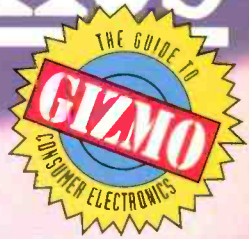


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Popular Electronics



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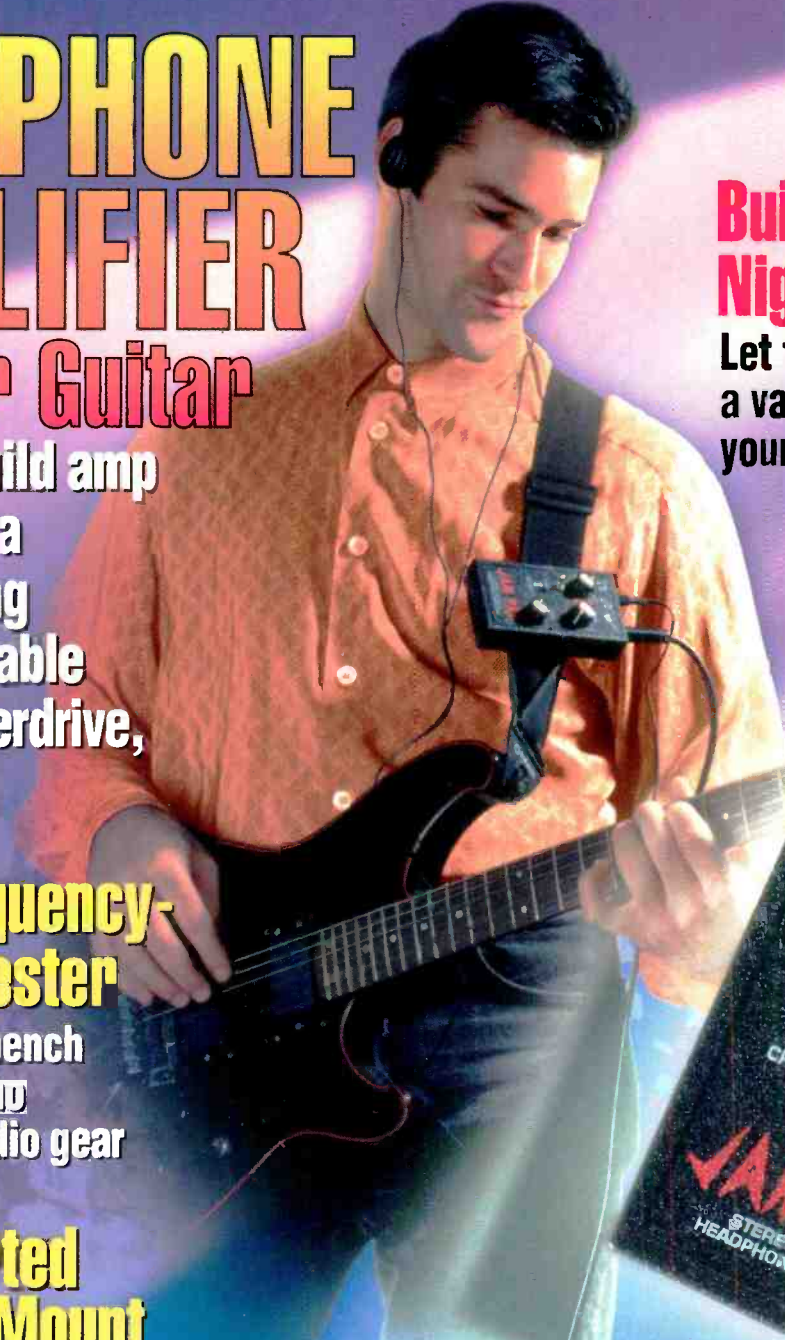
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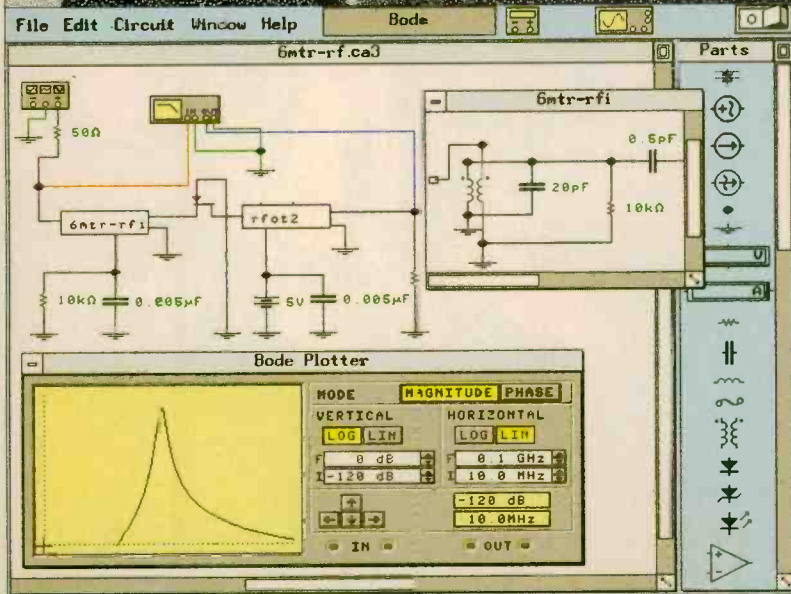
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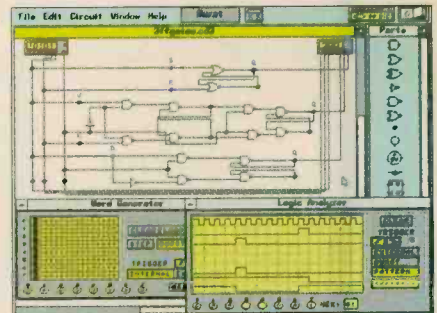
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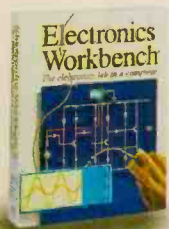
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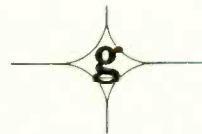


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MARCH 1995

Vol. 12, No.3



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EDITORIAL

HELLO DSS

If you were with us last month, you already know how I feel about my cable company. Because of that, I had long wanted to put in a satellite installation. Unfortunately, aesthetics (there was no getting around the need for an 8- to 10-foot dish) and other factors (namely numerous trees) made that virtually impossible. That's why Thompson's DSS (digital satellite system) was like a dream come true.

For those of you still unfamiliar with it, DSS uses two (soon to be three) closely spaced, high-power satellites to beam roughly 175 channels of audio and video programming directly to consumers' homes. The high power means that you can use a small (18-inch) dish, while the close spacing means that you do not need an actuator to move the dish from one satellite to the next.

I've had my system for a little under a month now, and so far I am very pleased with it. While not perfect, the video and audio quality far surpass what I was getting from cable, and should improve as a more advanced digital-compression scheme is phased in early this year. As for programming, although I am paying a little less per month than I used to for premium cable, I have picked up almost 125 additional channels, including 50 pay-per-view channels and 25 audio-only music channels; and the number of channels is expected to expand still further during the year. Of course, there is also the initial outlay of \$699 to \$899, plus installation costs. Due to high demand, there is little if any discounting going on at this time.

In deciding whether or not DSS is for you, there are a few downsides to consider. First, you need a clear line-of-sight to the satellites. Second, if you want local programming, you will need to either get it off-the-air or subscribe to your cable company's "broadcast basic." The five major networks are also available via satellite if you live in an area where over-the-air reception is not satisfactory. Finally, unlike large dishes, there are no in-the-clear (unscrambled and free) signals.

DSS is an evolving technology, but the early results, and acceptance, are promising. We will be keeping an eye on it, as well as other satellite-TV services, and are planning some in-depth coverage for later in the year. Look for it.



Carl Laron
Editor

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LETTERS

PINNING US DOWN

A sharp-eyed reader spotted two errors in my article, "Switching with PIN Diodes" (*Popular Electronics*, December 1994). In Fig. 5, diode D3 is drawn in backwards. The "arrow" should point up. In Fig. 7, diodes D3, D6, D9, and D12 are also shown backwards. I hope those errors did not cause anyone too much confusion.—
Joseph J. Carr.

LOW-VOLTAGE POWER CONTROLLER

We have been advised of a few corrections for the article "Build a Low-Voltage Power Controller," which appeared in the December, 1994 issue of *Popular Electronics*. First and foremost, there has been a revision in the foil pattern for the main board; the revised foil pattern is shown here in Fig. 1. Second, the phone/Fax number for the supplier, TW Engineering, has changed; the new number is 714-527-2547. There were also a few typographical errors: In Fig. 1, pins 6 and 7 of U2-b are reversed; in Fig. 4, connection points P1 and P2 are reversed; and in the parts list, D2 should be specified as a 1N751 Zener diode. We apologize for any problems those errors may have caused.—
Editor

I am writing about Fazal A. Rehman's article, "Build a Low-Voltage Power Controller" (*Popular Electronics*, December 1994). I am wondering about the use of multiple IRFZ40's for currents of more than 4 amps. I

believe that the use of a heat sink for Q1 would be easier and more cost-efficient. According to the data in the November–December 1994 Digi-Key catalog, the IRFZ40 has an ID continuous rating of 35 amps, and a PD maximum rating of 125 watts. Even with derating to one-half, heat sinking of Q1 would allow a current much larger than 4 amps. Also, for lower currents, the IRFZ20, at less than half the cost of the IRFZ40 and the IRFZ42, should be an excellent choice. The IRFZ20 is rated at 15 amps and 40 watts. Because of the higher on resistance of the IRFZ20 (0.1 ohm versus 0.028 ohm for the IRFZ40), a small heat sink should probably be used if the current is as high as 3 or 4 amps.

The article presents an excellent idea. I have never seen a similar DC power controller, and I can think of several uses for one. I think most of the construction articles (and others) in *Popular Electronics* are good, although I frequently make minor changes in the projects, which (I think) are improvements. B.S., CET
Hillsboro, MO

BELATED THANKS

I'm offering a very belated thank-you for publishing my "Haves & Needs" letter in the

December 1993 issue of *Popular Electronics*. I was trying to get parts and a service manual for my Gulbransen electronic organ. Health problems, both my wife's and mine, including a couple of small strokes, kept me from my computer and from working on the organ.

I received letters from New York, Minnesota, and Missouri, and even as far away as Puerto Rico. A gentleman from Connecticut even phoned and offered to test the tubes, replace them, and provide a service manual!

Again, thank you. You can be sure that any time I have a problem with an electronic device, I will turn to *Popular Electronics* for a solution. J.W.H.
Leewood, KS

LEARNING VS. TEACHING

This letter is in response to the letter by A.S. from Taneytown, MD, which appeared in the December 1994 issue of *Popular Electronics*. I cannot claim to fully understand the U.S. educational system, nor will I pretend to. I wish to state, however, that claiming that trigonometry and complex algebra are not important in today's society is pure nonsense. There are virtually no engineering fields—electronics among them—in which you are not required to use those branches of mathematics.

No one is forcing the writer to forget his skills; it is solely his responsibility that they remain strong. Most teachers I know do their absolute best when it comes to teaching, and I have yet to see one who will not answer a question that is off the beaten path of what is currently being taught. I believe that the writer has a bad attitude when it comes to learning or just is not interested in the subjects being taught. Perhaps both. My advice for him is to find a field that grabs his interest—it does not

sound as if it is electronics. The learning will then be replaced by a natural desire to know all he can about the field, and it won't seem like learning at all. F.B.
Canada

MONITORING SOLAR FLARES

Thank you for the article "Ground Zero: The Other End of the Radio Spectrum" by Karl T. Thurber (*Popular Electronics*, October 1994). That is an area that deserves more visibility.

