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THE MAGAZINE FOR THE HANDS-ON ELECTRONICS ACTIVIST!

FEATURES

PRODUCT REVIEWS

DEPARTMENTS

AND MORE

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"We Interrupt This Broadcast..."

"Ladies and gentlemen, it has been an honor and a pleasure to share my humble services and visions with each and every one of you. I'd like to think that I did my best to keep the spirit of Hugo Gernsback alive within these pages. I trust that my replacement will follow suit."—From "End of The Trail," by Joseph Suda, Managing Editor/ghostwriter

So it was, that Christopher La Morte was promoted to managing editor (or as he prefers to think, *Editor-at-Large*). From this point on, under the guidance of Editor-in-Chief Larry Steckler and with the *massive* support of a competent crew of professionals, this "newbie" is going to try to make a difference.

"Never one to filibuster, I'll save the introduction. Credentials are available upon request; and all questions, comments, and criticism are welcome. Be advised: Due to a sour stomach, I can only eat six pounds of crow a day."—From La Morte's "Yargh!"

Now Back To Our Show (Already In Progress)

This month, we feature Skip Campisi, Kenny A. Chaffin, and Laona Gale Knighton—all three writers shed some light on current technologies.

Campisi and Chaffin delve into the world of optics. For the last forty years or so, advances in the study of optics have allowed mankind to master light—to some extent. Now you can read about the application of lasers in optical computers, as well as experiment with your own laser projects.

Knighton shows us how a computer moves into a household and takes over the family—sort of. This essay explains how young and old alike are becoming dependent upon a tool that was once used only by the "larger-than-average frontal lobe-set."

Enjoy!

Christopher La Morte
Managing Editor

LETTERS

mailto: letters@gernsback.com

When Is A Standard Not A Standard?

I thoroughly enjoyed Thomas Gould's article, "A Colorburst-Based Frequency Standard" (**Poptronics**, September 2000). He demonstrated a PLL technique that is interesting, elegant, and potentially useful for a number of applications.

However, as a frequency standard his "reference" is practically worthless. Due to the nearly universal use of frame synchronizers, the frequency that his unit produces will be no more accurate than the frequency standard of the received station's sync generator. This signal might be accurate to one part in 10^6, but it is a far cry from the one part in 10^9 that one would expect from a typical rubidium standard.

I realize Mr. Gould has made no claims for rubidium-standard accuracy, but if he believes that 10 Hz out of 3.579545 MHz (roughly 2.79 parts per 10^6) is high accuracy, he does not understand what "high accuracy" means.

JOSEPH D. RICHMOND
Joppa, MD

And The Answer Is....

I tried to be clear regarding the accuracy of the reference obtained from using the oscillator. As you correctly state and as I also stated in the article, the FCC requires the accuracy of the color burst on over-the-air broadcasts to be 3.579545 MHz ± 10 Hz.

The reference obtained was never implied to be as accurate as a typical rubidium standard. Accuracy is a relative term, and most electronics hobbyists do not have any frequency standards available to calibrate their frequency counters. This unit provided a low-cost, simple way to see if their counter is within the accuracy range provided by an over-the-air TV signal. As in any project one may build, the end user must determine whether the project would meet his or her requirements. Thank you for taking the time to express your opinion.

THOMAS GOULD

KEEP IN TOUCH

Letters
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All of our columnists can be reached through the e-mail addresses at the head of each column.

And don't forget to visit our Web site: *www.gernsback.com.*

Surprise

The April issue has pages 42 to 48 upside down! After looking at it a while, I finally figured out how it can be read!! I also saw, afterwards, that you had a P.S. in your editorial about this.

In addition, I saw the point that Dean Huster made in his first answer in "Q&A." He said **Poptronics** and *Nuts & Volts* are the only two electronics hobby magazines in the whole USA!! Is that true? That's really amazing, if so! After all, there's far more electronics parts dealers now than ever before.

While on the subject of electronics hobby projects, how about a telephone box that passes only selected phone numbers and rejects all others? Since there's "telephone caller ID" boxes, there must be a way to do this too.

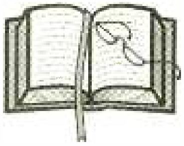
MOSES BERNARD, JR.
N. Las Vegas, NV

Mr. Bernard has been a loyal subscriber and letter writer to this magazine and its predecessors for many years. We look forward to and enjoy his monthly epistles.—Editor

Haves & Needs

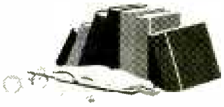
I am looking for ARC-5 receivers. I would like about fifty units, preferably in original condition, but any would be considered.

JOHN BROUSSARD
312 Guilbeau
Breaux Bridge, LA 70517



YESTERDAY'S NEWS

A PEEK INTO THE GERNSBACK ARCHIVES



1900

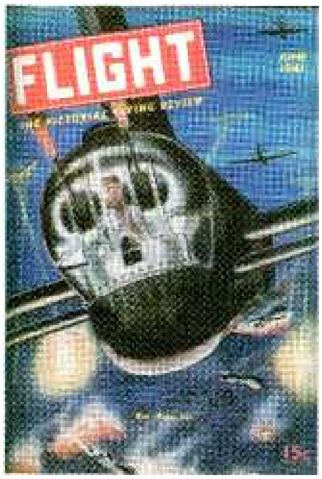
1910

1930

Dateline: June 1941 (60 years ago)

Flight is an illustration-intensive monthly, which highlights technologies relevant to aircraft, air armament, and air defense. Every issue of this classic magazine contains technical data and dozens of detailed drawings pertaining to the role of aircraft in the war—Allied and Axis powers alike. *(**Flight** ran until September 1941—two months before the United States of America officially entered World War II.)*

1941



1950

1960

1971

Dateline: June 1971 (30 years ago)

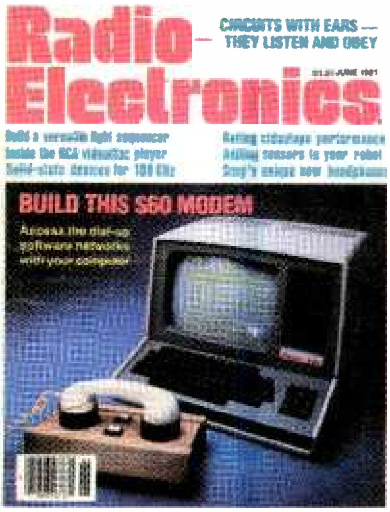
Radio-Electronics features an article ("At Last! Home Video Recording") that predicts the availability of affordable VCRs and a boom in videotape sales. Other features in the magazine include a "how-to" on repairing electro-static air cleaners, as well as an informative piece on preventive maintenance of tape cassettes. *(In 1971, a typical VTR and camera set-up could cost $1500—almost half the price of a new car. Today, a decent camcorder can be purchased for less than $500, and some stand-alone decks cost only $50.)*

1980

Dateline: June 1981 (20 years ago)

Once again, **Radio-Electronics** shows its readers the latest in home-brewed technology. Readers can examine the plans for building a 300-baud acoustic modem, the inner workings of a twelve-inch videodisc player, and samples of voice-recognition circuits. The "Hi-Fi Stereo" column introduces Sony's *MDR-7*—one of the first truly lightweight headphone units *(The headset would set the stage for the* Walkman *rage.).*

1981



1990

2000

COMPUTER *BITS*

TED NEEDLEMAN

mailto: computerbits@gernsback.com

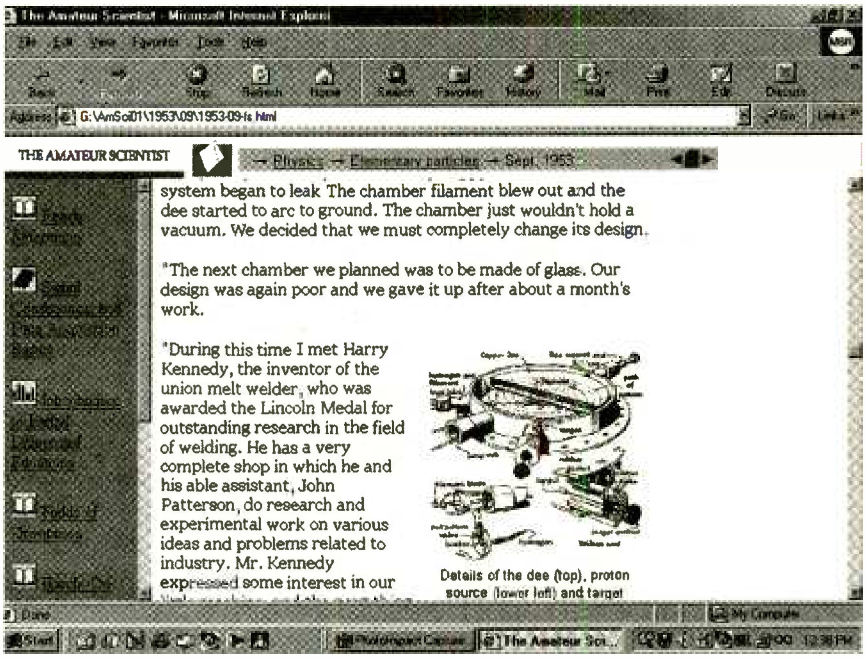
Anyone Up For Building A Cyclotron?

While it may be a strange thing for a self-admitted computer geek to proclaim, I'm really not a big fan of electronic books. These seem to be a coming thing, with e-book readers like the one from RCA and software-based readers from both Adobe Systems and Microsoft.

At the risk of sounding like a Luddite, I admit to preferring the feel and smell of paper when I'm reading, especially when I'm reading for pleasure. Another strike against the current trends in e-publishing, at least in my mind, is the cost. I could probably get one on loan, but if it's coming out of my pocket, there's little chance that I'd spend $299 on an electronic reader. Because of that, I cannot, in good conscience, recommend that you spend that amount, either.

The "bottom line" is that there's no compelling economic reason to go the electronic route. One quick visit to the e-books section of *www.barnesandnoble.com* or *www.amazon.com* will show you that while there are a large number of books now becoming available in electronic format, they are usually priced exactly the same as their paper versions.

That makes sense in a way. After all, you are receiving the same intellectual product regardless of the form factor. At the same time, the expenses of publishing in paper and electronic formats are vastly different. All the up-front work and costs are the same—acquisition of the manuscript, advances on royalties, editing, layout, and illustration. After that, though, things become very different.



Want to build a cyclotron? Here are the instructions in a Scientific American *column from 1959.*

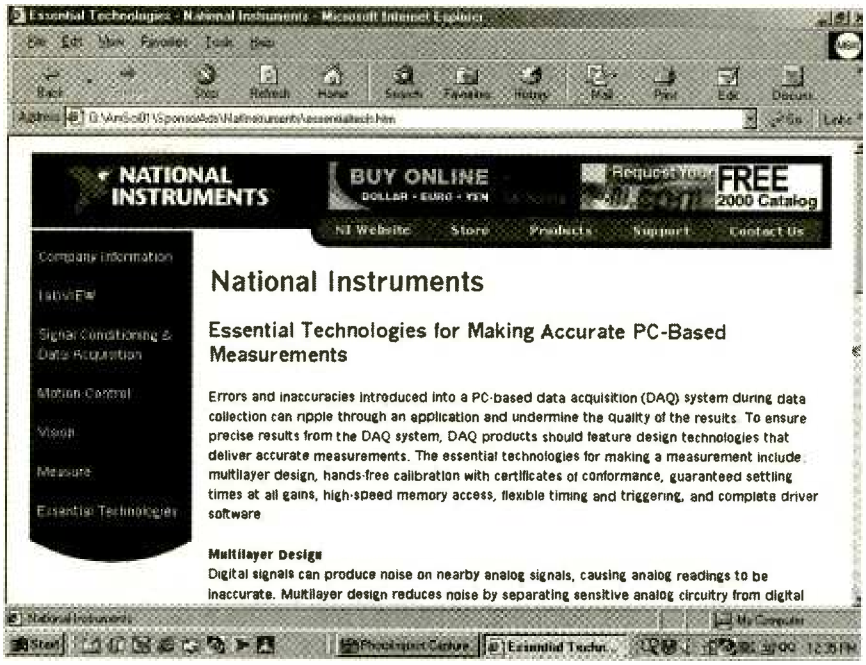
With paper-based publishing, there are then final pages, usually called "bluelines" (due to their color—they come directly from the film-based image that will create the actual printing plate). When everything is satisfactory, pages are printed, assembled, bound, packaged, and delivered to bookstores to be sold.

With e-publishing, the "book" is formatted in special software and uploaded to a server. It's quicker, substantially less expensive, and no trees are killed in the process.

THERE AIN'T NO SUCH THING AS A FREE...

Since publishing electronically is so easy—at least in comparison to paper-based publishing—you might wonder why there aren't more authors and publishers taking advantage of the medium.

Actually, more and more authors are experimenting with self-publishing. The most visible of those "early adopters" was Stephen King, who started publishing his last book on the Web, selling several chapters at a time. At the time this is being written, that endeavor seems to have been suspended, leaving the novel unfinished—at least to Web subscribers.



Along with the columns, the CD contains additional material, such as this National Instruments white paper on making detailed measurements with PC-based instruments.

Science-fiction publisher Jim Baen is trying something a bit different with his Baen Books. Several of Baen's authors have agreed to put some of their older works up on Baen's Web site (*www.baen.com*). Those "tales of yesteryear" can be downloaded for free, with the hope that you'll discover a new author whose work you like and will then run over to the bookstore to stock up on the rest of those authors' titles. Baen has also started a new subscription service where readers get "first dibs" on new books coming out, downloading chapters over the Web months before the books hit the stores (and, incidentally, saving money over the paper-based versions, as well!)

Considering that Hugo Gernsback, the founder of this magazine's predecessors, was also a science-fiction author and publisher (this year is the 75th anniversary of **Amazing Stories**, as was reported in the April issue), it doesn't surprise me that one of the more innovative approaches to electronic publishing comes from Baen. Of course, you'll still need to download the book (or read it on-line). Baen offers each free title in several formats and has links to reader software if you don't want to use rich-text format (RTF) or HTML.

SOMETHING A BIT DIFFERENT

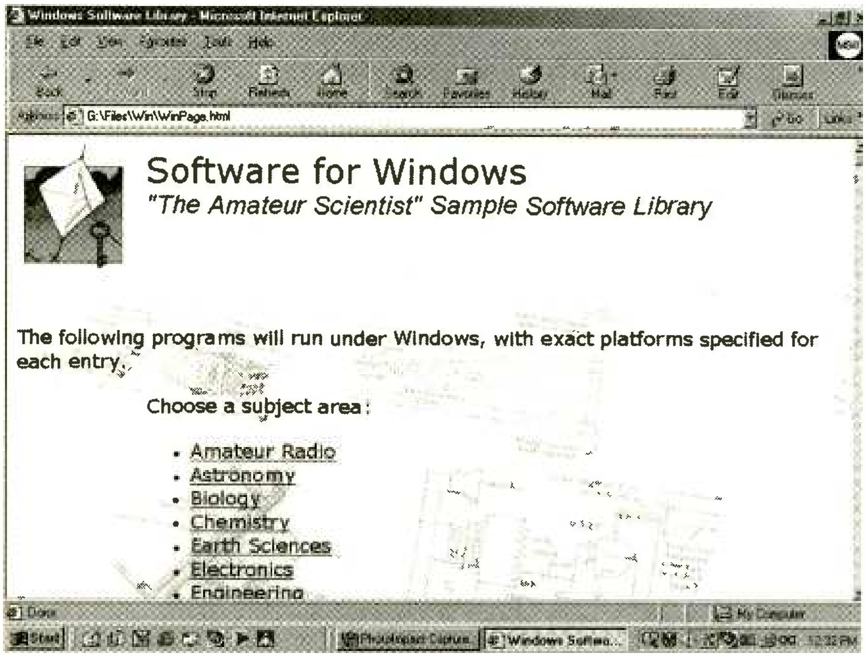
As much as I appreciate Baen's approach, I think the real potential for electronic publishing lies in the specialty titles. These are works with a limited audience. Right now, the trade-press publishers are the primary source of these specialty books. The problem is that while publishers limit their costs by producing only a few thousand books per print run, all of the other costs associated with the publishing process remain the same. What winds up happening is that the publisher has to price the book very high and, in many cases, loses money on the title anyway.

With the affordable, yet extremely powerful, tools now available for converting text into international-standards-based HTML pages or PDF (Adobe's proprietary portable-document file) format, publishing electronically is easier than ever. In fact, the most expensive and time-consuming parts of the process are the initial acquisition of the material and the editing required to make it readable.

Once the material is in a readable file format, the big problem is how to get the reader to pay for it. Some authors have tried subscription services over the Web. The approach that's been most successful, however, is publishing on CD-ROM.

The first real success with this approach was over a decade ago, when the 70s' classic *Whole Earth Catalog* was published on CD-ROM. There really haven't been a lot of other successes along the way, but that should change, given how easy it now is to burn

(Continued on page 46)



There's also a second CD-ROM full of shareware oriented to the amateur scientist.

TED NEEDLEMAN

mailto: peakcomputing@gernsback.com

New Life for Older Laptops

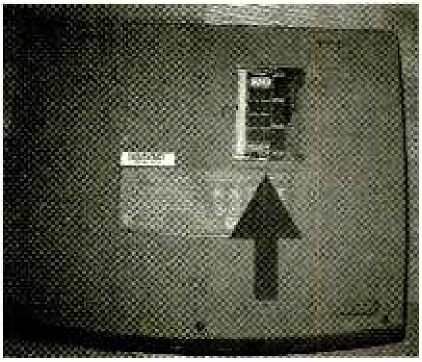
Recently, a friend of mine asked whether he should buy a new laptop or if it made more sense to try and upgrade the one he already had. When he first purchased it, the Compaq Presario was the top of the line, with a 166-MHz Pentium MMX CPU and an 11-inch color active-matrix LCD. With only 32 MB of RAM and a 2-GB hard disk (already an upgrade from the original 540-MB drive), the laptop was losing its charm. He was looking somewhat enviously at newer models, but was a bit loath to spend the $1500 to $2000 that even a moderately-equipped entry-level laptop runs these days.

DON'T FLIP THAT COIN

The decision whether to upgrade an older laptop or just throw in the towel and buy a new one isn't really a matter of guesswork. On the other hand, it isn't entirely a matter of dollars and cents. Rather, it requires that you analyze *exactly* what you use the laptop for, how well (or poorly) the current configuration serves, just what will be gained from each upgrade, and how much each alternative will cost.

Put the results of that analysis into a simple matrix or table, and you'll have a really handy tool to help with your decision.

Laptops are, by their basic design, more difficult to upgrade than desktops—at least internally. That doesn't mean that they *can't* be upgraded, but it does limit what you can do. For example, you are stuck with the display that your laptop has unless you plug in an external monitor. I have no doubt that there are some **Poptronics** readers capable of interfacing a 15-inch LCD in place of an existing 11-inch panel. However, the cost of that 15-inch panel, as well as the level of expertise required to perform the upgrade (and retrofit the laptop case), takes almost all of us out of consideration.



Upgrading the RAM was a simple matter of plugging a SODIMM into this socket.

The same is true for the keyboard. You can always plug in a full-size keyboard (or one of the available numeric keypads) using the PS/2 connector that most laptops offer. However, you are, again, going to be stuck with the bundled keyboard.

PUMP IT UP!

That being said, there are three areas that lend themselves to upgrades. One is the operating-system software. I'm not going to argue the merits of alternative operating systems, such as Linux. There's simply not enough room in this column. Moving up from Windows 3.X—or for that matter, Windows 95/98—to WindowsME usually does improve application performance. The downside, however, is that newer versions of Windows also require more resources, in the way of memory and disk space, than the older versions. Fortunately, those are the two areas that are easiest to upgrade on most laptops.

I had already upgraded the hard drive on my friend's Presario once, so I knew the drill. Before doing anything, we sat down and looked at what it would cost to perform upgrades of both the RAM and the hard drive.

This particular system was used primarily for word processing, creating and giving *PowerPoint* presentations, and surfing the Web. The 166-MHz Pentium CPU didn't deliver blistering performance in any of those applications, but my friend also had a much newer desktop for applications where performance was a factor.

After looking at what the upgrades would cost, we decided to go all the way: bump up the RAM from 32 MB to 96 MB, upgrade to WindowsME, and replace the hard drive with a 20-GB model. The total cost for that set of upgrades was just under $1000. That's a lot to spend on a laptop that's several years old. On the other hand, the large amount of RAM and hard disk space, which my friend considered necessary for his needs, would have put him in a $2000 laptop had he decided to simply replace the older unit.

Laptop memory is generally an easy upgrade, at least if your laptop is not more than four or five years old. Before that, vendors used a whole variety of proprietary modules. Newer laptop models use a type of module called a SODIMM, or small-outline DIMM (dual-inline memory module). You can find out

Kingston's StrataDrive Plus comes with a PC-Card interface, letting you transfer the operating system and applications to the new drive without strain or pain.

if those devices are available for your laptop model with a quick visit to the Web sites of the major memory suppliers, such as Kingston Technology (*www.kingston.com*) or PNY (*www.pny.com*). Both vendors have lookup facilities that will help you find the right part number. Memory-module prices vary, but computer stores frequently put the modules on sale, with 64 MB selling for as little as $50 or so.

On the Presario, we opted for a Kingston module. A small door on the laptop's bottom panel comes off, and there's a socket for the SODIMM. We simply popped it in, and the Presario's BIOS recognized the new amount of RAM. The total time for this upgrade was under five minutes.

We also opted to go with Kingston Technology for the hard drive upgrade. You can find "raw" laptop hard drives at numerous Web sites and computer stores. The problem with those units is that it's really difficult to get all of the applications and data files transferred.

There are about a half dozen companies offering upgrade kits that include an interface to use to transfer the operating system and all of your files to the new hard drive before you install it in the laptop. A few of these vendors include Apricorn (*www.apricorn.com*), Simple Technologies (*www.simpletech.com*), and the aforementioned Kingston Technology.

I've had good luck with all of those vendors. In fact, the 2-GB hard drive that was already in the Presario was an Apricorn EZ-GIG upgrade, performed several years earlier. For this upgrade, however, we chose the Kingston Strata-Drive Plus. This comes in various sizes, and the 20-GB model we used costs about $900 or so, depending upon where you buy it.

The StrataDrive Plus kit comes in a conductive plastic bag that turns into a static-draining wrist strap. The actual kit contains the 2.5-inch form-factor drive, a PC-Card interface with a connecting cable for the drive, and software. To upgrade the old drive, simply run the StrataMove software, and insert the PC Card into a PCMCIA slot when prompted. The software formats the new hard drive, and then moves the operating system, files, and applications over. It also expands the drive partition to encompass the size of the new drive. Finally, if the BIOS does not support large drives, it installs a utility that allows larger drives to be used with an older BIOS.

Once that process is finished—about 25 minutes on our system—you disconnect the cable from the drive, shut the system down, open it up, remove the old drive, and install the new one. Kingston provides instructions for a variety of different systems. On the Presario, the keyboard lifts up to provide access to the drive. The physical part of the upgrade added about 15 minutes to the process.

We left the WindowsME upgrade for last. If you will be upgrading the hard drive, you may want to perform this upgrade first, depending upon what file system is installed on the current drive. My friend had already upgraded to Windows 95 previously, so the hard drive already had the more efficient FAT32 file system. If he had been running FAT16, we would have performed the Windows update before upgrading the hard disk.

The total time to upgrade all three areas was about an hour and a half, with the greatest portion spent in performing the upgrade to WindowsME. My friend is delighted, since his applications do run noticeably faster with the additional memory; and the 20 GB of disk space gives him plenty of room.

At almost a thousand dollars, this particular upgrade was just marginally justifiable from an economic point of view. However, RAM upgrades almost always make sense, and smaller hard drive upgrades are a lot more affordable than the 20-GB drive we selected. So don't be afraid to pour some upgrade money into that older laptop if it will buy you another year or two of use out of it. **P**

VENDOR INFORMATION

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Poway, CA 92064
800-458-5448
www.apricorn.com

Kingston Technology
17600 Newhope St.
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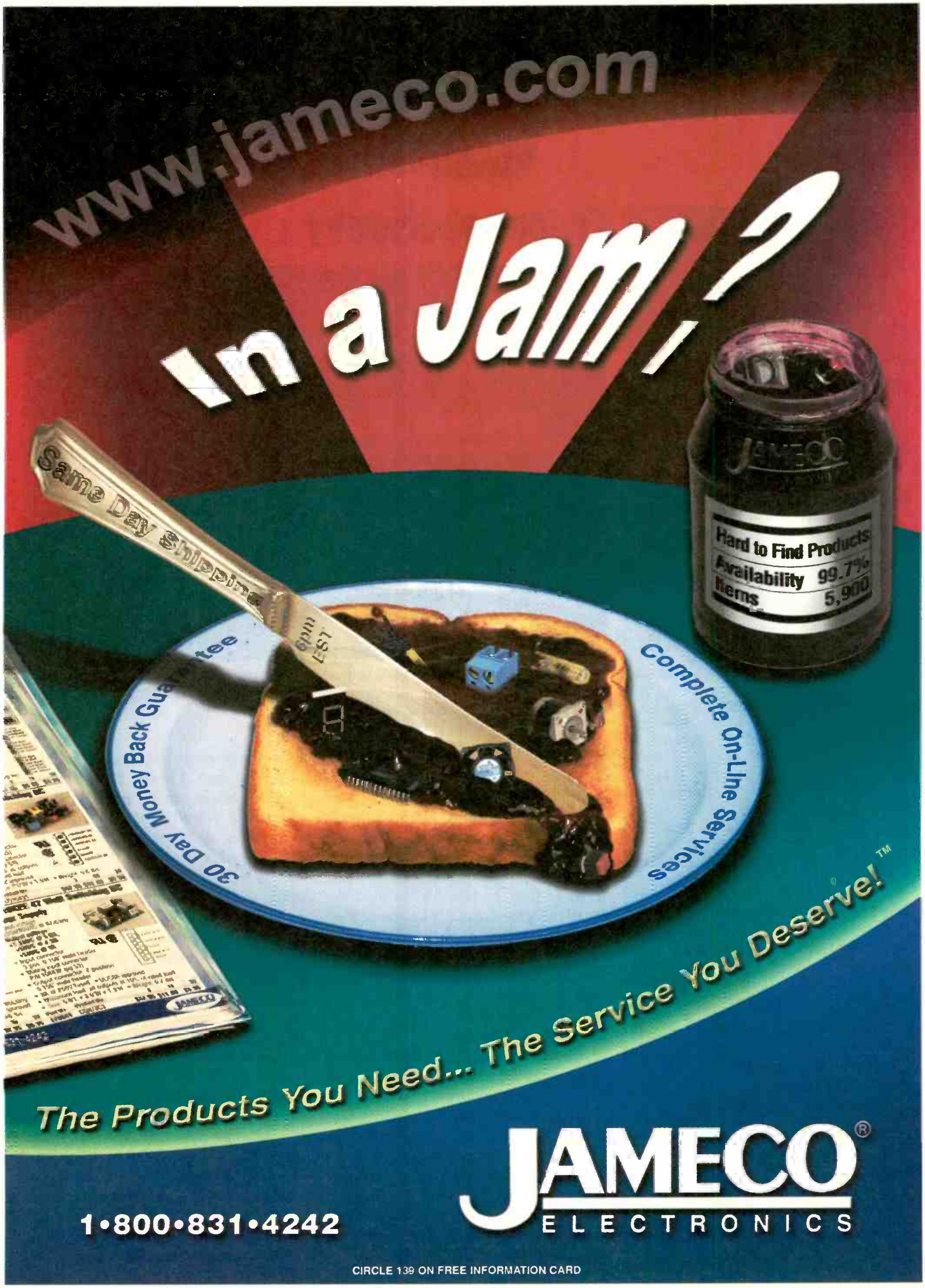
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Business Buzz

LUNCHROOM ID
Three Pennsylvania school districts (Lower Merion, PennCambria, and Tussy Mountain) are using a fingerprint identification program that enables pupils to buy lunch—no cash needed. Students place their index fingers on small scanners, and a template matches 27 grid points with the electronic fingerprint's ridges. Since the fingerprint image is discarded and the points are assigned numbers, those numbers cannot be reinterpreted into a fingerprint image. Sagem Morpho Inc., Tacoma, WA, supplies the system, which costs between $4000 and $5000 per lunch line. It was developed to comply with federal law prohibiting schools from overtly identifying those receiving free and reduced-price lunches. Within the next year, fingerprint scanners will be available as optional equipment for mobile phones and personal computers.

WHERE'S THE BEEF?
Effective January 1, 2001, the Canadian cattle industry implemented a tracking system for beef to prevent potential problems such as outbreaks of mad cow disease. This technology developed by Toronto-based Antitech Information Systems involves tagging all cattle at birth with either a bar-coded or electronic tag and placing data-collection stations in meatpacking plants. Its ability to be linked to a packer's existing computer system allows data to be collected on individual animals in real time as they are being processed.

TV/INTERNET INTEGRATION
Starting in the second quarter of 2001, twenty families in Raleigh, NC are taking part in a six-month pilot program from Texas Instruments called the "Complete TV" project. The program gives the families a home-entertainment experience that combines broadcast *H*igh-*D*efinition (HD) programming and Internet-based infotainment. They received a Panasonic large-screen, rear-projection HD home-entertainment system, which comes with both HD capability and PC interfaces to enable it to act as a multi-functional screen. The complete system includes a high-performance broadband "entertainment computer," integrated by RKR Video, Huntington Beach, CA. HD broadcasting will be provided by WRAL Digital—the first station to broadcast a digital signal and a full HDTV newscast in the US.

Flying Laboratory

NASA's DC-8 Flying Laboratory is a converted long-range jetliner that is now a world-class airborne scientific laboratory that can carry 30,000 pounds of scientific instruments and equipment along with scientists and experimenters.

For four months, a team of scientists from NASA and several research institutions conducted a comprehensive Earth-observing mission in the most volcanically active region in the world—the Pacific Rim. Called *Pacific Rim* 2000 (PacRim II), the program collected data in more than 15 countries around the Pacific Ocean. Among the areas studied were Cambodia's Angkor Wat Temple, French Polynesia, Papua New Guinea, the Philippines, and the Australian coastal wetlands.

Science In The Air

Conducted by NASA's Earth Science Enterprise, the mission used the DC-8 Flying Laboratory from NASA's Dryden Flight Research Center at Edwards, CA. This highly modified aircraft carried a suite of precision instruments to document geographic and atmospheric factors throughout the Pacific Rim area.

NASA's DC-8 Flying Laboratory, a dash-72 version powered by four CFM-56 high-bypass turbofan engines, is a former long-range jetliner that has been converted into a world-class airborne scientific laboratory. It can carry 30,000 pounds of scientific instruments and equipment along with scientists and experimenters, cruising at altitudes up to 42,000 feet. Its range is 5400 nautical miles, and it has a flight duration of up to 12 hours.

According to Ellen O'Leary, PacRim II mission coordinator at NASA's *J*et *P*ropulsion *L*aboratory (JPL) in Pasadena, CA, the mission gathered geographic and atmospheric data for coastal analysis and oceanography, forestry, geology, hydrology, and archaeology.

Seeing In The Dark

The primary PacRim II instrument is the *Air*borne *S*ynthetic *A*perture *R*adar (AIRSAR). Designed and built by JPL, AIRSAR is NASA's radar technology testbed and is used to demonstrate technology for spaceborne radar missions. AIRSAR also collects data for Earth Science research purposes and is an allweather imaging tool able to see through clouds and collect data at night. Radar's ability to collect data of the Earth's surface, even in cloud-covered regions such as the Pacific Rim, makes it a particularly valuable tool for tropical areas. The instrument's longer wavelengths can also penetrate into the forest canopy, providing scientists with data at different levels in the forest. The AIRSAR radar antenna panels are mounted on the outside of the aircraft and the instrument looks to the side of the flight path.

The radar transmits microwaves, and the return signal is collected after the Earth reflects it. Rough areas, such as cities, mountains and forests, have more surfaces from which the signal can reflect, and therefore return more of the radar signal to the antenna—appearing brighter on the resulting radar image. In contrast, smooth areas, such as deserts, roads and water surfaces, return less of the radar signal and appear darker on the radar images.

