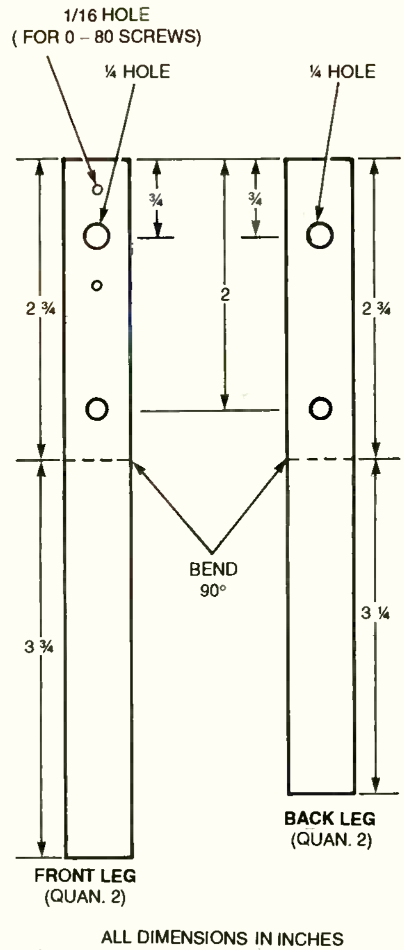


Fig. 4. Here are the guides for constructing the front and rear legs of the robot.

three legs (represented by the dark circles). Notice that the legs supporting the weight (dark circles) are in the shape of a tripod. This is a stable weight-supporting position. Our creature is unlikely to fall over. The three lifted legs (white circles) are free to move, and they move forward.

Figure 1C illustrates where the three lifted legs move. At this point, the creature's weight shifts from the stationary legs to the moveable legs, see Fig. 1D. Notice that the creature's weight is still supported by a tripod position of legs. Now the other set of legs moves forward, and the cycle repeats.

This is called a tripod gait, because a tripod positioning of legs always supports the weight.

Tri-Servomotor Walker Robot

The walker robot we will make is a compromise in design and construction, but allows us to build a walker that only requires three servomotors. Although it uses just three servomotors, it is a true tripod gait walker. The hexapod uses three HS300 (42-oz. torque) servomotors for drivers and a 16F84 microcontroller for brains.

Function

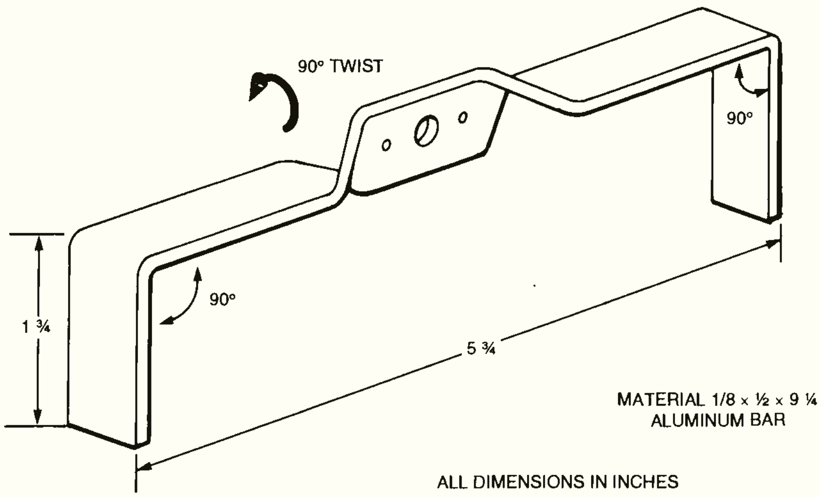
At the front of the walker are two servomotors. Each servomotor controls both the front and back legs on its side. The front leg is attached directly to the horn of the servomotor. It is capable of swinging the leg forward and backward.

The back leg connects to the front leg through a linkage. The linkage makes the back leg follow the action of the front leg as it swings forward and back.

The third servomotor controls the two center legs. This servomotor rotates the center legs 20–30 degrees in a clockwise (CW) or counter clockwise (CCW) rotation. This tilts the robot to one side, either left or right.

With this information under our belt, we can now see how our robot will walk. Look at Fig. 2. We start in the rest position. Each circle represents a leg. As before, the dark circles show the weight-bearing legs. Notice in the rest position, the center legs do not support any weight. These legs are ⅛-inch shorter than the front and back legs.

In position "A," the center legs are rotated CW by about 20 degrees from center position. This causes the robot to tilt to the right. The weight distribution is now on the front and back right legs and the center left leg. This is the standard "tripod" position described earlier. Since there is no weight on the front and



CENTER LEGS

Fig. 5. The center legs are constructed of a single piece of aluminum and are 1/8-inch shorter than both the front and rear legs.

back left legs, they are free to move forward as shown in the "B" position of Fig. 2.

In the "C" position, the center legs are rotated CCW by about 20 degrees from center position. This causes the robot to tilt to the left. The weight distribution is now on the front and back left legs and the center right leg. Since there is no weight on the front and back right legs, they are free to move forward as shown in the "D" position.

In position "E," the center legs are rotated back to their center position. The robot is not in a tilted position so its weight is distributed on the front and back legs. In the "F" position, the front and back legs are moved backward simultaneously causing the robot to move forward. The walking cycle then repeats.

This is the first gait pattern I tried, and it worked. There are other walking patterns you can design, develop, and experiment with. I will leave it to you to develop walking patterns for reverse (walking backward), turning left, and turning right. If you would like to see another article that continues the development of this robot, providing wall and collision sensors as well as providing the ability to walk backwards and turning, write to me in care of the magazine.

LISTING 1

```
'Hexapod Walker
' The Connections
' left servo motor      Pin RB1
' right servo motor     Pin RB2
' tilt servo motor      Pin RB0

' Moves in forward direction only

start:
FOR B0 = 1 TO 60
        pulsout 0,155        ' start by tilting CW lift right side
        pulsout 1,145        ' keep left legs back
        pulsout 2,145        ' bring right legs forward
    pause 18
NEXT B0
FOR B0 = 1 TO 60
        pulsout 0,190         ' tilting CCW lift left side
        pulsout 1,200         ' bring left legs forward
        pulsout 2,145         ' keep right legs forward
        pause 18
NEXT B0
for b0 = 1 to 15
        pulsout 0, 172       ' no tilt
        pulsout 1, 200       ' keep left legs forward
        pulsout 2, 145       ' keep right legs forward
        pause 18
next b0
for B0 = 1 to 60
        pulsout 0, 172        'no tilt
        pulsout 1, 145        ' bring left legs back
        pulsout 2, 200        ' bring right legs back
        pause 18
next b0
    goto start
```

Construction

For the main body, I used a 3- × 8- × .032-inch sheet of aluminum. The servomotors are mounted to the front of the body (see Fig. 3). The servomotor holes shown in the drawing should be photocopied and taped to the aluminum sheet. The photocopy will provide accurate hole-location for mounting the servomotors.

The four ¹¹⁄₆₄ diameter holes a little past halfway down the main body are for mounting the center servomotor. These four holes are offset to the right side. This is necessary to align the servomotor's horn in the center of the body.

The bottom two holes are for mounting the pivots for the two back legs.

Use a punch to dimple the metal in the center of each hole you plan to drill. This will prevent the drill bit from walking when you drill the hole. If you don't have a punch available, use the pointed tip of a nail for a quick substitute.

The legs for the robot are made from ½- × ⅛-inch aluminum bar stock, see Fig. 4. There are four holes that are drilled into the two front legs. The back

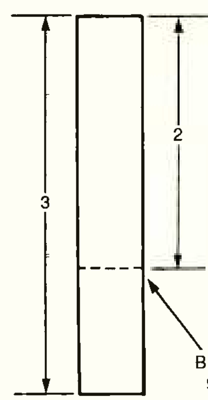


Fig. 6. Two L-shaped brackets must be constructed in order to attach the center servo to the body.

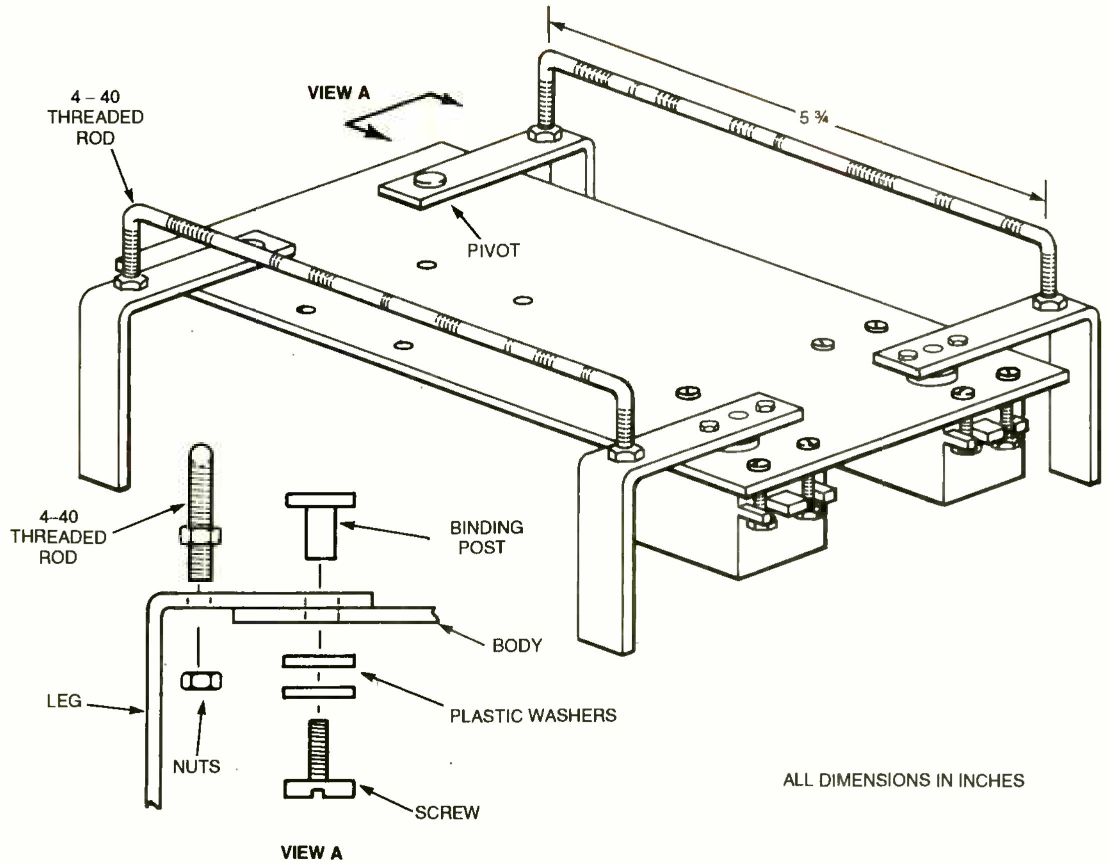


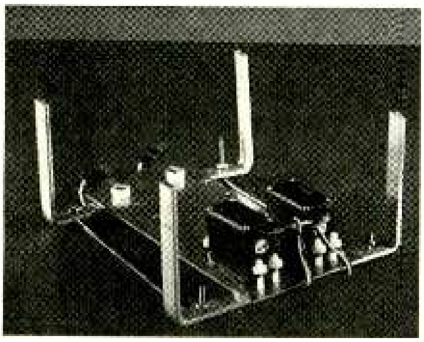
Fig. 7. The linkage system consists of two threaded rods that connect the front and rear legs, which permits synchronous movement.