Unfortunately, the information contained in the section on solar-flare monitoring is a bit outdated—much has happened since Cherman's book was published. For readers who might be interested in this fascinating area, I would like to direct their attention to Peter O. Taylor's book, *Observing the Sun* (Cambridge University Press, 1991). The author is the chairman of the Solar Section of the American Association of Variable Star Observers (AAVSO), and his book covers electronic solar-flare observation as well as visual techniques. Peter Taylor leads an active network of amateurs who, with simple radio equipment, monitor and report solar-flare activity. Those observations currently make up more than 70% of all stations reporting data to the National Oceanic and Atmospheric Administration (NOAA). Thus, it is an excellent way for electronics hobbyists to make very useful contributions to science.

The AAVSO observers receive regular reports that summarize all contributions, as well as a technical newsletter that describes new receiver circuits, antennas, computer-based and electromechanical data recording methods, surplus-equipment conversion, etc. Mr. Taylor has also published related information in *Communications Quarterly*. S.H.
Amherst, NH

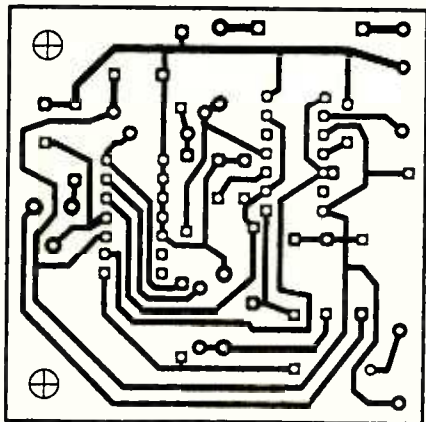


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MULTIMEDIA WATCH

By Marc Spiwak

A Multimedia Monitor

For a long time, basic computer peripherals performed the same old functions. A keyboard was just a keyboard, a modem was just a modem, a monitor was just a monitor, and a joystick was just a joystick. But at some point, various kinds of pointing devices started to appear on keyboards and fax capability was added to modems.

Today we also have monitors with speakers built-in, just like they are in a TV set. Specifically, I am now

neat zoom feature built-in. That eliminates the need to reposition and resize the picture for different applications.

The speakers are not self-amplified, so you need some kind of amplification, either from a sound card with a built-in amp or a separate add-on one. While the speakers are not the kind that an audio enthusiast (or loud-music listener) will want, they are more than adequate for the average guy or gal who just wants to enjoy a little multimedia, as well as for most business-audio applications.

The best thing about the Audio 15's speakers is that they don't take up any extra space on the desktop, which I know is always a very crowded place. I would not be surprised if eventually all monitors have built-in speakers, and audio enthusiasts will simply buy better ones just as they always have in the past.

The Audio 15 has a suggested retail price of \$499. Street prices, of course, will surely be much lower than that.

A NEW CONTROLLER

I mentioned before that at one time, joysticks were simply just joysticks. But I've played with some unusual joystick-like controllers recently, including the new *Phoenix* flight- and weapons-control system from Advanced Gravis. To start with, *Phoenix* includes Gravis' usual high-quality joystick control with adjustable ten-

sion. But *Phoenix* is much more than just a joystick.

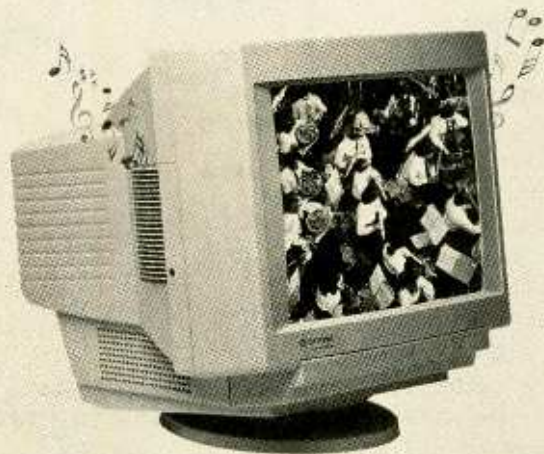
That bizarre-looking controller combines a joystick, a throttle and rudder controller, and 24 programmable buttons all in one unit. The buttons can be set to execute any joystick or keyboard command. The buttons can also serve primary and secondary functions, for a total of 46 customizable functions. The unit ships with pre-configured control settings for many popular games, and custom settings can be saved to disk.

Phoenix can control so many functions because it connects to both the joystick port and the keyboard connector. A *Phoenix* connector plugs into the keyboard connector on your PC, and your keyboard plugs into the end of the *Phoenix* connector.

Phoenix has a list price of \$149.95. For people who want the utmost in flight realism and control convenience, there's nothing like a *Phoenix*.

NEW STUFF

This month I have a few discs that are particularly useful to the staff here at **Popular Electronics**. The first one, *Books in Print Plus* from Reed Reference Publishing, is basically a database of all books that are in print. Naturally, the power of a computer and a CD-ROM make it easy to find what you are looking for. *Books in Print* does not come cheap, though. A year's subscription to the

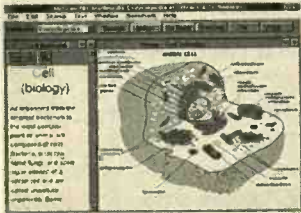


The Audio 15 from Tatung adds a pair of speakers to an excellent 15-inch computer monitor. It makes for a near-perfect multimedia workstation.

testing out a new 15-inch monitor from Tatung, the *Audio 15*. Besides having a nearly flat screen and a crisp, clean picture, the *Audio 15* has built-in stereo speakers. The digitally controlled monitor also has a

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The *Encyclopedia of Science and Technology* is a comprehensive reference work that includes 7,300 articles and more.

disc sells for \$1,095 for the regular version and \$1,595 a year for the version that includes 238,000 book reviews. Pricy as it is, it is mighty useful.

The second disc that's useful in the everyday production of a magazine like this one is the *McGraw-Hill Multimedia Encyclopedia of Science & Technology* for Windows. That disc includes 7,300 articles, 105,100 terms, and 122,600 definitions from 81 major subject areas. It is loaded with pictures, audio, and video. This disc is also an expensive one, priced at \$1,300, but it is an exceptionally useful disc to have on hand for anyone who can afford it, as it contains information on almost any conceivable technical or scientific topic—including electronics.

The third disc is a year's worth of Ziff-Davis' *PC Magazine* on CD-ROM—the complete text of 22 issues. While I prefer to read the printed version of the magazine, the CD-ROM version is the best way to look up information on a particular subject or product that has been covered within the last year. I find it difficult to keep up with all the reading material included in two 500+ page editions of the magazine each month, and so the CD-ROM is a good way to find anything important I might have missed.

Moving on, I also I have a small collection of discs that

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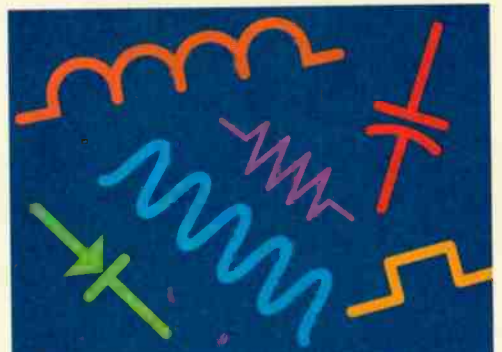
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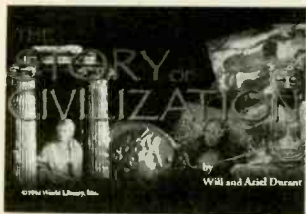




The Phoenix flight and weapons control system from Advanced Gravis is a game-player's dream come true.

all deal with history in one way or another. The first one, *America's Civil War—A Nation Divided*, from Software Marketing Corporation, is a complete collection of Civil War trivia presented via stories, photos, videos, narrations, maps, and more. All of the major players are covered. Any war buff or person needing to research the war between the states should check out the disc. It retails for \$59.95.

The next disc deals with history on a much larger scale than just one war. *The Story of Civilization*, from World Library, Inc., is Will and Ariel Durant's compilation of more than 3,000



The Story of Civilization covers more than 3,000 years of history on a single CD-ROM.

years of history on a single multimedia CD-ROM. The full text of all 11 volumes of the Durant's work, including over 800 illustrations, audio, and video, details history

and culture from prehistoric times to around 1840. The disc is a wonderful study aid for history students and historians, alike. It has a retail price of \$99.95.

Leonardo The Inventor, from Future Vision Multimedia, is about one man who made his own history—that man being Leonardo daVinci. Many of daVinci's inventions, or visions, while unused in his time, have come to pass in ours. His many accomplishments can be explored through animations and more on this disc that's a lot of fun to play with.

Another disc is—or was—history in the making. *A Hard Day's Night* from The Voyager Company is the complete and uncut Beatles movie in QuickTime for Windows format with lots of extras thrown into one CD-ROM. While it's better to see the movie on the big screen, the disc includes stuff that might be hard to find elsewhere, such as the original script including deleted scenes, the theatrical trailer, and more. Beatles fans will probably want this CD-ROM in their collection, simply because it's the Beatles.

A while back, I looked at

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Reed Reference Publishing
121 Chanlon Road
New Providence, NJ 07974
Tel. 908-464-6800

Software Marketing
Corporation
9830 South 51st Street
Building A-131
Phoenix, AZ 85044
Tel. 602-893-3377

Tatung Inc.
2850 El Presidio Street
Long Beach, CA 90810
Tel. 213-979-7055

The Voyager Company
578 Broadway, Suite 406
New York, NY 10012
212-431-5199

World Library, Inc.
2809 Main Street
Irvine, CA 92714
Tel. 714-756-9500

Ziff-Davis
One Park Avenue
New York, NY 10016
Tel. 212-503-5100

a disc published by The Discovery Channel, *In The Company Of Whales*; it's an entertaining multimedia look at those unusual ma-

rine mammals. It seems that The Discovery Channel plans on producing lots of new CD-ROM's on various topics. One of them, *Normandy—The Great Crusade*, is certainly history-related. That disc chronicles D-Day—June 6, 1944. That's the day that Allied forces invaded the beaches of Normandy in order to liberate Europe and crush the Third Reich. Two other new discs have less to do with history and more to do with the neat stuff you see on The Discovery Channel. *An Interactive Journey With... Sharks* is an entertaining look at those creatures that have roamed the seas for 400-million years. *Beyond Planet Earth* takes you on an interactive journey through the heavens.

I like cars—I've been interested in them for as long as I can remember. If cars are also your passion, this month I have two discs that you won't want to miss.

The 1994 *Auto Almanac* from CE3 Incorporated contains over 2,000 pages of automotive information. There's almost a quarter-million vehicle specifications and prices, photos, video, and more. The 1995 version should be out by the time you read this. The disc has a suggested retail price of \$14.95.

The second disc on cars is called *Cars! Cars! Cars!* and is published by MPI Multimedia. The disc is loaded with videos, photos, facts, and trivia on all kinds of cars ranging from dream cars to racing cars to wacky cars, and will be enjoyed by any car buff.

Last this month is a new screen saver from LucasArts called *Star Wars Screen Entertainment*. The software comes on floppy discs, but is great nonetheless. At \$35.95, it's a must-have for fans of the film.