Three-Dimensional Images

In addition to collecting data about the roughness characteristics of the surface, AIRSAR can also collect data that is processed to high-resolution *D*igital *E*levation *M*odels (DEMs), which are three-dimensional topographic maps of the surface. A third type of AIRSAR data is used to measure motion of currents and waves. DEM data are particularly important to disaster managers around the Pacific Rim who are responsible for developing plans to mitigate and respond to natural hazards such as typhoons, earthquakes and volcanic eruptions.

This three-dimensional perspective view of the volcanic island of Manam in Papua New Guinea is an example of a dramatic image acquired by AIRSAR, NASA's Airborne Synthetic Aperture Radar. The volcano was in the midst of its largest eruption since 1992 when this image was taken. Two weeks later, the eruption intensified, killing several people and forcing the evacuation of thousands of others.

Also onboard the DC-8 is the MASTER instrument, which is the *MODIS/ASTER* airborne simulator. The *Mod*erate Resolution *I*maging *S*pectroradiometer (MODIS) and the *A*dvanced *S*paceborne *T*hermal *E*mission and Reflection *R*adiometer (ASTER) are two instruments on NASA's *E*arth *O*bserving *S*ystem (EOS) Terra satellite launched in December 1999. The MASTER instrument is used to obtain detailed maps of land surface temperature, emissions and reflectance.

PacRim II is the first mission to operate both the AIRSAR and MASTER instruments simultaneously on the DC-8. Combining AIRSAR and MASTER data collected over the same site could produce dramatic results. For example, MASTER data can be draped over digital elevation model data generated by AIRSAR, providing scientists with additional insight on how topography affects the vegetation and land surface temperature as seen in the MASTER data.

Currently, data from PacRim II is being analyzed and shared with the participating countries. PT

"Smart" Batteries Included

In today's vehicles, engines, transmissions, suspensions, brakes, and air conditioning are all electronically controlled. The one obvious exception is the battery. However, this is about to change with *S*mart *E*nergy *M*anagement (SEM) technology developed by Canadian iQ Power Technology Inc., Vancouver, B.C., and its German subsidiary, iQ Battery Research & Development GmbH, Munich.

The "brains" of the iQ SEM system are Texas Instruments microcontrollers. The *smart* battery communicates with

Research Notes

THERE ARE SPRITES AMONG US

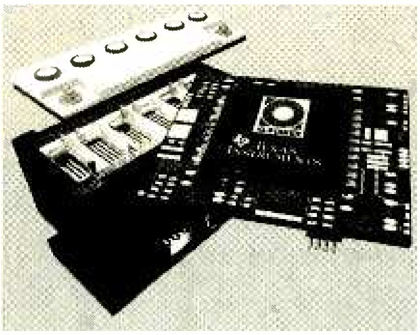
Magnetic field measurements of ghostly, high-altitude "sprites" were recently conducted by Martin Fuellekrug of Frankfort University's Institute for Meteorology and Geophysics and Steven Cummer, assistant professor of electrical and computer engineering at Duke University. Sprites are faint, colorful, and exceedingly brief flashes that erupt just below the ionosphere—only scientifically documented in the past decade. Cummer's antenna studies analyzed low-frequency *e*lectro*m*agnetic (EM) returns, showing unaccountable gaps in activity between bolts. He teamed up with Fuellekrug, who works with magnetic field sensors exceptionally sensitive to ultra-low EM frequencies. Applying mathematical modeling analysis, Cummer found continuing cloud-to-ground currents in one event that varied from about 4000 to 7000 amps over a period of about 150 milliseconds.

DON'T ADJUST YOUR TV!

Scientists at the DoE's Los Alamos National Laboratory have developed a transmission algorithm that compresses a HDTV data stream for broadcast over the same channel as analog TV signals. The algorithm allows both new digital and old analog TV sets to receive a compatible signal without requiring two distinct signals on two separate channels to be simulcast. No converter is required, since an added software loop in the HDTV receivers recovers the digital information from the same channel. Since Congress has mandated HDTV broadcast television signals by 2006, this technology makes the transition easier.

IDAHO SOLID ELECTROLYTE

A team of chemists at the DoE's *I*daho *N*ational *E*ngineering and *E*nvironmental Laboratory (INEEL) has unveiled an award-winning lithium-battery solid electrolyte, which lasts about 50% longer than other electrolytes. The INEEL electrolyte is also safer and more environmentally friendly, since the waste products are essentially glass, phosphate, and nitrogen compounds. A mix of a liquid polymer and a ceramic powder that turns into a clear, non-toxic flexible membrane, it creates a stable scaffold. Liquid polymers weave through it like ribbons. Most importantly, this way of stabilizing the polymer interferes with lithium transport 20 times less than other stabilization methods.



Seen here is a cross section of the iQ Power smart battery. The "brains" of the system are microcontrollers from Texas Instruments.

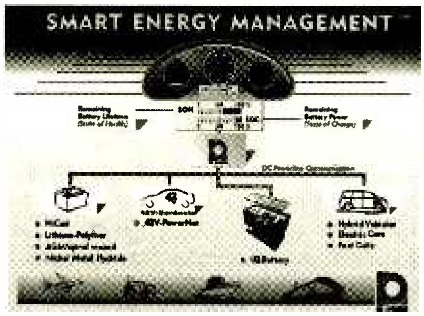
the vehicle's onboard computer via the existing data bus or *P*ower*l*ine *C*ommunication (PLC), exchanging data with the alternator, other computerized systems, or the diagnosis systems. Extra wiring is not required because data is transmitted through the two battery terminals. The solid battery case is made of polypropylene foam (BASF) to protect against vibration, to better survive a crash, and to provide thermal insulation.

The microchip in the self-learning SEM system calculates the optimum operation for the battery, and then it electronically manages the battery to adjust for the driving conditions and driving profile of the individual car. The SEM system can keep the driver informed of the battery's *s*tate *o*f *c*harge (SOC)—remaining power—and the *s*tate *o*f *h*ealth (SOH)—remaining battery life. In addition, the battery stores basic operating values for later diagnostics—in the same way that an aircraft's flight data recorder does.

According to iQ CEO Peter Braun, their next-generation battery is lighter, smaller, more powerful, and longer lasting than other batteries on the market. While providing as much power as normal lead-acid batteries, the iQ battery weighs 40- to 50-percent less because it requires about 30-percent less lead. This is a real benefit in today's weight-sensitive automotive designs.

iQ Power also asserts that there's a 600 percent improvement in charging capacity with more current provided in a shorter time. Using SEM technology, the smart battery performs several energy management functions. For example, it controls the electrochemical processes in the cells through a sophisticated mixing system that ensures an optimum acid concentration.

A temperature-control system and built-in electric heater supplies heat to stimulate the chemical processes inside the battery for easier cold starts. Sensors record the ambient and operating conditions including the internal and external temperature. At below-freezing temperatures, this means both reliable cold-starts and a doubling of battery life. The battery will start the engine reliably even in extreme temperatures of -40° C (-40° F). While it usually takes around an hour to recharge a conventional battery, the iQ battery is ready in just ten minutes. A dead battery recharges considerably faster when it is equipped with iQ technology. In just one hour, a 32-amp-hour (Ah) battery that is 57 percent charged recharges to 92 percent of its nominal capacity.



This poster illustrates how Smart Energy Management (SEM) technology would maintain and display the battery status on a dashboard—state of battery health and state of battery charge—in various types of batteries and/or vehicles.

While a normal 32-Ah battery has little chance of starting an engine at -25° C, the same battery using iQ technology easily starts the engine at that temperature. Indeed, its performance is even better than that of a normal 68-Ah battery, which is twice the size.

The iQ battery technology was developed for use in current lead-acid-battery production lines with only minor changes. The SEM technology can also be used with other battery chemistries including Lithium Polymer, Nickel Cadmium, or Nickel Metal Hydride. In addition, the performance of AGM/spiral-wound batteries can be increased significantly when equipped with iQ's SEM system. This technology can be used with 42-volt systems when they become available. Indeed, because of the iQ battery's compact size, both the 12-volt and 36-volt batteries that will be initially used in 42-volt systems could be installed in a common casing, which would not take up more space than one of today's batteries.

The world's first "thinking" battery has been a collaborative effort. iQ Power has actively pursued industry feedback and participation. The company was invited to join the MIT/Industry Consortium on Advanced Automotive Electrical/Electronic Components and Systems. The Consortium is a cooperative effort between the Massachusetts Institute of Technology and such major automotive names as Audi, BMW, Daimler-Chrysler, Ford, General Motors, Toyota, and Volvo, as well as electronic-parts suppliers such as Delphi, Dow, Johnson Controls, Lear, Matsushita, Mitsubishi, Motorola, and Siemens.

Currently, 1500 iQ SEM system batteries are being tested by major auto manufacturers. Israeli battery-maker Schnapp and Co. will produce the world's first microchip-controlled automotive batteries. Initially, theses smart batteries will probably be exported to Europe. Check *www.iqpower.com* for the latest developments.—**by Bill Siuru** PT

Other Battery Research

The California Air Resources Board is maintaining their mandate for *z*ero-*e*mission *v*ehicles, ZEV, (electric) to become a reality in 2003. Automobile and truck manufacturers are clamoring for practical, economic, and powerful batteries to fulfill their needs.

Over the past three years, inventor Alvin A. Snaper, who holds several hundred patents ranging from the IBM Selectric Ball to a Rocketdyne Fluidic Missile System, has been developing a battery to replace the lead-acid battery. It is intended for use in automobiles, trains, airplanes, and marine craft; and it's also meant to power electric vehicles more effectively. Mr. Snaper and his team have developed the Power Technology battery with a unique electrode structure, which increases the electrochemically active surface area within the battery 1000 times. It is also lightweight, produces more charge, and recharges very quickly.

Power Technology's, Generation No. 2 has an internal battery structure, which, when coupled with the correct application of nickel and iron, will require half the size and half the charging time of a lead-acid battery to produce an equal number of watt-hours. In addition, it does not require thermal-management packages for high-output uses such as EVs.

This technology improves the use, ease, and efficiency of any battery-powered product, by using specially formulated reticulated foam plates and metallic pastes. Previous foam plating developed by competitors has proven too weak to support the battery's internal structure.

The company is in the process of developing commercial production. While Power Technology, Inc. is initially seeking to deliver an updated battery for the electric car, it can be used in boats, ships, and airplanes to reduce weight and increase power today. PT

➤ Get A Grip

Advanced Elastomer Systems, L.P. (AES) recently introduced the B100 Series of *ThermoPlastic Vulcanizates* (TPV), announced as the first that bond to ABS copolymers, *PolyCarbonate* (PC), ABS/PC blends, *PolyStyrene* (PS), and other such materials. Santoprene, the initial developmental grade, enables designers, molders, and manufacturers to injection mold or extrude a soft TPV onto a variety of rigid substrates to produce a durable bond without adhesives. These soft type grips will help enhance user/product interaction.

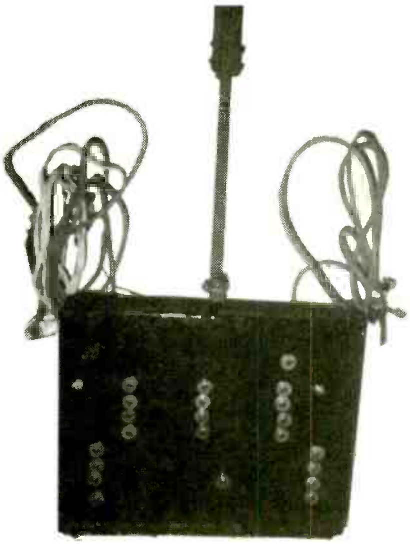
The first application on the market is a handle grip on Oreck's new ergonomically designed upright Dual Stack commercial vacuum. In this application, the pre-form requires no preheating. Other applications include comfortable grips for power tools, lawn equipment, household appliances, and hand-held electronic devices such as cellular phones. More information can be found at the company's Web site: *www.aestpe.com*. PT

The first application of the breakthrough in thermoplastic technology is the insert-molded handle grip on Oreck's new ergonomically designed upright Dual Stack commercial vacuum.

A Mechanic, A Tinker, A Retiree, A Thinker

In his spare time, "tinkerer" Curtis Ford continues to work on KOOL CHEK, his patented automotive invention. KOOL CHEK is a thermostat and cooling system tester that can quickly and accurately pinpoint malfunctions in the cooling system of a liquid-cooled internal-combustion engine— especially in the engine's thermostat. The thermostat controls the engine temperature, and the correct engine temperature ensures efficient operation and protects air quality.

Clean air is a major problem worldwide. In many metropolitan areas, air quality is below the EPA standards—and motor vehicles are big factors. An accurate instrument that diagnoses an engine's cooling system can effectively "rebalance" the equation. KOOL CHEK can improve emissions monitoring and help motorists comply with *The Clean Air Act of 1990*, according to Ford, since engine temperatures are important in automobile emissions. An engine running below the correct temperature emits excessive carbon monoxide (CO) and hydrocarbons (HC), while above the correct temperature it emits excessive nitrogen oxide (NOX).



It's a black box. It's a VCR. It belongs to ET. No, it's KOOL CHEK, an automotive tester that pinpoints malfunctions in the cooling system of a liquid-cooled internal-combustion engine—especially in the engine's thermostat.

On new vehicles, the Computer Command Control (CCC) system cannot function properly unless the engine runs at the correct temperature. The computer can crunch numbers and process data very quickly, but it cannot, for example, figure out that the thermostat is stuck in the open position. The CCC system "sees" a cold coolant sensor and orders more fuel to the engine, retards the ignition timing, and causes the computer to stay in open-loop mode and not control anything. If the thermostat is functioning but set at too low a temperature (160° F), 100-200 parts per million of HC could be emitted in a vehicle's exhaust.

Ford, a veteran mechanic, used KOOL CHEK at his job at the NYC Department of Transportation Queens Repair and Maintenance Shop for four years before he retired. During that time, he was able to pinpoint difficult-to-diagnose problems. For example, he discovered that defective water pumps on a fleet of new trucks caused an overheating problem. They were returned to the vendor for repair at no cost to the department. PT

CD ROM based resources for learning and designing

The internationally renowned series of CD ROMs from Matrix Multimedia has been designed to both improve your circuit design skills and to also provide you with sets of tools to actually help you design the circuits themselves.

matrix multimedia

Electronic Circuits and Components provides an introduction to the principles and application of the most common types of electronic components and how they are used to form complete circuits. Sections on the disc include: fundamental electronic theory, active components, passive components, analogue circuits and digital circuits.

The Parts Gallery has been designed to overcome the problem of component and symbol recognition. The CD will help students to recognize common electronic components and their corresponding symbols in circuit diagrams. Quizzes are included.

Digital Electronics details the principles and practice of digital electronics, including logic gates, combinational and sequential logic circuits, clocks, counters, shift registers, and displays. The CD ROM also provides an introduction to microprocessor based systems.

Analog Electronics is a complete learning resource for this most difficult subject. The CD ROM includes the usual wealth of virtual laboratories as well as an electronic circuit simulator with over 50 pre-designed analog circuits which gives you the ultimate learning tool. The CD provides comprehensive coverage of analog fundamentals, transistor circuit design, op-amps, filters, oscillators, and other analog systems.

Electronic Projects is just that: a series of ten projects for students to build with all support information. The CD is designed to provide a set of projects which will complement students' work on the other 3 CDs in the Electronics Education Series. Each project on the CD is supplied with schematic diagrams, circuit and PCB layout files, component lists and comprehensive circuit explanations.

PICtutor and C for PICmicro microcontrollers both contain complete sets of tutorials for programming the PICmicro series of microcontrollers in assembly language and C respectively. Both CD ROMs contain programs that allow you to convert your code into hex and then download it (via printer port) into a PIC16F84. The accompanying development board provides an unrivaled platform for learning about PIC microcontrollers and for further development work.

Digital Works is a highly interactive scalable digital logic simulator designed to allow electronics and computer science students to build complex digital logic circuits incorporating circuit macros, 4000 and 74 series logic.

CADPACK includes software for schematic capture, circuit simulation, and PCB design and is capable of producing industrial quality schematics and circuit board layouts. CADPACK includes unique circuit design and animation/simulation that will help your students understand the basic operation of many circuits.

Analog Filters is a complete course in filter design and synthesis and contains expert systems to assist in designing active and passive filters.

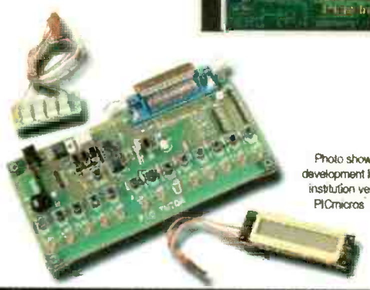


Photo shows PICmicro development kit supplied with institution versions of C for PICmicros and PICtutor

Shareware/demo CD ROM with more than 20 programs $4.99 refundable with any purchase.

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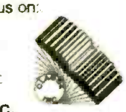

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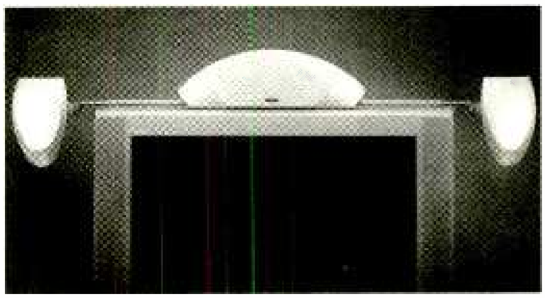


Sometimes it seems as if it's just as hard to find the right places for your home-theater speakers as it is to find the right speakers for your home theater. Infinity cleverly solves both problems with its *Modulus Home-Theater System* ($1699) and optional TV mounting bracket ($150).

The Modulus satellites feature an integral swiveling-mounting bracket that allows them to be mounted on a wall, in a corner, or freestanding on a shelf. The bracket can be mounted anywhere along the satellite's curved-bottom mounting surface, so that the speaker can be positioned to face straight ahead or at a downward-firing angle.

The system boasts four two-way satellite loudspeakers and a dedicated center-channel speaker, each featuring a 4-inch woofer (the center speaker has *dual* 4-inch woofers) and a ¾-inch tweeter. The included compact subwoofer has a 12-inch driver, a built-in 300-watt amplifier, and Infinity's Room Adaptive Bass Optimization System (R.A.B.O.S.). The low mass, highly rigid diaphragms in these drivers are said to deliver extraordinary clarity, transient response, detail, and resolution, while reducing distortion. R.A.B.O.S. allows the user to precisely optimize the bass to the individual room characteristics. All tools needed to calibrate the system, including a test CD, sound-level meter, and step-by-step instructions, are included.

The optional TV bracket links the left and right speakers to the center speaker on telescoping arms. The arrangement can be placed atop any 30- to 55-inch television, extending the right and left speakers beyond the TV screen for a wide, panoramic sound field.

Infinity Systems, Inc., 250 Crossways Park Drive, Woodbury, NY 11797; 800-553-3332; *www.infinitysystems.com*.

CIRCLE 50 ON FREE INFORMATION CARD

Outboard CD Burner

TDK's *Model FE-161040 veloCD burner* ($399) offers PC users the ease of IEEE-1394 Firewire connectivity for high-performance recording and rewriting of discs. With 16X writing, the external peripheral can burn a full CD in just five minutes and rip a three-minute track in less than six seconds. The device offers 10X rewrite and 40X data read and is capable of ripping CD audio tracks at 32X with bit-perfect musical accuracy. With BURN-Proof write-assurance technology, you're free to surf the Web or download music while you burn CDs.

Designed as an all-in-one solution for CD music and multimedia recording, the outboard veloCD burner comes with TDK's *CD Blender* software suite, plus *Nero 5.0* CD recording software, *InCD* drag-and-drop packet-writing software, and other utilities.

TDK Electronics Corp., 901 Franklin Ave., Garden City, NY 11530-2933; 516-535-2600; *www.tdk.com*.

CIRCLE 51 ON FREE INFORMATION CARD

Tabletop Remote Control

Reduce coffee-table clutter with the *RR-1090* tabletop remote control ($299) from Rotel. The elegant, gently curved device can replace up to eight of those easily misplaced handheld remotes with their closely spaced, tiny buttons.

The RR-1090 features a large backlighted LCD screen that provides instant feedback even in darkened rooms. Its intuitive layout makes even complex home-theater systems easy to operate. There are 12 "menu command" buttons for choosing components. Users can program the remote to activate up to 48 individual commands for each device. Two large, multi-axis buttons toward the bottom of the RR-1090's command panel control major functions.

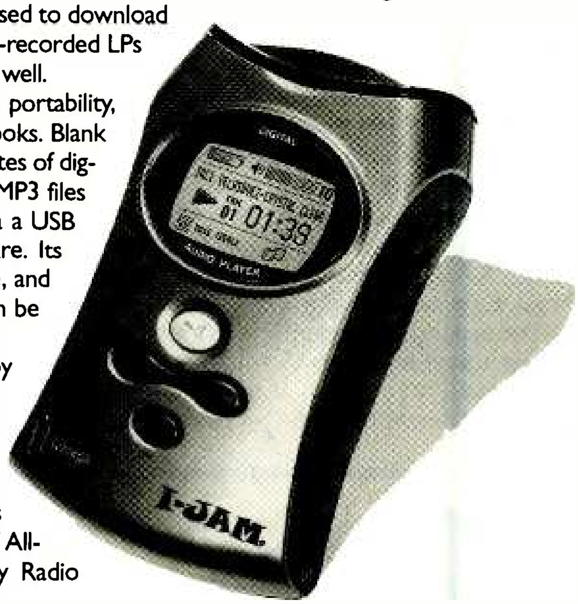
The self-contained menu system provides access to an extensive array of pre-programmed codes in the unit's non-volatile archival memory. Users can also "teach" the unit individual commands for other components. Once the desired IR commands have been placed in active memory, four macro keys can individually or sequentially activate up to ten of them. A "custom ID" option allows system-specific IDs for each device to be programmed in. Password protection is available to limit children's access to system functions. The RR-1090 also comes with *PC Link* software and cable to store or load IR codes. An AC adapter and rechargeable batteries are included.

Rotel of America, 54 Concord St., North Reading, MA 01864-2699; 978-664-3820; *www.rotel.com*.

CIRCLE 52 ON FREE INFORMATION CARD

Pocket Full of Tunes

If the term "LP" makes you think of a 12-inch, pre-recorded vinyl record, it's time to move into the 21st century. These days, *LP* stands for the *License Plate*, a silver-dollar-sized digital-audio storage medium from I-Jam Multimedia that is based on the PocketZip disk from Iomega Corporation. LP tracks are permanently recorded in the Windows Media Format and support Microsoft's Windows Media Digital Rights Management (DRM) system exclusively. Although LPs cannot be copied, they can be shared between compatible devices, including digital audio players that use PocketZip technology and Iomega PC Card drives. Blank LPs can be used to download audio files, and pre-recorded LPs will be available as well.



The disks, which are encased in metal for durability and carefree portability, carry suggested retail prices of $19.98 for music and $29.99 for books. Blank PocketZip disks sell for about $10; a 40-MB disk holds up to 120 minutes of digital music. I-Jam's IJ-360 digital audio player, which is compatible with MP3 files and the Microsoft Windows Media format, allows fast downloads via a USB connection and is bundled with Windows Media Player 7 software. Its $299.95 suggested retail price includes headphones, a carrying case, and two 40-MB PocketZip disks loaded with pre-recorded music that can be recorded over (as with any blank PocketZip disk).

Several popular book and music titles are scheduled for release by the time this is published. Recording artists include Bender, the Charlie Daniels Band, Snoop Dog, XTC, Al Green, Selena, and Amy Grant. Books from John Grisham, Danielle Steele, Michael Crichton, Bob Costas, James Bradley, and Rosamunde Pilcher will be offered. Rounding out the first releases will be a selection of radio shows including *Alfred Hitchcock*, *Jack Benny*, the "Smithsonian Collection of All-Time Radio Shows," the "Smithsonian Collection of Great Mystery Radio Shows," and 27 episodes of *Superman*.

I-Jam Multimedia L.L.C., 1092 National Parkway, Schaumburg, IL 60173; 847-839-1233; *www.ijamworld.com*.

Iomega Corporation, 1821 West Iomega Way, Roy, UT 84067; 888-446-6342; *www.iomega.com*.

CIRCLE 53 ON FREE INFORMATION CARD

Pint-Sized PDA

Royal's *Vista TS* ($69) is a credit-card-sized Personal Digital Assistant with a touch screen, an upgradeable operating system, and 2-MB of Flash memory. Packaged with a battery-operated desktop cradle, the device offers easy data entry. It can be directly synchronized to a PC with Royal Link PC Personal Information Manager (PIM) software, as well as *Microsoft Outlook*, *Schedule+*, *ACT!*, *Lotus Organizer*, and *Palm Desktop*. An optional, palm-sized, folding keyboard (less than $30) makes it simple to input text.

The Vista TS offers an address/phone book, a full-function calculator, a schedule function, to-do and anniversary trackers, home- and world-time clocks, and other management software features. Additional applications, such as an expense manager, can be downloaded from Royal's Web site.

Although the device is PC compatible, no computer savvy is required. In fact, no PC is required at all. The Vista TS is a self-contained unit that can be used right out of the box. Data can be input using a stylus and the touch screen, which has adjustable contrast for easy viewing.

Royal Consumer Business Products, 765 US Highway 202, Bridgewater, NJ 08807; 908-526-8200; *www.royal.com*.

CIRCLE 54 ON FREE INFORMATION CARD

CD Memory System

The *SongBank SL CD Memory System* ($799) delivers the benefits of CD players, CD mega-changers, and CD recorders in one unit. Up to 14 days worth of continual music is stored digitally—entire collections of up to 7000 songs. (For comparison, see I-Jam's LP—mentioned previously—that holds 120 minutes of digital music.) Simply insert a CD and the SongBank rips it, recording the full contents or a selected portion in one-quarter the usual playtime. An easy-to-use TV display guides you through the SongBank. A simple software upgrade will allow you to download music from the Internet directly, with no PC needed.

Lydstrom, Inc.; 617-451-5888; *www.lydstrom.com.*

Take Control With Light Pens

Have you had it with your mouse or track ball? Here's another option: a complete light pen kit (interface, light pen, cable and software). Basic kits start as low as $400. The *PXL-2000* USB interface doubles as a four-port hub (starter kit from $553) and the *PXL-795*, featuring an external-serial interface, is priced at $500 for a complete starter kit.

FastPoint Technologies; 800-962-3900; *www.fastpoint.com.*

FireWire/USB Scanner

The *ScanMaker 8700* ($999) is ideal for professional graphics, Web-site design, and photography. With a stunning 1200-dpi resolution and both OCR and PDF capabilities, the ScanMaker 8700 uses a 14-bit analog-to-digital converter and a 10,600-pixel element CCD for rendering crisp color scans.

Microtek; 310-297-5000; *www.microtekusa.com.*

The Amazing ZiO!

ZiO! is a USB device that allows you to transfer files from either SmartMedia, Compact Flash or MultiMedia storage cards found in devices like digital cameras and MP3 players. Priced at an affordable $40 and PC and Mac compatible, the *ZiO!* can be used for fast data transfer on the go.

Microtech International, Inc.; 203-483-9402; *www.microtechint.com.*

Network-Ready Laser Printer

The *HL-1670N* ($749) is a network-ready laser printer with built-in duplex printing that ensures flawless printing on both sides of a sheet of paper. With a print speed of 16-pages per minute, the printer has an expandable memory of up to 144 MB (16 MB is included) and is compatible with USB and parallel interfaces.

Brother International Corp.; 800-521-2846; *www.brother.com.*

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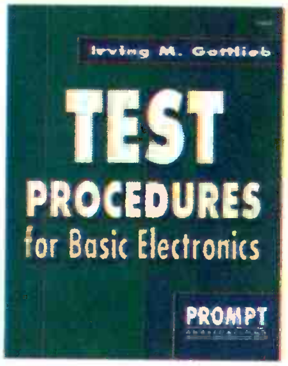

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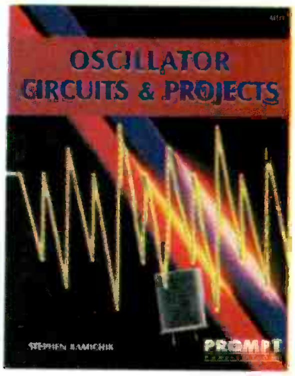

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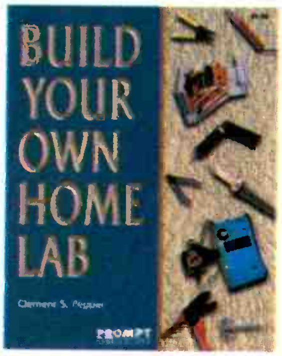

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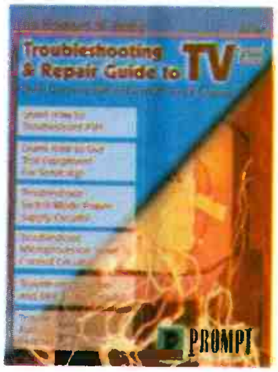

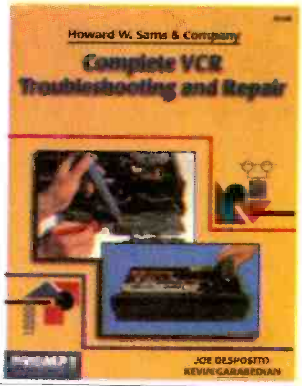

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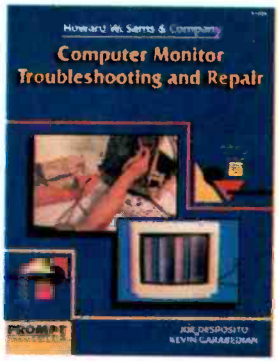

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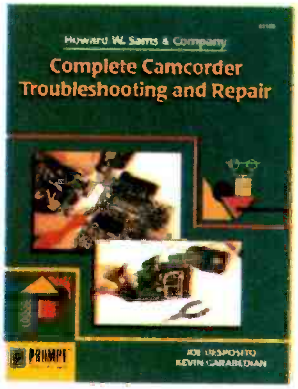

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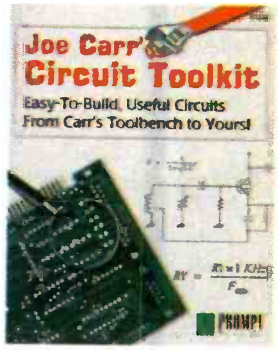

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CL04

CHRIS LA MORTE

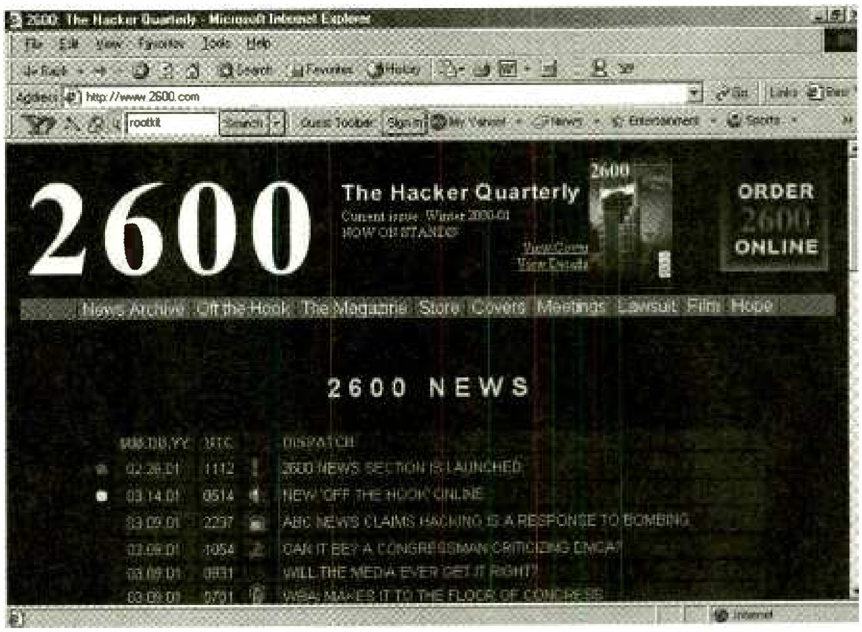
Germ-Warfare On The Cyber-Front

Even the most heavily guarded systems are threatened by "Binary" bacteria. Culprits with names like "CIH'" "Ska," and "I Love You" have managed to infiltrate and cripple networks across the planet. The widespread use of high-speed and always-on services (like cable- and DSL-modems) has allowed viruses, parasites, and other "malware" creations to achieve maximum dissemination. Hackers and crackers alike are finding the sport of crashing computers easier than ever.