legs only need two holes, one for the pivot and the other for the linkage. Also, notice that the back legs are .25 shorter than the front legs. This compensates for the height of the servomotor mounting horn on the front servomotors where the front legs are attached. Shortening the back legs makes the robot platform level.

After the holes are drilled, we need to bend the aluminum bar into shape. Secure the aluminum bar in a vise 2¾-inches from the end with the drilled holes. Pressure is applied to bend the aluminum bar at a 90-degree angle. It's best to apply pressure at the base of the aluminum bar close to the vise. This will bend the leg at a 90-degree angle, while keeping the lower portion of the leg straight without any bowing of the lower portion.

The center legs are made from one piece of aluminum (see Fig. 5). The center legs are about ⅛-inch shorter than the front and back legs when mounted to the robot. When centered, the legs do not support any weight. These legs are for tilting the robot to the left or right. The legs tilt the robot by rotating the center servomotor approximately ±20 degrees.

To make the center legs, first drill the mounting holes in the center of the ⅛ × ½ × 9¼-inch aluminum bar. Secure the aluminum bar in a vise. The top of the vise should hold the aluminum bar ¼-inch from the center of the aluminum bar. Grab the aluminum bar with pliers about ½-inch above the vise. Keeping a secure grip with the pliers, slowly twist the aluminum bar 90 degrees. Don't go fast, or you could easily snap the alu-

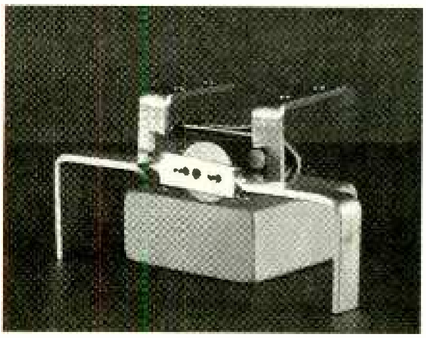


No, it's not dead...it's resting. Here you can see the underbelly of the hexapod with two servos in place.

PARTS LIST

Servomotors
16F84 Microcontrollers
Aluminum bars
Aluminum sheets
4-40 threaded rods and nuts
Plastic machine screws, nuts, and washers

Available from :
Images Company
39 Seneca Loop
Staten Island, NY 10314
718-698-8305
www.imagesco.com



The center servo is shown here ready to be attached to the body. The center legs and the two L-brackets have been attached to the servo.

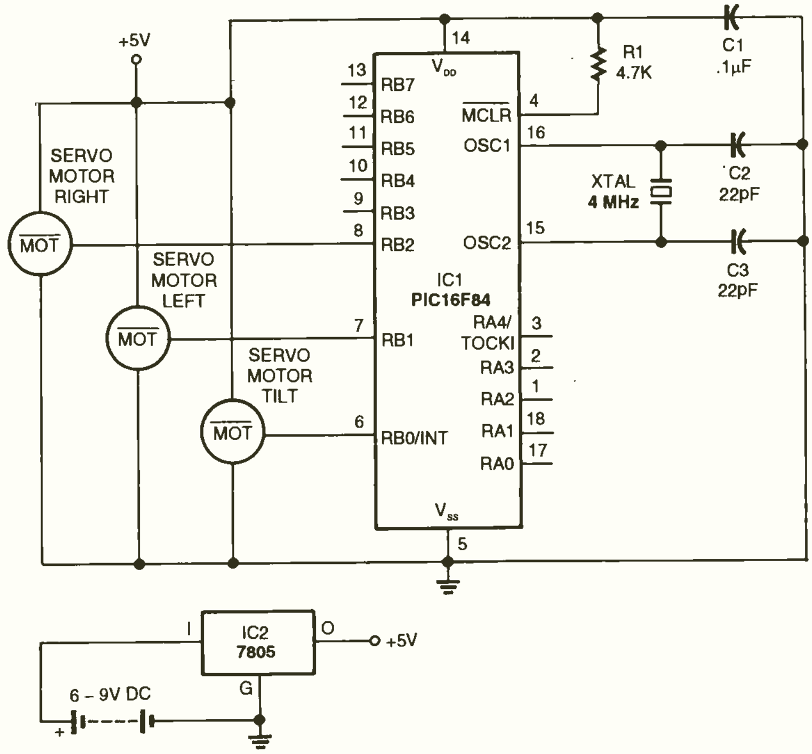


Fig. 8. At the heart of this hexapod lies a PIC16F84 with an external 4-MHz crystal linked to the oscillator pin-outs, 16 and 15.

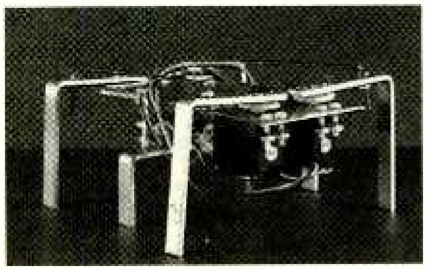
minum bar. Repeat the twist on the other side.

After the two 90-degree twists have been made, make the other 90-degree bend for the legs as we have done before for the front and back legs.

Mounting the Servomotors

The front servomotors are attached to the aluminum body using plastic 6-32 machine screws and nuts. The reason I am using plastic screws is that they are a little flexible, allowing the drilled holes to be slightly off center from the mounting holes on the servomotor.

The legs are attached to the servomotor's plastic horn. For this I used 0-80 machine screws and nuts. When mounting the servomotor horn on the servomotor, make sure that each leg can swing forward and backward an equal amount from a perpendicular position.



The hexapod is ready for action. Two threaded rods provide linkage for the synchronous movement of the rear and front legs.

Center Servomotor

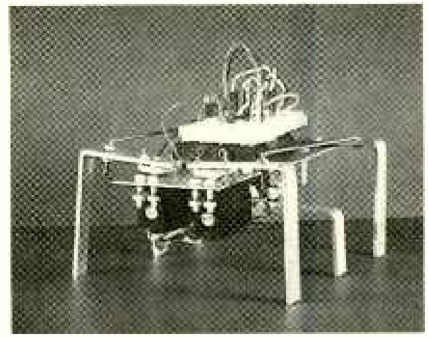
To attach the center servomotor to the body requires two L-shaped brackets (see Fig. 6). Drill the holes and bend at a 90-degree angle.

Attach the two L-brackets to the center servomotor, using the plastic screws and nuts.. Next mount the center servomotor assembly under the robot body. Align the four holes in the body with the top holes in the L-brackets. Secure with plastic screws and nuts.

Linkage

The linkage between front and back legs is made from 4-40 threaded rod (see Fig. 7). In the prototype robot, the linkage is 5¾-inches, center to center. The linkage fits inside the holes in the front and back legs. The linkage may be secured using a few 4-40 hex nuts.

The back legs must be attached to the body of the robot before you make the linkage. The pivot for the back legs is made from a ⅛-inch binding post and screw. The leg is attached as shown in the close-up in Fig. 7 (View A). The plastic washers underneath the body are necessary. They fill up the space between the aluminum body and the bottom of the screw. This keeps the leg close to the aluminum body without sagging. I chose plastic washers for less friction. Do not use so many washers that force is created binding the leg to the body. The joint should pivot freely.



Here is the completed hexapod. A breadboard containing the circuit is mounted to the top of the body. The robot is controlled by a PIC16F84.

Electronics

Figure 8 shows the schematic for the servomotors and PIC microcontroller. Notice the 6-volt battery pack is powering the microcontroller, as well as the servomotors. The battery pack uses four AA-batteries. The microcontroller circuit is built on a small solderless breadboard. The battery pack and circuit are laid on top of the aluminum body.

Microcontroller Program

The 16F84 microcontroller controls the three servomotors using just three I/O lines. This leaves ten available I/O lines and plenty of programming space left over to improve and add to this basic walker.

Not all servomotors are exactly alike and may not respond in an identical manner to the PULSOUT command. The PULSOUT commands that control the position of the servomotors you use may need to be adjusted. Adjust the numerical value of the pulsout commands to compensate for any differences with the servomotors used in your hexapod robot walker.

While this PICBasic program only provides for forward motion, a little experimentation on the part of the robotist can have this robot turning to the left or right and walking backward. A few sensor switches on the front can inform the robot when it has encountered an obstacle. P

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SCOTT M. SAVAGE

Tracking the Wall

Last month, my article dealt with configuring a robot that needed to travel down a hallway parallel to the wall, with the ability to measure its angle to the wall. The article covered some basic trigonometric functions, the Sharp GP2D12 Infrared Distance Sensor, and programming of the OOPic's oIRRange Object. Now my robot can *see* and determine its angle to the wall. This angle is considered the *angle of correction*. Now comes the second step: How does one get the drive motors to respond to the angle of correction and make course corrections based upon it?