GIZMO®

A CHRONICLE OF CONSUMER ELECTRONICS

Video CD-i

MAGNAVOX CDI450 COMPACT DISC-INTERACTIVE MULTIPLAYER WITH ADD-ON DIGITAL VIDEO CARTRIDGE. Manufactured by Philips Consumer Electronics Company, One Philips Drive, Knoxville, TN 37914-1810; Tel. 615-521-4316; Suggested retail price: \$299; Digital Video Cartridge: \$249.

We've always said that when we have kids, there will be no video games allowed in the house. Sitting zombie-like in front of a TV, controller in hand, cannot be a positive, life-enhancing way for kids to spend their time. Shouldn't they have some better things—sports, reading, playing, chores—to do? Will they ever do anything else if video games are around?

After all, we—and our editors—are well aware of the fact that we've yet to meet a deadline when we've had a game machine in for review. And we're "responsible adults." What effect would videogames have on our kids' homework assignments?

Well, if the system is *Philips' Magnavox CDI450* or *CDI550*, it's possible that those school assignments would be improved. Compact Disc-Interactive, or CD-i, is more than just a game system. It's an interactive "multiplayer" that can be used to research term papers (with an interactive encyclopedia); improve one's tennis or golf game (with interactive sports instructions); play audio CD's; view Photo CD's; watch full-length movies in full-color, full-motion video; and, of course, play games.

Compact Disc-Interactive has been evolving rapidly since its market introduction about three years ago (see *Gizmo*, February 1992). In fact, the latest generation of CD-i products bears little outward resemblance to its earliest ancestors.

The first CD-i players were full-sized components, designed to look like everything else in your entertainment center. And they bore a hefty suggested-retail price tag—\$1000. The CDI450 is less than



a quarter of the size and a third of the price of the original. The 11.75 × 7.5 × 2.6-inch player carries a suggested retail price of \$299.

It offers all the functions of the original player, with a very special optional bonus—a Digital Video Cartridge that allows the CD-i unit to play full-length feature films and advanced action games. The add-on cartridge (*Model 22ER9956*) retails for \$249.95, and can easily be plugged into a slot on the top of the CDI450 by the user. The step-up model CDI550 comes with the Digital Video Cartridge already installed, at a suggested retail price of \$499.

The Digital Video Cartridge is based on the MPEG-1 international standard, developed by the Moving Picture Experts Group. It delivers computing performance of 400-millions instructions-per-second (MIPS) with multiple RISC (reduced instruction-set computer) processors. The result is a 5-inch disc that contains more than 72 minutes of 30-frame-per-second, full-motion digital video, along with CD-quality audio.

Independent of NTSC and PAL broad-

cast standards, Video CD has been designed for compatibility with multiple playback platforms, including dedicated Video CD players, Video CD-compatible computer systems, and CD-i players equipped with the Digital Video Cartridge. The new generation of CD-i players are the first—and, so far, only—devices on the market that can be used to play Video CD movies and music videos.

The new CD-i players are also blessed with an abundance of available software, which has grown substantially since the product was introduced three years ago. The CDI450 is bundled with "International Tennis Open," and the CDI550 with the arcade hit, "Space Ace." Both players also come with the CD-i version of "Compton's Interactive Encyclopedia."

The quality, as well as the quantity, of the software has improved; many newer titles have been specifically designed to take advantage of CD-i's full-motion video capabilities. Philips' software division, Philips Media, recently created four publishing subdivisions—Games, Family Entertainment, Home Entertainment, and Video CD—each of which has been busy

creating new CD-i titles. More than 150 titles are currently available, including new releases resulting from Philips' agreements with such major motion-picture studios as MGM/UA and Paramount. A review of some assorted CD-i software follows our look at the latest hardware.

The CDI450 and CDI550 are virtually identical; the only difference is that the Digital Video Cartridge, which is included with the latter, must be purchased separately for the CDI450. The top of each CD-i player contains two covered compartments. The smaller one, on the left side, holds the plug-in Digital Video Cartridge. To the right is the larger disc compartment. The only thing on the front of the unit is the input for the wired game controller. The power switch is found on the left side panel. The rear panel contains a jack for the outboard power supply and a set of three RCA phono jacks for connecting the CD-i multiplayer to a TV and, if desired, a stereo audio system.

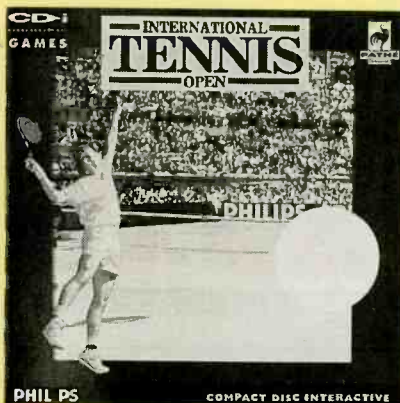
Installation of the Digital Video Cartridge is simple. With the player switched off, the disc compartment cover is opened to reveal latches used to remove the cover of the Digital Video Cartridge compartment. A special, pen-shaped tool is then used to remove a protective metal cover from the connectors within the compartment. The cartridge plugs into those connectors, and the compartment cover is replaced. Because the Digital Video Cartridge also contains memory that is required for some programs and games, removal is not recommended unless repair is required.

When the CDI450 is turned on, an opening screen appears on the television screen. It contains the Magnavox logo, a small box that notes the time and date, an indication if a disc is in place or if the disc compartment is open, and a bar labeled "Options." Clicking on the options bar opens the options screen, which is used for CD audio play, setting the time and date, and storage of audio and Photo CD programs.

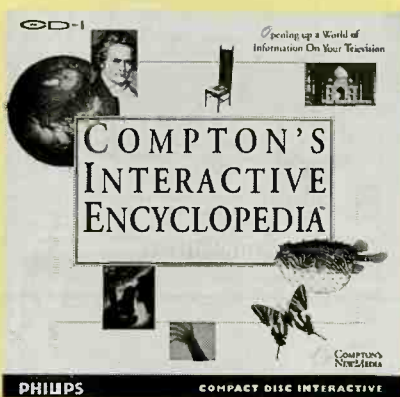
To play a CD-i disc, the disc compartment is opened by pressing on the front edge of the cover. The cover gradually opens to a 60° position, where it remains until the disc is in place and the cover is pressed closed. An LED flashes while the disc is starting up, and remains lighted while the disc is in play.

Each disc contains a brief set of instructions. Further help is often available on-screen, if needed, although most play is largely intuitive. (More so for some people

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The two-player version of International Tennis Open is included with the CDI450.



Including "Compton's Interactive Encyclopedia" with the CD-i player will make parents view it as more than just a game system.

than others—a 14-year-old relative using CD-i for the first time never even glanced at the instructions, yet he easily beat our high scores on every game!)

We were particularly impressed with the quality of CD-i movies. The video was not laserdisc quality, but it was easily equivalent to VHS tapes, and the digital audio sounded every bit as good as a CD or laserdisc. The full-spectrum sound was most obvious on "Star Trek IV: The Undiscovered Country." When the Enterprise's engines were placed on warp speed, they could be felt, as well as heard, throughout the viewing room. (Don't throw out the old VCR yet—the CD-i movie selection is still pretty limited, although several new ones are in the works.)

The full-motion video capability also is used to enhance some CD-i games, many of which require a Digital Video Cartridge. For instance, the adventure game "Dragon's Lair" features motion-picture style animation, and the interactive drama "The 7th Guest" uses real actors in ghostly digital video sequences.

The game controller included with the CDI450 is a wired, one-person device.

(An optional splitter allows two-player play with the addition of a second controller.) A 12-foot cord allows freedom of movement while playing. The controls are found on the rounded section that tops a narrower grip. At the center of the round section, a circular, directional thumb-pad moves the cursor up, down, left, right, and, in some programs, diagonally across the screen. To either side of the thumbpad are action buttons.

The controller is fairly accurate and easy to use. We had one problem with it, however. We tended to accidentally hit the left-side action button while working the directional controller, with the unfortunate result of inadvertently exiting a game—usually at a crucial point.

Several optional CD-i controllers—a joystick, a mouse, a trackerball, and a roller controller—are available. We tried out the Model 22ER9017 joystick, which carries a suggested retail price of \$29.95. That controller has a more traditional look; designed for two-handed play, it has a joystick on one side and four action buttons on the other. Traditional with a twist, that is: The optional controller is adaptable for left- or right-handed play. The player can hold the controller with the joystick on the right side, or flip it over so that the joystick is on the left. When a slide switch is also "flipped," the controls are reversed as well, so that pressing the joystick forward still makes the cursor move up or forward. The four buttons on the other side of the controller are actually two sets of A and B buttons; they are in the proper places no matter which way the controller is held.

The model 22ER9017 gave a finer degree of control to game play. It also totally eliminated the problem of hitting the wrong button at an inopportune time.

The CDI450 comes with "International Tennis Open" and "Compton's Interactive Encyclopedia." The tennis game allows you to assume the persona of Victor Player, a promising young hopeful just starting out on the pro circuit. Player strives to win the three major international Tennis Open Championships, held in London, New York, and Paris. On the way, he trains and plays "friendly" exhibition matches against four top players—Julio Jimenez, Thomas Ullman, Erik Andersen, and Robert Garrett. This two-player game also allows competition with a friend. At the end of each match, Player receives his International World Partner player ranking.

We wish we'd had "Compton's Interactive Encyclopedia" back when we were in school, writing reports. Not only is it much more convenient than going to the library and hoping that none of the other 29 kids in the class, all with the same assignment, were using that volume of the printed encyclopedia—it's also more inter-

(Continued on page 19)

CD-i Games People Play

CD-i SOFTWARE ASSORTMENT. Published by Philips Interactive Media, 11111 Santa Monica Blvd., Suite 400, Los Angeles, CA 90025; Tel. 310-444-6600; Price range: \$20 to \$60.

The following are some admittedly subjective reviews of several CD-i titles from each category. They represent each category produced by Philips Media: Games, Family Entertainment, Home Entertainment, and Video CD. Where available, prices for specific games are included.

GAMES

We are no experts when it comes to video-gaming, and our tastes differ from the average gamer. For instance, we tend to steer clear of any games that feature graphic violence and are won by brute force. And we've yet to play one of those interactive drama/mystery games to a successful conclusion—we just don't have the patience. However, we do get hooked on those games that combine strategy and timing.



Keeping those criteria in mind, it's not surprising that our favorite game by far—and the reason for this month's missed deadline—was "MegaMaze" (\$34.98). To be fair, its packaging did contain a clear warning that the game was highly addictive. Aimed at players aged 10 to adult, MegaMaze is essentially an electronic version of one of those handheld mazes in which you must guide a small ball into a hole by tilting the board. The CD-i adds some twists, however, including purple balls, which also move as you tilt the "board" but which explode on impact and can destroy the blue ball that you are trying to get "into the vortex." Then there are sink holes, and laser guns, and trap doors, and, well, you get the picture. There are 75 levels of increasing difficulty, with a total of 165 mazes. To reach the rank of

Mazemaster, you must complete a maze level within a pre-set time limit, or guide all four purple balls home before the blue ball.

"The 7th Guest" (\$59.98) is one of those "interactive dramas of mystery and intrigue" that leave us totally baffled. The double-disc set takes place in the haunted mansion of toymaker Henry Stauf, who disappeared a couple of months before the start of the game. He has invited six guests to a party at his home, and none of them



are ever seen again. The player takes on the persona of the 7th Guest, "a mysterious entity known only as Ego ... [whose] role, identity and purpose is not shown or explained, but is rather experienced as a seamless, integral part of the total environment." The goal is to explore the mansion, obtaining clues by solving puzzles and viewing dramatizations of the missing guests. Perhaps if we'd had more time or patience, we'd have done a bit better; as it is, we gave up after solving only a few puzzles. A Digital Video Cartridge is required, and results in video quality that far surpasses that of any of the other platforms on which we've seen the game.