WORMS, AND PARASITES

Worms are routines capable of self-replicating throughout an entire network. In 1988, Robert T. Morris released one of the first Internet worms. What began as an innocent experiment soon proved fatal for many servers. In the world of cyber-terrorism, worms are mostly used to clog e-mail servers. The Ska virus is a good example of a worm that implants itself as a .dll file and sends off clones of itself to the names found in a victim's address lists. The constant shuffling of data creates a logjam within a mail sorter.

A parasite is just like its biological counterpart. Computer-based parasites enter a system by deceptive means—perhaps piggybacked on a seemingly benign file—and set up camp. Once inside, parasites assume control of their host. After taking command, a parasitic code can use its host to attack other machines in a network or it might begin to destroy all the data it can reach.

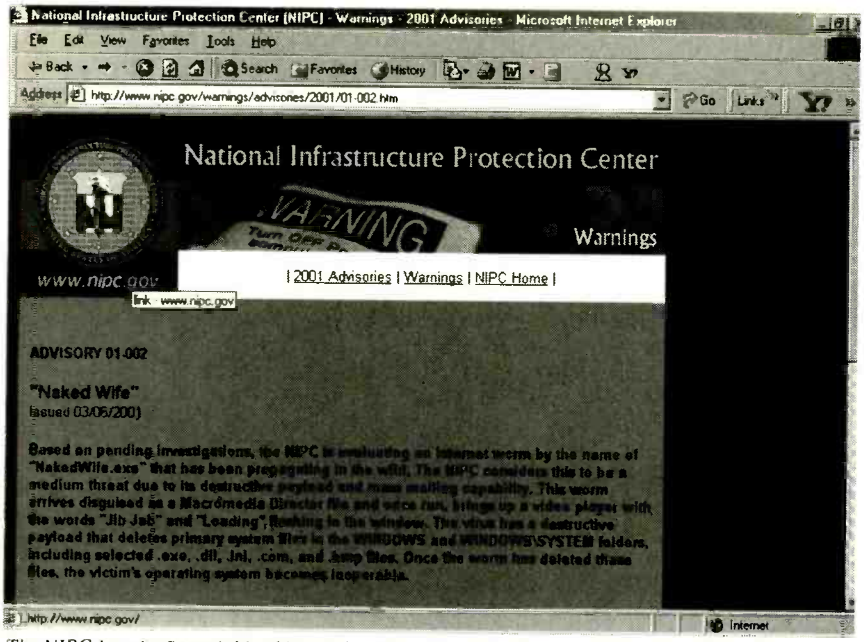


"Mommy, make the bad site go away!" 2600 has been offering only the best in "phreak" boxes, secret frequencies, and hacker advice for years. The group has grown with the times, and now it boasts a Web site in place of its aging BBS.

Devious programmers are having a field day creating and implementing their legion of contagion codes. Open-sourced applications and freeware platforms are often used as the skeleton for their creations. Two common building blocks for viruses are the psuedo-code compiling Java, and the freeware interpreter PERL (*P*ractical *E*xtraction and *R*eport *L*anguage). Free versions can be obtained for each of those languages via the Internet.

TOOLS OF THE TRADE

Every keen hacker has a virtual box of goodies often referred to as a "rootkit." Kits are collections of programs and applications that allow hackers and crackers to gain entrance into machines and assume root-privileges over a network (hence the name). Once inside, intruders can scan networks for sensitive information and even create and release viruses over the Internet. *WinNuke* was a popular program passed about hacker circles. The program allowed users to enter a target's IP address and send a "PING of Death" to a hapless victim, which resulted in the infamous "blue screen of death" a.k.a. the "BSoD." *Script Kiddies* are young terrorists-in-training who man-



The NIPC has the financial backing and cutting-edge technology to wage war against cyber-terrorists. This U.S. government organization is spearheaded by the FBI and is headquartered on Washington, D.C.

age to get their delinquent little digits on the various pre-written malicious scripts that are similar to *WinNuke*, rather than having to take the time and effort to design their own weapons of digital destruction.

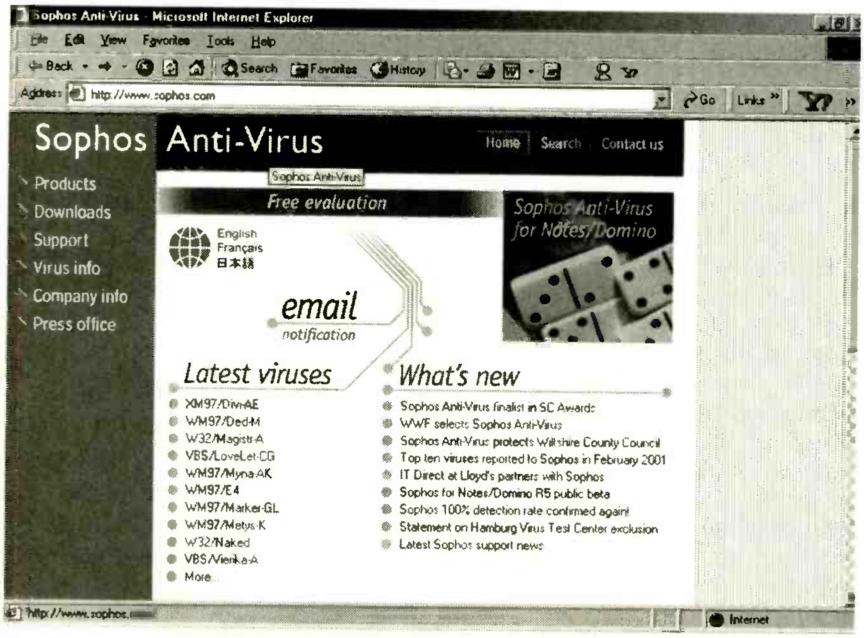
Some of the more popular applications used to breach and exploit systems include *Ethernet sniffers* used to "sniff" out passwords and usernames, *TTY watchers* designed to hijack terminals, *IP spoofers* that allow hackers to mask their identity, and *phage* programs for unauthorized modification of a victim's operating system and programs. The majority of tools needed for cyber-crimes are available via deviant Web rings and "floating" sites that never seem to be in the same location twice. One hot spot for Hackers has hit the mainstream—*2600 The Hacker Quarterly*. Once a "rag" that was traded on the university circuit, *2600* has its own URL at *www.2600.com*.

BUILDING IMMUNITY

There are many anti-virus programs available. Symantec, Sophos, McAfee, and F-Secure are just some of the heavyweights of system security. Like other converted conventional thieves who have traded a life of crime in for a steady paycheck as consultants, many rehabilitated hackers have been hired by firms to bolster security. However, you don't have a symposium of "sneakers" (hired hackers) at your disposal in order to assure your computer's safety. Purchasing a virus-protection suite complete with a firewall is usually sufficient and worth the price of updates and software. One cannot stress the importance of updating your virus-protection software. Most company Web sites offer weekly updates that include protection from the latest viral strains.

Unfortunately, no matter how current your system is and no matter how formidable your firewall seems, there always exists the remote possibility of intrusion. No computer is totally protected unless it's never turned on—defeating the reason for owning a system in the first place. Recent news releases have exposed the December 2000 attack on the USAF Space Command's network. *OS/COMET*— the program used to control the movement of U.S.-owned space objects—was "snarfed" (stolen electronically) from a server located within the Mt. Cheyenne complex. It is safe to say that the Air Force uses top-quality protection, but it only takes a bit of ingenuity and a slice of luck to crack into a system.

The only surefire defense is to limit a computer's access to the Internet. A hacker can't gain remote access without an initial connection. If you plan to leave your system unattended, disconnect from the Net. Idle connections are the breeding ground of malicious attacks. Another way of avoiding security breaches is by verifying incoming e-mail sources. It is safe practice to avoid "chain-letters" and forwarded documents with an extensive list of multiple receivers.



Sophos is just one of the many companies who are making a living protecting computers from malicious attacks. Weekly (if not daily) visits to the Sophos URL allow users to update their virus protection and scan the list of the latest viruses discovered.

(Continued on page 46)

REID GOLDSBOROUGH

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Searching For The Best Web Sites Around... Or For Whatever You Need

There's nothing more central to the Internet than looking things up, and there's nothing that changes at Internet speed as much as Internet search sites.

The Internet search industry is in a state of upheaval. Familiar search engines are losing their usefulness, in some cases with top management bailing out. Meanwhile, upstarts are trying to buy your patronage. Fortunately, a few standouts are eminently click-worthy.

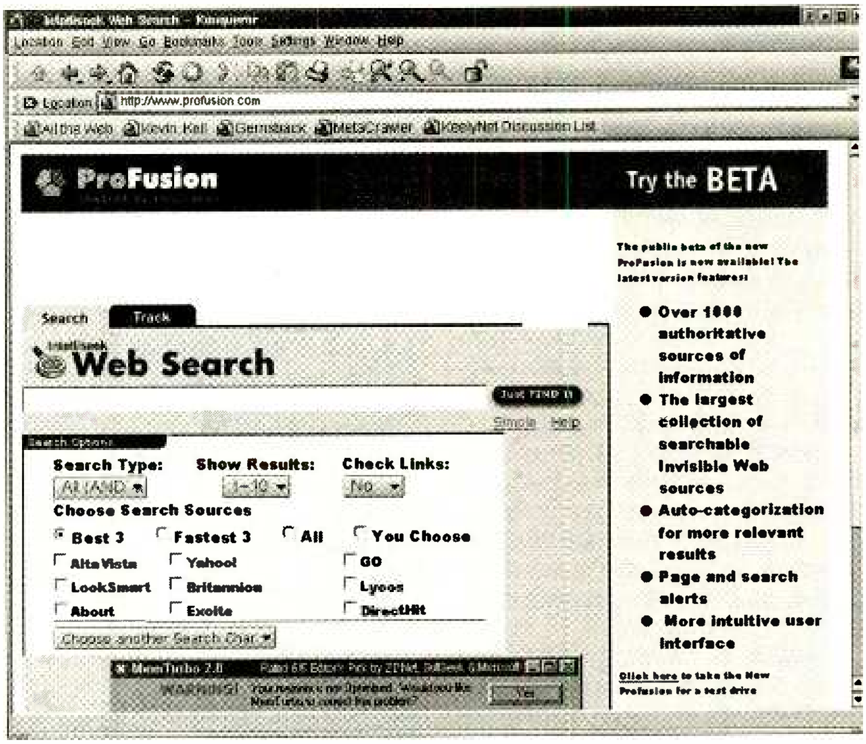
IN THE BEGINNING...

Web old-timers, many still in their twenties, might remember *Yanoff's List*—the first widely used compilation of useful Internet destinations. Created in 1991, it bit the dust in 1995 when overtaken by Yahoo!. First, it made its creators, Stanford University Ph.D. students David Filo and Jerry Yang, billionaires.

Yahoo!, at *www.yahoo.com*, has remained the dominant Web directory, organizing the vast stretches of cyberspace into a semblance of a library card catalog and helping surfers find their way.

Unfortunately, Yahoo! as a search tool has lost its own way recently as the company has diversified into a dizzying array of other Net activities, including—but not limited to—shopping, business-to-business e-commerce, Web e-mail, Web hosting, Web telephony, streaming video, and multimedia software.

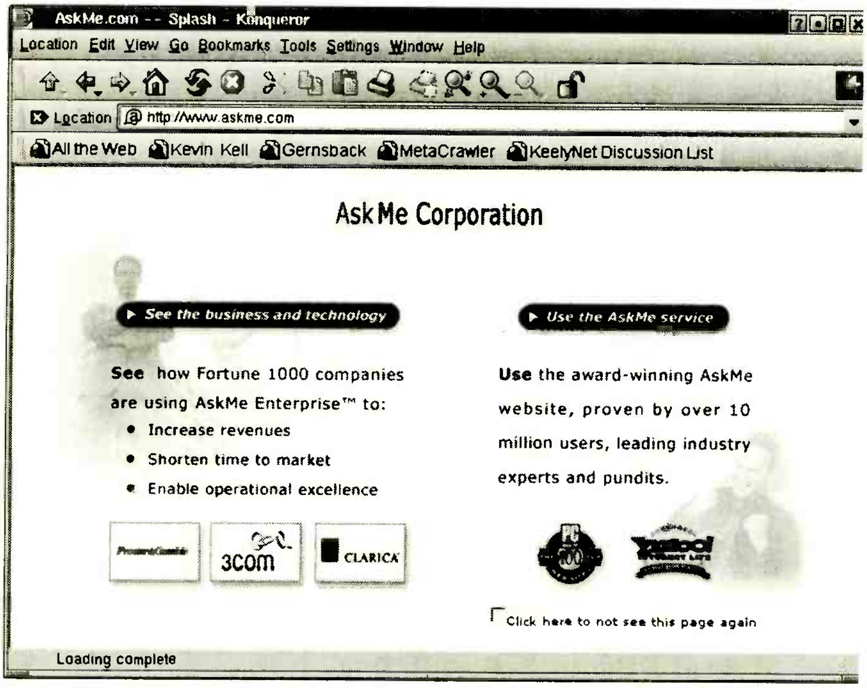
You're better off going elsewhere if you're looking for good Web sites. Many key sites aren't included in Yahoo!'s categories, some of its "Most Popular Sites" are wildly esoteric, and site submissions to it may never show up.



Tired of discovering after the fact that a better Web site wasn't listed on the search engine you just used? Try a "meta" search engine: Your search request is automatically sent to dozens of other search engines. Such sites—like ProFusion shown here—can even strip out the duplication and just show you the top hits.

AND IN THIS CORNER

A smarter choice for browsing categories of sites is a newer service called Open Directory Project, at *www.dmoz.com*. Spearheaded by Netscape (now a part of America Online), it has a database useful enough to be licensed by



Rather than having computers scour the Internet—resulting in hundreds of links that have little to do with the subject at hand—human-generated search engines deliver results that make sense to organic lifeforms.

AltaVista, HotBot, Lycos, and MetaCrawler, among some one hundred other sites.

AltaVista, at *www.altavista.com*, is another early "name" in the Internet search game experiencing a loss of stature. It was the first popular pure search engine, relying upon technology instead of people by sending its automated "spiders" to crawl through the Web and index what they found.

Search engines such as AltaVista were, and still are, better at finding narrowly defined information, while directories such as Open Directory Project and Yahoo! are better at presenting broad categories of information.

Despite its promising start, AltaVista suffered from a dearth of investment early on, and it has been superseded by newer search engines that return more relevant results. Recently, it slashed 25 percent of its workforce, and its CEO resigned.

THE CURRENT "TOP DOG"

The hottest search engine today is Google, at *www.google.com*, officially launched during the fall of 1999. It uses sophisticated technology that returns results based on the number of other URLs that link to specific information on a site. When key domains, such as CNN's, link to a particular page, that's counted more heavily.

The end result: An uncanny ability to turn up what you're looking for.

So confident is Google in its technology that it includes an "I'm Feeling Lucky" option. If you click on that after typing in your search terms, Google will take you directly to the site it feels is most relevant.

This is mostly braggadocio, though tolerable under the circumstances. You're usually better off looking at its list of possible locations, with brief excerpts, before deciding yourself which one you want. Still, the technology works so well that more than one hundred other sites have licensed it.

CHEERING ON THE UNDERDOGS

Some new search engines are trying to gain your surf-time by throwing money at you. The leader

POINT AND CLICK

AltaVista
www.altavista.com

AskMe.com
www.askme.com

Best of the Web
www.pcworld.com/reviews/article.asp?aid=17178

Gold Star Sites
www.zdnet.com/yil/goldstars

Google
www.google.com

iWon.com
www.iwon.com

Media Metrix
www.mediametrix.com

MetaCrawler
www.metacrawler.com

Nielsen//NetRatings
www.nielsennetratings.com

Open Directory Project
www.dmoz.com

Open Directory Best of the Web
www.dmoz.com/Computers/Internet/WWW/Best_of_the_Web

PC Data Online
www.pcdataonline.com

ProFusion
www.profusion.com

Readers Rate the Web
www.zdnet.com/pcmag/stories/reviews/0,6755,2643490,00.html

The Top 100 Family Web Sites
familypc.zdnet.com/learning/reference/feature/100websites

The Top 100 Web Sites
www.zdnet.com/pcmag/stories/reviews/0,6755,2394453,00.html

Web Business 50/50 Awards
www.cio.com/archive/070100_awards.html

The Webby Awards
www.webbyawards.com

Yahoo!
www.yahoo.com

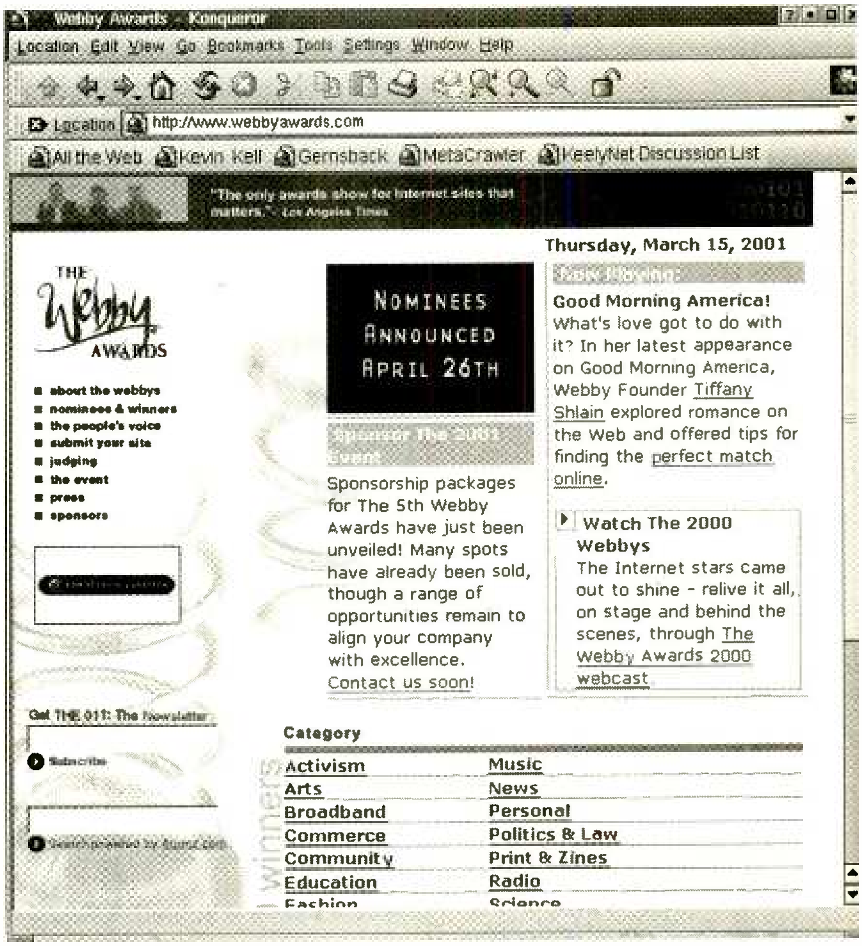
101 Most Incredibly Useful Sites
www.zdnet.com/yil/content/mag/0007/useful_main.html

here is iWon.com, at *www.iwon.com*. Backed by CBS, it has extensively advertised its $1-million-a-month sweepstakes giveaways on television. In aggregating news and other content to encourage users to stick around and read ads, it's better as a "portal" than for research.

So far, iWon's strategy seems to be working—it's now the 21st most visited Web site, according to the latest numbers from Media Metrix. Also, it's true to its word, recently awarding its twelfth million-dollar monthly prize to a New Jersey resident.

Despite recent advances, searching through the Internet's murky depths is still an inexact science; and it sometimes pays to use more than one search engine. You can do this automatically with a "metasearch" site. After you type in your search terms, it sends them out to a number of search sites and compiles the results. The best metasearch sites are ProFusion, at *www.profusion.com*, and MetaCrawler, at *www.metacrawler.com*.

Finally, despite the Web's technological wizardry, sometimes you can't beat the human touch. AskMe.com, at *www.askme.com*, is one of a number of so-called expert sites whose volunteer staffers try to dig up information for you.



Create a truly "award-winning" Web site, and some day you might be able to say, "I'd like to thank the Academy..."

WHO'S THE BEST AND BRIGHTEST?

In just a decade, the World Wide Web has grown from a physicist's research project to a gargantuan marketplace contributing hundreds of billions of dollars and millions of jobs to the nation's economy. Three billion Web pages, according to market research firm Cyveillance, are now out there for your perusal. Some are more surf-worthy than others.

In recent years, a number of organizations, publications, and Web sites have made qualitative designations of the best Web sites. Such designations are necessarily subjective and sometimes idiosyncratic, but useful nonetheless.

If you're looking for specific facts, you're best off drilling down directly with one of the aforementioned search engines. However, if you're browsing categories of information, you're often better off surfing to Web addresses that have been chosen as the best by someone, rather than clicking to URLs listed by portals such as AOL, Yahoo!, or MSN.

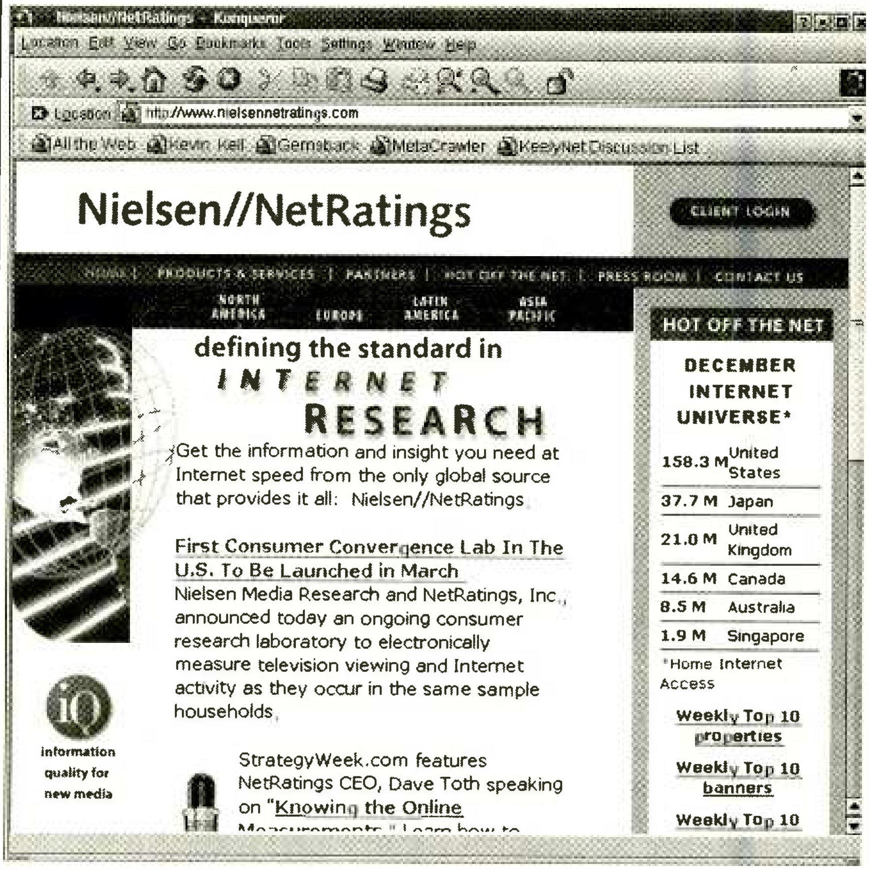
Some domains may be prominently listed by portals solely because they have business relationships with the portal, not because of the quality or comprehensiveness of the content. Here's a roundup of some of the top outfits that have selected top sites. Exploring these selections can be useful not only for the content available but also—if you're in the business of creating Web sites—for getting ideas.

The Webby Awards—Awarded by the 350-member International Academy of Digital Arts and Sciences, the Webbys are the Oscars of the Internet. See who won this year in the 27 categories, from commerce and science to activism and music, at *www.webbyawards.com*.

The Webbys also have a populist component, the People's Voice Awards. This year more than a hundred thousand surfers voted for their favorites.

Best of the Web—The editors of *PC World* magazine, the most widely circulated consumer-oriented computer magazine, identified what they consider the best 64 sites in 32 categories, including career information, Webmaster tools, health, and entertainment. Check out their recommendations at *www.pcworld.com/reviews/article.asp?aid=17178*.

The Top 100 Web Sites—The editors of *PC Magazine*, a biweekly publication targeted toward computer professionals, also published their choices of the best Web sites—100 in 20 categories—from small business services to lifestyle. Read all about it at *www.zdnet.com/pcmag/*



They're more than television. They're more than radio. The world-renowned Nielsen Ratings applies its expertise in the statistical analysis of what's popular to the Web.

stories/reviews/0,6755,2394453,00.html.

Readers Rate the Web—More than 3000 technologically savvy readers of *PC Magazine Online* chose the 53 best Web sites in nine categories, including investments, banking, shopping, and travel. Read their choices at *www.zdnet.com/pcmag/stories/reviews/0,6755,2643490,00.html.*

101 Most Incredibly Useful Sites—*Yahoo! Internet Life*, an Internet "lifestyle" magazine, identified what it considers the 101 best sites in nine categories, from home and shopping to mailing/shipping and automotive. Investigate further at *www.zdnet.com/yil/content/mag/0007/useful_main.html.*

Each month, the magazine also publishes a list of "Gold Star Sites" in a particular category. Recent categories include e-business, health, getting expert advice, trip planning, and finding a job. It's all at *www.zdnet.com/yil/goldstars.*

The Top 100 Family Web Sites—The editors of *FamilyPC*, a magazine targeted toward home-computer users, selected what they consider the best sites in 36 categories, including patenting, genealogy, food and drink, beauty, kids, and seniors. You can find out more at *familypc.zdnet.com/learning/reference/feature/100websites.*

Web Business 50/50 Awards—*CIO* magazine, a computer publication for chief information officers and other business people, recognized 50 business-oriented Internet and 50 internal intranet sites for excellence in the categories of business-to-business, business-to-consumer, small company, start-up, and nonprofit. Read who won at *www. cio.com/archive/070100_awards.html.*

In addition, there are lots of Web sites that select best pages. The Open Directory Project lists 184 of them at *www.dmoz.com/Computers/Internet/WWW/Best_of_the_Web*, including 93 that offer award designations and 32 URLs that review other sites.

Though popularity and quality don't necessarily go hand in hand, you may also find it useful to uncover the most popular sites—as a whole and in given categories.

Nielsen//NetRatings, at *www.nielsennetratings.com*, provides lots of statistics about the Web, including the top ten Web properties in terms of usage ("properties" encompass multiple sites owned by the same company). Media Metrix, at *www.mediametrix.com*, offers a listing of the 50 most popular Web properties in the U.S. and globally, as well as a listing of the 500 most popular ones. PC Data Online, at *www.pcdataonline.com*, publishes a list of the top 100 Web sites and the top 50 Web properties, according to the number of unique visitors and the "reach"—the percentage of the total Web population that visits.

COMPUTING WITH LIGHT

KENNY A. CHAFFIN

Squeezed light, holograms, and lasers sound like things you'd find in a science-fiction novel, but they can also be found in the labs around the world where they are used in the "thinking" machines of tomorrow—optical computers. Since they are based on light-wave technology, optical computers can process information a million or more times faster than electronic computers. They are inherently parallel processors and almost completely immune to interference.

Optical computers use laser beams in place of wires. Unlike wires, laser beams can cross and intersect without affecting one another. Furthermore, multiple beams can converge on a single switching point with any combination of one or more beams triggering the switch. An electronic equivalent of such a multiple-input switch is much more complex. Optical computers have all these advantages because of the fundamental nature of light.

Photons. Quantum theory tells us that light has the properties of both waves and particles. When discussing its particle nature, we call the particles "photons." However, because of light's wave-like properties, photons can do things that are impossible for typical particles—such as electrons. For example, thousands of photons can pass through a single point simultaneously without interfering with one another. Photons can also travel faster than electrons, which makes faster computational speeds possible.

Are the days of electron-based logic coming to a close? Scientists are now turning the job of computing over to beams of light.

As we'll discuss later on, light can also be used to represent information in many *different* ways. For example, one could modulate the brightness (photons per second) of a beam of light, which would produce an amplitude-modulated signal (AM) for analog computing. AM signals can also be used to transmit binary data—you just need to define a brightness threshold to represent a one and another to represent a zero. Furthermore, we can frequency-modulate (FM) light. Changing the frequency is equivalent to changing its color. More advanced methods of light manipulation—like "spatial modulation" and holograms—will be discussed later. All these intriguing possibilities have been tempting scientists since the 1950s, but the technology to support them only began to appear during breakthrough research dating back to the eighties.

The Early Days. The early optical-computer research in the 1950s was performed using mercury-arc lamps and sunlight. The method proved less than effective. Today, the laser (invented in 1960) is the key to optical computing. A laser produces a single coherent beam of light (all the light has the same frequency, energy phase, and direction) that is used to transmit optical information in a concise, coherent, and controlled manner.

The first laser used a ruby crystal rod. Ruby crystals emit photons when stimulated by a powerful flash of light. A ruby laser is made by using a ruby rod with a mirror on one end. A partially reflective mirror covers the other end. The mirrors help establish and direct the beam emitted by the rod.

Unfortunately, the first lasers had some drawbacks.

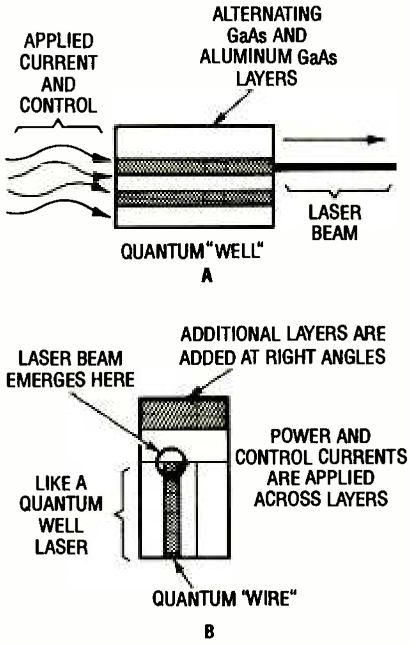


Fig. 1. The quantum-well (A) and quantum-wire (B) lasers are quantum-effect devices that take advantage of the physical layout of semiconductor layers to produce light.

They were bulky, needed lots of power, and generated a great deal of heat. The major problem in using them for computation was the lack of a practical optical-switching device. IBM was one of the first companies to explore optical computing using this young technology. They spent over four years and $100 million (1960s dollars) trying to develop a practical optical computer. Because of the energy, cooling requirements, and unreliability of the early switching devices, they finally abandoned the project. Various attempts at building optical computers over the next twenty years had some small successes, but the real advances had to wait for optical switches and semiconductor lasers.

Modern-Day Lasers. Since the original ruby lasers, many other lasers have appeared. Helium neon (HeNe) lasers are the most popular because they are relatively cheap. Carbon dioxide lasers—the result of weapons research—are among some of the most powerful newer lasers.

The problem with most of these lasers is that they are somewhat large. An optical computer may need thousands or even millions of controlled laser beams. We can create them by splitting a single beam into as many beams as necessary, but that is a messy approach. A better solution is provided by the semiconductor laser.

The first semiconductor lasers worked by applying a current through the alternating layers of gallium arsenide (GaAs) semiconductor material. The steadily moving electrons generate in-phase photons, which emerge from the edge of the layered semiconductor material as a coherent laser beam.

More recent semiconductor lasers take advantage of quantum effects that result from the physical layout of chip layers. This technology has given us "quantum-well" lasers (see Fig. 1A). Although these laser chips put out only a few milliwatts of power, they are useful in CD players, laser-based "tape measures," and optical telephone circuits.

One step beyond the quantum-well laser is the quantum-wire laser (see Fig. 1B). Quantum-wire lasers are composed of alternating layers of GaAs and aluminum gallium arsenide (AlGaAs). These efficient diode lasers are smaller and more powerful than their predecessor—producing about 10 milliwatts of output power. Optical computing requires this greater power because the beam must be sufficiently strong even after it is split.

The problem with quantum-wire lasers is the expensive cost of growing the zero-dimensional wires found in the AlGaAs lasers. A typical array consisting of four micro-lasers can cost upwards of $50,000. The price should fall dramatically in the near future with improved manufacturing techniques and larger quantities. Scientists in Japan's Basic Research Labs have predicted that quantum-wire lasers should be able to switch on and off at rates up to 100 GHz.

One Optical System. As mentioned earlier, there are many basic methods of sending signals by light. The simplest technique is to simply turn it on and off, like Morse code. As previously stated, the presence of a beam could denote a one and its absence a zero.