Before a formula could be devised, the mechanics of the robot needs to be evaluated. My robot uses two drive wheels, each with its own motor. One drive wheel is placed on each side of the robot, and a coaster is in the back with the weight of the batteries holding it down. Given this configuration, turns are achieved by slowing down the wheel on one side while speeding up the wheel on the other side. When both wheels turn at the same rate, the robot travels straight (see Fig. 1).

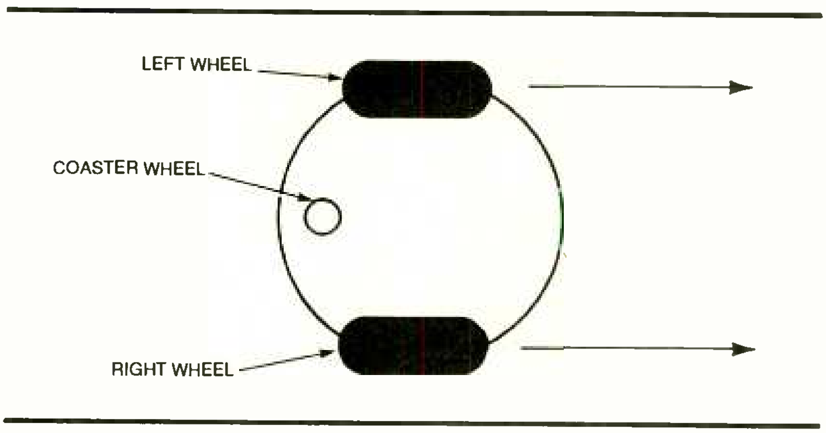

Fig 1. When both wheels are turning at the same speed, the robot travels straight down the hall.

The question now was: What formula would my robot need to take the angle of correction and apply it to both of the motors so that one would speed up and one would slow down in such a way as to cause the robot to travel down the hall parallel to the wall?

Formulating The Formula

The first idea I had was to simply add the angle to one motor's speed and subtract the angle from the other motor's speed.

RightSpeed = CurrentSpeed − CorrectionAngle

LeftSpeed = CurrentSpeed + CorrectionAngle

In theory, the robot would travel straight down the hall when the robot was parallel to the wall as shown in Fig. 2. The robot would do this because the measured angle would be 0 and would not affect the speed of either motor. Once the robot became non-parallel to the wall, the measured angle would slow down one motor and speed up the other, turning the robot back towards being parallel. Once parallel again, the motors would resume identical speeds.

After putting the robot on the floor, I quickly realized that this formula needed some additional input. Even with the angle of correction being applied, the robot did not travel parallel to the wall. Instead, it steadily curved towards the wall and eventually ran into it. After some investigation, I discovered that one motor was turning faster than the other motor when the same voltage was being applied. This was due to the construction of the motors. These motors were tuned to run faster when they spin in a particular direction. With the configuration of my robot, one motor turned clockwise and the other needed

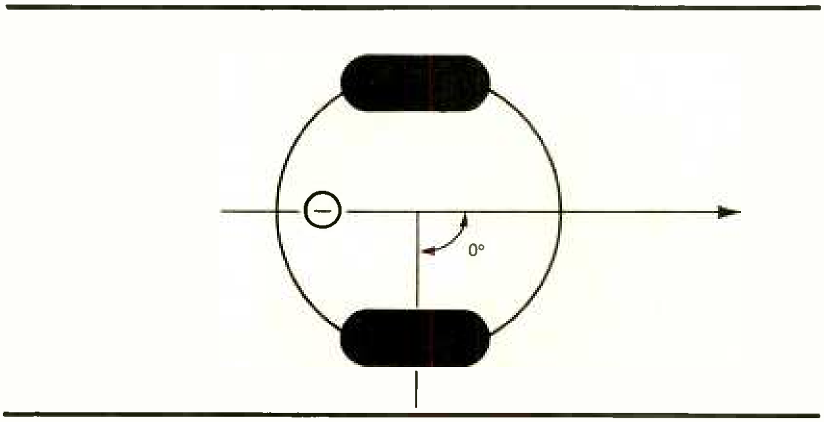

Fig. 2. When the robot is parallel to the wall, the angle of correction is 0. That angle does not affect the speed of either wheel, resulting in the robot traveling straight down the hall.

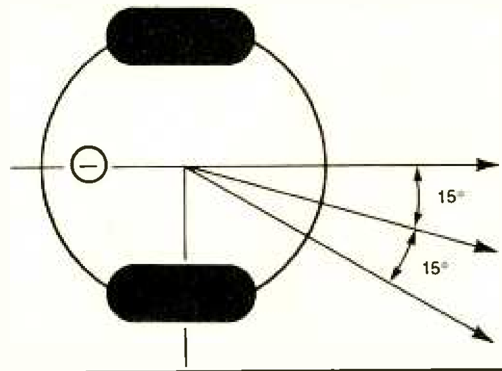

Fig. 3. Mechanical differences in the motors' speed can cause the robot to go at undesired angles.

to turn counterclockwise, because they were mounted 180° from each other. The motor that turned in reverse to make the robot go forward ran slower than its counterpart.

To describe how this caused the robot to go off course, let's suppose that the difference in speed of the motors causes the robot to have an exceptionally large turn error of 30° to the right when the motors are directed to spin at the same speed. Figure 3 shows the 30° split into two 15° sections. When the robot is at a 15° angle to the wall, the formula will direct the motors to turn left 15°. When subtracted from the turn error of 30°, it leaves the robot traveling at a 15° angle to the wall. Thus, the error angle and the angle of correction nullify each other, causing the robot to continue on course at 15°—eventually driving into the wall.

The solution to this problem was to incorporate the distance to the wall into the formula. This solution will work by generating a second angle of correction that increases in the opposite direction as the robot moves closer to the wall. The two angles of correction will be added to each other producing a new angle of correction. This result overcomes any error angle; as the robot approaches the wall, the second angle will counteract the first, driving the robot back away from the wall.

Just as in last month's article, the angle is calculated using a little trigonometry. As shown in Fig. 4, if the robot is not in the middle of the hall, then the angle that the robot will need to turn to return to the middle can be derived. Take the ratio of the robot's offset from center and the distance to a point out in front of the robot in an Arctangent calculation, as follows:

[Degrees2 = Arctangent(Y/X)]

Trigonometry Revisited

In last month's article, a detailed description of Arctangent is given. This month I will just touch on the major points. Arctangent is defined as the angle (A) that corresponds to a specific ratio created by dividing the length of the side opposite the angle (Y) by the length of the side adjacent to the angle (X). An Arctangent diagram is shown in Fig. 5.

One of the more interesting things

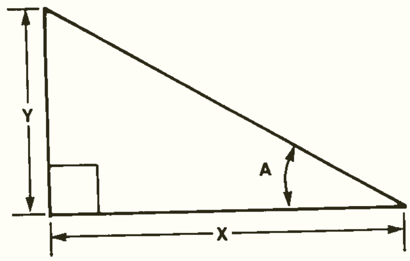

Fig. 5. Arctangent is the angle (A) that corresponds to the ratio of the length (Y) divided by the length (X).

about Arctangent that was covered last month is how the constant 55 can be substituted for the Arctangent function for angles less than 20°.

[Degrees2 = 55 * (Y / X)]

may be substituted for the formula

[Degrees2 = Arctangent(Y / X)]
for angles under 20°

Calculating the 2nd Correction Angle

To calculate the second angle of correction, the robot's offset from center will need to be figured out. This will be the Y value in Figs. 4 and 5. In the contest that I am entering, the halls are 18 inches apart, so the middle of the hall is 9 inches from the wall. As detailed last month, the robot already has two Sharp GP2D12 Infrared Distance Sensors mounted facing the same wall. See the configuration shown in Fig. 6.

The OOPic's oIRRange Object is used to read the Sharp GP2D12 Infrared Distance Sensor and returns the measured distance in 64 steps per foot. When the robot is in the center of and traveling straight down the hall, both oIRRange Objects will have a reading of 48. This calculation was done by taking 64 steps per foot/12 inches per foot * 9 inches. However, when the robot is at an angle to the wall, the front and back are different distances to the wall. Therefore, the measurements will not be the same.

By adding the two measurements together and dividing by 2, we get the actual distance that the middle of the robot is from the wall—even if the robot is at an angle to the wall. For the angle-of-correction formula, when the robot is in the center of the hall, the offset needs to be 0. Subtract 96 (48 for each side) from the measurement before dividing it by 2. Plugging this into the formula

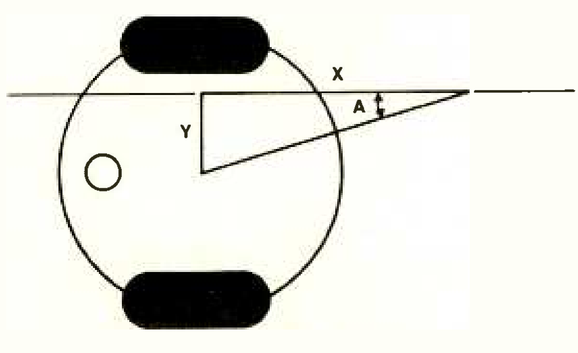

Fig. 4. When the robot is not in the middle, a second angle of correction can be calculated.

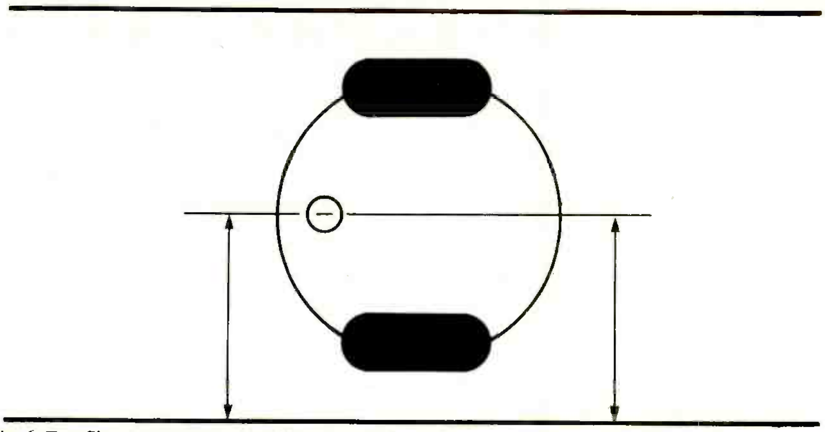

Fig. 6. Two Sharp GP2D12 Infrared Distance Sensors are mounted on the robot facing the same wall.

gives:

[Degrees2 = 55 * (((FrontDistance + BackDistance – 96) / 2) / X)]

The X value in the formula is an unspecified point in front of the robot.