"Dragon's Lair" (\$49.98) pits Dirk the Daring against a host of villainous obstacles as he battles his way through the evil wizard Mordroc's castle to rescue the lovely Princess Daphne. This game, which also requires a video cartridge, is an excellent example of how full-motion video can



be used to enhance game playing. The animation is excellent—colors bright, motion seamless—as is the accompanying soundtrack. The game requires speed, timing, and cunning, as the wizard attacks in various unexpected ways. Dragon's Lair was created by Don Bluth, who is best known for the arcade hit Space Ace.

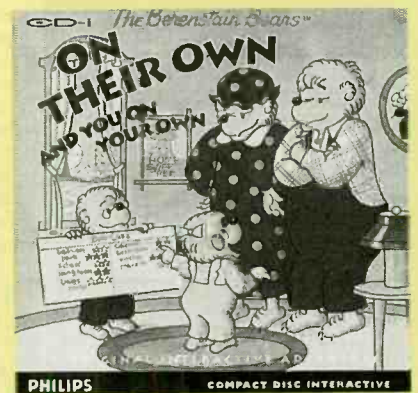
"Lil' Devil" stars Mutt, a little demon who has been "volunteered" to navigate through a winding obstacle course called The Labyrinth of Chaos to retrieve the Mystical Pizza of Plenty. Players must guide Mutt through five levels of increasingly difficult game play, all the while avoiding a wicked character called The Entity, who tries to whisk Mutt off to a torture chamber. Poor Mutt suffered mightily at our hands—being beaten by a club-wielding monster, and repeatedly drowning while trying to cross a river—



even when we switched to the upgraded game controller. "Lil' Devil" also uses the Digital Video Cartridge, and has the enhanced video and audio to show for it.

FAMILY ENTERTAINMENT

By "family entertainment," Philips Media means software for young children. In this category, there is no violence, and the emphasis is on learning.



"The Berenstain Bears on Their Own and You on Your Own" (\$39.98, for ages 4 and up) teaches "school skills" such as counting, colors, and the like, but its main emphasis is on responsibility. The pro-

World's first wireless home theater system makes professional-quality surround sound affordable...

Now you can add surround sound to your home entertainment lineup with the amazing new Chase Technologies decoder that works with your existing stereo and an assortment of wired and wireless speakers.

by John Lindner

Let's face it. As much fun as renting a video can be, it's just not the same as seeing a movie in a theater. I remember the first time I saw *Jurassic Park*—I nearly jumped out of my seat when the dinosaurs roared. One of the reasons movies seem so real is because surround sound makes it seem

The secret of surround sound

Surround sound has become the rage of the '90s because it adds depth and realism to stereo sound, giving you the home theater experience. In short, it makes you feel like you are actually at a concert or theater.

To get surround sound, some people have tried simply adding additional speakers to their home entertainment lineup. But it takes more than additional speakers to get surround sound; there needs to be a way of separating the original signal into distinct channels so that you're not just duplicating the same sounds and broadcasting them from different areas of the room.

The new Chase Technologies HTS-1 surround sound decoder does just that, and in a revolutionary way that rivals the best Dolby Pro-Logic and THX systems available. The HTS-1 provides five channels of sound from any two-channel stereo source.

The HTS-1 works with a variety of speakers. In the front, you can use your existing stereo speakers. For the rear, choose from inexpensive wired speakers, high-quality wireless speakers, or even an audiophile-quality wireless satellite subwoofer system. The HTS-1 also gives you the ability to add a powered center channel speaker (instead of using your TV's built-in speaker).



like you're actually there when events are happening. Now there's an incredible new device that lets you use your stereo receiver to get that same surround sound in your home.

The secret's in the signal. To get surround sound, you need to do more than simply add extra speakers. There needs to be a way of separating the signal from the musical score or movie soundtrack into distinct channels for each speaker. The new Chase Technologies HTS-1 surround sound decoder does just that, and in a revolutionary way that rivals the best Dolby Pro-Logic and THX systems available today.

Wins over critics. In the September 1994 issue of "High Performance Review," noted audio critic Daniel Kumin said "the HTS-1 can do quite a job of recreating a 3D theatrical experience...surround effects emanated with satisfying fullness...sound was clean at any level...with quite involving and natural sound ambience."



The new HTS-1 decoder won the **Design and Engineering Award at the Consumer Electronics Show for being one of the best and most innovative new products.**

Surround™ signals in every stereo, videotape or laserdisc. This passive method is superior to active decoders such as Dolby and THX because it requires no AC current to decode. As a result, you experience more clarity, more detail, and a greater sense of space. Plus, you won't experience the noise or distortion which can occur with active decoding methods. You don't need any extra amps! Just connect the HTS-1 to your stereo, add your speakers, and you'll experience the magic of home theater at a fraction of the cost of other systems.

Plus, John Sunier, a leading authority on surround sound and producer of *Audiophile Audition*, a nationally syndicated radio program for audio enthusiasts, says, "...the new Chase HTS-1, when used to decode the hidden ambience in all musical recordings, definitely outperforms all the Dolby and THX processors (which could cost you up to \$3,000)...I am impressed!"

Decoding breakthrough.

Last year, audio industry veteran Bob Rapoport invented a new five-channel "passive" circuit for decoding the Dolby



Five channel options. The HTS-1 decoder can be used with two, three, four or five channels of amplification, making it the most cost effective method for upgrading your stereo system to full home theater performance on the market. Best of all, the HTS-1 works with a variety of hard wired and wireless speakers.

In the front, most people use wired stereo speakers. Use your existing stereo's speakers or use one of a variety of wired speakers. Comtrad also offers the Chase Dialog center channel speaker. If your front speakers are more than eight feet apart, adding a center channel speaker will help keep voices and sound effects centered on the screen for stunning localization and clarity. The Dialog is self powered and video shielded to prevent interference with your television set.

The Chase HTS-1 decoder is the most cost-effective method for upgrading an existing stereo system to full home theater performance on the market.





The new Chase Technologies HTS-1 surround sound decoder gives you the option of using either traditional wired speakers like the Chase ELF-1s, or using wireless speakers or a wireless satellite subwoofer system for additional convenience and enhanced sound quality.

Wireless freedom. When it comes to rear speakers, you can again choose standard wired speakers like the Chase ELF-1s. But if you want to avoid the hassle of running speaker wire up and down walls, behind furniture, and under carpet, you can add the freedom and convenience of wireless speakers.

Recoton wireless speakers utilize a transmitter which broadcasts sound signals up to 150 feet through walls, floors and ceilings. The speakers can be placed anywhere; they plug into a standard electric outlet. This eliminates the need to have wires running from the stereo to the speakers, which can be a nuisance with surround sound since the rear speakers are often elevated or wall mounted.

Affordable option. Recoton's W440 speakers allow you to add wireless rear channel speakers without compromising the sound quality that wired speakers deliver. Each self-amplified speaker contains a two-inch tweeter and four-inch woofer. They deliver 10 watts per channel for strong, clear fill sound. Their compact design (9" high x 6" wide x 5.5" long), make them the perfect bookshelf-sized companion to your home entertainment set up.

Audiophile quality. For the true stereo enthusiast, we offer the Recoton self-amplified wireless satellite subwoofer system. The satellite speakers in the system each bolster 25 watts of clean, distortion-free sound. The subwoofer adds a whole new dimension to your home theater with its 50-watt amplifier that's capable of creating enough rumble to make you feel like you're in the middle of an earthquake.

The Recoton wireless subwoofer's 50-watt 10-inch speaker delivers thunderous bass that adds depth and realism to the surround sound experience.



Even the most discriminating surround sound enthusiast will be engulfed by the abundant power and delighted with the full-range, first-rate sound from these black oak vinyl veneer speakers.

Easy to install. Every speaker option offered by Comtrad can be easily installed with the HTS-1 in a matter of minutes. Just connect the speaker outputs of your receiver or amp to the HTS-1, then

connect speaker wire to the front and rear speakers. When using wireless speakers, connect the transmitter to the output. One transmitter will broadcast to each wireless speaker.

Risk-free home trial. The best way to evaluate surround sound is in your home—not a showroom. That's why we're offering the 30-day risk-free home trial. Try these products in your home and if you're not delighted with the the surround sound experience, return them for a full "No Questions Asked" refund.

HTS-1 surround sound decoder.....\$99 \$10 S&H
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For fastest service call toll-free 24 hours a day

800-704-1211



To order by mail, send check or money order for the total amount including S&H (VA residents add 4.5% sales tax.) Or charge it to your credit card, enclosing your account number and expiration date.

COMTRAD INDUSTRIES

2820 Waterford Lake Drive, Suite 106
Midlothian, Virginia 23113

Speaker Options

Wired Speaker Options

Front Speakers: The Chase HTS-1 surround sound decoder can utilize your existing stereo speakers, or any of a variety of wired speakers available through Comtrad or your local electronics dealer.



Center channel speaker. If the front speakers are more than eight feet apart, adding a center channel speaker will keep voice cues centered on the screen. We offer the Dialog. It is self-powered and video shielded to prevent interference with TVs. Dialog \$75 \$8 S&H



Rear channel speakers. We recommend the quality Chase ELF-1 in either white or black for inexpensive rear channel speakers. Mount them with the enclosed color-matched mounting brackets or flush mount them on the wall. ELF-1\$99/pair \$10 S&H

Wireless Speaker Options



Rear channel speakers. Recoton W440 wireless speakers are the perfect option for people who want quality stereo rear channel speakers without having to run speaker wire. Their two-inch tweeters and four-inch woofers deliver 10 watts per channel—clear, strong stereo fill sound. The speakers work up to 150 feet from the transmitter without loss of sound quality. TX1000 transmitter (works unlimited speakers)\$69 \$7 S&H
W440 wireless speaker (each)\$89 \$9 S&H

Get the Chase HTS-1 **half off** (\$49) when you buy the W440 speaker system!



Rear channel speakers. For true audiophile-quality rear channel speakers, we offer the Recoton wireless satellite subwoofer system. This first-of-its-kind system combines a 10-inch rear-firing subwoofer with a pair of 25-watt satellite speakers. The subwoofer provides that distinctive "low-end punch" that you feel in movie theaters, while the satellites are designed to coincide



with surround sound processor specifications balance perfectly with the front speakers. WHT470 transmitter...\$69 \$7 S&H
WHT421 wireless 50-watt subwoofer\$299 \$24 S&H
WHT462 pair of wireless 25-watt satellite speakers \$329 \$24 S&H

Get the Chase HTS-1 **FREE** when you buy the satellite subwoofer system!

gram has two distinct parts: a cartoon, and a self-paced tour of Berenstain Bear country. In the cartoon, the two Berenstain cubs want to go to the Country Fair by themselves. Before their parents will grant permission, the cubs must prove that they can behave responsibly, by completing a list of chores and challenges—get ready for school on time, go to the market, share, etc. Further lessons in responsibility are found in the “on your own” segment. As the players travel through the bear’s house, the market, the school, the park, and the fair, they learn important safety tips and play learning games. Successful completion of the games earns them gold stars, as well as tickets to the fair, where they can play still more games. The story is charming, and there are plenty of activities to keep kids busy. This version does not require the Digital Video Cartridge.