That is the binary method used in the most widely known optical computer, built at AT&T Bell Labs by Alan Huang. Let's look at how he and his colleagues built their optical computer, and then we'll discuss some other approaches. You may even get some ideas for experiments along the way.

Huang has been working in the optical computer field for over thirty years. When he started thinking about optical computers, lasers and semiconductor chips were both relatively new developments. In the beginning, he had to work with crude technology. Then, he needed to wait for many new developments to occur such as better lasers, ICs, and the optical switch.

The switches, known as *S*elf *E*lectroptic-Effect *D*evices (SEEDs), are key to the computer's operation. A control laser beam turns each switch on or off. The switch controls the passage of a second

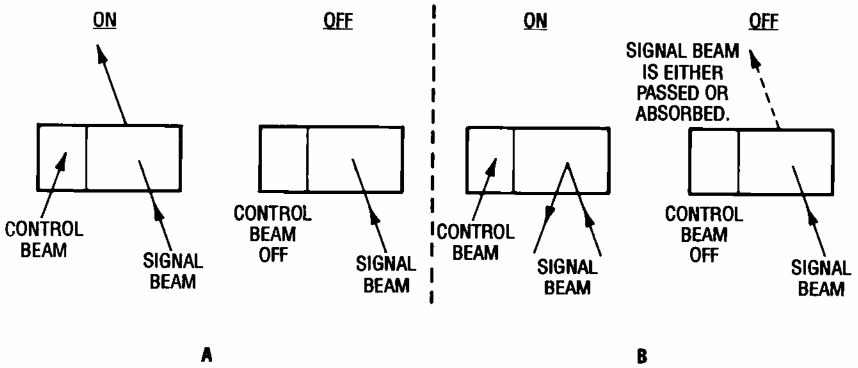


Fig. 2. There are two main types of optical switches: transmissive (A) and reflective (B). Both of them can keep a beam from traveling to a particular destination, but a reflective switch can redirect the beam to a new destination.

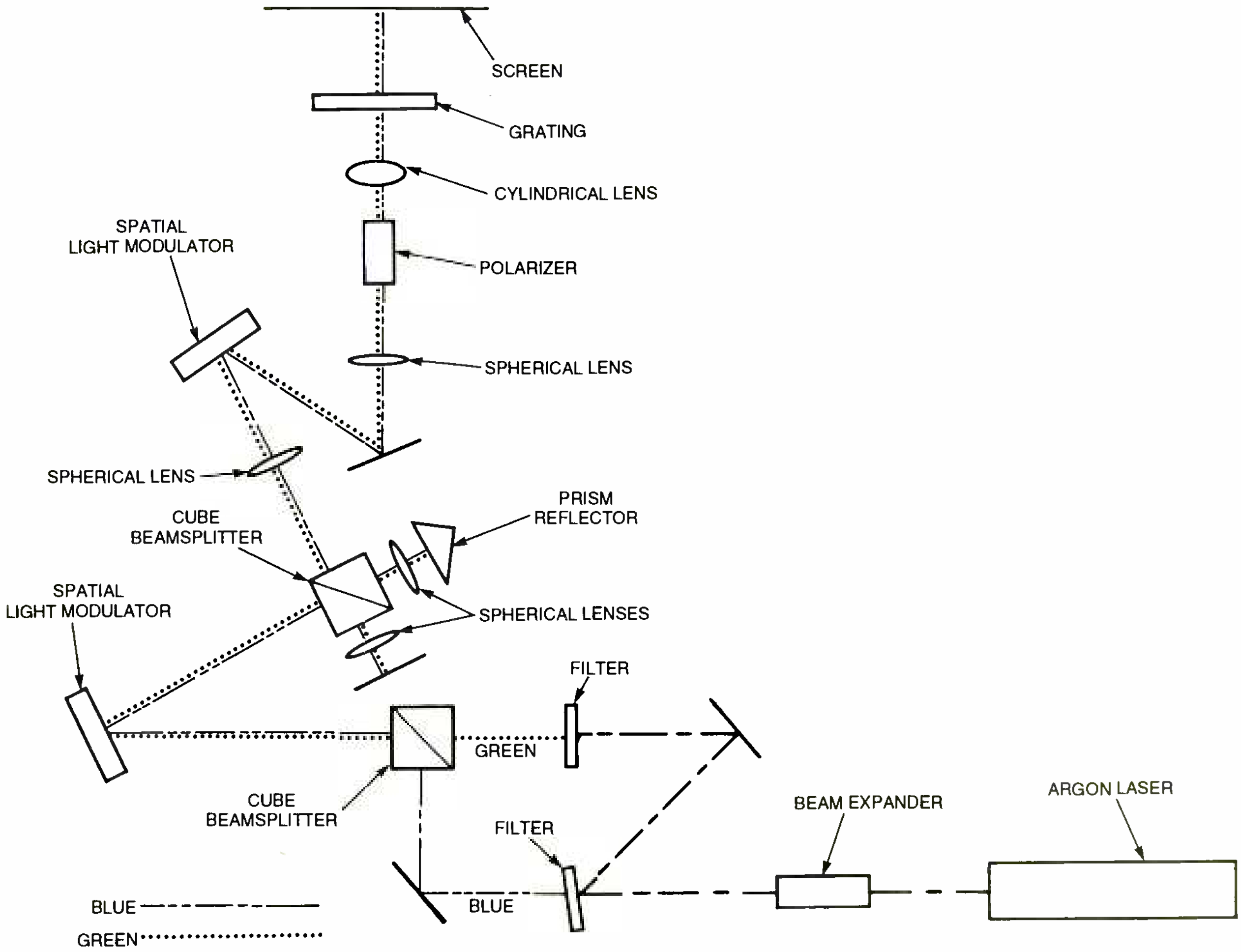


Fig. 3. A pair of reflective spatial-light modulators redirects the blue-green light of an argon laser after it passes through a cube beamsplitter.

laser beam—the signal beam—based on the presence or absence of the control beam.

There are two classes of optical switch: transmissive and reflective (see Fig. 2). A transmissive switch (Fig. 2A) either blocks the signal beam or allows it to pass to its destination. A reflective switch (Fig. 2B) reflects the signal beam to a destination or prevents it from getting there, either absorbing it or permitting it to pass through to somewhere else.

Regardless of its type, when a switch is on, the signal beam can continue to travel. When it's off, the signal beam is stopped, so a SEED acts exactly like a transistor in an electronic computer. In fact, an optical computer works like any other computer; it just uses the optical switches and laser beams in place of transistors and electric currents, respectively.

Although David Miller (also of Bell Labs) developed the switches in 1986, it still took five years to build an optical computer. Alan Huang and twelve colleagues built an optical computer at Bell Labs early in the nineties. It has 8000 optical switches—each one only ten micrometers (.00004 inch) wide. Huang's optical computer uses only a small percentage of its thousands of switches. For now, it only counts, but even that is significant for a completely optical computer. It has proven the theory behind optical computing.

Huang's computer uses the SEED switches connected as NOR gates to form two eight-bit counters. Each NOR gate has a switching time of one nanosecond. That compares favorably to electronic NOR gates that switch at between 5 to 50 nanoseconds.

The computer also uses two ten-milliwatt lasers and various lenses, beam splitters, and pattern masks. Optical computers have one problem that electronic computers do not—alignment. You can't do much computing if a beam misses a switch, and it takes considerable work to line up all the beams precisely. Alignment difficulties are among the reasons Huang's computer only uses a part of its capability. That isn't a problem in a standard computer since the electrons travel within conductors—mask registration difficulties during IC wafer fabrication not-withstanding. Once an IC chip is built and tested, it will always work without worry of further alignment adjustments.

As we said, the AT&T computer is a straightforward reproduction of existing computer architecture on a different medium—light. There are other ways of using light to compute; let's look at some of the alternatives.

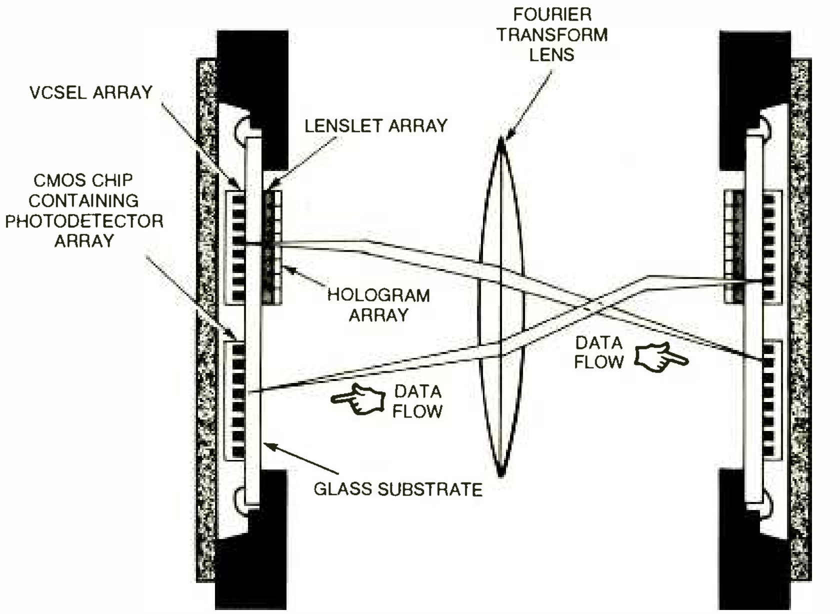


Fig. 4. Smart-Pixel Arrays are the latest in laser parallel ports. This diagram illustrates the data flow of light between two systems in an optical network. A laser array works in unison with a hologram array in order to direct light towards specific inputs of a photodetector array.

Spatial Light Modulators. Spatial Light Modulators (SLMs) take advantage of light's unique properties. They direct multiple beams in multiple directions to permit parallel-processing operation. SLMs are like a cross between a piece of photographic film and a Liquid-Crystal Display (LCD). They are made up of many tiny squares, and electronics or light controls each square. A square allows some, none, or the entire signal beam to pass.

One of their primary uses is pattern matching. An input signal controls one SLM. The result comes from comparing its output to a second SLM controlled by the computer. This method can determine exact matches or near misses. It also gives the answer, literally, at the speed of light, allowing for easier and faster "fuzzy-logic" matching than today's computers.

Like other optical switches, SLMs can be either transmissive or reflective. The transmissive type either passes or stops the light. The reflective type either reflects or absorbs (redirects) the light. The reflective type requires beam splitters to direct the reflected light (see Fig. 3).

As mentioned, SLMs can store reference patterns. These patterns might be actual images, numbers, or any other encoded information. They can hold binary numbers by encoding them positionally along the squares. With proper encoding and positioning, they perform extremely fast mathematical calculations. Using two SLMs and passing light through their associated squares allows them to add, subtract, multiply, or divide. The nice thing is that the calculation takes place immediately regardless of the length of the number. In a digital computer, calculations usually take a considerable amount of digit shifting and manipulation. An optical computer calculates the entire number simultaneously. It's only limited by the number of squares and the complexity of the SLM.

Using Holograms To Compute. Holographic computers work similarly to SLMs, but with greater accuracy. Such computers can compare a holographic image with a reference hologram. The reference hologram must be created specifically for the task and can be either computer generated or created from real-world input, such as an image or other signal. Refer to the sidebar for some more information on holograms.

To use a holographic computer, you apply a holographic input signal to the reference hologram, which is used as a filter. The resulting light pattern is usually monitored by a charged-coupled device (CCD) array. The CCD is a digital-imaging unit, like a television camera, that is used for optical imaging in camcorders, telescopes, and other devices. A CCD produces a digital output representing any image focused on its surface. This combination of holographic filtering and CCD matching and monitoring can identify faces, fingerprints, or parts on an assembly line.

Holograms are also being used to aid in data transfer and storage. Smart-Pixel-Array (SPA) modules use hologram arrays to help direct light sent by tiny Vertical-Cavity Surface-Emitting Lasers (VCSEL). Researchers at the University of Colorado at Boulder are currently working with SPA-modules for their ongoing optical-computer research (see Fig. 4).

A BRIEF HISTORY OF HOLOGRAMS

In 1947, Dr. Dennis Gabor developed the theory of holography while trying to improve the resolution of an electron microscope. Until the invention of the laser in 1960, no coherent source of light existed for the creation of holograms. Only four years after the creation of the laser, Emmett Leith and Juris Upatnieks created the first laser-hologram entitled "Train and Bird." The basic equipment has not changed from that day—a continuous wave laser, optics (lens, mirror, and splitter) for directing the light, a film holder, and an isolation table for exposing the subject to laser bombardment.

In 1971, Dr. Gabor received a Nobel Prize for his discovery. By that time, holographic art was flourishing and there were techniques that made it possible to view the images under white-light conditions. Over five decades have passed since the birth of holography, and, like all major breakthroughs, holograms have found themselves absorbed by the mainstream. Even bulk-mail advertising employs holograms as a flashy eye-catcher. Credit cards, UPC scanners, and heads-up displays—all of these use holograms. The latest advance in holograms is the use of blue-green laser light to record an image on a polymer called azobenzene. The process takes a matter of nanoseconds and requires no chemical processing—instant holograms! Holograms created from this method may one day be used to form waveguides for blazing optic switches.

Optical Storage. While the Bell Labs' computer has no significant storage capacity, the capability of optical storage is enormous. The commercial Compact Disc (or CD) can store about 650 megabytes of optical information with some CD recorders pushing the limit to 700 megabytes. Furthermore, that is by no means near the physical limit of optical storage. Experiments at the University of California at Irvine are approaching the true limits. They have shown that the theoretical storage density of a two-dimensional medium, like a CD, is about 350 megabits per square centimeter. This means a CD could hold about 44,000 megabits or about 5.5 gigabytes. That is the equivalent of 10 standard CDs. DVD discs have realized that density. One layer weighs in at 4.7 gigabytes.

Even that isn't the true limit of optical storage. The DVD specifications allow for two "layers" per surface. By focusing the laser deeper into the disc, a second "disc" becomes visible. Today's hardware is designed for eventual double-sided (top and bottom), double-layered discs. The four-layer "sandwich" will top out at a whopping 17 gigabytes. If we go to three-dimensional optical cubes, we can store 6500 billion bits per cubic centimeter. A handful of these cubes could easily hold the equivalent of the Library of Congress. Combining this type of storage with the speed of light for retrieval and processing will provide some significant technological achievements.

Quantum Limits. According to the Heisenberg Uncertainty Principle, the more you know about the position of a photon in time and space, the less you'll know about its mass and energy. Since a laser beam consists of photons that have approximately the same energy and frequency, we know the energy of the photons pretty well. That limits the certainty with which we can know where a particular photon is in space.

Because the most we can say about a photon's location is that it will be within a given area, we must allow for detection of photons over the entire area. That limits the minimum size and the applications of optical devices. Even so, the limit is so small that it is usually not a problem. By the time we reach the point where we must deal with the positions of single photons, we may have completely new computing methods or have learned enough that the uncertainty doesn't matter.

Scientists are using "squeezed light" to reduce some of the uncertainty. They do this by controlling a laser beam to create areas of greater uncertainty at certain points along the beam. Since the overall uncertainty is conserved, this process results in areas with lower uncertainty elsewhere in the beam. In other words, there are points along the beam where the photons are restricted to a smaller area than average; we are more certain where they are. By increasing most of the uncertainty in a particular area, we can work more precisely with the remaining areas.

Researchers in Colorado have managed to steer rubidium atoms through fibers as narrow as 10 microns. Advances in particle control may lead to the "painting" of circuits on an atomic scale—something far more practical than IBM's demonstration of writing the letters "IBM" with individual gold atoms.

The Optical Future. One of the holy grails of computing is artificial intelligence. A machine that can think like a human has been sought since before the beginning of the computer age. Recent neural-network research shows promise in that vein. It attempts to mimic the way neurons are connected and operate in the brain, but it is restricted by today's computer technology. One of the problems is duplicating the millions of parallel connections that exist between real neurons as well as imitating neurons' analog nature (see the sidebar for more information on neural networks).

Optical computing may overcome those limitations. Holographic and SLM techniques may give us the parallel and analog capabilities needed to mimic the brain. If so, optical computing will lead to true artificial intelligence and take us one giant step into the future.

However, the future of optical computing is still questionable. If optical computers are to become standard, they must be faster, better, and/or have significantly unique ability. Better is probably out of the question because of the critical alignment needs—an electronic computer is better from a maintenance and manufacturing viewpoint—at least for now. Today's computers are faster right now, but as semiconductors become smaller and chip designers begin taking advantage of quantum effects, speed may not be an issue in the future. The real advantage of optical computers will come from their special abilities: holographic storage and processing. The high capacity of three-dimensional storage and the non-interfering qualities of light are the keystones of optical computing and may help it overtake electronic technology.

NEURAL NETWORKS

Computers that learn are no longer characters in science-fiction novels. Major organizations have been funding research in the field of neural networks. As the name implies, neural networks are meant to mimic the operation of the neurons within our brain. The result is a mesh of tiny switches that exist in a spatial environment where (theoretically) parallel communication is possible in the direction of any of the three freedoms (x, y, and z axes). Information is passed along carriers of light waves at speeds pushing the envelope of the microwave-band frequencies. Neural networks can be used to control self-assessing assembly lines, replace deteriorating portions of a living brain, and serve as the AI (*A*rtificial *I*ntelligence) for an android.

Don't search the Web for an android just yet. Work in the field of neural networks is still in a highly experimental stage. Most of the work until now has gone into computer simulations rather than actual physical models. Those test systems are designed to recognize patterns in numbers. As computers begin to pick out patterns in data flow, the machines actually develop a memory of their own—the process of learning! It seems that neural networks, like most computer technologies, have to be developed from the ground up—no short cuts. Today's neural node struggling in a lab to count to one trillion by radicals of sixteen might be, in a decade, able to balance a budget for a nation.

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THE LASER CLINIC

SKIP CAMPISI

Here are five practical circuits that can be utilized as design guides for powering up your own laser, along with some tips on optical-beam collimation.

If you're like me and a lot of other hobbyists out there, you've probably succumbed to the tempting low surplus price of at least one laser tube or laser diode. After all, how could we resist? The pleasure of building our own operational laser system guarantees us a spot in the "high-tech" realm of our hobby, especially when impressing the uninitiated!

As you've probably since discovered, it might also have been a very wise idea to obtain the appropriate power supply along with the laser—something that always seems to get neglected. Having 20/20 hindsight is always wonderful! However, the laser is still collecting dust due to a lack of driver-design information on using off-the-shelf components. This article will teach you methods of using readily available, standard, parts to get your laser up and running quickly without spending a fortune.

We're not going to discuss laser-operating theory here—just the "nuts and volts" required to make them lase. We'll also have a look at using lenses to optically collimate the laser beam and at methods for heatsinking diode lasers. If you'd like to look more in depth at the subject of lasers, there are many good books available. Among them is *The Laser Cookbook* (published by TAB Books) by former **Poptronics** columnist Gordon McComb.

He-Ne Laser Tubes. We'll start our discussion with our old friend the Helium-Neon (He-Ne) laser tube, which requires the most difficult (and dangerous!) power-supply design. The high voltages necessary for plasma generation are usually beyond the average hobbyist's design capabilities, and high-voltage components are expensive and difficult to obtain. But, fear not! There is always another suitable method available.

Several years ago, I purchased a He-Ne laser tube from MWK Industries *without* the supply. It was their part number RO99 and was rated at 1 mW at 3.7 mA when using a 1230-volt DC supply. MWK recommended an 8- to 10-*kilovolt* (that's right: 10,000 volts!) ignition to light the plasma. Referring to Fig. 1, you'll see the circuit I finally designed from what I had on hand, which functioned perfectly.

The first problem was deciding whether to use a battery supply or straight AC from the wall socket. Many good 12-volt DC-operated laser supplies exist in surplus; however, they are somewhat "current-hungry" and soon run your battery down. Powering one of these supplies with an AC adapter is rather redundant, so I decided to "cut out the middleman" and design a straight AC supply. Of course, that meant finding an appropriate high-voltage transformer—not an easy task!

Luckily, I had a 450-volt, 30-mA AC transformer (T1) on hand. Similar types might still be available from electrical supply houses, but could take a little digging to locate. An alternate method is to use two 230-volt, 25-mA AC units: Wire the secondaries in series, with the 120-volt AC primaries in parallel. The Magnetek FP230-25 "Flat-Pack" transformers (Mouser number 553-FP230-25) are "hi-pot" tested at 2000 volts AC, and they should be ideal. Those devices just mentioned are PC-mounted types.

WARNING: Laser radiation is dangerous and can cause **permanent** eye damage. Avoid direct or **reflected exposure.** The voltages used in this project are hazardous and can be lethal. Have a partner work with you when building and testing this system.

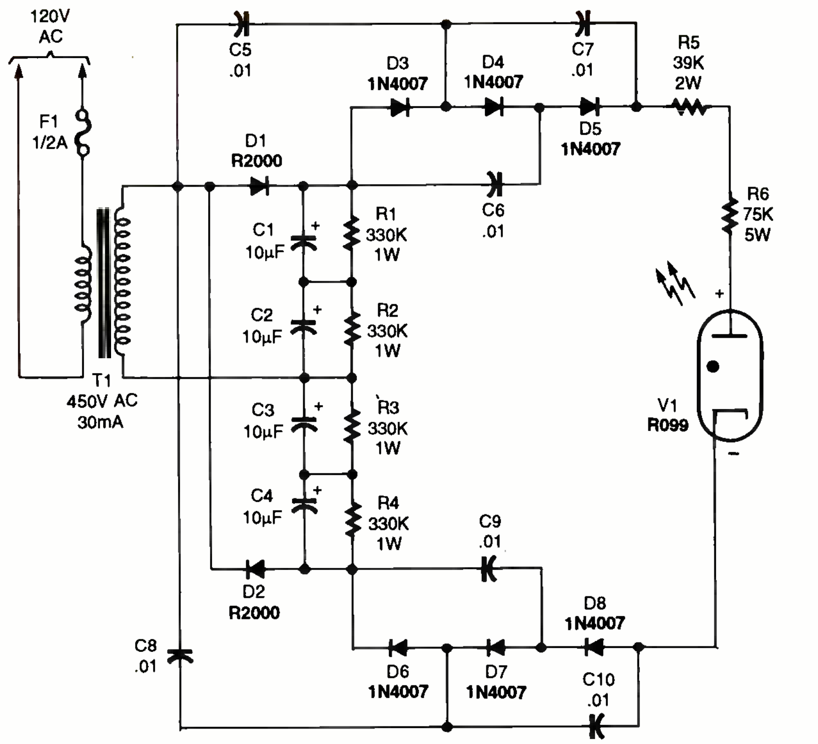


Fig. 1. This line-operated He-Ne laser power supply provides automatic high-voltage plasma ignition upon startup.

PARTS LIST FOR THE HE-NE TUBE DRIVER (FIG. 1)

SEMICONDUCTORS

D1, D2—R2000 silicon rectifer diode, 2000 PRV
D3–D8—1N4007 or 1N5408 silicon rectifier diode, 1000 PRV

RESISTORS

(All resistors are 5% units unless otherwise noted.)
R1–R4—330,000-ohm, 1-watt, carbon-film
R5—39,000-ohm, 2-watt (see text)
R6—75,000-ohm, 5-watt (see text)

CAPACITORS

C1–C4—10-µF, 450-WVDC, aluminum electrolytic
C5–C10—0.01-µF, 1000-WVDC, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

F1—½-amp fuse
T1—120-volt AC primary/450-volt AC, 30-mA secondary step-up transformer
V1—MWK type RO99 He-Ne laser, 1-mW
Terminal strips, heatsink material, lenses, enclosure, fuse holder, wire, hardware, etc.

Transformer T1's actual open-circuit output measured about 550 volts AC, and adding a well-filtered doubler yielded about 1500 volts DC unloaded. Using a dummy" load (drawing 3.7 mA) resulted in a 1375-volt DC output, which is typical for low-current transformers. The laser tube came with a 75,000-ohm, 5-watt ballast resistor (R6), which, at 3.7 mA, drops about 280 volts. Thus, the tube drops 1230 - 280, or about 950 volts at 3.7 mA. We need to drop an additional 145 volts (1375 – 1230) with R5 to maintain the tube voltage. A 39,000-ohm, 2-watt resistor was selected to drop 145 volts at 3.7 mA. Use a similar technique to select your ballast resistors. The higher-than-expected power ratings are necessary due to the high ignition voltages.

The doubler itself is comprised of D1, D2, CI-C4, and RI-R4. Use "R2000" diodes (devices with a 2000-volt peak-reverse-voltage, or PRV, rating) for D1 and D2; 10-µF, 450-WVDC capacitors for C1-C4; and 330,000-ohm, 1-watt resistors for RI-R4. For the sake of safety, all of the components (except T1 and the tube) were mounted on barrier-terminal strips using test-probe wire for all of the interconnections. Once you have the doubler working and have selected R5 and R6, you may proceed with the ignition multiplier.

NOTE: After removing power from the circuit, make sure that all of the capacitors are discharged before making any circuit adjustments. The charged capacitors present a shock hazard that could be harmful or lethal.

The remaining six diodes (D3–D8) and six capacitors (C5–CI0) comprise the high-voltage ignition circuit. Each diode/capacitor "cell" provides an additional 750 volts, totaling 4500 volts for the six cells used. Add that to the 1500 volts from the doubler, and the tube will see 6000 volts when power is first applied. This was sufficient to ignite the plasma in my tube; you may add more cells (if needed) for yours. Diodes D3–D8 can be either 1N4007 or 1N5408 units (1000-volt PRV rating), with 0.01-µF, 1000-WVDC ceramic capacitors used for C5–C10. Install those components on barrier strips, also.

Once the plasma is ignited, the supply voltage drops rapidly down to its 1375-volt level, due to the small values of C5–C10 as compared to CI–C4. The laser tube should now be drawing its normal 3.7 mA. To monitor that current, you may simply install a 5-mA analog panel meter in series with the laser's cathode supply lead. For best operation, the anode lead from the laser to the ballast resistor should be as short as possible, say, less than three inches. Note that this particular tube emits the beam from its anode aperture. Check yours to be sure! If you haven't figured it out yet, the cathode end of the laser tube contains most of the metal in the form of a "cage." The anode end is mostly empty glass, with the "capillary" tube running down the central axis.

The output beam from a He-Ne tube typically has very low divergence and can easily be focused to a small point with a simple, convex lens. On the other hand, if you want to project the beam for long distances, it will be necessary to eliminate the initial divergence as much as possible. First, use a short-focal-

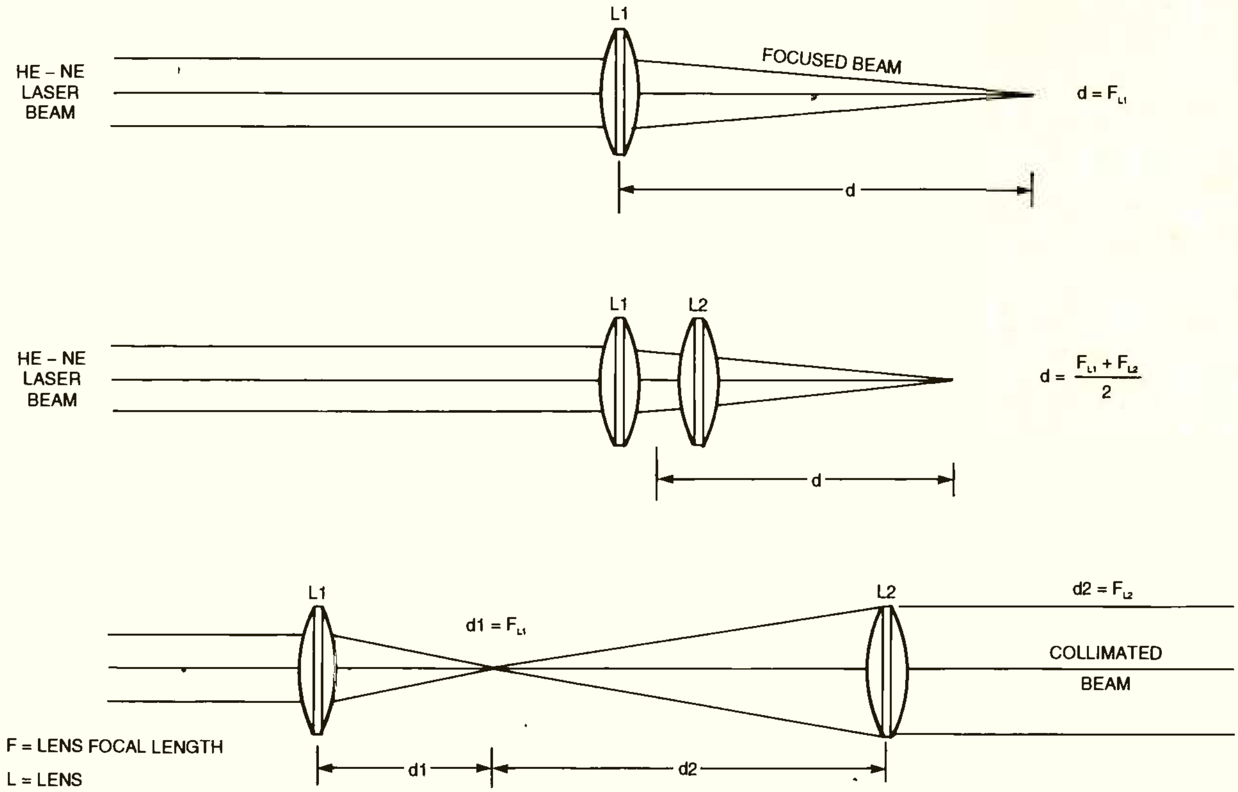


Fig. 2. Collimation and focusing of laser beam emission is quite easily accomplished using short focus (over ½ inch) small diameter glass or plastic lenses. If you require shorter focal lengths, stack two similar lenses back to back—the effective focal-length is then halved.

length convex lens to focus the beam to a point. Place another convex lens (about two to five times the focal length of the first lens) ahead of the first lens as shown in Fig 2. Adjust the spacing of the lenses to provide a parallel output beam. Have fun, but be super-careful with this laser system!

Semiconductor Lasers. So far, there are two basic types of laser diodes in use: *s*ingle-*h*eterostructure (SH) and *d*ouble-*h*eterostructure (DH) varieties. All require a heatsink of some type, and usually we have to determine the pinouts and polarity ourselves. To obtain a usable beam from them, we also need some sort of collimating optics to focus their diverging (and elliptically shaped!) outputs. The older SH-injection lasers were originally operated at cryogenic temperatures to ensure reasonable operating lifetimes. If you apply continuous operating current at ambient temperature to one of these, it'll simply explode! We'll be exploring the *pulse mode* type of operation for the SH laser. On the other hand, the DH laser has much lower output power and can be operated either in its continuous (CW) or pulse-mode operation at normal ambient temperatures.

A note of caution here: All diode lasers are electro*s*tatic *d*ischarge (ESD) sensitive and easily damaged from static discharge. Use the same handling techniques with the diodes as you would with CMOS ICs.

Single-Heterostructure Laser. Most lasers available to the hobbyist in the surplus market only provide outputs in the milliwatt range. However, the SH diode's output is measured in watts, and the operating currents are in amps—thus, the need for cryogenic cooling or pulsed operation at ambient temperatures. Those high currents make pulsed operation a real chore, as you'll soon see.

My driver circuit was designed around a LASD59 laser diode, which is similar to RCA's 40861. This laser has an invisible 904-nm (infrared) output beam rated at 5 to 9 watts, with a threshold current of 10 amps. The maximum pulsed operating current is 40 amps, with a maximum pulse width of 200 ns and a maximum duty cycle of 0.1%. The circuit illustrated in Fig. 3 achieved those criteria. The circuit oscillates at about 4 to 5 kHz, providing a 20–25-amp current pulse to the laser with a duration of about 50–100 ns—a safe region for this particular diode.

The waveshape of the current pulse is extremely critical, and any current "under-shoot" can damage the laser. I elected to base the current-switching section of my de-sign on a circuit designed by the "original guru" himself, Forrest M. Mims. This one appeared in the October 1971 issue of **Popular Electronics.** In that article, he explained an excellent method for using a transistor (Q1) operating in its "avalanche-breakdown" mode to supply the correct current-pulse waveform to the diode.