Any distance, within certain limits, can be used. If the distance is too small, then the robot will overcompensate for being out of center and will wind up weaving back and forth around the center of the hall. If the distance is too large, then the second angle of correction will not adequately overcome any mechanical error. The correct distance really depends on the mechanics of your robot and needs to be tuned. As a starting point, I selected 20.625 inches because it allows the formula to be reduced. Using 20.625 inches at 64 steps per foot works out to be 110 (20.625 / 12 * 64). Plugging this into the formula gives:

[Degrees2 = 55 * (((FrontDistance + BackDistance – 96) / 2) / 110)]

This formula can be reduced by dividing by 55.

[Degrees2 = ((FrontDistance + BackDistance – 96) / 2) / 2]

which can be reduced to:

[Degrees2 = (FrontDistance + BackDistance – 96) / 4]

Adding the second angle of correction to the original angle of correction will give us a final angle of correction. The formula used to do that is:

[CorrectionAngle = Degrees1 + Degrees2]

Plugging the 1^{st} angle of correction formula from last month and the formula for the 2^{nd} angle of correction into this formula gives:

[CorrectionAngle = (FrontDistance – BackDistance) + ((FrontDistance + BackDistance – 96) / 4)]

Using the Magnevation PWMx2 Motor-Driver Board

Now that we have the formula, the next step is to get the wheels to turn under their own control. The motor controller that my robot is using is the Magnevation PWMx2 Dual DC motor controller.

This motor controller is capable of driving two DC motors rated at up to 55 volts at 3 amps with speed control, brakes, thermal overload signals, and current sense. It has a 40-pin connector on each side, which allows it to be directly connected to the OOPic's 40-pin connector, while passing all the control signals through to the 40-pin connector on the other side. It also has a 16-pin header that is configured for a standard PC joystick to be plugged into.

(Continued on page 54)

LISTING 1

c:\m1.osc

```
Dim M As New oUserClass("PWMX2.OSC")

Sub Main()
End Sub
```

NETWORK NODE(0)
- OOPic
- UserClass: M
  - oDcmotor: M.Right
  - oDcmotor: M.Left

LISTING 2

c:\m2.osc

```
Dim M As New oUserClass("PWMX2.OSC")
Dim F As New oIRRange
Dim B As New oIRRange
Dim A As New oByte

Const CurSpeed = 64

Sub main()
  Call IOSetup
  Do
    A = (F - B) + ((F + B - 96) / 4)
    M.Right.Value = CurSpeed - A
    M.Left.Value = CurSpeed + A
  Loop
End Sub

Sub IOSetup()
  F.IOLine = 1
  F.Operate = cvTrue
  B.IOLine = 2
  B.Operate = cvTrue
  A.Signed = cvTrue
End Sub
```

NETWORK NODE(0)
- OOPic
- UserClass: M
- oIrrange: F
- oIrrange: B
- oByte: A

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CHARLES D. RAKES

MORE BATTERIES TO TEST

Here we are again, ready to life test a few more types of batteries to determine which brands produce the greatest output for the buck. I'm going to share information and circuitry for life testing NiCad, Nickel-Metal Hydride, and Sealed Lead-Acid batteries. NiCad batteries have been one of the most popular rechargeable power sources for many years and most likely will remain so for a long time. However, the Nickel-Metal Hydride is beginning to challenge the NiCad in many applications.

One of the most used NiCads around is the "AA" battery—normally rated from 0.6 to 0.8 amp-hour capacity. The rating is based on the amount of output current for a given operating time—in this case, one hour. Discharging the battery for one hour at a fast rate is a good method to use in determining its high-current short-term value. A ten-hour discharge at one-tenth the rated current is a good life test for medium-current-demand applications.

If the battery is to serve in a low-current, long-term application, then a discharge rate equal to 1/20th of the amp-hour rating would give an indication of which battery is best suited for the job.

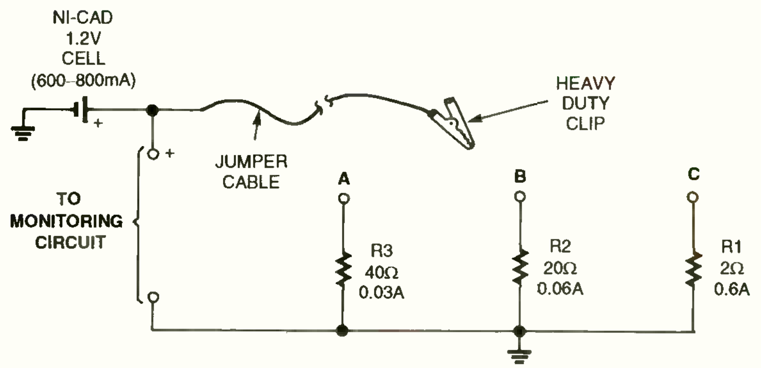

Fig. 1. This is a simple circuit for monitoring and testing the capacity of NiCad AA cells. The only components needed are inexpensive resistors.

Back To Basics

A sure and simple method to use in life testing NiCad AA cells is to use the basic discharge circuit shown in Fig. 1. The circuit is set up to discharge an AA battery at a rate of .6A, .06A, and .03A, depending on the batteries' end use. The maximum power dissipation of .72-watts occurs when using the 2-ohm load. A 2-ohm, 2-watt power resistor will do for R1, and the other two load resistors can be ½-watt units. One of the voltage-monitoring circuits discussed a couple of months back can be connected across the battery to give out an alert when the battery reaches the .9-volt discharge level.

The various life-testing circuits discussed earlier that are suitable for low-voltage testing may be used for NiCads as well. However, two or more batteries should be connected in series for the transistor-driven load circuits.

Our second basic-resistance load bank, see Fig. 2, extends the life testing to include stacked NiCad up to seven series cells, which adds up to the popular 9-volt battery. However, with NiCads, the actual voltage is only 8.4 volts. Any combination battery pack made up of seven or less cells may easily be life tested with this circuit. Each row of load resistors, A, B, and C, contains seven equal-value resistors. In row "A," the resistors are 40-ohms each, which places a current drain of 30 mA for each series cell. The jumper cable connects to the position number on the load string that matches the number of series cells. The jumper cable, for a single cell, would connect to position 1 of row A for a 30-mA load, to position 1 of row B for a 60-mA load, and to position 1 of row C for a 600-mA load. The voltage-monitoring circuit connects across the battery and adjusts to correspond to the number of cells tested.

Two load banks can be used to load test two batteries at the same time to obtain a comparison quicker than sequentially using a single load bank.

PARTS LIST FOR THE "BACK TO BASICS" LOAD TESTER (FIG. 1)

RESISTORS
R1—2-ohm, 2-watt power resistor
R2—20-ohm, ½-watt
R3—40-ohm, ½-watt

ADDITIONAL PARTS AND MATERIALS
Heavy-duty metal clip, #14 or 16 hook-up wire, etc.

Draining Nickel-Metal Hydride Batteries

Life testing Nickel-Metal Hydride batteries may, in most cases, follow the same procedures used in testing NiCads. Generally, the Ni-MH batteries have a much greater amp-hour current rating than the standard NiCads. A typical Ni-MH AA battery can have a 1.5-Ah rating, which is almost three times that of a standard NiCad.

The load bank in Fig. 2 may be used for testing the Ni-MH cells. However, the discharge time will be about three times longer than that of a standard NiCad cell. The load bank can be mod-

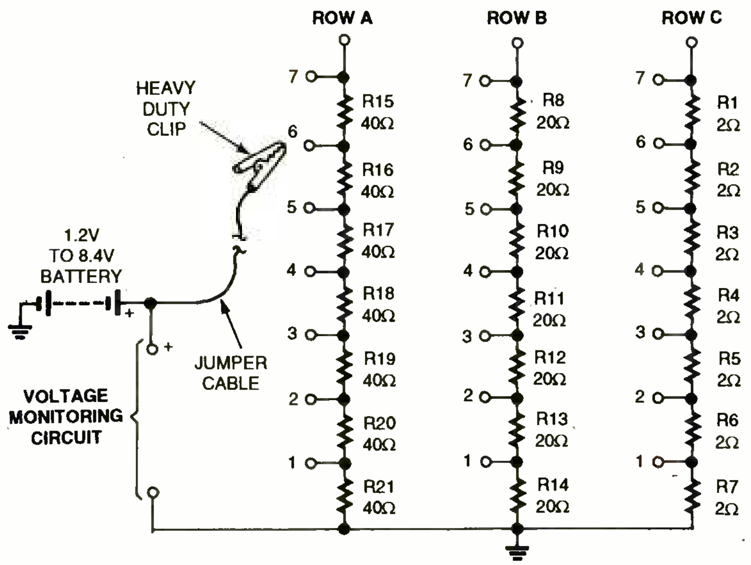

Fig. 2. The schematic above shows a battery tester capable of testing up to seven stacked NiCads. The load is adjustable for 30 mA, 60 mA, and 600 mA.

PARTS LIST FOR THE "SECOND LOAD BANK" (FIG. 2)

RESISTORS

R1–R7—2-ohm, 2-watt, power resistor
R8–R14—20-ohm, ½-watt
R15–R21—40-ohm, ½-watt

ADDITIONAL PARTS AND MATERIALS

Heavy-duty metal clip, #14 or #16 hook-up wire, etc.

ified for higher discharge rates by reducing the values of all of the load resistors. The resistors in row "C" may be reduced to 1-ohm values to increase the discharge rate to about 1 amp. The values in row "B" may be reduced to 5 ohms each for a current drain of 240 mA, and in row "A" to 10 ohms for a 120mA drain. The actual discharge rates may by customized for life testing for a specific load condition. Just divide the battery voltage by the desired load current. That will give the resistance value needed for the load.