The “Hanna-Barbera Cartoon Carnival” (\$39.98) brings back some fond memories for Baby Boomers who grew up with the Jetsons, Top Cat, Yogi Bear, the Flintstones, and the other characters featured on this disk. Each cartoon character has his own “booth” at the interactive carnival. The player (aged 6 and up) is challenged by a different game at each booth—guide Scooby Doo through a maze, help Fred Flintstone catch balloons

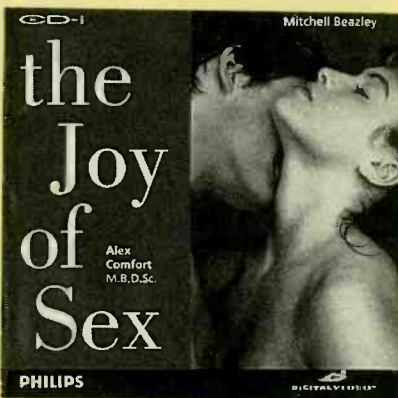


in a butterfly net, match colors at Huckleberry Hound’s Gift Emporium and sounds at Yogi’s Pic-a-Nic. (Top Cat’s trivia game reminded us just how long ago it was that we watched those Saturday morning cartoons!) Some of the games seem designed to hone the youngster’s gaming skills in preparation for the more sophisticated games he or she will be playing a few years down the road. For instance, the young gamer must help George Jetson navigate his space car past dangerous asteroids while trying to pick up stray satellites. Every time the player wins a game, he is awarded a letter on the “Cartoon Carnival” banner. When the banner is completely filled in, the player is rewarded with a short cartoon. Each game has several increasingly difficult levels, so players

won’t get bored quickly. The Digital Video Cartridge is recommended but not required; with it installed, the video quality was excellent.

HOME ENTERTAINMENT

Philips Media Home Entertainment produces a wide variety of adult interactive titles. By “adult,” they mean programs of interest to grownups. “Time-Life Astrology,” for instance, offers customized astrological information for every day of the year, draws astrological charts, provides personal horoscopes, and offers compatibility reports. “Titanic,” takes players on a tour of the ill-fated ship, narrated by Star Trek’s Patrick Stewart, that includes more than 2500 historical photos, actual ship diagrams, videos of the re-discovery of and more recent exploration of the wreck, and storylines of actual passengers and crew members.



The only Home Entertainment title that we received for review, however, earns its “adult” label in more ways than one. “The Joy of Sex” transforms Alex Comfort’s classic book into an interactive sex manual, complete with full-motion video (Digital Video Cartridge required), explicit line drawings, and partial nudity. While some segments are certainly titillating, the disc is not about gratuitous sex. Aimed at couples in committed, monogamous, loving relationships, it looks at sex from the points of view of four people—a twenty-something man and woman who each miss the passion of the honeymoon phase, and a man and woman in their fifties who would like to rediscover sex from a more mature perspective. “The Joy of Sex” tries to help those four representative people make the most of their sex lives through expert advice, game playing, quizzes, drawings, and video.

VIDEO CD

Video CD could very well be the wave of the future. Recently, seven major motion-picture studios—Disney, Warner Brothers, Columbia Pictures, MGM, Viacom, MCA/Universal, and Paramount—joined together in an “ad hoc advisory group” to



explore the possibilities of the format, which would put 135 minutes of video, preferably of laserdisc quality, on a single 5-inch disc. Philips and Sony are currently collaborating on a digital video system, as are Toshiba and Time Warner.

In the meantime, however, Philips Media’s Video CD Group was the first to release full-length movies and music videos on five-inch CD’s. The video CD-i discs can hold 72 minutes of VHS-quality video, along with CD-quality sound, so most movies come on two-disc sets. The platform also allows publishers to include such “value-added features” as behind-the-scenes information about the film and even on-screen sales of tie-in merchandise (parents, beware!).

The CD-i player allows customized control over the viewing experience. Via an on-screen panel, the Video CD viewer can select slow motion or freeze-frame with continuing sound, as well as fast forward, remote, and pause modes lacking the jitter associated with VCR’s. It’s also possible to skip forward or back to a specific scene in the movie, conveniently listed in the table of contents.



In “Star Trek VI: The Undiscovered Country,” as the Federation and the Klingons are preparing for a “glasnost-like” peace summit, Captain Kirk and the crew of the Enterprise (they’re baaack) are accused of attacking a Klingon vessel. The CD-i version of the film provides video

(Continued on page 19)

Family Computing

COMPAQ PRESARIO CDS 520. From Compaq Computer Corporation, P.O. Box 692000, Houston, TX 77269-2000; Tel. 713-370-0670. Price: \$1699.

Choosing a TV or home-theater system is confusing enough for most consumers—in fact, it can cause severe anxiety attacks. If you make the wrong choice in home-theater equipment, you can simply chalk it up to experience. But if you make the wrong choice when buying a computer for your family, you might permanently ban them from the heralded information superhighway!

Back in the early 1980's, everyone predicted a home-computer revolution. Even though millions of computers were sold, the revolution didn't happen back then. The incompatibilities between the computers that were sold, and the growing pains of the industry were only partially to blame; the main reason was that the computers weren't powerful enough for the mainstream mass market. What was powerful enough for many business uses just couldn't provide entertainment.

Today, of course, things are quite a bit different, as can be seen with the latest computers introduced by *Compaq*. We examined the base entry model of the company's new introductions, the *Presario CDS 520*.

Just what is an entry-level computer today? The CDS 520 is powered by a 486SX2 processor running at 66 MHz. The 486SX does not have a math coprocessor. However, according to Compaq, it performs 26% better than a 486DX2/50 in most Windows applications. The computer contains a single, high-density, microfloppy disk drive; a double-speed CD-ROM drive; a built-in sound card; and speakers. A Fax/modem and speaker phone are also standard.

The standard configuration for the CDS 520 is 4 megabytes of RAM (which is installed directly on the motherboard). Our machine was equipped with 8 megabytes; the machine can be expanded to 64.

The Presario CDS 520 has a unique all-in-one design; everything except for the keyboard and mouse are contained in a single package with a small footprint. Because of that, a Presario setup can be surprisingly neat. Neat enough, for example, to be kept in the family room.

To keep the size of the unit down, Compaq came up with an interesting configuration. First, the unit has no plug-in cards installed. All of the features that would normally reside on plug-in cards are instead integrated on the motherboard. That



eliminates the need for a disk controller, local-bus video card, fax/modem, sound card, I/O card, and CD-ROM controller. (The CD-ROM drive is run from the hard drive's IDE controller.)

The case can accept two ¾-length expansion cards. It wouldn't take much to run out of expansion slots. If you installed, for example, a video-capture card and PCMCIA adapter, you'd have no room when you went to install a network, radio, or TV card. Because the case offers only three drive bays—which are already occupied by the floppy- and hard-disk drives as well as the CD unit—an expansion to include, for example, a tape-backup drive would require an external case.

Although those somewhat limited expansion capabilities would be cause for concern to us, we doubt it's important to most new users, who probably have no intention of ever opening the computer case.

The Presario CDS 520 is equipped with a generous bundle of software, including MS-DOS 6.2 and Microsoft Windows 3.1. Application programs shipped with the computer include Microsoft Works for Windows, Quicken for Windows, Microsoft Encarta CD, Kidsoft CD, the Home Survival Toolkit, and The Even More Incredible Machine. In short, there's something for every member of the family.

Some utilities are supplied expressly for the Compaq machine, including the Welcome Center/Control Center/Learning Center, and Compaq Utilities. Startup kits, which provide one month's free service (but which also require that you subscribe by entering your credit card number), are provided for America Online, CompuServe, Prodigy, and the Imagination Network. Unfortunately, no

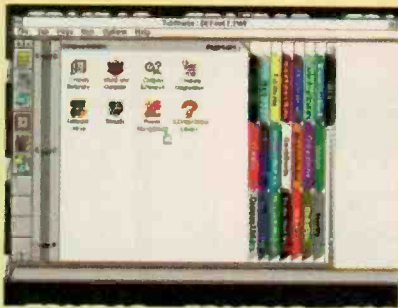
communications software is provided with the system other than the Terminal program that is part of Microsoft Windows.

It isn't easy to build a computer that can be purchased as a commodity at a local store, taken out of the box, and set up successfully even by someone who has never used a computer before. But building such a "family" computer is exactly what Compaq sought to do with the Presario, which is now available in more than 5600 stores across the country.

The system is packaged in a single, large carton with un-intimidating photographs of a father and son building a model airplane while referring to software describing historic aircraft. If everything goes according to plan, the largest problem that someone will have setting up the Presario is getting it out of the box. For hardware setup, the only other requirements are to plug in the cables for the keyboard, mouse, and telephone line. Even that is a breeze because of clearly labeled rear-panel jacks. Purchasers who are still intimidated might find some comfort in the VHS videotape that is included with the unit.

In the event that any problems occur, Compaq does offer a free (and toll-free) 24-hour technical hotline. Be prepared to wait for the service, however. In random calls, our wait times—when we didn't lose patience and hang up—ranged from 10 minutes to about 40 minutes.

Once the computer is out of its box and plugged in, and the keyboard, mouse, and phone line are attached, the power switch can be turned on. Setup software that is installed on the hard disk takes care of the rest. The user is asked for his or her language and country. When selected, the appropriate software is installed (de-



The Presario does its best to make even computer neophytes feel comfortable with the system. TabWorks (top left) is a replacement for the Windows Program Manager. The Phone Center (top right) is easy enough for anyone who has ever used a traditional phone. The sound-system controls (bottom left) also mimic real audio components. An "operator" (bottom right) tries to guide users along.



The Presario's motherboard contains many of the functions that would normally be incorporated on separate plug-in cards. For upgrades, the motherboard simply slides out in a drawer from the main chassis. Note the clearly labelled input and output jacks.

compressed) from the hard-disk drive. The software that is configured for other languages is deleted. The entire setup process takes about 35 minutes. The only other questions that the user needs to answer is for printer setup.

Although the software installation is straightforward and almost foolproof, it does present some potentially serious problems. Most of the software is contained only on the hard disk; no installation diskettes are supplied for most of the

applications, including Microsoft Windows. If power were turned off (or lost) during installation, it would likely cause a fatal error. If files became corrupt, a user would have no way to correct a problem unless he or she had done a full backup. (As with most computers, a practical backup system isn't included with the CDS 520 except to floppy diskette.) Even a full backup, however, doesn't give a user the same flexibility to correct a problem as having installation diskettes.

In our opinion, Compaq would have served its customers better by including all of the installation software on a CD-ROM instead of on the hard disk.

The software that the setup program installs is a collection of programs that a family will likely find useful along with some software that is probably of little use, and some demonstration packages that might whet a family's appetite to buy more.

The Documentation supplied with the CDS 520 should help most beginning computer users get familiar with the system.

The default configuration for the machine is to boot up running Windows. Instead of the Program Manager that is the default shell of Microsoft Windows, the Presario loads TabWorks, an alternate shell.

Although there is nothing inherently wrong with TabWorks, it doesn't seem to provide any better interface than the default Program Manager shell. If someone in the family is somewhat familiar with Windows through exposure to it at work or school, TabWorks could be a detriment to learning how to use the computer efficiently. Fortunately, Compaq makes it easy to switch between the TabWorks and Program Manager shells.