Once again, I chose an AC-outlet power for the supply. In this case, a standard "cube" adapter (T1),

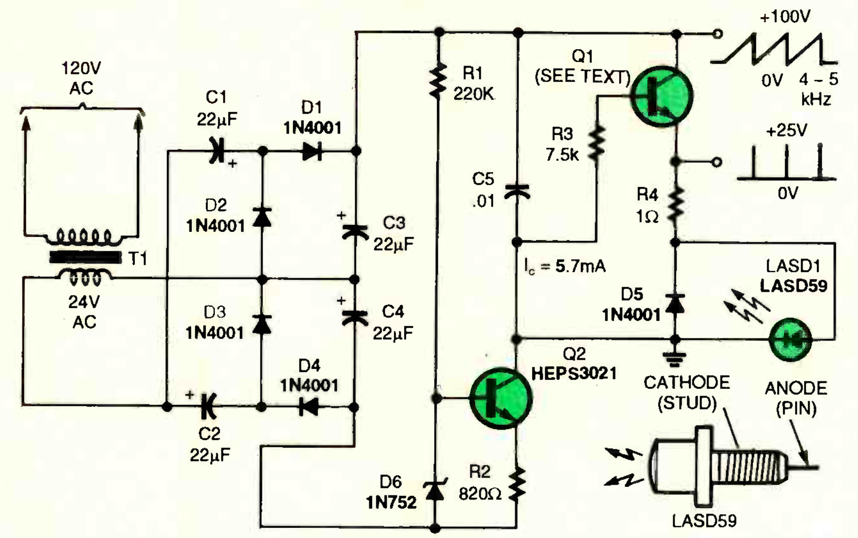


Fig. 3. The single-heterostructure laser diode requires special high-current pulse circuitry when operating at normal, ambient temperatures.

rated at 24-volts AC and 100 mA, drives a full-wave "quadrupler" with an output of about 120 volts DC. I used 1N4001 diodes for D1–D4; 22-μF, 50-WVDC capacitors for CI and C2; and 22-μF, 100-WVDC capacitors for C3 and C4. An HEPS3021 transistor was selected for Q2, configured as a 5.7-mA constant-current sink, along with R1, R2, and D6. Any NPN-type medium-power transistor with a rating of 1 watt and a V_{CE} of 150 volts or more can be used for Q2. Diode D6 is a standard 5.6-volt, ½-watt Zener diode.

Assemble all of the above power-supply components on a small piece of perfboard (except for T1) and attach a heatsink to Q2. Before you begin assembling the driver itself, Q1 must be hand selected for the proper breakdown voltage. **Note: Q1's collector—and thus its case and heatsink—is a high-voltage terminal and poses a shock hazard.** Capacitor C5 should be a 0.01-μF, 250-WVDC Mylar capacitor, with D5 a 1N4001 diode. Additionally, R4 should be a 1.0-ohm, 1-watt carbon or carbon-film resistor only.

Put R3, R4, C5, and D5 on a solderless breadboard, leaving holes open to properly

PARTS LIST FOR THE SINGLE-HETEROSTRUCTURE LASER DRIVER (FIG. 3)

SEMICONDUCTORS

LASD1—LASD59 laser diode, 5–9-watt, SH type
Q1—TO-5/TO-39 metal-can transistor (see text)
Q2—HEPS3021 NPN silicon transistor
D1–D5—1N4001 silicon rectifier diode
D6—1N752 silicon Zener diode

RESISTORS

(All resistors are ¼-watt, 5% carbon-film units unless otherwise noted.)
R1—220,000-ohm
R2—820-ohm
R3—7500-ohm
R4—1.0-ohm, 1-watt

CAPACITORS

C1, C2—22-μF, 50-WVDC, aluminum electrolytic
C3, C4—22-μF, 100-WVDC, aluminum electrolytic
C5—0.01-μF, 250-WVDC, Mylar

ADDITIONAL PARTS AND MATERIALS

T1—24-volt AC, 100-mA AC wall-mounted adapter
Terminal strips, heatsink material, lenses, enclosure, wire, hardware, etc.

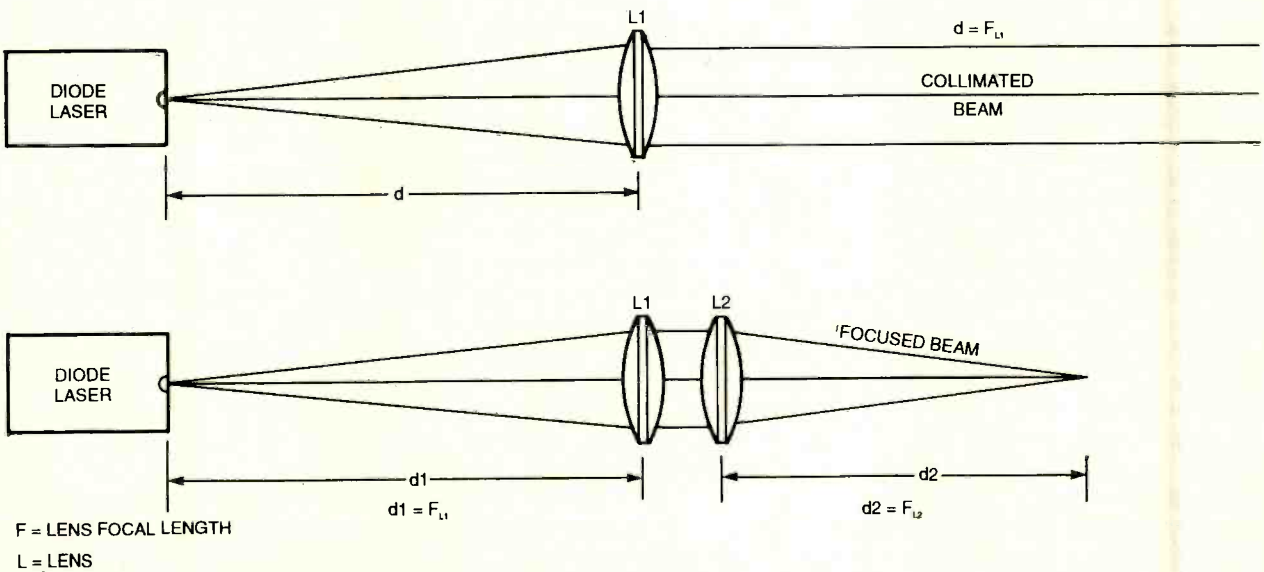


Fig. 4. Collimating and focusing a semiconductor laser takes a bit more thought than the He-Ne variety. Compare this illustration to that in Fig. 2 for the differences. Note that you have to work with a more diverging beam with semiconductors.

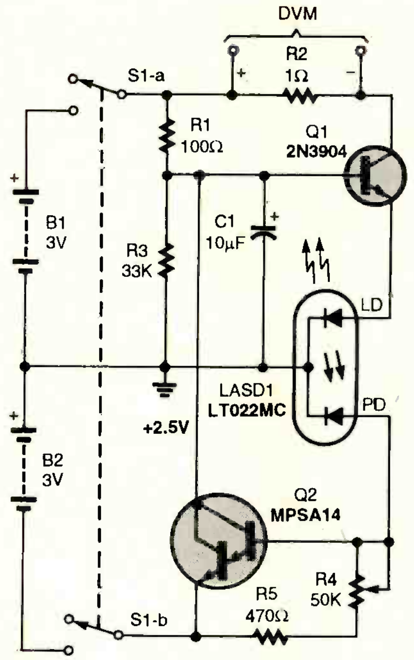


Fig. 5. Note the simplicity of the driver circuit used for the LT022MC 780-nm, 5-mW double-heterostructure laser diode. The ±3-volt supply is merely four "N" cells

PARTS LIST FOR THE 780-NM DOUBLE-HETEROSTRUCTURE LASER DRIVER (FIG. 5)

SEMICONDUCTORS

LASD1—SHARPLT022MC laser diode, 5-mW, DH-type
Q1—2N3904 NPN silicon transistor
Q2—MPSA14 NPN silicon Darlington transistor

RESISTORS

(All resistors are ¼-watt, 5% carbon-film units unless otherwise noted.)
R1—100-ohm
R2—1.0-ohm
R3—33,000-ohm
R4—50,000-ohm, multi-turn potentiometer
R5—470-ohm

ADDITIONAL PARTS AND MATERIALS

B1, B2—1.5-volt "N" cell, alkaline
C1—10-µF, 15-WVDC, tantalum electrolytic capacitor
S1—Double-pole, double-throw mini-toggle or slide switch
Terminal strips, heatsink material, lenses, enclosure, wire, hardware, etc.

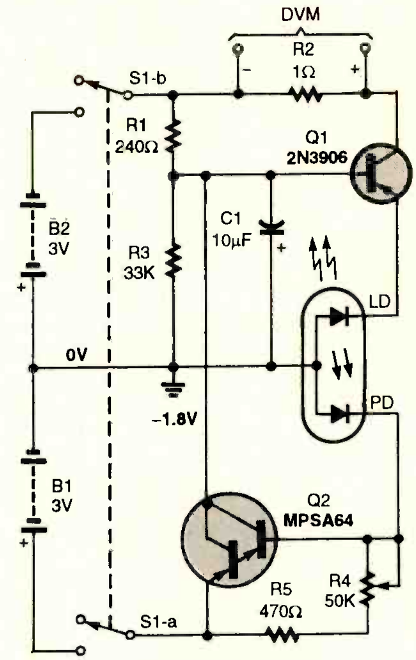


Fig. 6. Due to its common-anode package configuration, the ML720 1300-nm, 5-mW DH laser diode uses a "flip-flopped" version of the driver shown in Fig. 3.

PARTS LIST FOR THE 1300-NM DOUBLE-HETEROSTRUCTURE LASER DRIVER (FIG. 6)

SEMICONDUCTORS

LASD1—ML720 laser diode, 5-mW, DH-type (Mitsubishi)
Q1—2N3906 PNP silicon transistor
Q2—MPSA64 PNP silicon Darlington transistor

RESISTORS

(All resistors are ¼-watt, 5% carbon-film units unless otherwise noted.)
R1—240-ohm
R2—1.0-ohm
R3—33,000-ohm
R4—50,000-ohm, multi-turn potentiometer
R5—470-ohm, 4-watt

ADDITIONAL PARTS AND MATERIALS

B1, B2—1.5-volt "N" cell
C1—10-µF, 15-WVDC tantalum electrolytic capacitor
S1—Double-pole, double-throw mini-toggle or slide switch
Terminal strips, heatsink material, lenses, enclosure, wire, hardware, etc.

plug in Q1. Don't install the laser diode yet. Install a bus wire "short" across D5 and connect this "ground" to Q2's collector on the perfboard. The positive lead from D1, R1, and C3 on the perfboard goes to C5 and Q1's collector. Transistor Q1 can be any metal-cased (TO-5/TO-39) NPN transistor such as the 2N2219 or 2N3053 series.

The smaller TO-18 transistors such as the 2N2222 may not survive in this application. Install a "slip-on" heat sink on the transistor and then plug it into Q1's location. Apply 24 volts AC power from T1 to the perfboard. (Use high-voltage precautions.) Using a digital voltmeter (DVM), verify the 120-volt DC output found across the C3-C4 series combination. Attach an X10 oscilloscope probe to Q1's collector with the common lead connected to circuit ground at D5's anode. If Q1's breakdown voltage is below 120 volts, you should see a linear ramp display running at several kHz. This is generated as C5 charges with the 5.7-mA constant current until Q1 breaks down, discharging C5 and restarting the charge cycle. The peak voltage of the ramp should fall between 90 and 110 volts DC to provide a 20–25-amp current pulse.

Keep substituting transistors for Q1 until you find one that breaks down in that range. Be sure to allow the power-supply capacitors time to self-discharge before attempting circuit changes. Verify that with your DVM! Finally, attach the scope leads directly across R4, the 1.0-ohm resistor. You should see a 50–100-ns, 20–25-volt pulse displayed at about a 4- to 5-kHz repetition rate. When satisfied, proceed with the final assembly.

SH-type laser diodes have a package with a threaded mounting stud (usually the cathode) and a center-conductor lead wire (usually the anode). Refer to the sidebar for polarity identification information. Mount the diode in a clearance hole through a ⅛-inch-thick piece of aluminum about 1-inch square or larger. Use a matching nut (the LASD59 has 4-40 threads) to hold the diode in place, while also capturing a solder lug under the nut. Assemble Q1, D5, R3, R4, and C5 on another small piece of perfboard using very short leads for interconnections.

Maintaining proper polarity, connect the laser diode/heat sink assembly to the driver board: Its

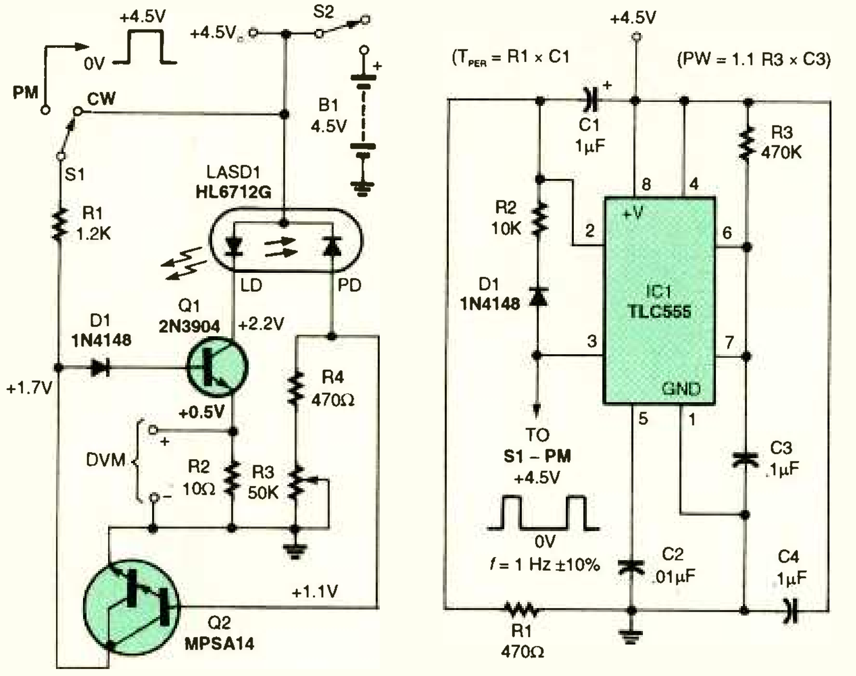


Fig. 7. The 670-nm, 5-mW visible DH laser driver (A) uses only a positive supply and may be operated in either continuous or pulsed mode. The simple fixed oscillator shown (B) provides a 50-ms pulse at a 2-Hz rate.

PARTS LIST FOR THE 670-NM DOUBLE-HETEROSTRUCTURE LASER DRIVER (FIG. 7A)

SEMICONDUCTORS

LASD1—HL6712G laser diode, 5-mW, DH-type
Q1—2N3904 NPN silicon transistor
Q2—MPSA14 NPN silicon Darlington transistor
D1—1N4148 silicon switching diode

RESISTORS

(All resistors are ¼-watt, 5% carbon-film units unless otherwise noted.)
R1—1200-ohm
R2—10-ohm
R3—50,000-ohm, multi-turn potentiometer
R4—470-ohm

ADDITIONAL PARTS AND MATERIALS

B1—1.5-volt "N" cell
S1, S2—Single-pole, single-throw mini-toggle or slide switch
Terminal strips, heatsink material, lenses, enclosure, wire, hardware, etc.

PARTS LIST FOR THE LASER-DIODE PULSER (FIG. 7B)

SEMICONDUCTORS

IC1—TLC555 or 7555 CMOS timer, integrated circuit
D1—1N4148 silicon switching diode

RESISTORS

(All resistors are ¼-watt, 5% carbon-film units.)
R1, R3—470,000-ohm
R2—10,000-ohm

CAPACITORS

C1—1-μF, 16-WVDC, tantalum electrolytic
C2—0.01-μF, ceramic-disc
C3, C4—0.1-μF, ceramic-disc

anode lead goes directly to D5's cathode lead, and its cathode lug is connected to D5's anode lead with a short piece of 18-gauge bus wire. Connect the previously assembled power-supply board to the driver board with a 3-inch or shorter "twisted-pair" of insulated/stranded wire. (Again, maintain proper polarity.) Install an appropriate power jack at the supply inputs for the wall-mounted "cube" adapter.

Once you have everything completely wired and checked out, you're ready to test the laser. **WARNING**: This device emits invisible, high-power, infrared laser radiation, which can cause permanent eye damage. Avoid direct or reflected exposure to the beam. Point the laser away from you and towards a non-reflecting surface. You may use an infrared-sensing phosphor card to locate the beam and collimating optics. RadioShack carries such an item: Their part number 276-1099 IR Sensor Card is made for this purpose.

To do any useful work with the SH laser, you'll probably want to collimate the diverging laser beam into a parallel beam or even focus it to a small point. Refer to Fig. 4 for an easy method that uses simple lenses to do so safely!

Double-Heterostructure Laser. Packages containing DH laser-diode chips resemble TO-18 metal-can transistors with a window installed on the end of the can. Those packages may have three or four leads, depending on their pinouts. All modern DH lasers include an optical-power monitor in their cans, along with the laser chip. The monitor is a PIN-type photodiode used as a negative-feedback element to maintain a constant optical-power output.

Several different pinout configurations are used, depending on the laser manufacturer. The laser anode may share a common lead with the monitor anode; the laser cathode may share a common lead with the monitor cathode; or the laser anode may share a common lead with the monitor cathode. Other possibilities do exist; if you're not sure about your laser, refer to the sidebar for safe polarity-identification procedures.

DH lasers also come in two different-size cases: 5.6 mm and 9.0 mm. Both sizes require adequate heatsinking. The smaller case has a barrel diameter of about 5/32 inch; the larger is about ¼ inch in diameter. A good heatsink could be anything ranging from a clip removed from a 3AG fuse holder to a re-shaped TO-18 transistor heatsink to a sophisticated "clamp" made from a piece of aluminum barstock. Many off-the-shelf collimating lenses include a built-in heatsink. Be sure to use something for a heat sink before powering up your laser!

SOURCE INFORMATION

American Science & Surplus
3605 Howard St.
Skokie, IL 60076
847-982-0870
www.sciplus.com
All types of lenses and other electromechanical "doo-dads." Item number 21332 ($2 each) contains an assortment of 20 small acrylic lenses—ideal for laser collimation

Meredith Instruments
5420 W. Camelback Rd. #4
Glendale, AZ 85301
623-934-9387
www.mi-lasers.com
All types of lasers and laser accessories

Mouser Electronics
958 N. Main St.
Mansfield, TX 76063
800-346-6873
www.mouser.com
All standard and high-voltage components and semiconductors

MWK Industries
455 W. La Cadena 14
Riverside, CA 92501
800-356-7714
www.mwkindustries.com
All types of lasers and laser accessories

Timeline, Inc.
2539 W. 237 St.
Building F
Torrance, CA 90505
310-784-5488
www.digisys.net/timeline
670-nm visible-red and 1300-nm IR laser diodes at $15 each

One of the main considerations in designing DH driver circuits is the operating voltage of the laser diode when drawing full operating current. That voltage drop dictates the voltage "ceiling" required for extended battery life and, thus, the minimum power-supply voltage needed. The low current drains of the following three circuits allow us to use alkaline 1.5-volt type "N" cells (series-connected) for the supply.

780-nm DH Laser Diode. The Sharp LT022MC laser diode is now quite commonly found through surplus suppliers for anywhere from $5 to $20 and is available in both package sizes. It is rated at 5 mW maximum at 780 nm or very-near infrared; all you'll see from this one is a dull red glow. However, be forewarned: it's just as dangerous as a 5-mW visible laser! Avoid direct or reflected exposure, as permanent eye damage could result.

Referring to Fig. 5, you'll notice that this design uses a 3-volt split supply (four series-connected "N" cells with a center-tapped ground) due to the common-cathode laser package configuration. At a typical operating current of 45 mA, the laser's operating voltage is about 1.8 volts. Adding this to the 0.7-volt V_{BE} of Q1 yields a total drop of 2.5 volts, only ½ volt below the 3-volt supply rail. This is a bare-bones ceiling. However, you can always swap the "N" cells from the negative supply (which draws little current) with those of the positive supply, when needed.

To get the most out of the positive power supply, R1 (100 ohms) was selected to draw 5 mA at the 0.5-volt drop. Reducing R1 to 51 ohms may further extend usage, at the cost of a 1-mA drain. When calculating this current, allow about 1 mA for biasing Q1. For extended use, it might be wise to add another "N" cell to the positive supply for a +4.5/–3.0-volt supply. You be the judge!

This simple circuit can be built on a small piece of perfboard—nothing is critical. However, it is recommended that you first breadboard the circuit, which will allow you to eventually replace R4 and R5 with a fixed resistor after calibration is complete. That way, you'll never have to worry about mechanical vibration disturbing the "delicate" setting of R4.

The first step is to purchase or fabricate a heatsink for the laser package. One square inch of metal is more than sufficient for those low-power units. Install the heatsink and proceed to breadboard the circuit. Transistor Q1 is a standard 2N3904 NPN general-purpose transistor, with Q2 being an MPSA14 NPN Darlington unit in a TO-92 plastic package. A 2N6427 unit is a good substitute for the MPSA14. Capacitor C1 is a 10-µF tantalum capacitor, and all fixed resistors are ¼-watt, 5% carbon-film units.

Select a good quality multi-turn trimpot for R4, the 50,000-ohm calibration unit. A 22-turn device would be ideal if you can find such a beast. Install the trimpot on the breadboard wired as a variable resistor. Using a DMM (digital multimeter), pre-set R4 to its maximum resistance. Failure to do so might result in the destruction of your laser diode! Connect the leads from a DVM across R2 (1.0 ohms nominal), whose voltage drop will be used to monitor laser current. **NOTE**: As with the previous laser driver, be sure to point the laser beam towards a non-reflecting surface!

When power is first applied to the circuit with R4 set at its maximum resistance, minimal lasing will occur with threshold current flowing through the laser diode. That result is due to the negative feedback action of the photodiode and Q2. The current appears at the bottom of the "knee" on the power-out/ current-in characteristic curve of the laser.

Before the knee, the diode behaves just like an LED, with a linear increase of *incoherent* radiation as the current increases. Lasing begins *at* the knee, producing *coherent* radiation, which increases at a much steeper linear rate per current increase.

THINK "SAFETY!"

WARNING: Laser radiation can cause permanent eye damage. Avoid direct or reflected exposure from the beam and never point the beam at other people or at animals.

DANGER: The high voltages used in these circuits pose a harmful or lethal shock hazard, including charges stored in the filter capacitors. Use standard high-voltage insulating techniques throughout and have a helper assist you in assembly and testing of such circuits.

POLARITY TIPS FOR SAFE PINOUT DETERMINATION

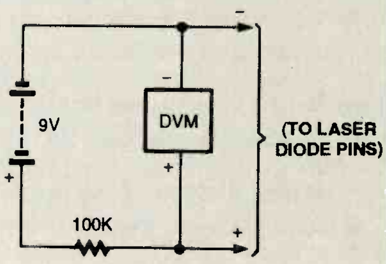
Semiconductor laser diodes tend to have very low reverse-breakdown voltages, where high reverse currents may damage or destroy the diode. Thus, testing these diode junctions with a standard ohmmeter is not recommended. Here's a way to fabricate a simple, low-current meter to test polarity and pinouts in a safe manner.

All you need for this test is a DVM (the voltage measurement section of your DMM) along with a 100,000-ohm, ¼-watt resistor connected to one terminal of a standard 9-volt battery. The resistor will limit current through the diode to less than 100 microamps. Using a clip lead, connect one end of the resistor to the positive terminal of the battery. Connect the other resistor lead to the DVM's positive lead. This connection will be your positive test lead. Connect the DVM's negative (common) lead to the negative battery terminal; this will become your negative test lead. Use color-coded clip leads from those two points for connection to the laser-package pins.

Apply those two leads to the first two package pins (observing ESD precautions) and note the DVM display. A reading of 0.4 to 0.6 volts is typical of a forward-biased PIN photodiode (positive test lead at the anode of the diode). Similarly, a reading of 1 to 2 volts is typical of a forward-biased laser diode. A reading of about 9 volts indicates that your connection has reverse-biased one of the diodes. Reverse the polarity of your connection to see which diode is connected.

There are two other possible displays using this method: a reading of about 1.4 to 2.6 volts might indicate that you've forward biased both the photodiode and laser together and are reading the sum of their forward voltages. That result can occur when the common lead of the package is shared by opposing diode polarities. Another reading might indicate something between about 4 and 9 volts on certain lasers. That result is due to the low breakdown voltage of the reverse-biased laser diode—some leak and some don't!

The easiest way to sort all of this out is to make a simple diagram of the pin arrangement of your laser diode. Make notes right on the diagram of the voltage readings you observe at each pair of pins. Be sure to test each and every possible combination of pin pairs, switching input polarity at each pair. That is not as complicated as it sounds! Once you've written down all of your readings, it's a simple matter to identify the pinouts and polarities used on your particular package.



The DVM should now be indicating about 40 mV or so. Thus, at a scale-factor of 1 mV per mA, the threshold current of the laser is about 40 mA. This is typical and may be anywhere from 35 mA to 65 mA, depending on the unit. Since this current is on the bottom of the knee, we can expect the "safe" operating level to be in the range of 5–10 mA higher than threshold. Indeed, I tested this circuit (and the following two laser drivers) at 15 mA above threshold with no apparent damage to the laser diodes. Going any further than that without an optical power meter is inviting disaster—stick with 10 mA or less above threshold!

Now that you have a threshold-voltage indication, slowly reduce R4's resistance while monitoring RI's voltage increase. Let it rise about 10 mV maximum above threshold while using an IR phosphor card to verify that you're still lasing. When satisfied, shut off the power and remove R5 from the breadboard. Without disturbing its setting, measure R4's new set resistance and the actual resistance of R5. Total those two values and select a fixed resistor of the same total value.

Install this new resistor in place of R4/R5 on the breadboard and apply power. You should see the same voltage level obtained during calibration, indicating a correct operating level. Once satisfied, assemble the circuit on a small piece of perfboard. Rather than soldering directly to the laser's leads, you can use a standard TO-13 transistor socket. You may mount it on the board or hang it on insulated, stranded hookup wire for off-board laser mounting. Refer to Fig. 4 for tips on optically collimating the beam.

1300-nm DH Laser Diode. The infrared laser diode used in this next circuit (see Fig. 6) is quite interesting! The ML720 has a rating of 5 mW maximum at 1300 nm—a totally invisible output beam. Mitsubishi (the manufacturer) evidently selected this far-infrared wavelength to match their fiber-optic material for low-loss transmission. It has a four-lead, 5.6-mm case, with the fourth lead attached to the case only. The other three leads are in a common-anode configuration and isolated from the case.

This laser is available from Timeline (see the supplier sidebar) for only $15 plus shipping. It comes in its own ESD-protected foil envelope, which is plainly marked with the operating levels for the individual unit contained within. Half of your work is already done for you! Its output power, threshold current, operating current, operating voltage, monitor current, and actual wavelength are all listed—a real bargain!

Referring to Fig. 6, you'll notice that this design also uses a 3-volt split supply (as in Fig. 5) due to the common-anode laser-package configuration. At a typical operating current of 20 mA, the laser's operating voltage is about 1.1 volts. Adding this to the 0.7-volt V_{BE} of Q1 yields a total drop of 1.8 volts, about 1.2 volts above the 3-volt supply rail. That's a fairly good "ceiling" voltage, resulting in extended battery life. Resistor R1 is selected to draw 5 mA once again, with a value of 240 ohms required for a 1.2-volt drop. You'll also notice that the common-anode configuration requires a "flip-flop" of the circuit shown in Fig. 5.

To maintain the proper forward-bias to the laser diode and reverse-bias to the photodiode, we have substituted PNP transistors for Fig. 5's NPN units. Otherwise, negative-feedback circuit action is exactly the same. Transistor Q1 is now a standard 2N3906 PNP general-purpose unit, and Q2 is a MPSA64 Darling-ton PNP unit in a TO-92 plastic package. Breadboard and calibrate this circuit exactly as the previous DH laser, except this time set the operating current per the laser's package data.

A word of warning: Since this laser has a beam that is totally invisible, it's doubly dangerous—you won't

even know it's causing eye damage until the damage is already done! Be extremely cautious when operating this device. Use the IR phosphor card to continually keep track of the beam.

Once you've set the correct operating level, select a fixed resistor (as with the previous driver circuit) and install it in place of R4/R5. When satisfied, assemble the circuit on a small piece of perfboard, using a TO-18 transistor socket for the laser diode connection as before. Using the IR phosphor card while referring to Fig. 4, you may collimate the beam parallel or focus it to a point as desired.

670-nm DH Laser Diode. Our last circuit is always the most popular of the semiconductor lasers: the 5-mW, 670-nm visible red laser diode. As luck would have it, the driver circuit turns out to be the most flexible of all my designs! This one is based on the HL6712G diode, which is index-guided, rather than gain-guided as with older devices. Once again, Time-line has this laser available for only $15 plus shipping.

Being index-guided, the HL6712G laser has a threshold current that's less than half of the gain-guided devices—about 35 mA is typical for this diode. Another nice feature is that the laser anode shares a common lead with the photodiode cathode, allowing us to use a single, positive supply instead of split supplies. At a typical operating current of 45 mA, the HL6712G has a voltage drop of about 2.3 volts that leaves only a 0.7-volt "ceiling" if used with a 3.0-volt supply. Assuming that we'd like to keep Q1 and Q2 from saturating, a 4.5-volt supply was chosen so that negative feedback is always 100% reliable in controlling output power. Refer to Fig. 7A to see the advantages gained.

The higher supply voltage allows us to increase the value of R2 (1.0 ohms previously) to 10 ohms and add D1 (IN4148) to Q1's base circuit. That forces Q2's collector to operate at about 1.7 volts, well above its 1.3-volt saturation level. Transistor Q1's collector then operates at 2.2 volts (4.5–2.3) at a V_{CE} of about 1.7 volts—again, well above its 0.7-volt saturation level. Thus, this driver can be switched at high frequencies to yield a pulsed-laser output beam without the risk of damage to the laser! The original 33,000-ohm resistor and 10-µF capacitor (used for "soft" starts in the previous DH drivers) are not required (or even desirable) in this high-speed circuit.

Switch S1 allows us to select either a continuous-mode (CW) or a pulse-mode (PM) signal for the output beam. For easy interfacing to low-power oscillators, such as TLC555/7555 CMOS timers, R1 (1200 ohms) has been selected to draw only 2 mA at a 2.8-volt (4.5 – 1.7) drop. Note that Q1 is a 2N3904 NPN unit, with Q2 a MPSA14 (or 2N6427) Darlington NPN unit. Breadboard this circuit as with the two previous drivers and perform a similar calibration with S1 set for CW.

DISCLAIMER

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This time, the scale factor for R2 (now at 10 ohms) is 10 mV per mA. The threshold level will now be about 350 mV (35 mA is typical). The operating level should then be set to no more than 100 mV above the threshold level.

Again, **avoid direct or reflected exposure** to this visible beam. Remember, laser radiation can cause permanent eye damage. Once more, select a fixed resistor to replace (in this case) R3/R4 and fabricate the circuit on a small piece of perfboard, using a TO-18 transistor socket for the laser. Note that this driver may be "flip-flopped" to drive a package configuration where the laser cathode shares a common lead with the photodiode anode. As with Fig. 5 and Fig. 6, Q1 and Q2 must be switched from NPN units to PNP units for proper biasing.

As previously mentioned, this driver allows the output beam to be pulsed. For a real attention-getting "pointer" display, try the simple circuit illustrated in Fig. 7B, which provides a 50-mS pulse every ½ second. Refer again to Fig. 4 for tips on collimation and focusing of the divergent laser beam.

There you have it—five different laser driver circuits, all of which are easily modified to suit your particular needs and laser type. Why not dig out that old laser, dust it off, build a suitable driver, and go out and impress the neighbors! ■

HOW I'VE TRIED TO REMAIN COMPUTER ILLITERATE ...AND OTHER SMALL FAIRY TALES

A quick guide to sanity maintenance in the 21st century.

COMMENTARY BY LAONA GALE KNIGHTON

I'm proud to say that, in this day and age, I've tried to remain computer illiterate! Dealing with computers at work has become mandatory; however, that doesn't mean that I want to bring them home with me. Besides, I don't like it when a machine laughs in my face because it is smarter than I am.