Just to confuse things, I'll go ahead and mention another type of NiCad battery. That is the Hi-Capacity NiCad designed for high-current discharge usage in cordless tools, high-performance RC toys, and other high-current-demanding devices. These batteries come with amp-hour ratings of over 4 amps for the "D" cell and over 2 amps for the "C" cell. Life testing these cells at a 1-amp or higher current drain is a good way to determine their useful life. The most meaningful information obtained from life testing any battery is when it is discharged at a rate equal to its application demand. Sometimes this can be an easy task if the current demand is continuous and constant. CDs and tape players fall in this category, but cordless tools, RC toys, and many other items do not. These "do not" items are the most difficult to match in a static-load discharge test. The preceding two columns offered circuits for dynamic load testing that could be used for these batteries. Some of the circuits may require beefing up to handle the higher currents, which may be achieved by using power transistors and higher wattage resistors.

Two Batteries/One Load

We can use the same load bank and life test two batteries at the same time, using the time-sharing circuit in Fig. 3. This method of life testing will insure that both batteries are exposed to the same load during test. This circuit is designed to discharge batteries with terminal voltages of 6 to 12 and discharge rates of 10 amps or less. The two HEXFETS are N-channel IRF540s, which should be mounted on a heat sink with at least a 25-square-inch surface area.

Here's how the two-battery, life-testing circuit operates. A single gate of a 4093 quad two-input NAND Schmitt trigger IC is connected in a square-wave oscillator circuit, operating as a clock generator for the 4017 divide-by-10 counter. The 4017 is connected in a divide-by-2 circuit, with outputs at pins 2 and 3. Each time that the 4017's clock input, pin 14, goes positive, the outputs change state. When pin 3 is high, Q1 is turned on, placing B1 across the load. When pin 2 goes high, Q2 is turned on, placing B2 across the load. The load time is exactly the same for both batteries.

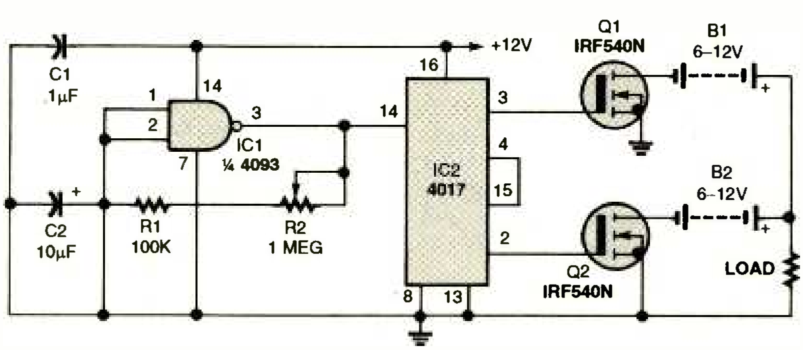

Fig. 3. Two batteries can be life tested at the same time with the circuit shown above. A NAND Schmitt trigger is at the heart of a square-wave circuit that controls the tester.

PARTS LIST FOR THE "TWO BATTERIES/ ONE LOAD" (FIG. 3)

SEMICONDUCTORS

IC1—4093 CMOS IC
IC2—4017 CMOS IC
Q1, Q2—IRF540N HEXFET

RESISTORS

R1—100,000-ohm, ¼-watt, 5%
R2—1-megohm potentiometer

CAPACITORS

C1—0.1-µF, ceramic disc
C2—10-µF, electrolytic

ADDITIONAL PARTS AND MATERIALS

Heat-sink material, IC sockets, etc.

The clock rate can be varied from a few cycles per second to several seconds a cycle with R2. Changing the value of the timing capacitor, C2, can vary the clock's frequency range. A larger capacitor will lower the frequency, and a smaller value will increase the frequency.

Almost forgot to mention that the inputs of all of the unused gates on the 4093 must be tied to either ground or battery positive. This includes pins 5, 6, 8, 9, 12, and 13. If any of these inputs are left flopping in the breeze, the circuit is guaranteed a visit from the CMOS ghost, which will make Mr. Murphy look like a saint. Believe me, you don't want to go there, so just do it!

Big Load Resistor

Life testing high-capacity batteries requires very low-value, high-wattage resistors to obtain the necessary load currents. A typical 12-volt battery with a 10-amp-hour rating would require a 1.2-ohm, 150-watt resistor for a one hour life test. The initial power dissipation would be slightly over 120 watts.

The biggest obstacle is the cost and availability of the power resistors. Finding a 1.2-ohm, 150-watt resistor is not an easy task. Generally, the two values available in the range needed for a 10-amp load are 1.0 and 1.5 ohms. The 1.0 ohm would draw too much current, and the 1.5-ohms would only pull about 8 amps. The 1.5-ohm resistor can be used, which will require a longer discharge time. The real kicker is the $30.00 plus price tag for a single power resistor.

You Might Try One Of These

Let's look at some other less expensive high-wattage loads for our testing. Automotive lamps come in a wide variety of wattages, are readily available, and are generally inexpensive. These are good loads for higher current life testing. In a pinch, I used a 120-ft #16-wire extension cord for a 10-amp load on a 12-volt battery. I shorted out the cord at one end and connected the other end across the battery. The 240-ft length of #16 AWG wire just happens to be about 1.2-ohms and handles the dissipation with moderate heating.

An electric heater is another available item that can be used as a load. A typical 1500-watt portable heater has a resistive wire element that is about 9 to 12 ohms. This wire would only be useful for load currents in the range of about 1 amp. The resistive wire from a broken heater could be taken out and paralleled in sections to obtain a much lower resistance and still dissipate several hundred watts.

Sealed Lead-Acid Batteries

Sealed lead-acid batteries are very popular and are used to power all kinds of equipment. Most often, they are 6- and 12-volt batteries with an amp-hour rating of 2 to 20. However, others are available with ratings over 60 amps. These batteries are excellent power sources, which are easily maintained and offer long service life. They don't mind being heavily discharged and revived with a high-current quick charge.

The sealed lead-acid batteries may be life tested in the same way as the previous high-current batteries. A good life-testing method to use for these and other similar batteries is to discharge at a 1/10th amp-hour rate.

This lower discharge rate will help in determining the batteries' useful life after several months or years of operation. Of course, as I previously mentioned, the best load test is one that closely matches the batteries' work habit.

Well, it's about time to close shop for this visit. Be sure to tune in again next month and see what we've got cooking. P

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ROBITICS WORKSHOP

(continued from page 49)

A single 40-pin cable is connected between the 40-pin header on the PWMx2 and the OOPic. All of the functions of the PWMx2 are routed to the appropriate I/O lines on the OOPic via this cable.

To use the Magnevation PWMx2 Dual DC motor controller in an OOPic program, a single instance of the user-defined class "PWMX2" must be created as shown in Listing 1. This user-defined class creates two instances of the oDCMotor Object class, and all of the I/O configuration is automatically handled, so nothing else needs to be specified.

Listing 1 works as follows: "Dim M As New oUserClass ("PWMX2"):" This line initializes a new instance of the PWMX2 user-defined object and names it "M." This object knows how to control the functions on the Magnevation PWMx2 Dual DC motor controller via properties such as Right.Value, Left.Value, Right. Brake, and so forth. The direction that the motors will spin is specified by whether the Right.Value and Left.Value properties are positive or negative. Positive numbers will cause the motors to spin forward, and negative numbers will cause the motors to spin backward. A value of 0 will cause the motors to stop, while values of positive 127 and negative 127 will cause the motors to run at full speed forward and full speed backward respectively. The user-defined object PWMX2 can be downloaded from Magnevation's Web site.

The oIRRange program code from last month is added to this program, along with the new formulas as shown in Listing 2. This program works as follows: All of the Dim statements create instances of the objects specified. A constant value named CurSpeed is set to 64. Some set-ups are done that define which I/O lines the oIRRange objects are to use. The variable A is set to the angle of correction, which is calculated from the values of the oIRRange objects. The angle of correction along with the CurSpeed value is applied to the speed of the Right and Left motor.

Next Month

Next month we will discuss how to simulate the robot's wall-tracking behavior with Cognitoy's *Mindrover*. In that article, a virtual circuit will be programmed into one of *Mindrover*'s 3-D virtual-reality robots—allowing the builder to test drive the entire robot and program in virtual reality before building it. Then, once the robot's behavior has been defined and tested, *Mindrover* will generate code for the OOPic, which can be downloaded to your robot.

On The Web

Both the OOPic and the Sharp IR Distance Detector are available from Acroname Robotics at *www.acroname.com*. More information on the OOPic can be found at *www.oopic.com*. Visit Magnevation's URL at *www.magnevation.com*. Learn about *Mindrover* at *www.mindrover.com*. ■

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SAM GOLDWASSER

BARCODE (UPC) SCANNERS

This month, I am going to discuss the topic of barcode scanners. Although, it is not directly repair-related, the subject should have material of interest to readers of this column. The use of the Universal Product Code (UPC) has revolutionized grocery/supermarket and other retail store checkout and inventory control. It has also been applied to other numerous applications, as varied as package routing and tracking and tagging of wild animals. There was even an aborted attempt to use similar codes to those printed in the weekly TV section to program VCRs with a hand-held barcode wand!

Barcode Primer

Some would argue that the use of such technology in supermarkets, at least, has dehumanized the buying experience and stacked the deck in favor of the merchant. Prices no longer tend to be printed on each item, and the checkout process is now so fast that it is virtually impossible to catch mistakes should they occur. Since the price-to-item relationship is stored in a computer somewhere, there are indeed errors—but these are generally rare.

Space and other factors prevent me from going into the details of the Universal Product Code, itself. The quick summary is that the pattern of black lines familiar on virtually all products nowadays—the UPC code—has been carefully designed to be easily decoded when scanned in either direction, at an arbitrary angle, and with variable speed. There are actually many other barcodes besides the UPC—used for inventory control, tracking, and other diverse applications. (If you should need to stay in a hospital, *you* will be given a barcode!)