The CDS 520 offers energy-saver power-management options. During periods of inactivity, the monitor and hard disk can be turned off to conserve power. A strike of a key or movement of the mouse restores the computer to full operation virtually immediately. The monitor comes up to full brightness in only a matter of seconds; the hard disk takes a little longer to come up to speed.

The time-out settings for the monitor can be set in five-minute intervals from five minutes to a half hour, and the hard-disk time-out can be set in one-minute intervals between ten and twenty minutes. The energy-saver feature can be turned off if it is not needed. Because the system looks as if it's off when in its sleep mode, the user can choose to have the power LED blink.

An interesting and useful feature of the Presario is a built-in, full-duplex speakerphone, with an answering machine that can be set up with individual voice mailboxes for family members. Although the speakerphone performance was surprisingly good, we were happy that a handset could be plugged in for more privacy.

When we initially saw the Presario CDS 520, we thought that it would be fine for non-serious users, but unsuitable for performing serious tasks. We no longer think that, and, despite some limitations, would feel comfortable recommending the machine to most families. ■

Slip Slidin' Away

WQ-CH800 PORTABLE MUSIC SYSTEM WITH FIVE-DISC CHANGER.
From Sharp Electronics Corporation,
Audio Division, Sharp Plaza, Mahwah,
NJ 07439-2135; Tel. 1-800-BE-SHARP.
Price: \$249.95.

Most of us associate portable music with the Walkman—pocket-sized, lightweight, and private. But there are times when we'd like to take music with us, and still be able to share it with friends. That's where the boombox comes in.

Aimed primarily at teenage and twenty-something males (who tend to prefer their music loud, and are strong enough to lug around a good-size portable music system), the boombox can be carried from a dorm room to the park or beach. It allows the listener's choice of music to be heard by anyone in the immediate vicinity.

Today's portable stereo systems often incorporate a CD player, along with the requisite AM/FM radio and tape deck. Some even offer CD changers.

Sharp's *WQ-CH800* is a portable stereo system with a unique five-disc changer. The discs are loaded label-side-up into the top of the unit. The changer mechanism slides the stored discs to either side of the center position. To move a CD into play position, the changer glides to the left or right to pick up the selected disc. The labels of the discs remain face up and visible as they pass through the system. The time needed to change from disc 1 to disc 5 is an impressively quick 4.7 seconds.

The *WQ-CH800* is about the size of many of today's mini, bookshelf stereo systems. It measures $21\frac{1}{4} \times 10\frac{3}{16} \times 9\frac{1}{4}$ inches, and weighs in at a hefty 15 pounds. A handle folds up from the top to facilitate carrying. The CD changer also is set in the top of the unit. Three windows allow you to view the disc in the play position and those in the top slot on either side of it. CD controls include track-selection buttons (numbered 1-5), and **PLAY** and **STOP** buttons.

The front center section of the boombox contains a small display that indicates the disc and track number, and mode or programming information when applicable. To the left of the display is a four-band graphic equalizer; to the right are the remaining CD controls.

The tuner is centered on the front panel, with the rotary **VOLUME** and **TUNING** knobs placed to its left and right. Just beneath the radio dial is a four-position slide switch that doubles as a power switch and function selector. The dual-well tape deck is located below the tuning dial, with tape controls arrayed along the bottom of the front panel. Two-way speakers with four-



inch woofers flank the CD changer, radio, and tape deck.

The back panel is stark. It contains a headphone jack, the input for the included AC power cord, a flip-up telescoping antenna, and a large battery compartment that holds the eight D-size batteries required to power the *WQ-CH800*.

Loading the CD player is a breeze. By pressing the disc select buttons in order (one through five), you can position five discs in the changer. Each disc is placed on its tray, and when the next button is pressed, the tray lifts the disc and whisks it off to the side. You're then ready to load the next one. When all five are loaded, the CD compartment lid is closed manually.

To play a disc, you simply press its number to move the CD into the play position and press the **PLAY** button. Playback automatically begins with the first track on the first disc and proceeds in order through the tracks and discs, unless you opt for one of the available playback options.

Those options include disc-number selection, direct-selection play, random play, Automatic Programmable Music Selection (APMS), and repeat play. Any disc number can be selected during playback or when the changer is stopped, simply by pressing the desired disc number button. It's also possible to select a specific track on any disc in the disc holder, by pressing first the disc number and then using the up or down button to choose the track number.

Random play is programmed by simply pressing the **RANDOM** button either during playback or in stop mode. The random indicator will light up, and random play will begin with the next track.

Up to 32 tracks can be selected in any order to create a programmed sequence using APMS. Pressing the **MEMORY** button while in stop mode puts the *WQ-CH800*

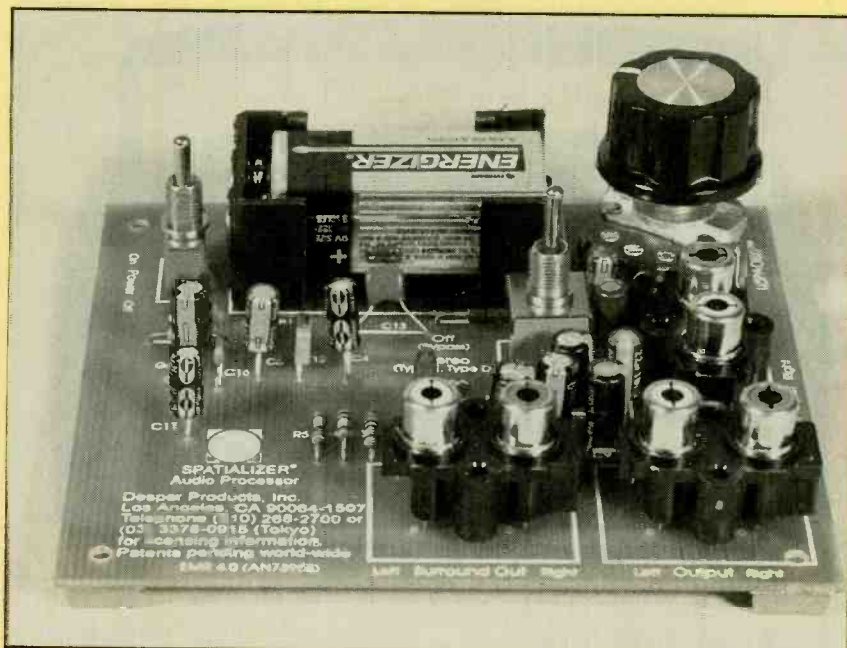
into the program mode, and the program indicator appears in the display. To select each song, first the disc number button is pressed, and then the up/down buttons are used to reach the desired track number. A second press of the **MEMORY** button stores the track in memory, and the programmed number will appear in the display.

Repeat play can be used to repeat all the tracks on every disc in the disc holder, or to repeat a sequence programmed using APMS. Pressing the **PLAY/REPEAT** button twice causes all the tracks on all the discs in the disc holder to be repeated. If the **PLAY/REPEAT** button is pressed twice when a sequence of tracks has been programmed (the program indicator will be lighted), that sequence will continually repeat.

Other CD functions include Auto Program Search System (APSS) and cue-and-review. APSS automatically locates the beginning of the next track. Cue and review allows you to fast forward audibly to reach a specific portion of a track.

The tuner is the weakest section of the *WQ-CH800*. Tuning is manual, not digital, so it is not as accurate and, of course, it is not possible to store station locations in memory for immediate access.

The dual-cassette deck allows you to record from the CD, radio, or tape 1 to tape 2. A synchronized recording system makes it easy to record from the CD player. When the **RECORD** button on the tape deck and the **PLAY** button on the CD player are pressed, recording begins automatically. The tape stops when the disc ends or is stopped or paused. Pressing the **STOP/EJECT** button of the tape deck ends the recording session. Although continuous playback (from tape 1 to tape 2) is possible, only tape 2 can be used for recording. That means that the *WQ-CH800* can't be used to record long radio programs on two tapes, for instance. ■



Spacing Out

SPATIALIZER EMR 4.0 AUDIO PROCESSOR. Manufactured by Desper Products Inc., 11400 West Olympic Blvd., Suite 1100, Los Angeles, CA 90064; Tel. 310-268-2700; Price: N/A.

Stereo, it seems, just can't cut it any more. Surround sound is no longer limited to movie releases and instead is being used more and more in the recording studio. The booming popularity of surround sound—it is now included in most main-line stereo receivers—is testament to the fact that three-dimensional ambience is here to stay.

Audio-equipment manufacturers have long sought a way to get the performance of a surround-sound system from a single pair of speakers. Various strategies have been developed through the years to extend the sound beyond and behind the loudspeakers and to add a third dimension of depth to audio. In other words, to improve the stereo process so that its reproduction duplicates what you might hear in a live performance.

Desper Products, Inc., has developed a new audio-processing technique called *Spatializer* that promises to add another dimension to audio so that sounds seem to come not only from beyond and behind the speakers, but from in front of them as well. In a departure from what we normally do here at *Gizmo*, we will not review a *Spatializer* equipped product as much as we will describe *Spatializer* technology, which you are bound to encounter frequently in consumer products in the coming years.

You may have, in fact, already encountered one form of the technology, the PRO *Spatializer*. The professional system was used, for example, to mix the audio for Disney's *The Lion King*, some of the performances on the MTV Music Awards, Bonnie Raitt's latest album, and many others. The Pro *Spatializer* allows recording engineers to place audio from any recording track in 3-dimensional space.

Spatialization is a one-way process—that is, *Spatialized* program material does not require a decoder for the effects to be heard. It was possible, for example, for us to experience the *Spatializer*'s effects with a demonstration CD that contained A/B comparisons between *Spatialized* and non-*Spatialized* recordings. The CD provided some insight into how *Spatializer* can work.

Even more convincing, however, were the effects produced by Desper's *Spatializer EMR 4.0 Demonstration Board*, which is designed to demonstrate the new EMR 4.0 integrated circuit. Matsushita Electronics Corp., a subsidiary of Matsushita Electric Industrial Company, the consumer electronics giant whose brands include Panasonic, Technics, and Quasar, is manufacturing the EMR 4.0 IC under license for Desper Products. The chip will make it easy for manufacturers to incorporate *Spatializer* technology into a wide range of products.

The demonstration board accepts a stereo signal input via board-mounted RCA-type phono jacks. It provides a stereo output, as well as an optional surround output. It is powered by a 9-volt battery, and contains a power switch, a bypass switch that permits A/B comparison, and a potentiometer that allows the effect to be varied.

The heart of the board is a 20-pin integrated circuit mounted on the bottom of the board.

The bypass switch on the EMR 4.0 demonstration board also switches the chip between its three separate *Spatializer* modes: Type E (*Spatial Expansion*), Type D (*Directional Positioning*), and Type S (*Spatial Synthesis*).

Spatial Expansion enhances and expands the sound from normal stereo recordings and requires only two speakers. Although centered images remain in the center, off-center instruments and sounds are expanded so that hard-panned images sound as if they originate from locations well outside the speakers, and even around the listener. That is the mode that, say, TV-set or boom-box manufacturers would use if they choose to incorporate *Spatializer* technology in their products.

The *Directional Position* mode is essentially the same as *Spatial Expansion*. In fact, the mode switch is left in the same position for either mode. The *Directional Position* mode, however, requires additional circuitry that is not included on the demonstration board, notably *pan pots* such as those found on a mixing console. The *pan pots* provide the ability to locate and move individual sounds up to 270 degrees around the listener in real time. As the sound is panned from one side to another, it moves outside the speaker boundaries and around the listener.