I remember when my favorite, open-minded third grade school teacher (it was 1970) very astutely explained to twenty-five restless, yet eager, children the concept of the "*world to come.*" She told us that in the not-too-distant future people would be able to stay in their own homes and feel as though they were actually experiencing adventures. She continued to explain what sounded (to us) like a *Twilight Zone* episode.

"A person's body will actually be sitting still in a chair," she said, "but the mind will be able to experience such things as flying, scuba diving, race car driving—the possibilities will be endless!"

Of course, our eight-year-old minds thought she was an old lady and, maybe, even a little off her rocker. Well, guess what, Mrs. McKissick? It's true! This wonder you were describing has arrived. It is called the *personal computer*, and at the ripe old age of thirty-eight, I have finally decided that "if you can't beat 'em...join 'em."

My PC is the fourth in our household. My needs had to follow our four-years-old's yearning to play her *Barbie* and *Blue's Clues'* games, even though Daddy was home at night laying claim to his own Compaq Presario 4880-Series P-II 400. Hers was our third investment, a Pentium 120. However, it didn't take long to figure out that Daddy's computer is faster; so she manages to commandeer his quite often, nevertheless.

Of course, we have the standard ongoing race for the "best in the house" between my husband and my teenage son's technological hardware. They claim that it isn't a power war, but I've noticed that whenever one of them gets more megabytes of RAM, the other must immediately run out and get more, too! With my son's new job at Domino's and his careful spending habits, he has won momentarily with his AMD-K7 800, which was the fastest (without refrigeration) on the market for one whole week.

I still have one question: "With all this modern technology in the house, why is it so hard for Mommy to be blessed with using one?"

"Honey? May I use the computer to type a letter?" I asked the back of my husband's head.

"Sure...in a minute. Let me finish this first," he said. To a computer junkie, a minute could be hours, days, or—if you're lucky—the next time nature calls!

Iced tea helps.

"Darling pie?" I turned to my son. "Can I type a letter on your computer real quick?"

"Gee, Mom. I don't think my computer does that anymore. I had to remove the software to make room for my 'Super-Duper-Crazy-Driver-Space-Racing' game."

I turned then to my four-year-old daughter, "Baby-doll? Can Mommy use your computer, just for a minute?"

This is almost always met with tears and whining (hers, not mine), which makes me lose my train of thought completely, rendering it utterly impossible to even begin the task at hand.

"I just want to type a simple letter!" I said to the backs of three heads in my living room. I would have considered myself lucky to have received even a grunt in reply from any of them.

Dinner time was another issue. I am a firm believer in the whole family sitting down together for at least one meal a day to study each other's faces and, maybe, even have a little light conversation. Of course, if the dinner is really good, there is not much conversation anyway since all mouths are full.

With computers in the house, delivering the exciting message, "Dinner's ready!," can receive the following popular replies:

Husband: "In a minute!"
Teenager: "But I'm the farthest I've ever got!"
Four-year-old: "Whaaaaa !"

One evening, after staring at three cold, thirty-minute-old, well-balanced meals, I was forced into retaliation. I pretended to give their dinner to the dogs. It was really just some leftover scraps "disguised" by being placed on our good dinner plates.

"If you guys don't want my dinner, the dogs would love to have it." I promptly set two of the plates out the door.

This offensive tactic brought forth looks of horror and disbelief from my "computer nerds." Now, they come right away (almost) when they are called for dinner.

I am finally the proud owner of my own personal computer made up of cast-off portions from the others. I call it a "mutt" series, and that is fine with me. Now, I can type a plain, old-fashioned letter to "Grandma Moses" any time I like!

I've set mine up in a different room from the rest and can actually have a little peace and quiet without explosions, singing, or car wrecks for background ambiance. Of course, my family members walk by the open doorway (I'm on the route to the bathroom) and laugh and point at me occasionally. "Can you imagine, a mother *playing* computer!"

My four-year-old asks, "Mommy? Can I play your computer now?"

"Mommy's computer doesn't play games," I reply. "It just makes words." (Guilt, guilt, guilt.) The best part is when I hear, "I'm hungry. When is dinner going to be ready?" I smile as I answer, "In a minute!"

One extremely important tip to remember: When people ask if you have an e-mail address, quickly answer "NO!" and try to have a vague look in your eye. I made the mistake early on of giving my prized address out to a couple of friends. Now when I check my messages, I have no less than fifty "you've-got-mails" awaiting me. Let's not even mention being in the middle of scheduling an airline flight, only to have "Hi! Whatcha doin?" flash on your screen via instant messaging. It is a frightening experience. I could easily become a nightly prisoner to this rolling chair if I'm not careful. I may have to learn to sleep upright and arrange to have food thrown at me for nourishment.

It reminds me of my former answering machine. The last time ours hit the floor, it broke. I was actually relived to be able to throw the thing away. I no longer

come home to a blinking light nagging me to return Aunt Jewel's or Cousin Alberta's call (you realize, of course, that once they've left a message you are surely nabbed).

I must say this for computers: It keeps my family off the streets at night. In regard to that subject—like computers—sometimes ignorance can be bliss. ▣

mailto: q&a@gernsback.com

Inadequate Clock-Radio Antennas

Q *We have several clock radios that use their power cords as FM antennas. It is hard for us to pick up the NPR (National Public Radio) stations we prefer to wake up to. I thought that we could buy one of the inexpensive FM transmitter kits advertised in your magazine and use a hollow-core inductor to transmit its signal into our house wiring. Will this work at all? What would be a good type of inductor to use as the coupler? Would it be possible to have more than one transmitter going at a time on different frequencies?—G.S., Davis, CA*

A I've had similar problems with clock radios. Let's work yours from two angles. When I opened up our clock radio, thankfully I found that it had a little power transformer in it. If your radio(s) doesn't have a power transformer, don't attempt any external electrical connections. I found that my radio coupled to the line by wrapping a wire around the line cord several times inside the radio. I unwrapped it and soldered the end to a pin jack that I mounted on the cabinet. Now I could have an external antenna. Instead of the reception being finicky with placement of the power cord, it was finicky with placement of the antenna.

Another idea I heard of was to replace the two-wire line cord with one of those flat three-wire cords. Install a regular two-wire plug on the end and clip the ground wire back from the plug; make sure that it doesn't contact anything in the plug. Connect that third wire to the antenna input.

The transmitter idea might work, although I would try over-the-air transmission first rather than a "carrier-current" method using the AC power lines. A low-power transmitter in your house will put out a stronger signal at your radios than a powerful transmitter that's nearby. Just be sure to tune the transmitter, one for each station you're trying to rebroadcast, to a clear area on the dial so you don't upset the neighbors or degrade the transmitted signal. Ramsey Electronics has their model FM10A transmitter that may work in your application. You can find them at *www.ramseyelectronics.com* on the Internet.

Metal-Can IC Sockets

Q *Where can I obtain sockets for an integrated linear transistor, RCA type CA3018 or SK3542, with 12 leads?—W.D., Benson, AZ*

A Sockets for the TO-5, TO-99, and TO-100 metal-can ICs that were commonplace in the 1970s are a lot more difficult—but not impossible—to find. One hint is to look in catalog indices under "transistor sockets" rather than "IC sockets." Often, 8-pin "canned" ICs, such as the LM741, have their leads preformed to fit a standard DIP socket. You could do the same with a 10-pin IC, if necessary, although the end leads may get a little long. You'll have to be careful with each lead while inserting the IC into the socket.

New sockets are available from Newark (Augat), catalog number 65F1881, for $4.25 each. Digi-Key has their catalog number ED2154-ND for $1.77 each, and Allied/Avnet (Mill Max) has catalog number 900-0298 for $1.36. I might add that most manufacturers long ago discontinued using sockets, not to save money but to enhance product reliability, which ends up saving money in both manufacturing and in customer satisfaction. They have found that a significant percentage of warranty and other repair work has been traced to intermittent sockets and connectors. Many of us with "vacuum tube" mentalities just can't pull ourselves away from sockets. I stopped using them years ago and have never regretted that decision.

Here is some pertinent contact information for the companies I just mentioned:

Allied/Avnet
7410 Pebble Dr.
Ft. Worth, TX 76118
800-433-5700
www.allied.avnet.com

Digi-Key
701 Brooks Ave. S.
Thief River Falls, MN 56701
800-344-4539
www.digikey.com

Newark Electronics
4801 N. Ravenswood
Chicago, IL 60640
800-463-9275
www.newark.com

Splitting Hairs...Or Phases

Q *What's a phase splitter?—H.F., via e-mail*

A A push-pull output amplifier input requires two complementary (180 out of phase), equal-amplitude signals. It is the job of a phase splitter to provide those two signals. The circuit has been around since the vacuum-tube days, and a more modern transistor equivalent is illustrated in Fig. 1. Its name is derived from the fact that the collector load is split between the collector and the emitter. Since the collector and emitter resistors are of equal value (R5 is bypassed by C4, so does not figure in to the AC resistance), the output voltages from the collector and emitter will be nearly the same.

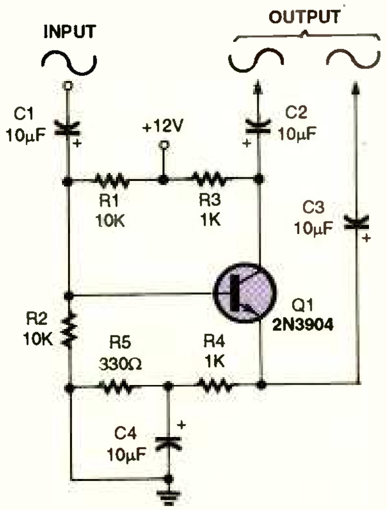


Fig. 1. A transformer with a center-tapped secondary makes a nearly perfect "phase splitter" at the sacrifice of lower- and upper-bandwidth limitations.

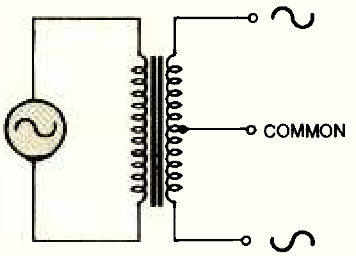


Fig. 2. The traditional phase splitter "divides" the original signal into two complementary signals using a unity-gain amplifier.

As you may know from transistor theory, a common-emitter circuit (signal taken from the collector) has a signal that is inverted from the input. A common-collector circuit (signal taken from the emitter) has a signal that is in-phase with the input. This circuit is a combination of the two. Capacitors C1, C2, and C3 are DC-blocking capacitors that are used to isolate one amplifier stage from another.

There are other ways to do this "phase splitting." The simplest way, shown in Fig. 2, is to use a transformer with a center-tapped secondary. This was a common practice in vacuum-tube days and is still a common practice in modern-day tube amplifiers that are sold for ridiculous prices to unsuspecting consumers.

Ah, but that's another story.

With respect to the transformer's center tap, one leg of the secondary will be 180° out of phase with the other.

The circuit of Fig. 3 uses two diodes biased up by R1 and R2. At first glance, one would assume that the diodes act as rectifiers to direct the positive alternation to Q2 and the negative alternation to Q1, effectively "splitting" the signal. However, the diodes are biased "on" all the time and are transparent to the AC-input signal. Their purpose is to offset the base-emitter drops of Q1 and Q2, in order to eliminate the crossover distortion during the times when the input signal is less than ±0.7 volts. The transistors themselves either go into conduction or into cut-off, depending upon the voltage level at their bases.

The final circuit of Fig. 4 is a dual op-amp circuit that provides a buffer (IC1) for the non-inverted signal and a unity-gain inverter (IC2) to provide the complement of that signal.

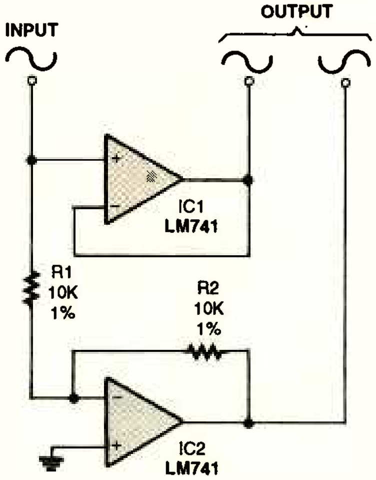


Fig. 4. A bargain-basement phase splitter really isn't a phase splitter. Instead, it uses diodes to set transistor bias to reduce crossover distortion while the transistors naturally conduct or cut off on the appropriate waveform alternations.

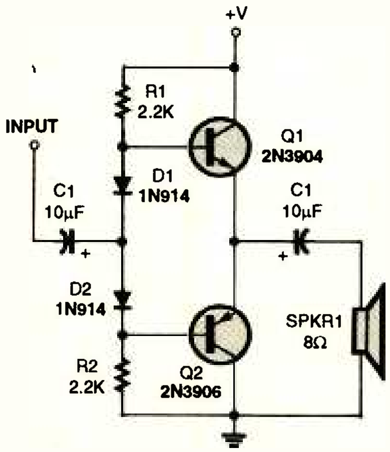


Fig. 3. A simple dual op-amp "phase splitter" is a slick way to obtain complementary signals. Careful selection of devices can yield bandwidth from DC to 1 MHz to guarantee frequency-independent phase splitting.

DC "Phase Inversion"

Q *I'm trying to design a circuit to modify the output of an automotive manifold absolute-pressure (MAP) sensor. The sensor puts out a DC analog signal of 0 to 5 volts. I want to replace the original (air flow restrictive sensor), which has an output of 5 to 0 volts. The new sensor's output is reversed from what the onboard computer has to have.*

I'm using an LM307 in the circuit, which worked on Circuit Maker 2000. I wired it up on a breadboard, and it does not work. With 5 volts in, pin 6 should be near 0 volts, but it's at 4.9 volts or so and decreases as I decrease the input level. I must be doing something fundamentally wrong, possibly with grounding. Should pins 4 or 7 be involved somehow? I know little about electronics and sure do need some help.—R.S., via e-mail

A Your circuit, as you described it in your letter, is shown in Fig. 5. Not too bad for someone who "knows little about electronics." It's fundamentally sound and should work just fine. Your voltages and your questioning of pins 4 and 7 tell me that the op-amp is floating. Without pin 4 (V–) connected to ground and pin 7 (V+) connected to 12 volts, the op-amp is nothing but a pretty lump of impure silicon. I have a couple of suggestions, including the power-supply connections, illustrated in Fig. 6, which should make things better.

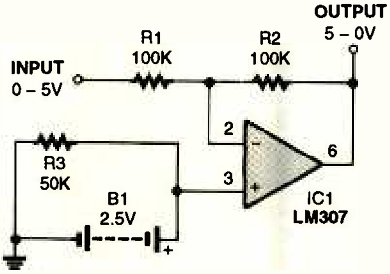


Fig. 5. This reader-designed unity gain op-amp inverter is intended to reverse the output "phasing" of an automotive sensor.

I'm not sure what you're using for the 2.5-volt supply, but I'd derive it from the same 5-volt supply that feeds the sensor. That way, the 2.5 volts will track small variations in the 5-volt supply and hold the 5-volt output point better. The adjustment of R3 will allow you to set the 5-volt point (with 0 volts in) accurately. I've added some capacitors to help decouple the circuit from noise spikes that might appear on the power

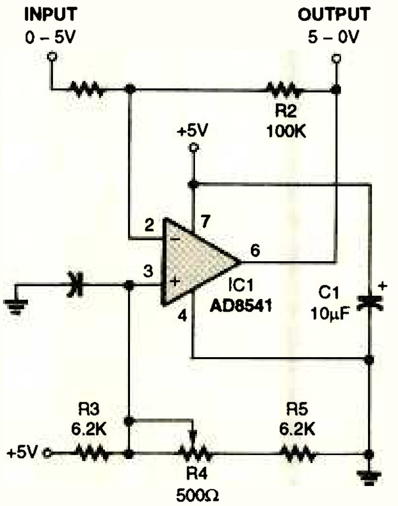


Fig. 6. Modifications to the unity-gain op-amp inverter include a "rail-to-rail" op-amp and additional offset adjustment circuitry.

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.

supplies.

There's one more important thing that you'll have to do: Find a different op-amp. The LM307, although a nice amplifier, is older than my 1973 edition of National Semiconductor's *Linear Databook*! It suffers from the fact that as the output voltage approaches the supply rails, it begins to get non-linear and saturates about 1.5 volts away from the rail. That means that your amplifier output won't be able to go below about 1.5 volts. Manufacturers have had 28 years since then (am I getting that old?) to develop what are called "rail-to-rail" op-amps. Those amplifiers are usually targeted for lower-voltage systems, where they want to get every last millivolt of output range.

I'd suggest trying the AD8541 from Analog Devices (*www.analog.com*). If you need more op-amps in a similar design, the same amplifier is available in dual (AD8542) and quad (AD8544) configurations with common power-supply connections. It has exactly the same pinout as the LM307, and if it wasn't for the fact that it's available only in surface-mount packages, you could plug it right into the same socket. The maximum power-supply voltage for the AD8541 is only 5.5 volts, but it sounds like you have a 5-volt supply you can use for that, and it'll be a lot cleaner than the junk that runs your power windows.

Contact Analog Devices for a different amplifier if you have to have it in a dual in-line package. Be sure to specify that you need a rail-to-rail, single-supply, general-purpose op-amp for use with a 5-volt power supply. You should be able to find what you need on their Internet site. Analog Devices is very nice about providing free samples of their reasonably-priced chips.

I think these improvements will result in a circuit that will work well for you.

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

COMPUTER BITS

(continued from page 6)

and label even a modest quantity of CDs.

One new title that I think really epitomizes CD-ROM-based publishing is *The Amateur Scientist—The Complete Collection* on CD-ROM. Priced at $90, this two-CD set is published by a small company called Tinkers Guild (*www.tinkersguild.com*).

SOURCE INFORMATION

Tinkers Guild
405 El Camino Real
PMB 326
Menlo Park, CA 94025
650-853-1001
www.tinkersguild.com

CIRCLE 100 ON FREE INFORMATION CARD

It's considered "bad form" to mention one magazine in another *(Perhaps, but we're not that insecure. Look at all the titles Dean Huster listed in "Q&A" back in April!—Editor)*, but I've always enjoyed the "Amateur Scientist" column that *Scientific American* has been publishing since 1928. I'm not quite old enough to have been reading it since then, but I did start during the 1960s when it was edited by C.L. Stong. In fact, one of my cherished books was a compendium of those columns, published by Scientific American Press in the 60s. That book, unfortunately, disappeared during a move and has been out of print for some time.

The CD-ROM from Tinkers Guild solves that problem. Not only does it have the columns from the original book, but it has every "Amateur Scientist" from its inception in 1928 through 1999. Missing, however, are last year's columns as well as those published so far this year. The columns are navigated through a Web Browser, since the original text and illustrations have been converted into HTML.

Much of what has been published is pretty dated. Some of the projects published in the 50s and 60s use vacuum tubes that might not be available any more. The same is true about transistors and ICs used in the 70s and 80s.

On the other hand, many of the techniques and fabrication problems that were cleverly addressed in those old columns have become much easier to accomplish. Materials and equipment that were unavailable and unaffordable 40 years ago are commonplace now.

What I really love about this set of CD-ROMs, however, is how it catches my imagination every time I go through it. The 1959 column about how students at a California high school built a cyclotron is not only fascinating, but even more practicable now.

The CD is divided into different scientific disciplines. You can learn how to grind a telescope mirror, build an X-ray machine (though you'll probably have to blow your own glass tube), or use electrophoresis to separate compounds. A second CD-ROM has loads of science- and math-oriented shareware, and there's even a trial copy of Wolfram Research's terrific *Mathematica* software on a third CD.

The $90 price tag will definitely put some readers off. To be honest, though, this CD was on my holiday gift list until I received a review copy. I can't imagine any **Poptronics** reader who wouldn't enjoy receiving this CD as a present, or who won't spend hours perusing the material.

If you've read this column for a while, you'll know that I don't have any special awards that I give products. No "Editor's Choice" and no "Best Buy." My highest accolade is finding something that I would actually buy myself.

With the wealth of software and equipment I receive to review, there aren't that many products that meet that criteria. The Tinkers Guild CD, however, is something I would definitely spend my own money on. **P**

NET WATCH

(continued from page 20)

STRIKING A BALANCE BETWEEN PARANOIA AND APATHY

Although cyber-terrorism is on the rise, it is not quite a pandemic. Just because your computer is surfing the Net doesn't mean that it will be stricken with some awful virus. Hackers and crackers usually strike specific targets. Common sense is our best protection against malware assaults. The FBI, together with various private-sector players, has formed the National Infrastructure Protection Center (NIPC). Established in February 1998, the NIPC is working to further digital security in a constant effort to protect U.S. national security.

How can you do your part to help in the fight against cyber-terrorism? Although there have been cases of violent JavaScript exploding into systems uninvited (like a busload of drunken party crashers), nine out of ten times a virus attack is triggered by a user executing a file or opening an attachment. Obtain and run a virus-protection program and be sure to update it regularly. If you see suspicious e-mails or programs from an unknown origin, quarantine and delete them. As for protection against intruding hacks—there is little hope. Where there is a will there is a way, and hacking is certainly no different. A software firewall program is at best a minimum form of protection. At least when users run a firewall, they can see whenever their system either accesses or is accessed by another computer. Final advice—stay alert! You'never know what or who is poking around the Internet. **P**

HOT SITES

2600 The Hacker Quarterly
www.2600.com

F-Secure
www.fsecure.com

McAfee
www.mcafee.com

NIPC
www.nipc.gov

Sophos
www.sophos.com

Symantec
www.symantec.com

mailto: amazingscience@gernsback.com

JOHN IOVINE

Fuel-Cell Finish

Well, we're back to finish the series on fuel cells. Let's get right to it and construct a derivative of the fuel cell made famous by NASA.

Hydrogen-Oxygen Fuel Cell

This fuel cell, see Fig. 1, would more properly be called an *open-air fuel cell*, because leaving one side of the cell open to the atmosphere provides the oxygen. Using pure O_2 at the oxygen electrode provides superior performance. However, the additional work required for construction and subsequent operation doesn't merit the performance increase.

Gather together the items listed in the sidebar. While you're out shopping, pick up some galvanized nails (a good source of zinc) and some hydrochloric acid—muriatic acid (found in home-improvement stores for cleaning brick and stone); you'll need those items to produce hydrogen—the fuel cell's fuel.

The fuel cell is make from ⅛-inch thick plastic. The plastic is fashioned into three 2½-inch squares. Two of the plastic squares have an internal 1½-inch square cut out from the center, see Fig. 2. Two gaskets are cut to the same dimensions as the two internal plastic pieces. The nickel screen is cut to fit inside the cell and overlap the internal cutout. A tab is placed on each electrode that extends outside the fuel cell to make electrical connections easy. The outer plastic piece has two additional center holes for gas vents.

Make a solution by mixing one gram of platinic chloride in 100 milliliters of distilled water. Clean the nickel screens in the alcohol to remove any grease or dirt. Then plate the two nickel screens with platinum by soaking them in the platinic chloride solution until they turn black.

To activate the fuel cell, soak some filter paper in a solution of potassium hydroxide. You can use the same solution from last month's alcohol fuel cell.

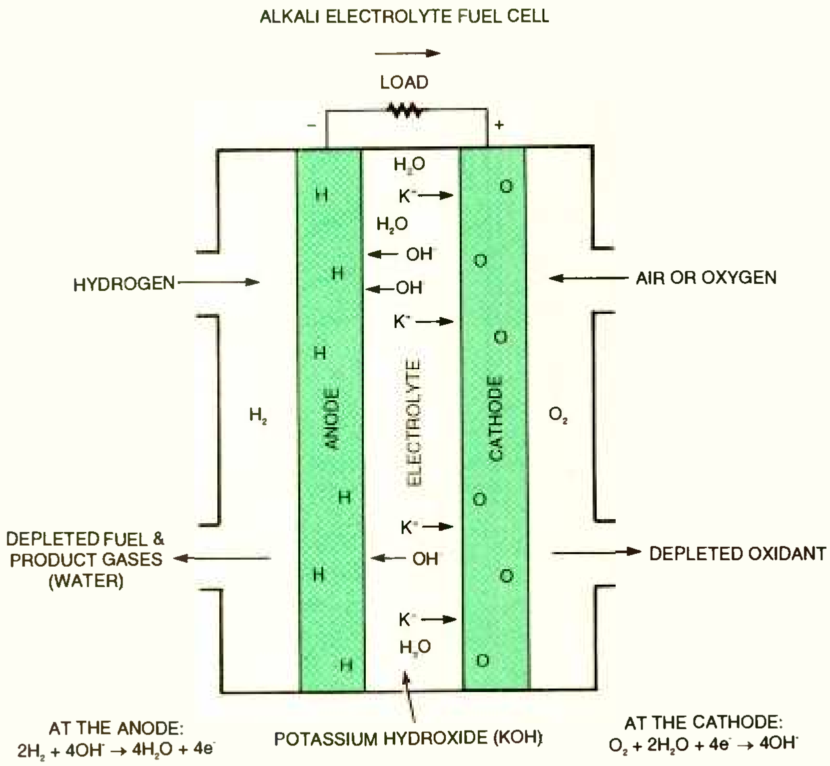


Fig. 1. An alkali-electrolyte hydrogen/oxygen fuel cell, in the process of combining hydrogen and oxygen, strips a few extra electrons during the chemical reaction to create an electromotive force—electricity.

After the filter paper has absorbed the electrolyte, blot the excess liquid from the paper with a blotter, leaving the filter paper damp.

Next, assemble the fuel cell. Place a gasket on the outside case, followed by a nickel screen, filter paper, nickel screen, second gasket, and finally the open plastic piece. Make sure during assembly that the two nickel screens don't touch one another; if they do touch, they will short the output of the fuel cell.

Use the plastic machine screws and nuts to keep the assembly together.

Hydrogen Gas Production

Many experimenters generate hydrogen gas from the electrolysis of water. I did not want to set up the apparatus to do this; I wanted a fast and simple method of H_2 production. Zinc and magnesium react with hydrochloric acid to generate hydrogen gas. I assume that you've already picked up the muriatic acid (a solution of hydrochloric acid) and galvanized nails—zinc is the "galvanizing" coating that protects iron and steel from the elements when used outside. Roofing nails are a good example. Although I've probably already said it until I'm "blue in the face," always wear gloves and eye protection when handling acid.

Prepare a gas-generating vessel using a jar with a metal screw-on lid, see Fig. 3. First, drill a ¼-inch hole in the cover of the jar. Next, pass an inch or two of ¼-inch rubber or silicone tubing through

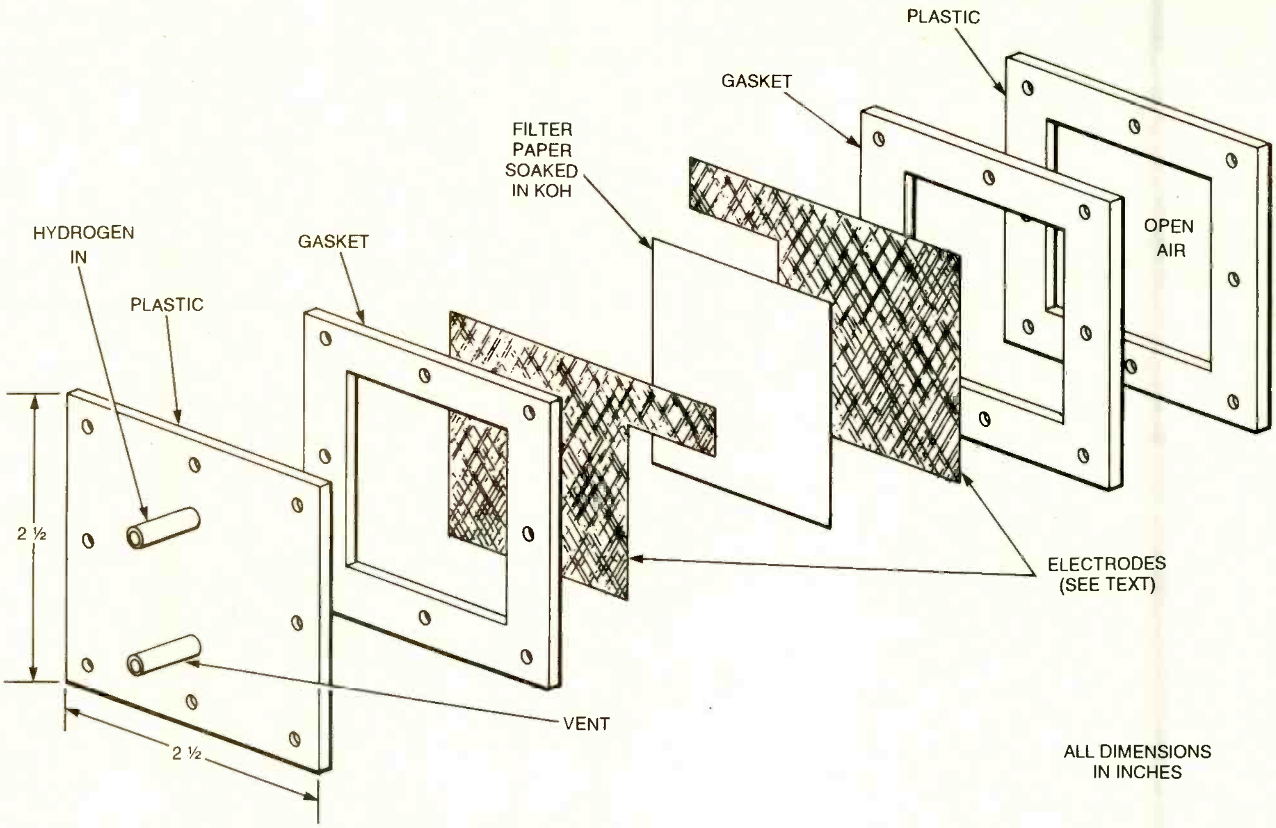


Fig. 2. The construction cross section of the hydrogen/oxygen fuel cell is a sandwich of electrodes, electrolyte-soaked paper, and gaskets surrounded by a pair of flat plastic end pieces.

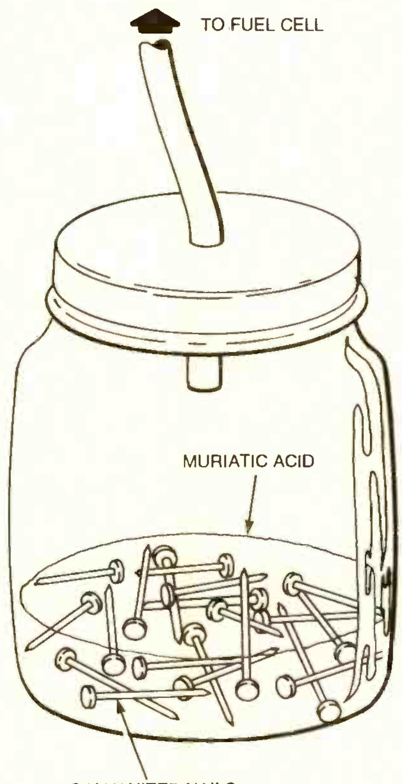


Fig. 3. A "quick and dirty" hydrogen-gas generator uses galvanized nails and hydrochloric acid to produce hydrogen gas.

the hole. Make the junction between the jar lid and tube airtight by coating the seam—both on the top and bottom of the lid—with aquarium silicone sealant. Allow the sealant to dry (about 24 hours).

To generate hydrogen gas, cover the bottom of the jar with galvanized nails. Pour in enough muriatic acid to cover the nails. Screw the lid of the jar in place. Let the hydrogen gas vent for a minute through the rubber tube and then attach the open end of the tube to the fuel cell.

Remember, muriatic acid is corrosive; take proper precautions when handling this chemical. Hydrogen gas is explosive. Do not operate the hydrogen-gas generator near open flames or sparks (remember the Hindenburg!). The hydrogen-gas generator, when generating gas, must always remain open to the atmosphere, allowing the hydrogen gas to vent. This will prevent any gas pressure from building that could cause the jar to explode.

The finished fuel cell, see Fig. 4, generated between 0.8 and 1.0 volt. You should expect similar results with your fuel cell.

Now that we've taken that "small step for [a] man" in building NASA-style fuel cells, let's move on to...

Microbial Fuel Cell

The "bug battery," as it's affectionately known, uses yeast to generate electric power. Originally, I believed that the yeast cells metabolized sugar to produce alcohol and that the alcohol became the fuel to power the fuel cell. While that secondary type of fuel cell has been built many times, it is not the principle behind this fuel cell. The actual process is more complex and elegant. Essentially, current is generated by cellular respiration and digestion!