The UPC consists of 12 digits. The first digit is the type of product (0 is for groceries, 3 is for drugs, etc.), the next five digits on the left half are the manufacturer code, the first five digits of the right half are the product code, and the last one is a modulo check digit. Each digit, as its name implies, can have a value from 0 to 9, encoded as a set of four alternating bars and spaces, each of which may have a width of 1, 2, 3, or 4 units—called "modules." The total width of each digit is defined to be 7, which allows for 20 unique codes—ten used for the left six digits, the other ten for the right six digits. The left six digits are coded with odd parity; the right six digits with even parity. Additional details can be found at the first Web site, below.

Here are some Web sites that have info and many links to barcode manufacturers, barcode-generating software, and other information that may be useful: *www.barcode-1.com*—Russ Adams' BarCode 1 (information and links, shareware, books, specifications, discussion group, and more can be found here) and *www.taltech.com*—TAL Technologies (bar code and data acquisition software).

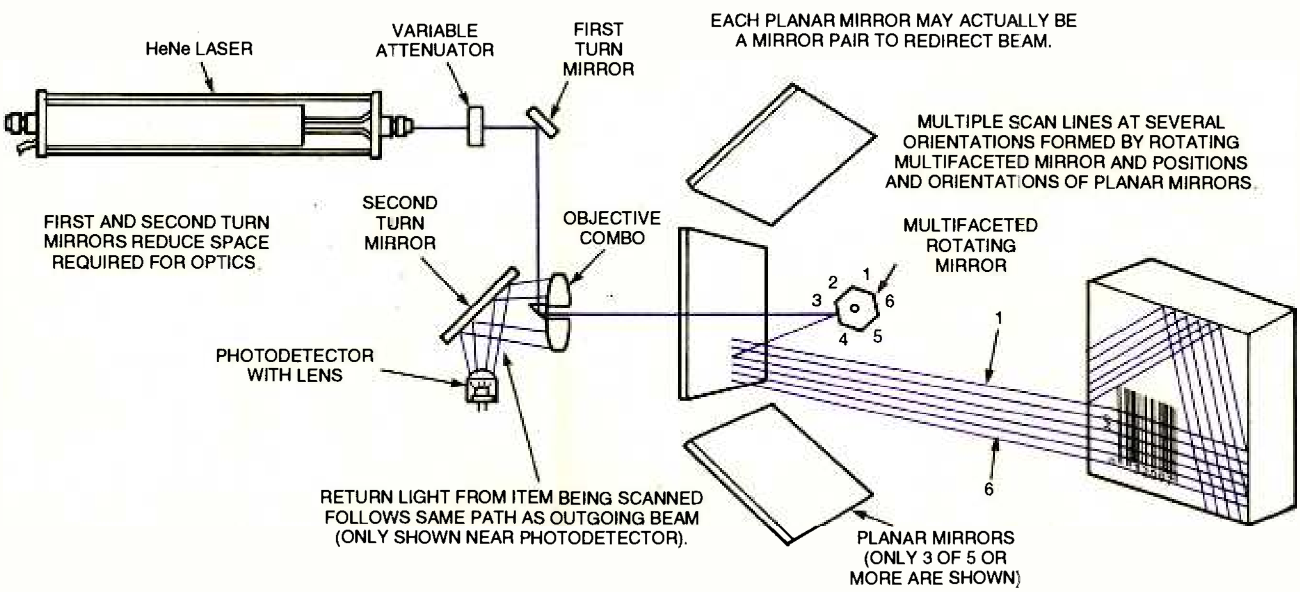


Fig. 1. Here is a diagram that shows the optical path of a typical barcode-scanner. The HeNe lasers used can often be found via wholesale and liquidation companies.

This HeNe laser is the one of the more common types found in supermarket barcode-scanners.

Scanner Anatomy

For the purposes of the discussion below, we restrict our attention to the type of equipment found at your local supermarket—the barcode scanner that is mounted under or beside the conveyer counter (and may include an electronic scale, but that is another story). While details vary, the basic architecture of these devices tends to be very similar. Once you are familiar with one model, parts identification and the optical path of any other will be almost immediately obvious. Hand-held scanners may not even use a laser, but a linear array of LEDs (one that actually uses a helium-neon laser is described below). Large industrial barcode scanners may contain a much more powerful laser and somewhat different optical path. Some of the newest barcode technology does away with the laser scanner altogether and uses a 2-D video-camera (CMOS or CCD)-based imaging system and high-speed DSP (Digital Signal Processor), instead. This technology eliminates most of the complex and costly optical and mechanical components making for a compact robust system. Currently, the electro-mechanical laser scanner is still the most common.

The basic principle is to use a collimated laser beam, rotating multifaceted mirror, several stationary mirrors, and other optics to generate a scan pattern above or beside the scanner that will intercept the UPC code printed on the item to be scanned. While the scan may appear to consist of multiple lines or a continuous pattern, it is in reality a single rapidly moving spot.

Through the glass of the scanner, it may appear that all sorts of stuff is arranged at random. However, this is not the case. Refer to Fig. 1, as you read the following descriptions (which also includes some comments on potentially useful parts that may be obtained from these units).

Lasers—The source of the beam is either a low-power helium-neon (HeNe) or diode laser. Older (and larger) scanners tended to use HeNe lasers. However, size alone is no sure indication until you get to the very small (6-inch cubes or hand-held wands), which are almost always based on diode lasers (if they use a laser at all). A better test is to check the color of the beam—the light from HeNe-laser-based scanners appears orange-red (632.8 nm), while that from diode-laser-based scanners tends to be a deep red from the 670-nm wavelength—less expensive (but just as effective). Just explain that you are doing scientific research when the people in the white coats come to take you away for staring into the scanner!

HeNe lasers are typically 1 to 3 milliwatt (mW)—mostly near 1 mW, using tubes between 5 and 10 inches in length. The divergence of the raw beam from HeNe-laser tubes used in barcode scanners tends to be greater than the diffraction limit, possibly 5 to 10 *mR* (*milliradian*) or more. Some HeNe tubes even have a lens glued to the output mirror to mess up the beam in this way! (However, the beam quality is just as good as a similar 1 or 2 mR, 1 part in 1000 divergence tube—it just looks more like a flashlight than a laser!) Where an external lens is actually glued to the output mirror of the HeNe tube, it can probably be removed with a suitable solvent or some heat—leaving a low divergence tube. Locate the collimating lens that is present in the scanner or one of your own and use that to adjust the divergence or focus of the beam, as desired. In fact, since you can intercept the beam wherever you want, using the high divergence tube provides added flexibility to generate a very low divergence beam (e.g., 0.1 mR) with a single additional lens.

The HeNe laser power supply may be a self-contained brick or may be built on the mainboard. The former is, of course, much more desirable from the perspective of salvaging parts! In either case, turning on the laser will probably require grounding or pulling up an enable signal since, in most systems, the laser is automatically turned off after a period of inactivity.

Here is a power-supply-circuit that is used to power an HeNe laser.

Diode lasers are typically 670 nm (deep red, like older diode-laser-based laser pointers) with 5-mW maximum output. A collimating lens and possibly some other optics will be part of the diode laser assembly.

The laser-diode-driver circuit will be in close proximity to the laser diode, itself, and may be on a separate board. However, it is most likely part of the mainboard, and it is difficult to identify correct use without a schematic. A graded density filter may be used as a variable attenuator. It would be placed immediately following the laser's output to adjust the beam intensity to compensate for variations in laser power (mostly for HeNe lasers—diode lasers will have a potentiometer for this purpose).

Turning Mirror(s)— There may be one or more high-quality planar first surface-protected aluminum or dichroic mirrors to direct the beam. (If dichroic, the peak reflectivity wavelength will match that of the laser used and may possibly also be optimized for the actual reflection angle in the scanner.) Their mount will probably be adjustable in X and Y to some extent. While nowhere near the precision of a Newport MM2 mirror mount, they should be perfectly adequate for basic optics experimentation when attached to a rigid surface. Note that these mirrors do not serve any fundamental purpose—they simply fold the optical path resulting in a smaller physical package.

Main Objective Combo—The outgoing and return beams (reflection from the item being scanned) follow the same path except that the return is not a nice narrow collimated beam. The outgoing beam passes through a window inset into a large positive lens. This may include a mirror or prism to redirect the beam and the collimating/focusing lens to produce a nice small spot at the item being scanned. This is the strange part! The large lens focuses the return beam onto the photodetector (see below); and since optical quality isn't critical at this point, it is likely made from molded plastic.

Multifaceted Rotating Mirror—The collimated outgoing beam is deflected by a 3- to 6-facet polygonal mirror directly driven by a speed-regulated brushless DC motor. The motor/scanner assembly is generally a separate module in older equipment, requiring only DC power and an enable signal to run. However, like the HeNe-power supply, newer systems usually mount it directly on the mainboard. Most of the larger barcode scanners use motors of similar quality to those in disk drives, since they may need to run continuously. However, smaller scanners may use something that looks like the core of a cheap DC fan!

Unlike those in a laser printer, the mirror facets are large, since they have to reflect the diffuse return beam as well as the tiny spot of the outgoing beam. They are fabricated as individual mirrors glued to a cast-metal wheel-type affair and are all set at slightly different angles so that each rotation of the mirror wheel results in scan lines at three to six slightly different locations depending on the number of facets.

Multiple Planar Mirrors—The final optical component before the outgoing beam hits the item being scanned is made up of several large fixed first surface mirrors. Despite their appearance of having been just plunked down at random, these have positions and orientations carefully chosen to direct the beam in a pattern providing the best chance of intercepting the UPC code with at least one scan line and resulting in approximately equal spot-scanning speed for each scan line. Depending on design, the beam may strike either one or two of these mirrors on its journey each way (out and back).

These are usually decent quality aluminized first surface mirrors and could find all sorts of other uses. Although generally shaped as strange four-sided polygons, they can be subdivided into more useful sizes using a glass cutter from the rear or a water-cooled diamond cutoff wheel.

The outgoing beam is set up to be a small spot in the active area above or beside the scanner—the scanned item volume. However, the return from the UPC printed on the item is, in general, not in sharp focus, but is a diffuse reflection. Thus, as noted, all the mirrors have to be large to capture as much of this as possible to feed to the photodetector. The return path is the same as the outgoing path until the objective combo lens, which focuses the return beam onto the photodetector.