One use for the Type D mode would be in computer videogames, where the software equivalent of *pan pots* would position the sound in relation to game play. According to Desper, multiple sounds can be directionally positioned. However, each would require its own *pan pot* (or software equivalent), and the outputs of all the potentiometers would be summed together.

The final operating mode is Type S or *Spatial Synthesis*, which provides a pseudo-stereo image with mono inputs. Because much multimedia sound is mono, this mode should be effective in providing greater depth and realism.

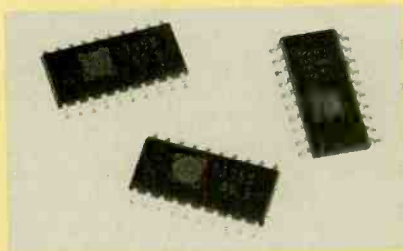
As mentioned earlier, the intent of *Spatializer* technology is to create an expanded sound stage from a single pair of stereo speakers. The effect is intended to be more than simple expansion, and instead closer to surround sound.

Previous attempts that we have heard from other companies had drawbacks ranging from an ill-defined sound stage to a small "sweet spot" to mono incompatibility to a sound that was simply unnatural. In contrast, however, *Spatializer* works amazingly well.

We auditioned *Spatializer* with a variety of program material and a variety of hardware. We sampled, for example, stereo television broadcasts on a run-of-the-mill, 26-inch, stereo TV receiver with small,



Spatializer technology is already in use in a variety of products. The PRO Spatializer was used in recent CD releases including a box set of the original Woodstock album, and new releases from Bonnie Raitt and Barbara Streisand to name a few. Hardware products that contain Spatializer include a Panasonic boom box and a unique multimedia sound board from Multiwave Innovations.



The Spatializer audio processor is available in a 20-pin surface-mount integrated circuit.

built-in speakers. Because of the limited distance separating the speakers, stereo performance was really in name only. With the EMR 4.0 installed, the speakers no longer seemed to be located in the TV cabinet. Instead, they shifted far to the left and right.

In one test, we placed dummy speakers at various locations along the front of the room and asked subjects to pick the speaker pair that they thought they were listening to. By varying the space control—and therefore the Spatialized soundstage—we could position the sound so that it seemed to emanate from the dummy speakers. Our test subjects, who were unaware of what we were doing, confirmed that Spatialization was doing its job.

We found that it was possible to adjust the ((space)) control until the sound became unnatural, but it was also possible to create a very pleasing performance. The Spatializer processor varies not only the width of the soundstage, but its depth, as well. The soundstage becomes a true three-dimensional space, and that, we pre-

sume, is how Desper came up with the Spatializer name.

According to the company, the effect is obtained by creating the equivalent of optical illusions for the human ear-brain mechanism. The position of a sound source is determined from several clues, such as the phase difference between the sound at each ear. Humans instinctively and instantly perceive the sounds and reflections of sound to determine the distance, location, and size of sound sources.

Spatializer technology will never replace Dolby Surround, but it is completely compatible with Dolby Surround and it should make itself useful in many applications where the expense of surround sound and the requirement of rear speakers make it unjustifiable. Spatializer technology would make sense in a TV set in a bedroom or dorm room where surround sound would normally not be considered. The computer multimedia market is already incorporating Spatializer in its products. Multiwave Innovations, for example, has incorporated the chip in its new Command 3-D Sound Engine audio processor. Boom boxes could benefit immensely from the technology, as could many television sets. Audio/video receivers could also benefit from Spatializer as an addition to the DSP features that are already incorporated. ■

VIDEO CD-i

(Continued from page 10)

esting and, yes, even fun to use. It offers videos, audio selections, pictures, photos, maps, and a built-in dictionary and atlas.

You can search for a topic by typing it in on the on-screen keyboard, by scrolling through an alphabetic list of all articles, or by using the Topic Tree Fact-Index. The Topic Tree breaks down all of the major articles on the disc into menus of topics and subtopics for easy reference. The Fact-Index includes close to 30,000 short articles on a wide range of subjects, as well as thousands of references to articles. Selecting the "jump" icon in the Fact-Index will call up the main article on that subject. The Time Machine lets users select past eras in history and learn about major events and life during that time.

Our review unit also came with an assorted sampling of CD-i titles—several games, a couple of movies, a few sports programs, and some kiddie titles. (Reviews follow.) Unfortunately, the interactive encyclopedia was the least frequently used title in our house—as we suspect it might be in most homes.

The encyclopedia is a tremendously useful information resource. And its inclusion with the CDi450 might make parents more willing to bend the "no video games in this house" rule. But, in reality, CD-i remains a high-tech video-game player and, with the added Digital Video Cartridge, movie playback system. ■

GAMES PEOPLE PLAY

(Continued from page 14)

and audio quality far superior to that of the VHS tape we'd rented several months earlier. The disc comes with "liner notes" about the making and makers of the film, and an "About the Cast" section that features biographies similar to that found in a theater playbill.

"Peter Gabriel: All About Us" (\$24.95) provides a behind-the-scenes look at the musician's award-winning music videos, including "making of" footage, video clips, and interviews with Gabriel's production team. Viewers learn, for instance, how the special-effects team created the illusion of snails crawling across Gabriel's eyes and how it was possible for his head to appear as if it emerged from a speeding train. In exclusive interviews, Gabriel reveals his motivation for lyrics, personal moments in his life, and his feelings about the state of the world and the human condition. The Video CD features the music videos "Digging in the Dirt," "Steam," "Blood of Eden," and "Kiss that Frog," from the CD "Us." It also features music videos for songs from the "Passion" CD, including "Come Talk to Me" and "Zoar," as well as a music video from the 1977 hit, "Solsbury Hill." An on-screen function panel gives viewers complete interactive control of the viewing experience. ■

GIZMO NEWS

Audio on Demand

A unique combination of existing technology promises to create a new way for information junkies to get their fix. The Information Highway Media Corporation of Cupertino, CA is planning to launch its Audio-On-Demand subscription service.

The service will allow users to select from a wide variety of audio programming, and store the programming on a pocket-sized device. Up to ten hours of personalized programming can be obtained in about five or six minutes. It can then be played back through a car stereo system or through a portable audio device.

The programming that will be offered will consist of audio versions of newspapers, magazines, and books, as well as radio programs, special-interest programming, and even TV audio.

The audio will be sent in digital form to

Stop That Car!

Almost anyone who's ever received a speeding ticket has fantasized that he or she could have outrun the cops if he or she had really wanted to. Such thoughts remain fantasies for most rational people. Even so, high-speed auto chases occur frequently, resulting in thousands of accidents each year.

In the future, new anti-vehicle electronic countermeasures—or AVECM, as their creators like to call them—will offer a way to catch fleeing suspects without a chase. According to Creative Electronics Consultants, small, portable electronic devices that are capable of disabling the engine operating system of a pursued vehicle will bring it to a standstill within seconds. Those devices are, according to the company, "a promising alternative to conventional barrier technology."

that can be set up to "interrogate" vehicles. Vehicles with the proper code will pass over the device safely.

There is no firm word when those devices will be available to law-enforcement agencies. The company, which is headquartered in Sleepy Hollow, Illinois, is seeking venture capital investment.

Consumer Electronics No-Show

The Consumer Electronics Show - Interactive (CES-I), which was scheduled to be held in May in Philadelphia, has been canceled. Gary Shapiro, vice president of the Electronic Industries Association Consumer Electronics Group, said, "After reviewing the pressure and stress put on potential exhibitors, buyers, and journalists to decide between two major industry shows being held at the same time, on two separate coasts, we chose to do what was best for the interactive industry and reschedule our show in 1995 to 1996."

CES-Interactive was the scheduled replacement for the Summer CES that was traditionally held in Chicago in late spring. CES-I has been rescheduled to be held in Orlando in May 1996.

The other industry show to which Shapiro was referring was the Electronic Entertainment Expo (E3) that will debut in Los Angeles from May 11 to 13—the same days that CES-I had been scheduled. The E3 show will focus exclusively on the development, marketing, and merchandising of software titles for all game platforms and CD systems.

Following the EIA decision, the organizers of E3 (the Interactive Digital Software Association or IDSA) released a statement saying, "We believe this is the right decision for everyone involved and are pleased to have the matter finally resolved. It underscores the coming of age of the \$8 billion interactive entertainment industry, which has long needed to make a statement of independence with its own dedicated show."

Strong Sales

As the consumer-electronics industry looks for "the next VCR"—that is, the next product that will send consumers in droves to their local electronics retailers and restore life to the industry—some old products are showing renewed strength. Even though the household penetration of TV sets is over 98%, sales are strong—stronger than ever, in fact. In September of last year, the last figures that were available as we went to press, the TV industry had its best month ever. For the first time, unit sales of TV sets passed 3-million. ■



Listen Up audio receivers. The primary means of distribution will be through cable-TV systems, which will receive the audio data via satellite. The service might also be made available to TVRO (big-dish) and DBS (little-dish) satellite-TV system owners.

Preliminary field testing is going on now, and initial production units should be available by the end of this year. Although prices haven't been determined yet, the Listen Up audio system should cost less than \$500. Monthly service charges will apply to basic audio programming. Premium programs will also be offered.

The device is a pancake-like disc with a diameter of 42 inches and a height of about 3 inches. It is made of high-strength polycarbonate and contains several high-voltage electrodes.

When it is set up in the road, it appears only as a small bump. However, the disc can be armed before the target vehicle passes over it by the pursuing police officers or by other officers at the scene. When the target vehicle passes over it, the disc discharges high-energy electric charges, which disable engine controls, sensors, computers, and other circuits.

The developers envision future versions

ELECTRONICS WISH LIST

Mini-Component Audio System

The six-plus-one CD changer in the *MS 7766* bookshelf stereo system from *Sansui USA Inc.* (1290 Wall Street West, Lyndhurst, NJ 07071) provides hours of uninterrupted music. The changer has an internal stacking design and features 24-track programmability. With the touch of a button, the user can choose one of 30 preset radio stations, thanks to the system's PLL digital tuner. The dual-well, auto-reverse cassette deck makes dubbing simple. A clock/sleep timer adds to the system's convenience. The 50-watts-per-channel system also offers sound-field control, Dynamic Bass Boost System, and a remote control. Price: \$649.95.



Sansui Mini-Component Audio System

Game Boy/Super NES Adapter

The *Super Game Boy* accessory from *Nintendo of America Inc.* (4820 150th Avenue N.E., Redmond, WA 98052-5111) allows video-game enthusiasts to play any of the more than 350 available Game Boy cartridges on the Super Nintendo Entertainment System (Super NES), displaying them in full color on the TV screen for the first time. The Super Game Boy is a Super NES cartridge that contains a Game Boy adaptor. When a Game Boy cartridge is inserted, it is transformed from a black-and-white game to a bright, multi-colored image on a big television screen, complete with stereophonic sound. Game action is displayed in varying shades of four colors that can be customized by the player. The player can also use one of several pre-stored, animated border designs or can create his or her own using a paint-type program. New titles specifically designed for the Super Game Boy will use the 256-color palette of the Super NES. Price: \$59.95.



Game Boy/Super NES Adapter

Plain-Paper Fax

The *FX5500* is *Samsung Electronics America's* (105 Challenger Road, Ridgefield Park, NJ 07660-0511) first entry into the plain-paper fax market. The fax uses LED printing technology, features a 256-KB receiving memory, and offers a telephone answering-machine interface. It has a nine-second transmission speed, a 20-sheet automatic document feeder, and a printing speed of five pages per minute. The *FX5500* can store 20 one-touch and 50 two-touch programmable numbers. Price: \$1699.99.