I was surprised to find out that bug batteries aren't new technology. In fact, they date back to 1910, when Michael

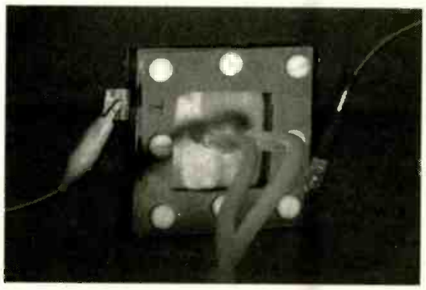


Fig. 4. The finished hydrogen/oxygen fuel cell might not be as pretty as some of NASA's best space-faring designs, but it works the same.

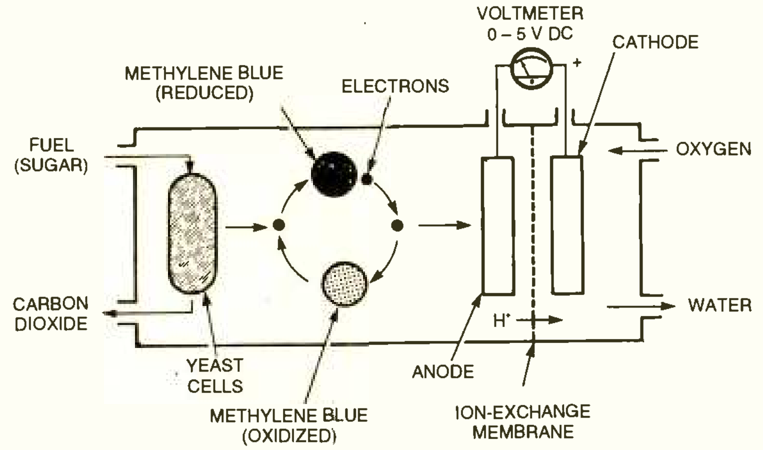


Fig. 5. A microbial fuel cell uses yeast as the active element, with methylene blue as a mediator.

Potter placed a platinum electrode into a solution of yeast and another in an organism-free solution and measured a current. In 1931, Barnett Cohen, a biochemist at Cambridge University, put together a 35-volt microbe-powered battery.

The basic bio-chemical mechanics of microbe-powered fuel cells follows the process of digestion and respiration. Carbohydrates, such as sugars, starches, and cellulose, are basic food nutrients. When a carbohydrate is broken down, electrons in the molecule are released (oxidized). Those electrons are used (reduced) in intermediate compounds before they finally react with oxygen in respiration:

$$6O_2 + 24H^+ + 24e^- \rightarrow 12\ H_2O$$

Electrons may be stolen from the respiration cycle by a *mediator*. The mediator ferries the electrons to an electrode. To complete the circuit, a second (positive) electrode is needed in the solution, usually separated by an ion-exchange membrane.

A basic microbial fuel cell is illustrated in Fig. 5. On the left side of the illustration, we have sugar being fed to a yeast culture. The yeast cells digest the sugar, producing carbon dioxide. The electrons in the digestion cycle are stolen by the mediator—in this case, methylene blue—and delivered to the electrode. Hydrogen ions are able to pass through the ion-exchange membrane to combine with the electrons on the cathode side with oxygen gas to form water.

In the demonstration bug battery and microbial fuel cell, a solid oxidizing reagent (potassium ferricyanide) is used in place of oxygen gas.

Bug Battery Design

A basic bug battery is shown in Fig. 6. The electrodes are carbon rods salvaged from old dry-cell batteries. The electrodes, once removed from the batteries, should be cleaned first with alcohol to remove as much chemical compound as possible and then washed in distilled water and allowed to dry.

Standard metal electrodes should be avoided when constructing a bug battery because the metal could cause spurious electric current from its electrochemical dissolution.

First, one needs a standard phosphate buffer with a pH of 7.0 made by dissolving 4.08 grams Na_2HPO_4 and 3.29 grams NaH_2PO_42H2O in 500 milliliters of distilled water.

The oxidizing solution (catholyte) is a 0.01-0.10 Mole solution of potassium ferricyanide in the standard phosphate buffer. (See the warning on potassium ferricyanide.)

The anode and cathode of this cell are separated by a length of tubular dialysis membrane that's made into a bag by tying a knot in one end. The bag is filled with the second electrode—the microorganisms (yeast or E.coli) suspended in the pH 7.0-buffered solution and a mediator (methylene blue 5-10 mM or

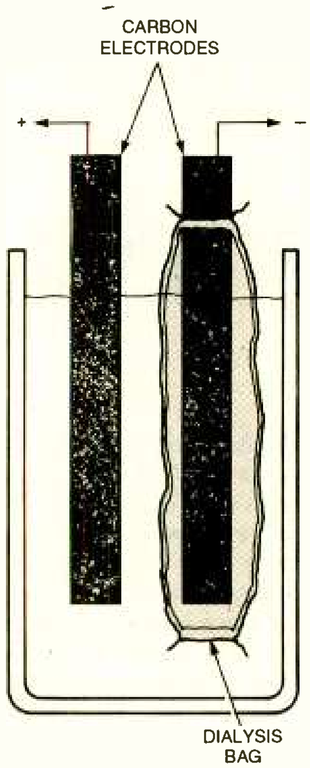


Fig. 6. A simple "bug battery" contains the living portion of the fuel cell in a dialysis membrane. Carbon electrodes collect the electrical energy.

milliMole in water). The top of the dialysis bag is tied with string. The bag/electrode assembly is placed in the vessel with the potassium ferricyanide solution.

The current and voltage generated by this bug battery is measured in millivolts and microamps. The dialysis bag is permeable to ions, including the potassium ferricyanide oxidant. However, the dialysis membrane will only last for about 30 minutes—more than enough time for a demonstration.

Microbe Cell Recipe

One may also purchase a microbial fuel cell in kit form, see Fig. 7. However, be aware that the kit does not include

(Continued on page 53)

FUEL-CELL COMPONENTS

Nickel Screen	150-200 mesh	2.5 × 5 inches long
Platinic Chloride		1 gram
Isopropyl Alcohol (rubbing alcohol)		1 pint
Potassium Hydroxide		500 grams
Distilled Water		2 liters
¼-inch thick plastic acrylic plastic		
Filter Paper		
1/16-inch rubber gasket material		
6-32 plastic machine screws and nuts		Eight

SERVICE CLINIC

mailto: serviceclinic@gernsback.com

SAM GOLDWASSER

The End Of A Saga

We've finally reached the end of our series on VCR repair—you can now breath a sigh of relief! This "Grand Wrapup" will cover a couple of the unfortunate types of accidents that can and do happen and how to deal with them. I'll also toss in a list of references for more VCR-related information and suggestions for parts suppliers when you have found the cause of a particularly nasty problem.

Most VCRs live out their lives peacefully, but sometimes those that are perched on top of the TV sitting on the rickety roll-around stand take a nose-dive to the floor. They could also get wet due to rain through a window or for some other reason that we won't describe (I'm sure your imagination can fill in the gaps!). Camcorders, which are basically portable VCRs with a bit of extra stuff (image sensors, optics, and viewfinders), more frequently take a dunking at the beach.

We'll start with the biggest "oops" of all:

Hit The Deck!

So your cat decided that it was time to practice its long jump and didn't quite pick a stable destination. Your VCR is on the floor and Tabby is cowering in the basement. Where do you start?

Overall, VCRs are quite tough. However, falling in just the right (or wrong, come to think of it) way can do substantial, and possibly not immediately visible, damage.

If you take the unit in for service, the estimate you get might make the national debt look like pocket change in comparison. Attempting to repair a VCR that has been dropped is a very uncertain challenge—time is money for a professional. Spending an unknown amount of time on a single repair is very risky. There is no harm in getting an estimate (though many shops charge for just agreeing that what you are holding is a VCR!)

This doesn't mean you should not tackle it yourself. There may be nothing wrong or very minor problems that can easily be remedied.

First, unplug the VCR even if it looks fine. Until you do a thorough internal inspection, there is no telling what might have been knocked out of whack or broken. Electrical parts might be shorting due to a broken circuit board or one that has just popped free. Let me say that again if it didn't sink in: **DON'T** be tempted to power the VCR even if there are no obvious signs of damage—turning it on might blow something due to a shorting circuit board.

Inspect the exterior for cracking, chipping, or dents. In addition to identifying cosmetic problems, this will help locate areas to check for internal damage once the covers are removed.

Next, remove the top and bottom covers and the front panel. Check for mechanical problems like a bent or deformed cassette basket, broken or cracked plastic parts, or anything that might have shifted position or jumped from its mountings.

Carefully straighten any bent metal parts. Replace parts that were knocked loose. Glue and possibly reinforce cracked or broken plastic. Plastics, in particular, are troublesome because most glues—even plastic cement—do not work very well. Using a splint (medical term) or sistering (construction term) to reinforce a broken plastic part is often a good idea. Use multiple layers of Duco Cement or clear windshield sealer and screws (sheet metal or machine screws might be best depending on the thickness and type of plastic). Wood glue and Epoxy do not work well on plastic. Some brands of superglue, PVC pipe cement, or plastic hobby cement might work depending on the type of plastic.

Cycle the cassette-loading and tape-loading mechanism manually by turning the appropriate motor shaft, if possible. Check for free movement of the various parts of the tape transport.

Inspect for any broken electronic components; these will need to be replaced. If the fluorescent panel is broken, you can run the VCR without it; however, you won't be able to see any front-panel displays. Check for blown fuses—the initial impact might have shorted something that, in turn, blew a fuse.

There is always a slight risk that the initial impact has already fried electronic parts as a result of a momentary short or from broken circuit traces. Obviously, those will still be problems even after repairing the visible damage and/or replacing the broken components. Remember the old saying: Inside every big problem is a little problem struggling to get out!

Examine the circuit boards for any visible breaks or cracks. These will be especially likely at the corners where the stress may have been greatest. If you find *any* cracks—no matter how small—in the circuit board, you will need to carefully inspect any circuit traces that might run across those cracks. If they do, then there are certainly breaks in the circuitry which will need to be repaired. Circuit boards in VCRs are never more than two layers, so repair is possible. However, if any substantial number of traces are broken, it will take a great deal of painstaking work to jumper across those traces with fine wire—running over them with solder will not last. Use a fine-tipped low-wattage soldering iron under a magnifying lens and run 28- or 30-gauge insulated wires between convenient endpoints. Those connections don't need to be directly on either side of the break, as long as they make prop-

MECHANICAL INTENSIVE CARE

1—Disassemble the unit as much as possible. Sand and surf (or other liquids) can find their way into the tiniest nooks and crannies. You need to get it all.

2—Make a drawing of the belt routing, remove the belt(s), wash and dry them, and label and set them aside.

3—Use a soft brush (like a paintbrush) to dust out as much sand as possible. Hopefully, you can get it all that way. A vacuum cleaner with a wand attachment may prove handy to suck out sand. Sand will tend to collect on lubrication, especially grease, which will need to be completely cleaned out and replaced. Don't use high-pressure compressed air; you will just spread the sand around. Any grease or oil on which sand has collected will need to be totally removed and replaced with fresh lubrication.

4—If there is evidence of salt (yes, I said to forget repairing it, but if you insist...), you will need to *wash* it off—yes, wash it. Keep water out of the motors. Use low-pressure compressed air (a blow dryer on low heat should be fine) to dry the unit so that it does not rust. The same advice applies if it is still wet with contaminated liquid. Wash with fresh water to remove all traces of salt and contamination as quickly as possible and then dry completely. Depending on the situation, a final rinse with 91% or pure isopropyl alcohol may be desirable to decrease drying time. That should be safe for most mechanical assemblies. A chemical degreaser may be used if it is safe for plastic and rubber parts.

5—Lubricate all bearing points with a drop of light machine oil such as electric-motor oil, sewing-machine oil, etc. Never, *never*, **never** use WD-40! Lubricate the gears, cams, and sliding parts with a light, plastic-safe grease such as Molylube.

6—Parts like the idler clutch may need to be disassembled to get at the friction felt. Other mechanical parts like cam gears may need to be removed to be properly cleaned. Don't mess up the timing relationships when you do this!

7—Reinstall the belts and reassemble the unit in reverse order.

er electrical continuity. Double-check each connection after soldering for correct wiring and for any possible shorts before proceeding to the next.

If the circuit board is beyond hope or you do not feel you would be able to repair it before the reading of your last will and testament, replacements might be available. The sad fact is that their cost more than likely will be more than the VCR is worth. Locating a junk VCR of the same model for parts cannibalization might be a more realistic option.

Once all visible damage has been repaired and broken parts have been replaced, take a deep breath, cross your fingers, and power the VCR up to see what happens. Be prepared to pull the plug if there are serious problems—billowing smoke would qualify. Determine if it appears to initialize correctly without shutting down. Play a garbage tape to check if there are any problems that might damage the tape. Watch and listen carefully for any evidence of poor tracking, video noise, tape-speed instability, or weak or muddy audio that might indicate that tape-path alignment requires further attention. Listen for any unexpected mechanical sounds that were not there before.

Very likely, the VCR will be fine. If so, you can replace the covers and find a more secure spot for it.

Use your own judgment with respect to the cat.

Surf's Up!

Someone took your camcorder to the beach, and now it has sand or perhaps salt inside. A similar situation on the home front is that cup of tea on top of the VCR that wasn't as stable as you thought. Now the system behaves... well...strangely. Can this possibly be fixed? Will it be worth the effort or expense?

Unless this is a really sophisticated (i.e., costly) unit, I doubt whether it will pay you to take it anywhere for repair. Even if it is successfully repaired, its reliability might be questionable. Furthermore, as with any equipment that has been dropped or physically abused, few repair shops will be inclined to touch the job. They really don't like challenges of that sort.

That leaves you!

If anything got wet with salt water and it has been just sitting, you can probably forget it. Without immediate attention, and I mean *immediate*—not later, not tomorrow, **NOW**!—salt-water corrosion can set in very quickly and attack electronic components, circuit-board traces, cable wiring, and mechanical parts. The only thing worse might be a peanut-butter and jelly sandwich "played" in your VCR. On second thought, food probably would not be all that bad compared to the corrosive characteristics of sea water.

Although it is probably too late, the first thing to do when electronic equipment gets wet is to remove the power source; pull the plug or remove the batteries. Don't be tempted to apply power

ELECTRONIC INTENSIVE CARE

1—Remove the circuit boards and label the connectors if there is any possibility of getting them mixed up. If the circuit board(s) are soldered to the rest of the equipment, then you will have to improvise and work around them.

2—Wash with water and dry thoroughly. This does work—I do that routinely for degunking remote controls and rubber-membrane keypads, for example. I have heard of people cleaning contaminated computer keyboards in their dishwasher! The important objective should be to get corrosive liquids off the components and circuit traces as quickly and completely as possible. A final rinse with 91% or pure isopropyl alcohol will decrease the drying time. However, there is a slight risk of damage to sensitive electronic components should some water be trapped inside. Pat dry and then use warm air from a hair dryer (or a heat gun on low) to completely dry everything. Moisture will be trapped in controls, coils, selector switches, relays, transformer cores, connectors, and under large components like ICs. **DO NOT** operate the unit until everything inside and out is thoroughly dry.

3—Use a spray-type contact cleaner on the switches and control cleaner on the control and adjustment pots. **DON'T** turn the internal adjustments without precisely marking the original position, or else realignment will be needed. However, exercise the user controls to help the cleaning process.

Note that the drying time might be quite long. For parts with inaccessible areas like membrane keypads, you might need to wait a *week* before normal operation is restored. Be patient!

4—Once everything is completely dry as a bone and reassembled, power up the system; but be prepared to pull the plug or pop the batteries if there are serious problems. See if the display comes alive and the transport appears to initialize. Attempt to play a garbage tape to determine if there are any mechanical problems that might damage the tape. Look and listen for any abnormalities that might require additional attention and then address specific problem areas.

SUGGESTED VCR REPAIR TITLES

All-Thumbs Guide To VCRs (Gene B. Williams)
Guide To VCRs, Camcorders, And Home Video (Gene B. Williams)
Home VCR Repair Illustrated (Richard C. Wilkins)
How To Keep Your VCR Alive (Steve Thomas)
Maintaining And Repairing VCRs (Robert L. Goodman)
Operating Your VCR (Victor A. Wayne)
Practical VCR Repair (David T. Ronan)
Troubleshooting And Repairing VCRs (Gordon McComb)
VCR Troubleshooting And Repair (Gregory R. Capelo)
VCR Troubleshooting And Repair Guide (Robert C. Brenner)

until you have determined that everything is completely dry inside and out.

DO NOT use strong solvents anywhere! They can attack various plastic parts or cause internal damage to electronic components.

I've collected a pair of general-purpose lists—one for mechanical, one for electrical—in the accompanying sidebars on how to triage a system that decided to play "U-Boat Commander." Those instructions were written assuming that sand, salt, and liquid contamination is everywhere! Modify those instructions as needed based on your specific situation.

Although it should go without saying, the procedures outlined in those sidebars are very simplistic. The important thing is to get every last grain of sand, salt, and other contaminant off the mechanisms and circuit boards quickly.

When VCRs get wet, moisture may collect *within* certain electronic parts—motors, for example. It is essential that these items be dried completely before applying power to the unit. If you do not, the best to hope for is that the unit will not work properly. Of course, luck never shines when you need it most; and you may do additional serious damage due to short circuits.

For camcorders, some parts of the optics or enclosed DC-DC converter modules might be impossible to access and clean of scum.

In addition to the mechanical tips, here's something else to keep in mind: certain parts need lubrication to operate. If the unit took a dunk in the drink, that lubrication might have washed away or become contaminated with solid particles. Some of those lubrication points might not be readily accessible or obvious. Don't be tempted to overdo the lubrication—too much is worse than too little.

Advanced VCR References

Of all modern consumer electronics, VCRs probably have the most books covering maintenance and repair. Having such a reference handy when you're up to your armpits in VCR parts can be a godsend. I've collected a short list of titles (see sidebar) that would be a good addition to any amateur repair technician's bookshelf. Before someone complains that I didn't mention <insert title here>, I apologize in advance for any that I left out. Just because a particular guide isn't listed does not mean that its omission was intentional or implies anything about any book's quality or usefulness—I only have so much space to write.

Service Parts Sources

For general electronic components like resistors and capacitors, most electronics distributors will have a sufficient variety at reasonable cost.

However, for consumer-electronic equipment repairs, places like Digi-Key, Allied, and Newark do not have the variety of Japanese semiconductors like ICs and transistors or VCR-specific components like RF modulators, idler assemblies, belts, tires, pinch rollers, video heads, etc.

On my Web site, *www.repairfaq.org*, I have a document that discusses that issue: "Major Service Parts Suppliers." That page lists some companies that I have used in the past, as well as others that have been recommended. Those companies include MCM Electronics, Dalbani, and Parts Express. I've also listed a few in the sidebar.

For VCR parts in particular, there are several good replacement part sources for the do-it-yourselfer. Studio Sound Service stocks a large selection of new VCR parts, including belts, idlers, gears, mode switches, semiconductors, rebuild/cap kits, and much more for Panasonic and Samsung VCRs. They will ship direct to you with no minimum order—an important consideration for the home-based repair technician. They will even help you determine what part you need if you don't have the part number—all at no extra charge.

The Dale Harper Web site looks like a promising resource for help and for new/used VCR parts for the DIY'er. They have a collection of VCRs with salvageable parts as well as general repair info.

REPAIR PART SOURCES

Allbrand Audio and Video Parts
368 Ball Hollow Rd.
Pulaski, TN 38479
615-427-6262
allbrand@juno.com
www.usedvcrparts.com/
www.quickpage.com/V/vcrgraveyard/

Dale Harper's VCR Parts and Help for the Do-It-Yourself Technician
vcrparts@superb.net
www2.superb.net/vcrparts

Studio Sound Service
3404 Greenview Dr.
New Albany, IN 47150-4229
studio.sound@datacom.iglou.com
www.iglou.com/studiosound/

There are also some places specializing only in used VCR parts. (Perhaps they would get more respect if they were called "previously owned" or "broken-in" VCR parts!) Allbrand Audio has huge quantities of used and rebuilt VCR parts. For example, a lower drum for a two-head machine usually goes for around $15. Major parts come with a 30-day warranty. Well, it beats no warranty, I guess! Such places are even better than junk yards as they do the searching and pulling for you. For major subassemblies in older VCRs, this may be the only realistic economical option even if the original part is available from the manufacturer.

The Big Finale

While we've only covered a small fraction of the troubleshooting and repair of VCRs, I hope that, if nothing else, some of the mystery surrounding these indispensable gadgets has been eliminated. Once you have an understanding of the "secret voodoo" that goes on behind the front panel, you won't fear opening the top in an attempt to determine why your faithful servant is being uncooperative. For much more information on the VCR subject, see the VCR-related resources at my Web site, *www.repairfaq.org*. For even more in-depth coverage, consider an actual book. You know, one of those low-tech "thingies" that can be borrowed from a public library or ordered on-line!

elcome feedback on this and all s "Service Clinic" columns. I recognize that the series on VCRs probably dragged on about 50 percent too long and won't make that mistake again.

What would you like to see in this column? How about the format? Would you like to have specific questions addressed? Please send your comments to me at the e-mail address at the top of this column.

See you next time! **P**

AMAZING SCIENCE

(continued from page 49)

any of the chemistry or microbes to make it work. To make the kit work, you need:

- Dried baker's yeast
- 50 milliliters of methylene blue solution (10 mM)
- 50 milliliters of glucose solution (1M)
- Potassium ferricyanide

In addition, you will also need 0.1 Mole solution of phosphate buffer with a pH of 7.0 made by dissolving 4.08 grams of Na_2HPO_4 and 3.29 grams of $NaH_2PO_42H_2$ in 500 milliliters of distilled water.

If you do not have the means to obtain or make the above-mentioned chemistry, do *not* purchase the microbial fuel-cell kit.

Fig. 7. Here's an experimenter's microbial fuel-cell kit. You add the chemistry and microbe portion of the formula.

CHEMICAL WARNING

Potassium ferricyanide is poisonous. Eye protection should be worn when handling this chemical. If the solution comes into contact with the eyes, flood them with tap water and seek medical attention. If swallowed, give plenty of water to drink and seek medical attention.

SOURCE INFORMATION

The microbial fuel-cell kit in this month's text is available for $100. NY residents must add appropriate sales tax.

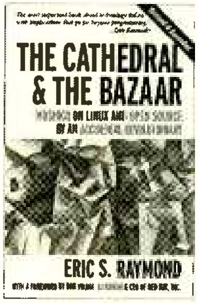
Images Company
39 Seneca Loop
Staten Island, NY 10314
718-698-8305

Toward The Future

While microbial fuel cells are just starting to peek out of the laboratories, two key microbial fuel-cell researchers—Peter Bennetto and John Stirling—see a bright future for bug batteries. Looking ahead, they anticipate electric cars getting eight miles per pound of sugar. Bug batteries can theoretically provide energy densities comparable to lithium. **P**

NEW LITERATURE

The Cathedral and The Bazaar, Revised Edition

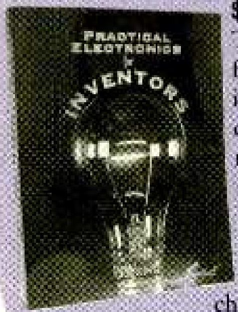


by Eric S. Raymond
O'Reilly and Associates, Inc.
101 Morris St.
Sebastopol, CA 95472
800-998-9938 or
707-829-0515
www.oreilly.com
$16.95

This is the tale of an open-source creation (*Fetchmail*) from its conception to its implementation. Readers have the chance to see the computer programming industry from an insider's perspective. Recently updated, this edition includes essays that address both open-source economic principles and the mechanics behind *bazaar* (open-collaboration) software development.

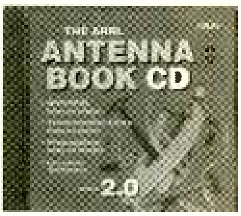
Practical Electronics for Inventors

by Paul Scherz
McGraw-Hill
2 Penn Plaza, 12th Floor
New York, NY 10121-2298
800-2MCGRAW
www.books.mcgraw-hill.com
$39.95



This book provides a foundation for budding inventors. Even a *mad* scientist can benefit from reading this text, which is a complete reference for the hands-on study of basic electronics. Each chapter educates and challenges the reader on subjects ranging from basic electronic theories to circuit troubleshooting. There are numerous colorful illustrations, which highlight the text.

The ARRL Antenna Book CD, Version 2.0



from ARRL
225 Main St.
Newington, CT 06111
888-277-5289 or 860-594-0200
www.arrl.org
$39.95

Whether you are a Ham who wants to build the perfect Yagi antenna or a RF technician who needs to brush-up on transmission theory, this *e-reference* is just as handy as its paper counterpart. The CD version—both Windows and Macintosh compatible—contains over 70,000 *pages* of propagation tables, as well as Windows- and DOS-based utilities for analysis and design.

The Loudspeaker Design Cookbook, Sixth Edition

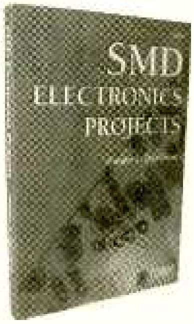
by Vance Dickason
Audio Amateur Inc.
P.O. Box 876
395 Union St.
Peterborough, NH 03458-0876
888-924-9465 or 603-924-9464
www.audioXpress.com
$39.95

Completely revised, this edition is a comprehensive discussion of loudspeaker design and construction. New material includes reviews of current technologies, such as Dr. Earl Geddes' Acoustic Lever enclosure design. Accompanied by graphs and drawings, a complete five-speaker home-theater system construction project features LCR, surrounds, and a powered subwoofer.

SMD Electronic Projects

by Homer Davidson
Prompt Publications
Sam's Technical Publishing
5436 W. 78th St.
Indianapolis, IN 46268
800-428-7267
www.samswebsite.com
$29.95

SMDs (Surface-Mounted Devices) have opened up a brand new area of electronic project construction. Each of the 30 projects here is accompanied by a parts list, schematic, wiring hook-up, board layout, photos, drawings, and troubleshooting tips. Projects include an earphone radio, baby monitor, a code oscillator, and a pink-noise generator.



NEW GEAR

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

Satellite Radio

The *IC-910H Satellite Radio* ($1799 with included cable and microphone) provides 100 watts VHF and 75 watts UHF for mode-J satellites. Packet operation is easy with the radio's two data sockets for simultaneous receiving on the main and sub bands. With an easy-to-read display and a 10-key entry pad, the IC-910H is ready for portable operation any time.

ICOM AMERICA, INC.
2380 116th Ave., N.E.
Bellevue, WA 98004
425-454-8155
www.icomamerica.com
CIRCLE 60 ON FREE INFORMATION CARD

Linear Power Supplies

The *HWD Series* Linear Power Supplies (priced from $950 to $1200) are designed for the lab bench or for system applications. They feature a digital voltmeter and an ammeter that eliminate the need for external DVMs. The availability of RS485 and RS232 programming makes them versatile test instruments.

MID-EASTERN INDUSTRIES, INC.
100 School St.
Bergenfield, NJ 07621
201-385-0500
www.mideastind.com
CIRCLE 62 ON FREE INFORMATION CARD

Clamp-On Meter

Meant for electrical measuring applications, the *AC40A Clamp-On Ammeter* ($79.95 with carrying case) is a compact 400 A, 4000-count, AC digital mini-meter. A non-invasive instrument, it has a T-shape design that fits the hand and is ideal for field work.

The control buttons and an amps/volts/ohms/power switch are conveniently located on the front of the meter. The large display features Digi-Glo backlighting. Protective precautions include extra fusing, safety test leads, voltage safety testers, and a warning beeper that sounds when a wrong input is used.

WAVETEK METERMAN TEST TOOLS
P.O. Box 9090
Everett, WA 98206-9090
877-596-2680
www.metermantesttools.com
CIRCLE 61 ON FREE INFORMATION CARD

Rechargeable Batteries

The *Millennium Rechargeable Power Systems* provide high performance for high-drain portable devices like hand-held computers and digital cameras. For example, the cells (priced from $7–$13) are said to take 270,000 pictures during their lifetime compared to an alkaline battery's 216 photos. Battery chargers ($16–$22) and rechargeable power packs ($31–$93) for camcorders and cellular phones are also available.

MILLENNIUM RECHARGEABLE POWER SYSTEMS
P.O. Box 147114
Gainesville, FL 32614-7114
877-661-6302
www.millenniumbatteries.com
CIRCLE 63 ON FREE INFORMATION CARD

Mini Soldering Iron

Ideal for work with heat-sensitive components, the *Antex Model M/3U* Miniature Soldering Iron (under $24, with tips at $4.25 each) heats up to 650°F in under 45 seconds and cools within two minutes. It measures only eight inches and has a three-wire grounded cord. The iron operates on 115-volts AC with heat directly into the tip, keeping the plastic handle cool.

M.M. NEWMAN CORP.
24 Tioga Way
P.O. Box 615
Marblehead, MA 01945
781-631-7100
www.mmnewman.com
CIRCLE 64 ON FREE INFORMATION CARD

Multimedia Generator

The *VP300 "Video Pro"* Multimedia Video Generator ($1995) is a portable, lightweight, battery-operated, reliable video signal source. An all-in-one instrument for home-theater installation, the tester provides everything needed for fast, accurate alignment of all video modes—such as composite, S-Video, and NTSC/PAL.

SENCORE INC.
3200 Sencore Dr.
Sioux Falls, SD 57107
800-736-2673
www.sencore.com
CIRCLE 65 ON FREE INFORMATION CARD

Test-Clip Set

The *Model 6405 Insulation-Piercing Test Clip Set* ($30) provides the exact pressure needed to pierce through a wide range of insulated wires: plastic, Teflon, or silicone. A rotating banana jack prevents the test lead from twisting while the wire is pierced. The small, easily attached clips can access individual wires within large bundles.

POMONA ELECTRONICS
1500 E. Ninth St.
Pomona, CA 91766
909-469-2900
www.pomonaelectronics.com
CIRCLE 67 ON FREE INFORMATION CARD

In-Circuit Meter

The lightweight, battery-powered, hand-held *Synthesized In-Circuit LCR/ESR Meter (Model 885)* tests components at frequencies up to 10 kHz. Designed for both production-line and bench-top testing, the meter ($549 with included manual, battery, surface-mount probe, and case) quickly checks the ESR of a capacitor. In addition, the surface-mount probe gives users an easy way to test these tiny components.

B&K PRECISION CORP.
1031 Segovia Circle
Placentia, CA 92870-7137
714-237-9220
www.bkprecision.com
CIRCLE 66 ON FREE INFORMATION CARD

Embedded Controller

An embedded DOS controller, the *LogicFlex* is a compact, expandable Single-Board Computer (SBC) with flexible Internet and Ethernet protocols. Powered by a 25-MHz Intel 386Ex processor with 512 kB, each of SRAM and Flash memory, the board ($279 individually) offers non-volatile mass-storage options from 2–144 MB. Source code for a Web server, along with other protocols and example code, is included in the LogicFlex Development Kit ($449).

JK MICROSYSTEMS, INC.
1403 Fifth St., Suite D
Davis, CA 95616
530-297-6073
www.jkmicro.com
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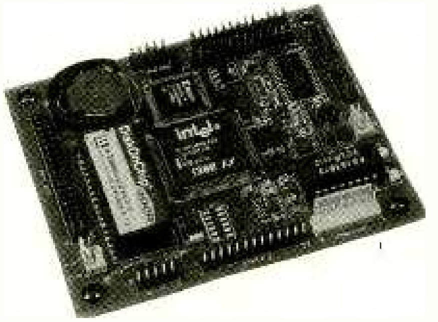

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CHARLES D. RAKES

CRUISING DOWN THE RAILS

Around Christmas time each year, I drag out and dust off a few of my model electric trains and arrange a hurried layout for the holidays. Believe me, if you have a train fan in the family, a simple layout will really get them into the holiday spirits. A beautiful Märklin Maxi 1 gauge "Glaskasten" (a Glass Palace) lightweight tank locomotive and two passenger cars were added to my meager Garden railroad layout this Christmas. Thanks, dear!