Photodetector—A silicon photodiode, often of moderate area (typically 2 × 2 mm, good for a laser power meter) intercepts the return beam focused by the objective combo. (Some light is lost to the inset optic for the outgoing beam, but this is small.) There may be an additional focusing lens and/or red ambient light blocking filter associated with the photodetector.

Controller—A microprocessor-based system analyzes the datastream from the photodetector, isolates any section that appears to be valid data, decodes the UPC symbols, and sends the result via an RS232 line (or possibly a proprietary interface for older models) to the host computer. Handshaking assures (hopefully from the point-of-view of the store owner!) that data isn't lost.

Power Supply—Depending on the model, these supplies may plug directly into the AC line or be powered from a wall adapter.

As you can see, these full-size barcode scanners contain a virtual treasure trove of useful electronic, mechanical, and optical parts for the experimenter and hobbyist. See the document: <A HREF="http://www.repairfaq.org/sam/gadget.htm">Sam's Gadget FAQ</A> on my Web site for more on salvaging parts from barcode scanners.

Safety Precautions

There really aren't too many safety issues with respect to these devices even though they contain a Class IIIa (1 to 3 mW) laser, and the beam may appear to be quite bright. (Note that barcode scanners systems are listed as Class II laser devices, since access to the laser and optics requires some disassembly.)

There is really no risk to the user or customer in proximity to a checkout scanner. The laser beam is moving rapidly and is low power. A rough estimate of the maximum possible eye exposure to a properly functioning scanner is about 10 microwatts or less. The only possible risk would be if the scanner motor failed for some reason, and the laser beam was stationary.

However, some if not all scanners have a safety device to shut off the laser, should the return beam not behave properly. With laser power of around 1 mW, the normal blink and aversion reflex should provide adequate protection. The perceived brightness is somewhat of an illusion due to the peak intensity and pulsed nature of the beam.

When you poke around inside a barcode scanner, there are somewhat greater risks of being dazzled because the laser beam will be stationary and collimated along portions of the optical path. However, anything more than very temporary after-images is unlikely.

For AC-line-powered units (no wall adapter), there will be some exposed 115 or 230 V_{AC} points near the line cord and on the mainboard or power supply. For HeNe-laser-based systems with the high-voltage power supply on the mainboard, there will be exposed pads with voltages up to 5 kV or more (during starting). Since these may not be clearly marked, it pays to identify them beforehand and take appropriate precautions. Those with brick-type HeNe-power supplies are usually pretty well insulated.

Then, there is the rotating mirror that can catch long hair or jewelry.

Finally, since these scanners may have seen service under less than sterile conditions with all sorts of icky and disgusting stuff passing their way, including meat and chicken parts dripping with blood, there can be all sorts of surprises in store for you from mummified mice to maggot colonies. Take appropriate precautions in your exploration and/or disassembly!

Metrologic Model MH290 Examined

This hand-held HeNe laser-based barcode scanner apparently was the source of the power supply described in the section: <A HREF="laserhsc.htm#hscic1">HeNe Inverter Power Supply Using PWM Controller IC (IC-HI1)</A> on my Web site. The entire HeNe-laser (tube and power supply) is about 1 × 1.5 × 5 inches and weighs only about 3.5 ounces!

Virtually the same laser was used by Metrologic in a pre-diode laser pointer. We'll look into (well, not literally!) laser pointers in a future "Service Clinic."

Art Allen, KY1K (aballen@colby.edu), recently sent me a Model MH290 unit to examine.

The following comments on the device all come from Art. The unit I have that uses a power supply that is 100 percent identical to the schematic and PCB layout of IC-HI1 is a Metrologic Model MH290. It is labeled with a 1990 date of manufacture and says 12 V_{DC} at 550 mA on the scanner unit itself. The wall wart that runs the system is rated at 12 V_{DC} at 1 A.

The MH290 is a hand-held unit with a trigger. You pull the trigger when you are ready to scan, and the laser starts scanning for four or five seconds and then shuts down. To attempt a second scan, you have to pull the trigger again. Inside the hand unit, there is the receiver and a second PCB to support the receive electronics and the spinning mirrors (driven by a small 15-degree-per-step stepper motor). The MH290 is smart enough to know when the laser is on and produces an error if it doesn't come on OR if it stays on longer than it should.

The MH290 connects to another unit via a 9-pin RS232 type connector; the other unit has the EEPROM and related components for decoding and interfacing to the computer itself. The MH290 hand-held scanner does not connect directly to the computer, and all power sent to the MH290 comes from this other box.

Wrapup

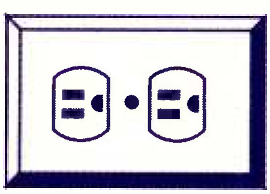
I hope you consider this diversion into something not directly repair-related worthwhile. I was going to add a paragraph or two on barcode scanner repair just to maintain the flavor of "Service Clinic," but decided that this would be of interest to at most three people on the planet. If you do have a barcode scanner in need of repair, deal with it in terms of the individual subsystems and troubleshoot in a systematic manner. Much more on laser-related topics can be found on my Web site, *www.repairfaq.org*. As always, I will be happy to reply to questions or comments via email to sam@repairfaq.org. (Sorry, I cannot answer snail mail.) See you next time. P

TEST YOUR KNOWLEDGE

Try to match each law with its description.

1. Coulomb's law

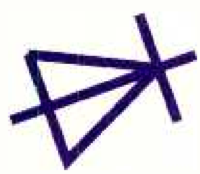
2. Lambert's law



3. Kirchhoff's law

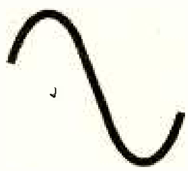
A. (1) The mass of a substance liberated in an electrolytic cell is proportionate to the quantity of electricity passing through the cell. (2) When the same quantity of electricity is passed through different electrolytic cells, the masses of the substances liberated are proportionate to their chemical equivalents. (3) Also called the law of electromagnetic induction. When a magnetic field cuts a conductor, or when a conductor cuts a magnetic field, an electric current will flow through the conductor if a closed path is provided over which the current can circulate.

B. The strength of a magnetic field at any given point due to any element of a current-carrying conductor is directly proportional to the strength of the current and the projected length of the element, and is inversely proportional to the square of the distance of the element from the point in question.



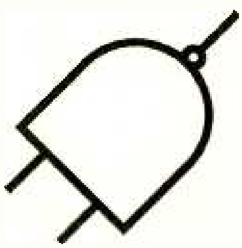
C. The voltage across an element of a dc circuit is equal to the current in amperes through the element, multiplied by the resistance of the element in ohms. Expressed mathematically as $E = I \times R$. The other two equations obtained by transposition are $I = E/R$ and $R = E/I$.

4. Laplace's law

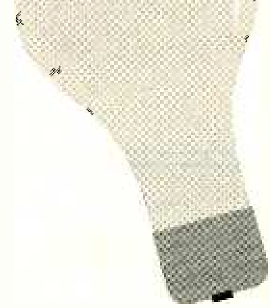


D. The illumination of a surface on which the light falls normally from a point source is inversely proportional to the square of the distance of the surface from the source. If the normal to the surface makes an angle with the direction of the rays, the illumination is proportional to the cosine of that angle.

5. Ohm's law



E. Also called law of electric charges or law of electrostatic attraction. The force of attraction or repulsion between two charges of electricity concentrated at two points in an isotropic medium is proportionate to the product of their magnitudes and is inversely proportionate to the square of the distance between them. The force between unlike charges is an attraction, and between like charges repulsion.



6. Wiens's law

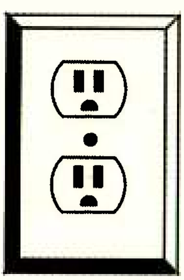
F. The current induced in a circuit due to a change in the magnetic flux through it or its motion in a magnetic field is so directed as to oppose the change in flux or to exert a mechanical force opposing the motion. If a constant current flows in a primary circuit A, and if by motion of A or the secondary circuit, B, a current is induced in B, the direction of the induced current will be such that, by its electromagnetic action on A, it tends to oppose the relative motion of the circuits.

7. Faraday's law

G. The wavelength of maximum radiation intensity is inversely proportional to the absolute temperature of a blackbody, and the intensity of radiation at this maximum wavelength varies as the fifth power of the absolute temperature.

8. Lenz's law

H. (1) The current flowing to a given point in a circuit is equal to the current flowing away from that point. (2) The algebraic sum of the voltage drops in any closed path in a circuit is equal to the algebraic sum of the electromotive forces in that path. (Laws 1 and 2 are also called laws of electric networks.) (3) At a given temperature, the emissive power of a body is the same as its radiation-absorbing power for all surfaces.



Answers: 1E, 2D, 3H, 4B, 5C, 6G, 7A, 8F

LETTERS

(continued from page 4)

"Riddle of the Ages" in my theory, "The Williams; Hydraulic Theory of Cheops", described at: www.tsc-global.com/cheops.html. In my heavily documented theory, a vertical hydraulic elevator near the pyramid's center lifted up the stones to the top level under construction. And that the Grand Gallery was actually a large water storage reservoir for powering the system.

Interestingly, the article mentions that the required temperature for electrolysis could be lowered, "by using some sort of current-carrying fluid between the electrodes." And I have experimentally determined that a column of mineralized water in a capped 10-foot PVC pipe has antenna characteristics. So why not in a 481-foot stone-encased elevator shaft?

It should be noted that the first known use of copper tube plumbing was found in Cheops. There are many other mysteries to Cheops, including how they cut 2.3 million stones with greater hardness than the known tool metals of the day.

Also, the State University of New York at Buffalo have developed crude electronic devices (e.g. diodes, temperature sensors, heat sinks/sources) from Portland cement.

JOHN J. WILLIAMS
Albuquerque, NM

I've been very disappointed in your magazine's lack of response to the power shortage in the west. I did enjoy your article in the September issue on "Radio Signals and the Great Pyramid." This is a good beginning. However, there was an exposé on "Sixty Minutes" about two years ago about a type of circuit that can be built by the hobbyist (like myself), that will help lower the consumer's power bill and usage by preventing the total power usage from registering on the power meter. According to this report, these circuits are totally legal. If you could help me find these circuits, I would be very appreciative, as the power bills really exploded last year.

Any response to the power shortage would be welcome, but these circuits would be especially welcome.

DONNA GOOLEY
North Hollywood, CA

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Many electronics enthusiasts discovered that the bridge from classroom theory books to hands-on project building is difficult to span at times without a handy pocket guide. Even the equipment manual to operate a gadget often makes things murkier rather than clearer. A compact text authored by a seasoned expert with hands-on knowledge and a knack of writing in an easy-to-understand style is many times more valuable than the price of ponderous theory and equipment manuals or the parts for a project that could be damaged. Here's a sampler of some titles you may want to own!

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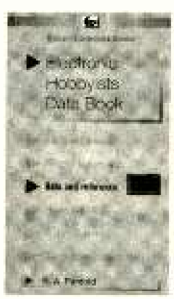

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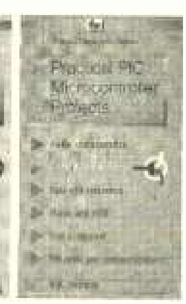

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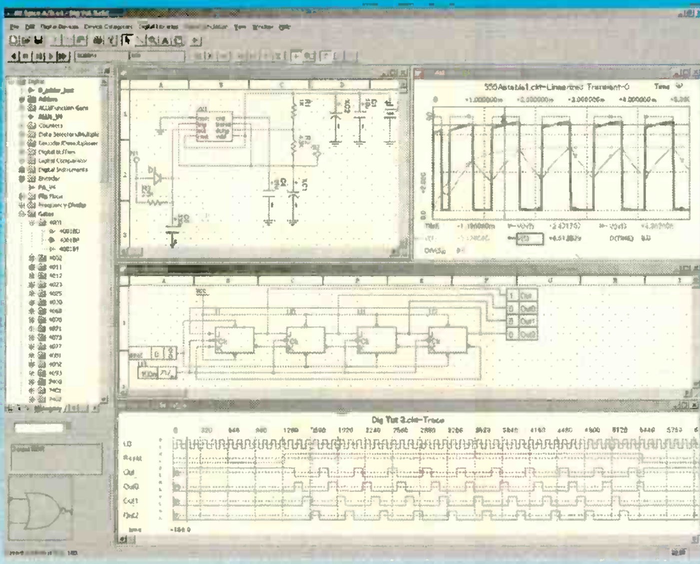

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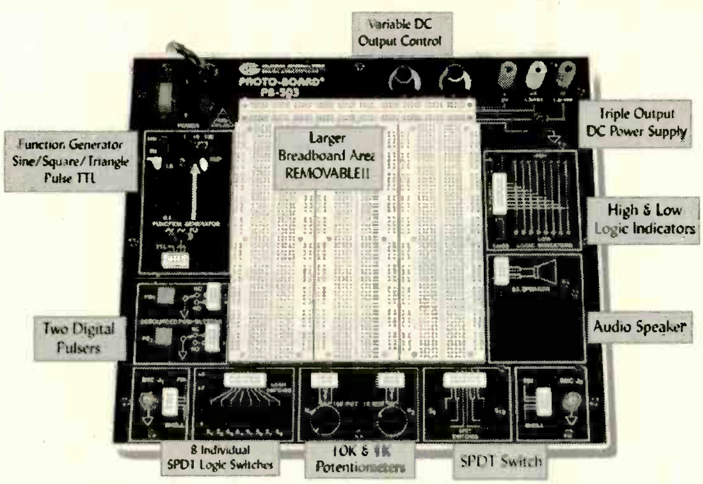

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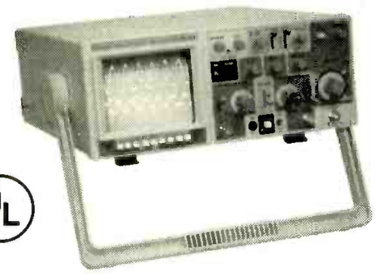

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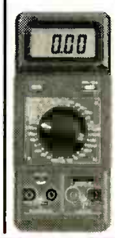

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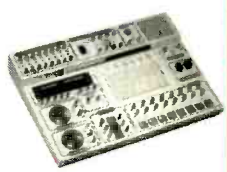

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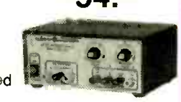

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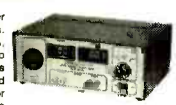

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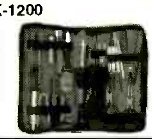

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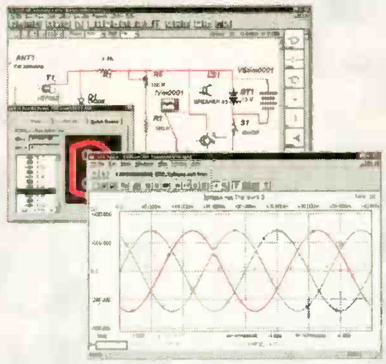

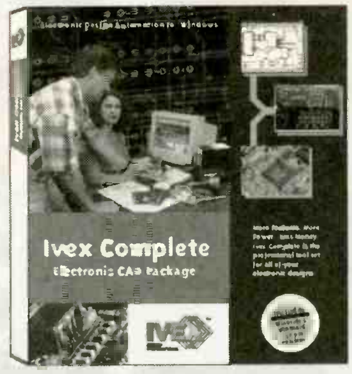

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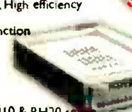

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- *Back Light Compensation Circuit*
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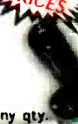
Bullet CCD Cameras *B&W and Color*



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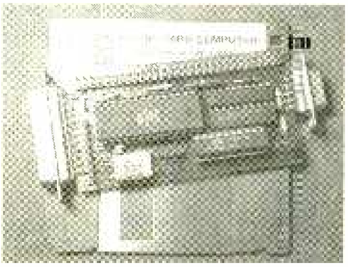

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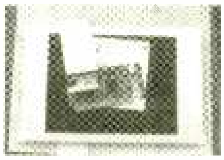

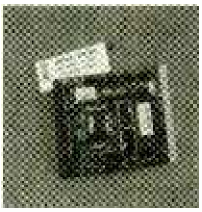

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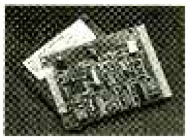

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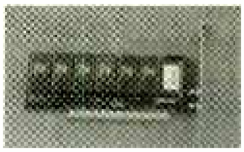

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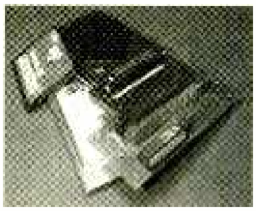

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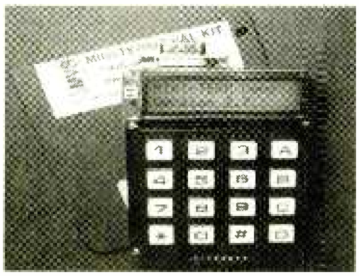

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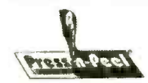

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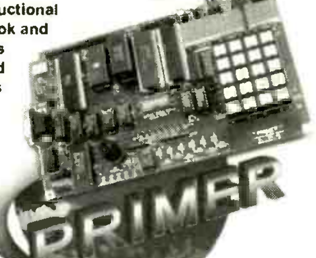

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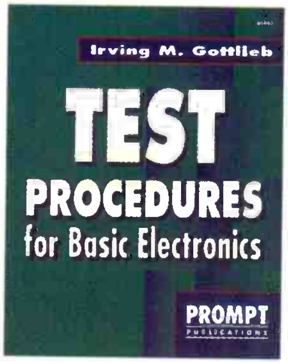

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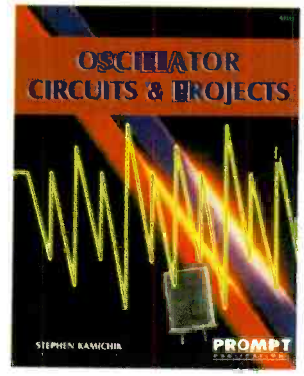

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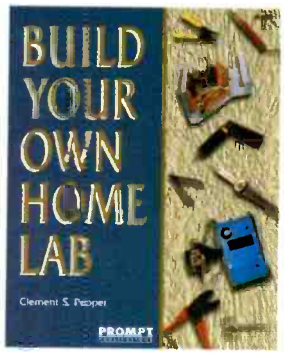

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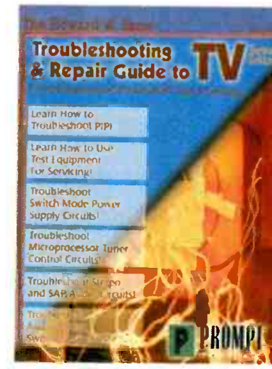

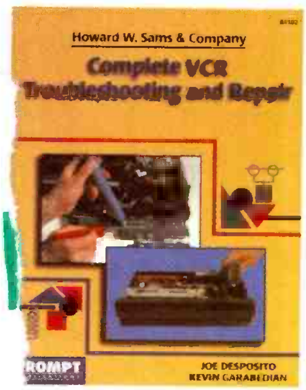

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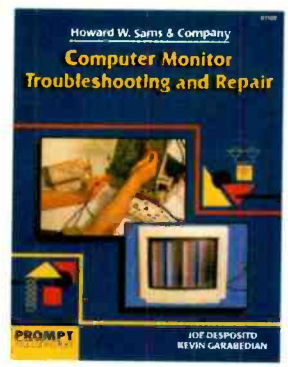

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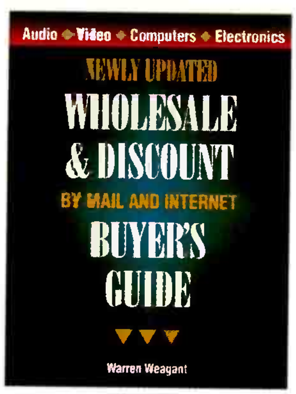

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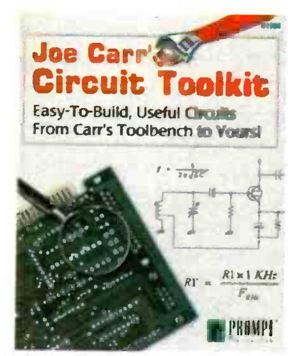

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