No matter what gauge—Z to G—you favor, all model electric trains require some electrical equipment to operate. The model trains available today are truly an embedded part of the digital age. It's not difficult to run almost any number of trains on the same track at the same time; each locomotive can be controlled individually. Electronics and model trains are a great combination that goes back decades. If you enjoy building both electronic circuits and mechanical devices, stick around and we'll look over some basic electronic train circuits. Hey, even if you are not into model trains, these circuits can be used for many other applications and could end up in one of your future projects. So stay tuned.

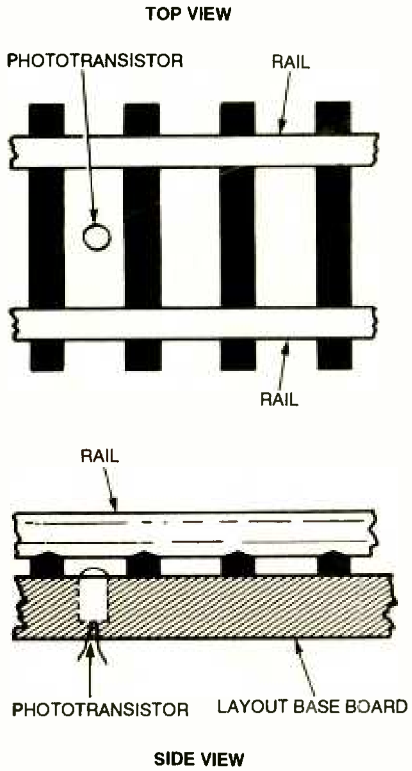

Fig. 1. If you want an easy method of sensing model train locations on the track without resorting to sophisticated electronic-detection circuits wired to the rails, you can't get much simpler than placing a phototransistor between the rails. Ambient light in the layout room lets the devices sense when a train passes over them.

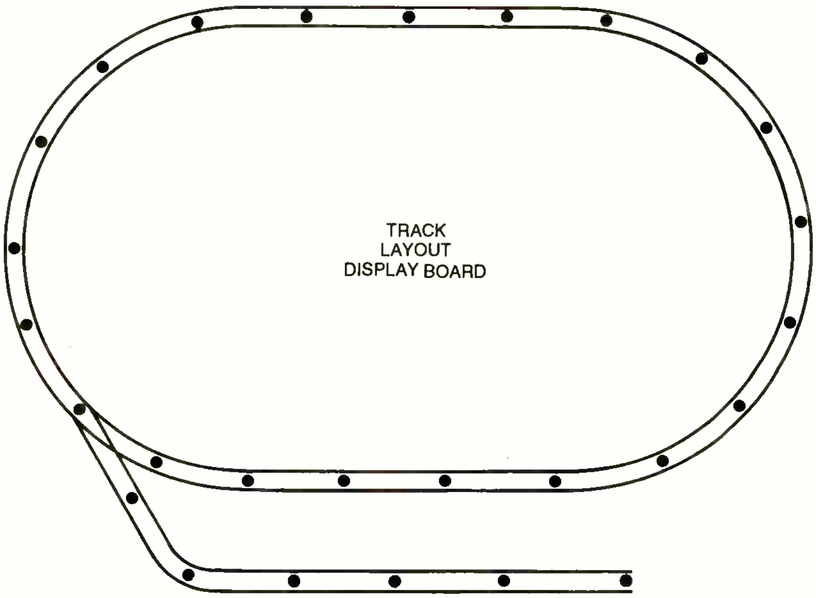

Fig. 2. By spacing sensors at regular intervals around the layout, you can create a board that lights up to indicate train position.

Keeping Track

I've always been intrigued with the control systems used in the operations centers of full-sized railroads. You've probably seen them in railroad-centric

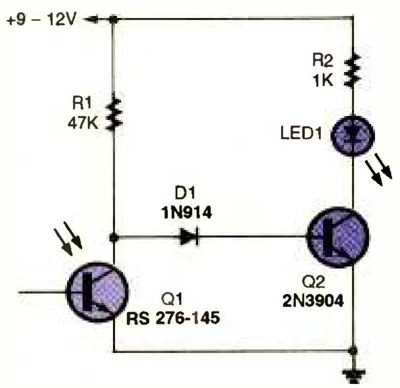

Fig. 3. This detector circuit uses a second transistor to drive an LED indicator.

PARTS LIST FOR THE BASIC PHOTOTRANSISTOR CIRCUIT (FIG. 3)

D1—1N914 silicon signal diode
LED1—Light-emitting diode, any color
Q1—Phototransistor (RadioShack 276-145 or similar)
Q2—2N3904 NPN silicon transistor
R1—47,000-ohm, ¼-watt, 5% resistor
R2—1000-ohm, ¼-watt, 5% resistor

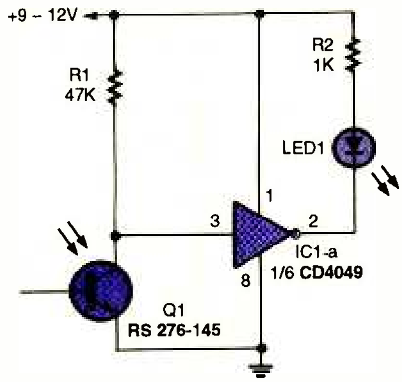

Fig. 4. This detector circuit substitutes an IC inverter for the second transistor of Fig. 3.

PARTS LIST FOR THE IC-BASED PHOTOTRANSISTOR CIRCUIT (FIG. 4)

IC1—CD4049 CMOS hex-inverter buffer, integrated circuit
LED1—Light-emitting diode, any color
Q1—Phototransistor (RadioShack 276-145 or similar)
R1—47,000-ohm, ¼-watt, 5% resistor
R2—1000-ohm, ¼-watt, 5% resistor

films: the series of lights that display the train's location. The lights are configured in the shape of the actual track patterns on a large wall-mounted display. Following a similar scheme for model trains should be an easy task, and that is what we'll look at for our first entry this visit.

Assuming that most model train layouts are operated in a lighted area, our simple approach to keeping track of our model train is as easy as monitoring the ambient light around. Placing phototransistors along the track, as shown in Fig. 1, supplies the data necessary to track the train (pun intended!) as it moves around the track. Each phototransistor is mounted between the rails face up to detect ambient light from above. When the train blocks the light source, the phototransistor's output changes and signals an LED to turn on at that location on the display board. All covered phototransistors send out the same signal, turning on their corresponding LEDs and giving a moving light display of the operating train. Figure 2 shows one layout scheme for a display board.

The number of phototransistors and LEDs used in a layout will determine the display's resolution as to the actual train's position on the track. A "Z" gauge (the *really* tiny stuff) layout might require phototransistors located as close as every two inches; a "G" or "No. 1" gauge layout (the "garden-scale" size) should probably be no closer than one foot. In any case, it's your choice.

Circuit Choices

There are many ways to approach the problem electronically. Our first choice, see Fig. 3, uses a phototransistor and a general-purpose NPN transistor to light the LED. Transistor Q1's collector is near ground level when exposed to ambient light. The base of Q2 is also near ground level, keeping it turned off and the LED dark. Blocking the light from Q1 allows its collector to rise in voltage, supplying a positive bias through D1 to Q2, which lights LED1. This scheme is a good one if your junk box is overflowing with similar general-purpose NPN transistors.

The second choice (Fig. 4) is one that I prefer, using a CMOS CD4049 hex inverter/buffer as the LED driver. One advantage of the CD4049 IC is that it has six inverters in a single package and is inexpensive. The circuit operation is very similar to our previous circuit. Ambient light hitting the phototransistor causes it to conduct, pulling its collector to near ground level. Whichever logic level, either a high or a low, is applied to the input of a CD4049 inverter/buffer, the output will always be opposite. A high input produces a low output, and a low input produces a high output. In the circuit in Fig. 4, the IC's input at pin 3 is low and the output at pin 2 is high. Therefore, no current will flow through the LED, and it will remain dark as long as no input change occurs. A locomotive or car crossing the phototransistor will block the ambient light source and turn on the LED.

PARTS LIST FOR THE COMPLETE SENSING SYSTEM (FIG. 5)

IC1—CD4049 CMOS hex-inverter buffer, integrated circuit
LED1–LED3—Light-emitting diode, any color
Q1–Q3—Phototransistor (See text for type)
R1–R3—47,000-ohm, ¼-watt, 5% resistor
R4–R6—1000-ohm, ¼-watt, 5% resistor

Putting It All Together

A simplified version of the display board circuitry is shown in Fig. 5. Since all circuits are identical, only three are shown in the drawing, but a total of six circuits may be built with each CD4049 IC. If your layout require 24 sensors, then only four CD4049 ICs are needed.

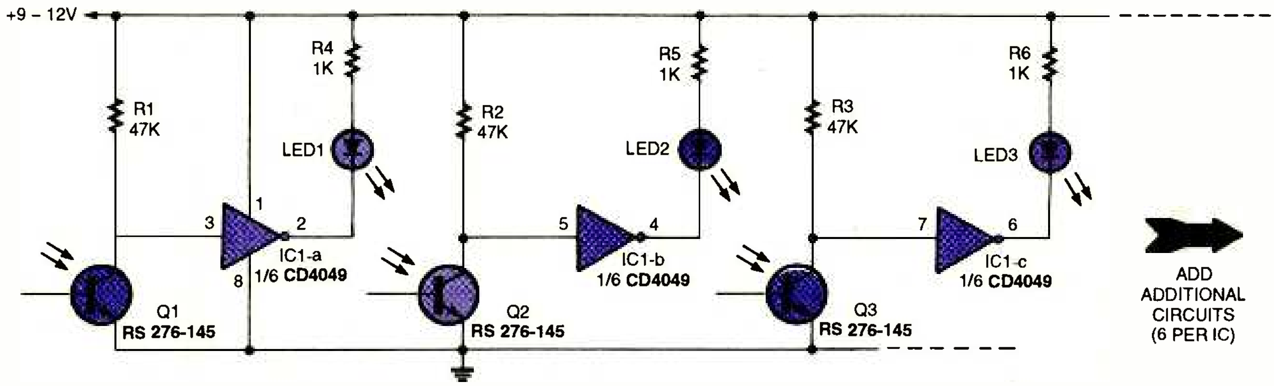

Fig. 5. Although only three stages of the Fig. 4 circuit are shown, you can have six detectors per IC chip—one for each gate.

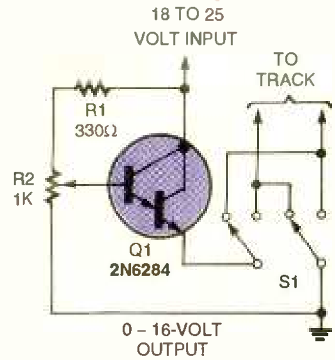

Fig. 6. This simple DC-control circuit uses a Darlington transistor to control the current to the track. Switch S1 sets the train direction.

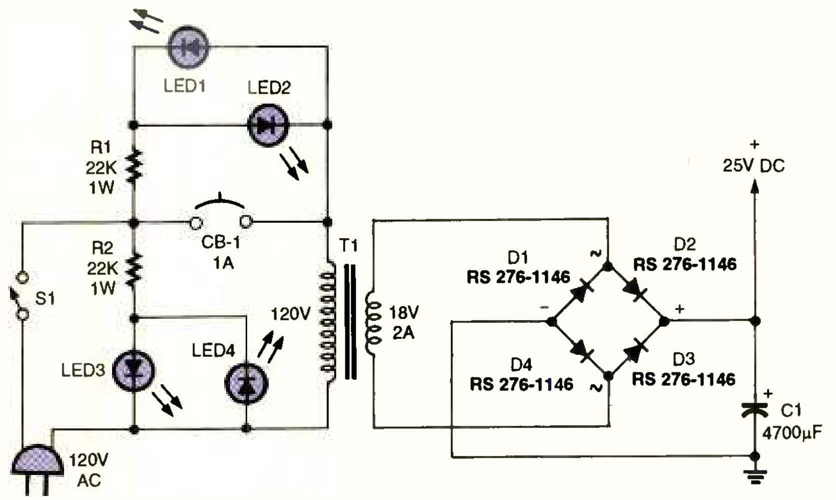

Fig. 7. To power the Fig. 6 controller, this power supply has indicators for both "power on" and "circuit breaker open."

PARTS LIST FOR THE TRANSISTOR-BASED DC-CONTROL CIRCUIT (FIG. 6)

Q1—2N6284 Darlington NPN silicon power transistor
R1—330-ohm, ¼-watt, 5% resistor
R2—1000-ohm potentiometer
S1—Single-pole, single-throw switch

Selecting A Suitable Phototransistor

The heart of the circuitry is choosing the right phototransistor for the job. The best way to determine if a particular type of phototransistor will work with your layout is to breadboard the Fig. 4 circuit and substitute various phototransistors in Q1's position. Drill a hole in the base of your layout between the rails (refer back to Fig. 1) for the phototransistor to snugly slide into place facing up. Ideally, the voltage at the collector of Q1 should be less than 2 volts with ambient light. Roll a train car over the photocell, and the voltage should rise to near supply level. If so, the selected type of phototransistor will suffice.

The following list of inexpensive phototransistors should get you well on your way to building your very own tracking circuit. For starters, RadioShack's 276-145 is a handy item to try and should work in most cases. The following are devices available from Mouser Electronics (*www.mouser.com*) and all cost less than 50 cents each:

- 512-QSD122
- 512-QSD123
- 512-QSD124

Those are all 0.195-inch diameter devices. Layouts that are not well lighted still have a chance of operating with one of the following photo Darlington transistors from Mouser. These average about two bucks a shot:

- 512-L14F1
- 512-L14F2

Those are 0.189 inches in diameter.

Tracks running through tunnels or other dark locations can also be monitored by using infrared-(IR) emitter LEDs mounted over the track above each of the phototransistors. Using these basic circuits, you can make the layout display board as simple or as complex as you like. The CD4049 inverter outputs may also be used to activate crossing signals, horn signals, or just about anything else you desire.

PARTS LIST FOR THE DC POWER SUPPLY (FIG. 7)

D1–D4—4-amp, 50-volt silicon rectifier diode (RadioShack 276-1146 or similar)
CB1—1-amp circuit breaker (Mouser 655-W28-XQ1A-1 or similar)
C1—4700-µF, 35-WVDC, electrolytic capacitor
LED1–LED4—Light-emitting diode, any color
S1—Single-pole, single-throw switch
T1—18-volt transformer (RadioShack RSU 10524239 or similar)

Power Source and Control Circuitry

Our next entry is a simple variable-DC control unit suitable for operating DC-powered model trains. The circuit, shown in Fig. 6, takes the output of an 18- to 25-volt DC source and supplies a variable DC output to the train tracks. Switch S1 is connected as a polarity inverter that allows the train to change directions.

The 2N6284 Darlington transistor can output several amps to the train tracks and should be mounted on a heat sink with at least 25 square inches of surface area. If the DC source is not fused, it would be a good idea to insert a 3-amp fuse in series with the circuit's positive input lead. This circuit will work with many of the HO trains and G gauge trains. Of course, you should always check to be sure what your train requires for power and how it reverses direction before using any control system not specifically designed for it.

DC Power Supply

Our next entry (Fig. 7) is an unregulated 25-volt DC power source for use with the controller circuit in Fig. 6. An 18-volt, 2-amp RadioShack (or other suitable source) transformer is the power source for the DC supply. Four 4-amp silicon diodes arranged in a full-wave bridge produces an output of about 25 volts DC. Capacitor C1, a 4700-µF, 35-WVDC electrolytic capacitor, helps to filter out the AC ripple and store the DC energy. Light-emitting diodes LED3 and LED4 indicate that S1 is closed and the AC power is on.

Protection is provided by CB1, a 1-amp circuit breaker, should a short occur on the railroad tracks. Light-emitting diodes LED1 and LED2 will turn on if the circuit breaker blows, indicating the fault condition.

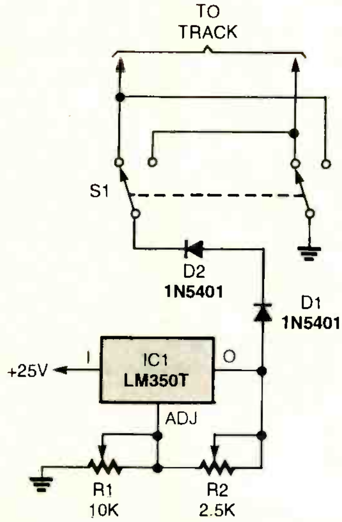

Fig. 8. A variation of the Fig. 6 circuit is to use a high-amperage voltage regulator in place of the simple transistor. Be sure to provide ample heatsinking for IC1.

PARTS LIST FOR THE REGULATOR-BASED DC CONTROLLER CIRCUIT (FIG. 8)

- D1, D2—1N5401 3-amp, 100-volt silicon rectifier diode
- IC1—LM350T variable voltage regulator, integrated circuit
- R1—10,000-ohm potentiometer
- R2—2500-ohm potentiometer
- S1—Single-pole, single-throw switch

Another DC-Controller Circuit

The controller circuit shown in Fig. 8 uses an LM350T variable voltage-regulator IC, which can supply over 2 amps to the rails. The output may be varied from less than 1 volt to over 18 volts, using the power supply in Fig. 7. A double-pole, double-throw switch, S1, reverses the DC output. Potentiometer R1 is the voltage control, and R2 sets the maximum output voltage. The IC must be mounted on a heat sink of at least 25 square inches in order to output its maximum current. Diodes D1 and D2 allow the circuit to adjust to near zero volts out at the low end. Without the two diodes in place, the minimum output voltage would be slightly over one volt.

A Variable Dual-Polarity Controller Circuit

Our last train circuit for this visit, see Fig. 9, is a complete single-control positive and negative 0-to-16 volts DC variable power supply. A RadioShack 25.2-volt, 2-amp center-tapped power transformer serves as the power source for both positive and negative outputs. Diodes D1 and D4 provide the positive DC output voltage, and diodes D2 and D3 provide the negative DC output voltage. Capacitors C1 and C2 are filter and energy-storage capacitors.

Two complementary Darlington power transistors are connected in a common-emitter output circuit, with the NPN transistor (2N6284) controlling the positive output voltage and the PNP transistor (2N6287) controlling the negative output. When the output voltage-control potentiometer, R3, is adjusted to its center position, the output voltage will be zero. As the potentiometer is turned toward the positive supply, Q1 is biased on, supplying a variable positive output to the tracks. Rotating R3 toward the negative supply turns Q2 on, producing a variable negative output. Although I seem to be repeating myself with this requirement this month, remember the two power transistors should be mounted on at least a 25-square-inch heatsink for maximum current output.

Looks like the train has just pulled into the station, and it's time to depart. Come back next month, and we'll look at some more basic circuits. May your train never jump track. **P**

PARTS LIST FOR THE VARIABLE DUAL-POWER CONTROLLER CIRCUIT (FIG. 9)

- C1, C2—4700-µF, 35-WVDC electrolytic capacitor
- D1–D4—1N5401 3-amp, 100-volt silicon rectifier diode
- D5, D6—1N4002 1-amp, 200-volt silicon rectifier diode
- F1—1-amp fuse
- Q1—2N6284 NPN Darlington power transistor
- Q2—2N6287 PNP Darlington power transistor
- R1, R2—10,000-ohm, ¼-watt, 5% resistor
- R3—2000-ohm potentiometer
- S1—Single-pole, single-throw switch
- T1—25.2-volt, 2-amp power transformer (RadioShack 273-1512 or similar)

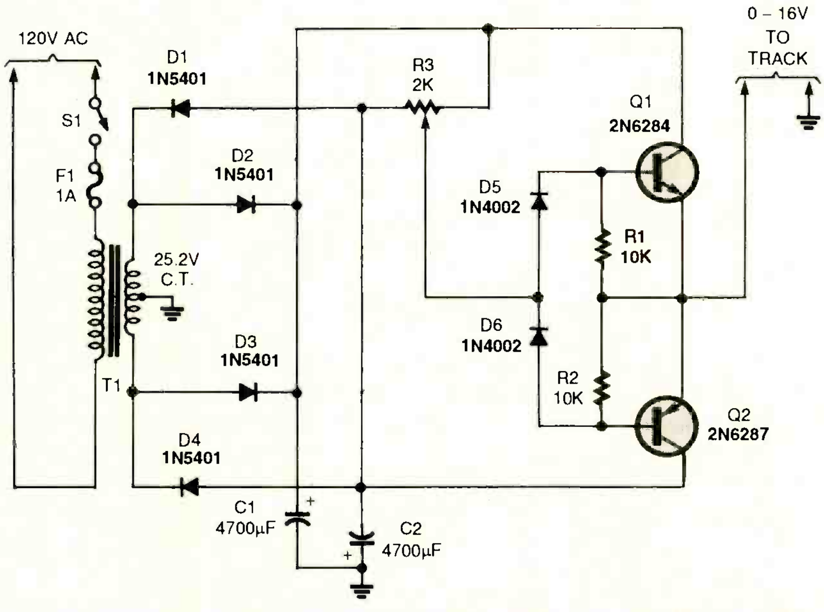

Fig. 9. An interesting approach to reversing track polarity, and therefore train direction, is this circuit. By simply turning R3 in the appropriate direction, voltage of either polarity is applied to the track. An advantage of this design is that you can reverse direction of your train in a smooth and prototypical manner: in order to reverse direction, you must reduce the voltage (and speed) to zero. With the switch in Figs. 6 and 8, you can reverse direction while going full blast—an arrangement your model passengers and cargo won't enjoy in the least!

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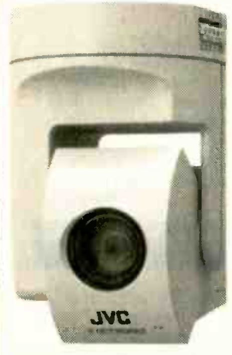

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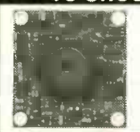

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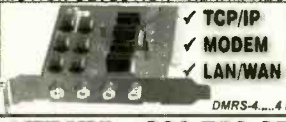

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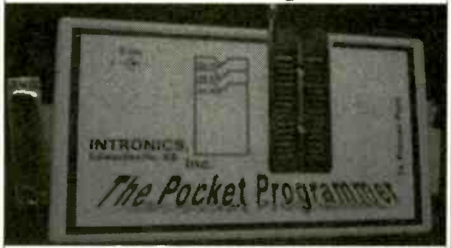

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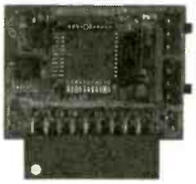

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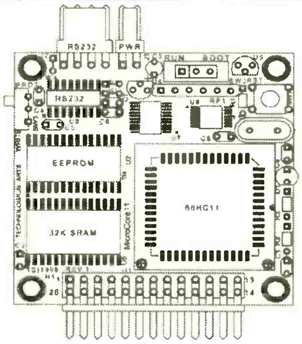

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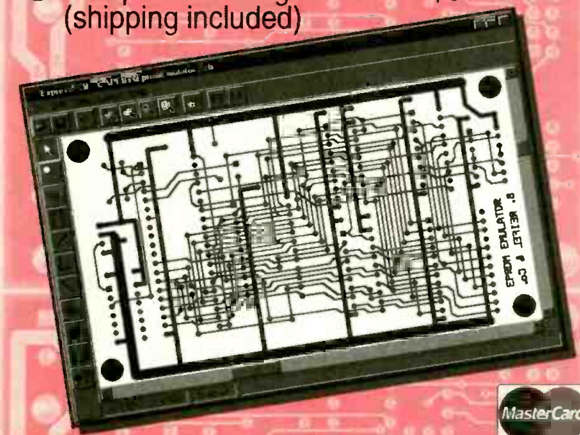

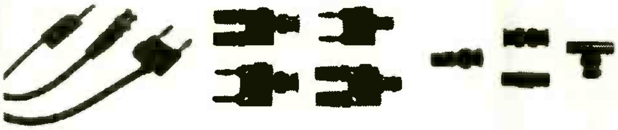

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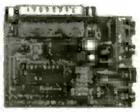

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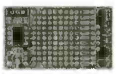

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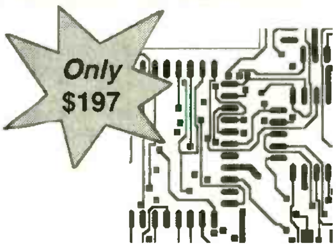

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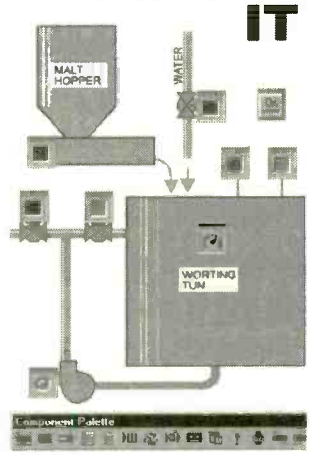

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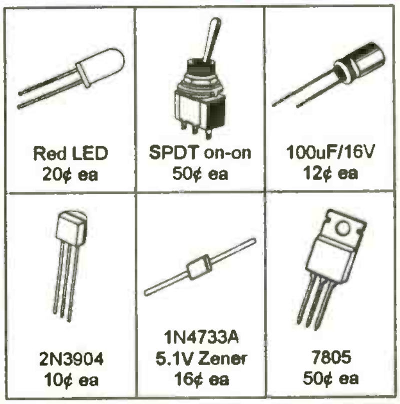

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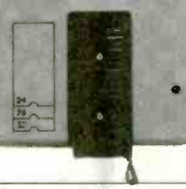

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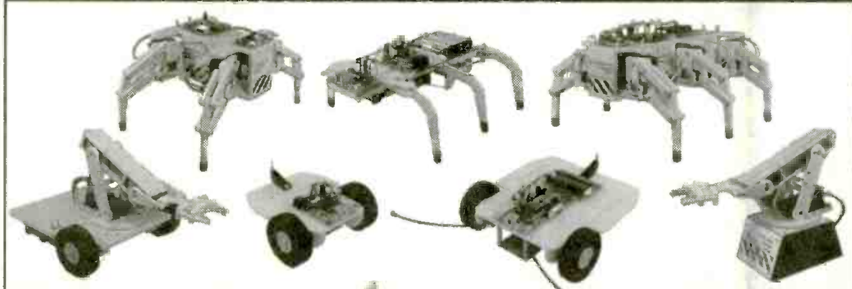

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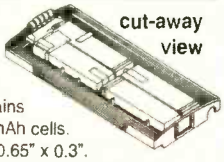

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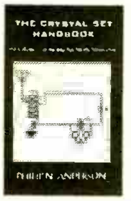

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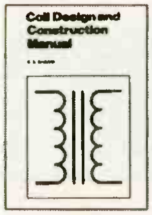

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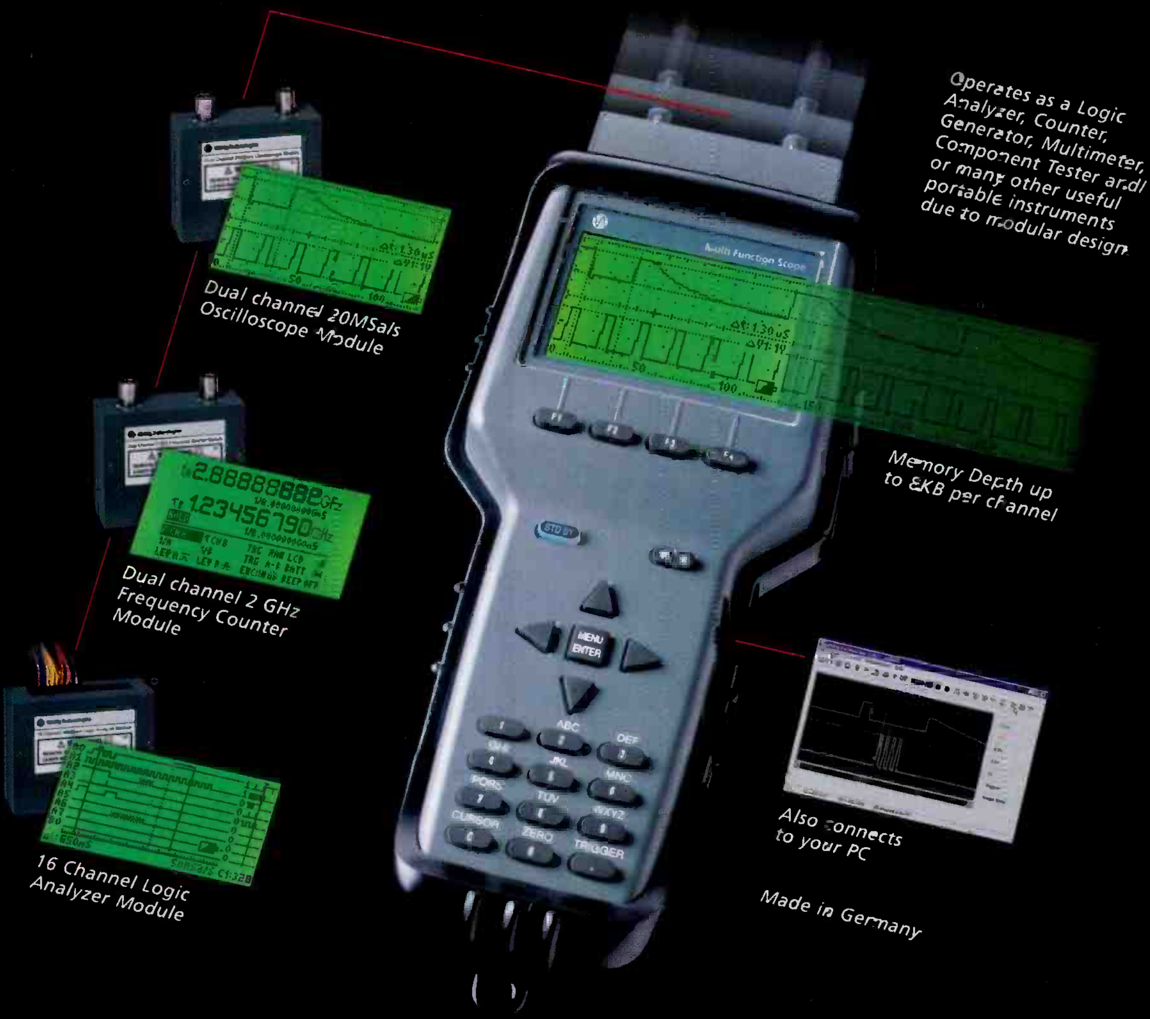

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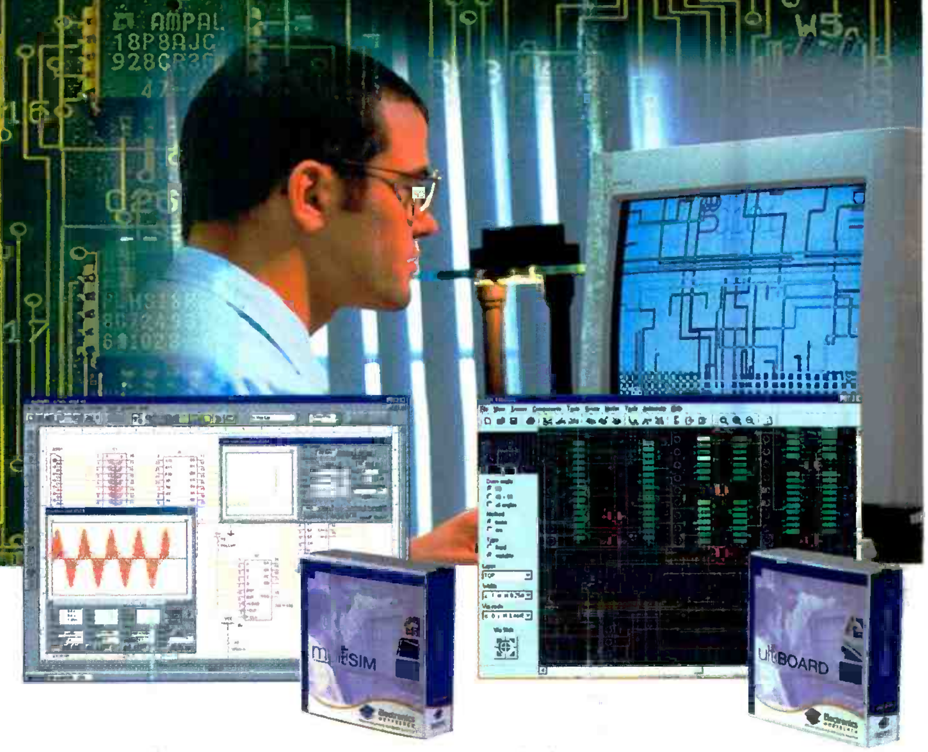

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