Multiroom, Powered "Tube" Loudspeaker

The *Bang & Olufsen* (1200 Business Center Drive, #100, Mount Prospect, IL 60056) *Local Control System 9000* is a unique, two-in-one active loudspeaker that was specifically designed for multiroom applications. It can bring both sound and control of a centrally located audio system to different rooms. Right and left amplified speakers, a status display with clock, an independent volume control, and an infrared remote-control transceiver are all housed in a slender oval cabinet of polished aluminum, intended for horizontal placement. The black speaker grilles are divided by a field that contains an illuminated status display and two sets of sensi-touch controls for hands-on operation. A Beolink remote control also can be used to gain access to all available sound sources. The tube-shaped *LCS 9000* measures $43\frac{3}{4} \times 3\frac{3}{4} \times 4\frac{3}{8}$ inches and comes with a bracket that allows it to be wall mounted. An optional stand is available for table-top or bookshelf placement. The *LCD 9000* uses *Bang & Olufsen's* Adaptive Bass Linearization (ABL) technology to provide large speaker sound. It features two loudspeakers, each with its own amplifier. One, for the treble, drives a $\frac{3}{4}$ -inch tweeter; the other, for the bass, drives a $3\frac{1}{2}$ -inch woofer. The close connection between the amplifier and loudspeaker is said to give improved signal control and provide extra power for a purer, more authentic sound. Price: \$1395.



Bang & Olufsen LCS 9000 Powered Loudspeaker

ELECTRONICS WISH LIST



Radio Shack Mini Cellular Phone



Sanyo Fuzzy Logic 8mm Camcorder



MicroPak Mini Travel Clock Radio

Mini Handheld Cellular Phone

Weighing just seven ounces and measuring a compact $5.25 \times 2.1 \times 0.9$ inches, the *Radio Shack* (700 One Tandy Center, Fort Worth, TX 76102) *CT-352* handheld cellular phone makes it easy to keep in touch while commuting, at a job site, on a business trip, or on a family outing. It will store up to 98 different names or numbers for quick dialing. To dial by name, you enter the first one or two characters of the name and the phone automatically locates the number. Incoming calls can be answered by pressing any key on the keypad. The phone can also be set to automatically answer without pressing any key. A menu system lets you quickly view and change the current setting of any phone function, including ring type, volume, light control, and auto-answer. Other features include a supertwist, backlit LCD; continuous battery-power-level and signal-strength indicators; touch-tone compatibility for special services such as banking by phone and voice mail; and scratch-pad memory for temporarily storing a name and number during a call. Price: N/A.

Adjustable Monitor Arm

Designed to free up valuable desk space, the *EasyVue Model 6130* adjustable monitor arm from *MicroComputer Associates* (Division of Rubbermaid Office Products Inc., 9920 La Cienega Blvd., Inglewood, CA 90308-7032) lifts the monitor above the worksurface. To provide the most comfortable viewing angle, a notch-slide mechanism is used to adjust the height in one-inch increments, four, five, or six inches above the desktop. The monitor platform rotates, tilts, and swivels for enhanced viewing, and the base also rotates. The platform holds monitors weighing up to 40 pounds with foot separations up to 12 inches. The arm attaches to the desk with a metal clamp. Price: \$49.95.

Fuzzy Logic Camcorder

The *VM-RZ2R* 8mm camcorder from *Sanyo* (21350 Lassen Street, Chatsworth, CA 91311-2329) offers fuzzy-logic control and preset shutter speeds for easier operation and better videomaking results. The high-speed (up to $1/10,000$ second) electronic shutter offers six presets identified in the viewfinder as sports, auto high-speed, low-light, flicker, close-up, and normal. Those settings eliminate guesswork and simplify shutter-speed selection. Sanyo's fuzzy-logic technology automatically adjusts the focusing, iris, and white balance by imitating the human thinking processes. For instance, the automatic white balance corrects color for different lighting conditions by analyzing picture information from 64 separate image areas. Manual focusing is also possible. The *VM-RZ2R* also features an 8:1 power zoom lens, a flying erase head, a wireless remote control, 1-lux low-light capability, and a built-in omnidirectional microphone. Price: \$699.99.

Tiny Travel Clock/Radio

According to *Executive Travelware* (P. O. Box 59387, Chicago, IL 60659-0387; Tel. 1-800-397-7477), its *MicroPak* is the world's smallest full-feature, AM/FM travel clock radio. Because of its ultra-compact size, it can be packed into the tightest space. The clock radio measures $4\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{16}$ inches when closed. With the touch of a button, the *MicroPak's* black clam-shell case pops open to reveal a large LCD time display, angled for easy reading. The power switch is located under the lid to prevent the power from being accidentally turned on while the radio is packed in a suitcase. The *MicroPak* provides a choice of music or beeper wake-up alarms. It features a telescoping whip antenna, a snooze button, and an earphone jack. Price: \$49.95.

Your own TV station for less than \$100?

Recoton's engineering breakthrough transmits cable, TV, VCR and satellite programs throughout your home...without wires!

By Charles Anton

Today television choices are virtually unlimited. With cable, satellite TV, videos and network programming to choose from, it's a full-time job just trying to keep up with everything. And it promises to get worse from here. Newly developed fiber optic technology will bring more than 500 TV channels to your home.

Home broadcasting breakthrough. The only problem with all this technology is the expense. Now, a newly developed wireless video broadcasting system gives you the power to utilize this technology, without the hassle and expense of wiring your entire home.

Recoton's research and development team brings you the next generation in wireless broadcasting. The wireless video broadcaster enables you to transmit (re-broadcast) cable, TV, VCR or satellite programs to any other TV in your home, without wires!

Wave of the future. Never again will you have to drag your VCR from room to room, or have to buy more than one. With the wireless video system you can broadcast videos to any other TV in your home.

You won't have to worry about running cable wire all over the place either. Besides, who could afford to install cable in every room anyway? With the wireless video system, you won't have to. You can even watch one program on your main TV and watch a different program or video on the other. It's like having a personal broadcasting system in your own home—and it's legal in every state.

Hi-tech home broadcast. Recently, the Federal Communications Commission allocated a band of radio frequencies specifically for wireless, in-home product applications.

Recoton's research and development group took advantage of the 1989 FCC ruling by creating and introducing wireless home transmission equipment that could transmit pictures and sound in the prescribed frequency over distances of 150 feet or more.

One transmitter, unlimited receivers. One transmitter operates an unlimited number of receivers. That means one transmitter in the den can send signals to the TVs in the bedrooms, kitchen and wherever else. Put your favorite programs in the places you want them most.

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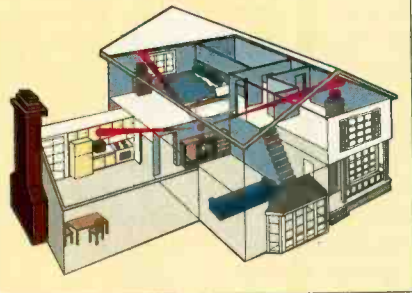
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March 1995, Popular Electronics



ELENCO ELECTRONICS XK-525 DIGITAL/ANALOG TRAINER



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Breadboard analog and digital circuits the easy way with this versatile digital/analog trainer.

Breadboarding circuits is always difficult work. It requires lots of patience and extreme concentration because it's very easy to misplace a lead or leave a connection out entirely. It makes sense, then, that any device that makes breadboarding circuits neater, simpler, or less time-consuming is a good investment—as long as it's not an expensive one. In that light, one of the best breadboarding investments that I have found is the Model XK-525 *Digital/Analog Trainer* from Elenco Electronics, Inc. The trainer is sold as a kit for \$149.95.

Features. The XK-525 makes short work of breadboarding circuits by putting lots of what you need to do it right at your fingertips. Different power supplies, a function generator, and a digital-logic section are all combined on one control panel. There's also plenty of room for installing your own components: two large breadboards, each with 830 tie points. In addition, six separate power-bus lines that span the width of the breadboards can be

used as common tie points for different voltages. Everything is housed in a rugged plastic case.

A power supply is essential in any circuit, and the XK-525 provides five different DC voltage sources that can satisfy almost any conceivable circuit requirement. To begin with, there are two variable supplies, one positive and one negative. The positive variable supply is adjustable from +1.25- to +20-volts DC, and the negative variable supply is adjustable from -1.25- to -20-volts DC. The variable supplies can output a full ampere at up to ± 15 volts and half an ampere at ± 20 volts. Positive and negative, 12-volt, fixed power supplies are also included, both of which can output up to 1 ampere. There's also a fixed +5-volt, 1-amp supply. All of the supplies are regulated and short-circuit protected. A 30-volt AC, center-tapped supply is also present. The trainer draws its own power from any convenient 117-volt AC outlet.

A function generator is a valuable accessory when designing or testing out a new circuit. It's a quick way to

input signals of different frequencies into a circuit. The XK-525 has a built-in variable function generator that can generate sine, square, and triangle waveforms from 1 hertz to 100 kilohertz in 5 steps. The output is variable from 0- to 15-volts peak-to-peak. The DC offset can be adjusted ± 10 volts from the zero crossing. An AM input allows an external signal to amplitude modulate the function-generator output, while an FM input allows an external signal to frequency modulate the function-generator output.

The digital section of the XK-525 includes 8 data switches that set outputs to high and low logic values (+5 and 0 volts). The 8 outputs each have 5 tie points, which can be used to set conditions on a data bus, as well as for other applications.

Two logic switches are included, both with normal and complimentary outputs. The logic switches are bounce-free. If you are unfamiliar with that concept, the contacts of a regular switch can "bounce," causing sensitive, high-speed digital logic in-

(Continued on page 94)

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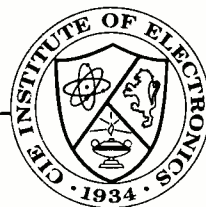
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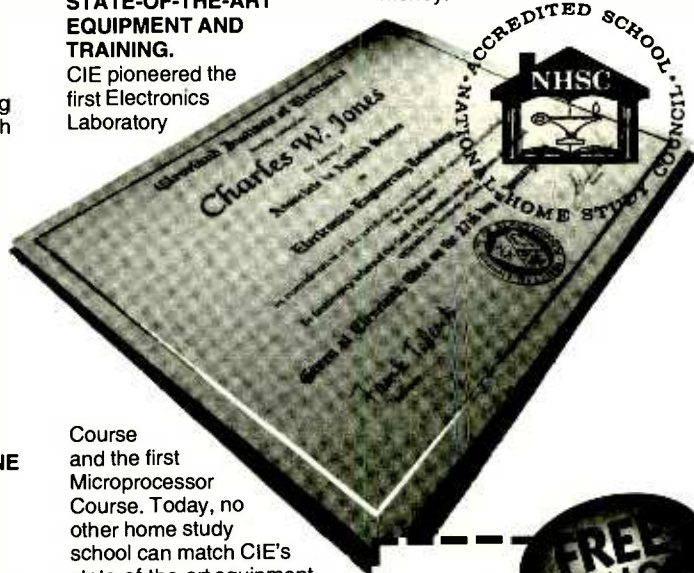
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THINK TANK

By John J. Yacono,
Technical Editor,
Windows Magazine

Model-Railroad Circuits

Last month, we talked about the various wattages that resistors come in and how to tell the wattage of a resistor by its appearance. We'll continue our discussion of resistors this month, and also get to a few model-railroad-related circuits sent in by some contributors.

As you'll recall, the wattage of a resistor determines how much heat it can dissipate per second. Another even more important characteristic of a resistor is its resistance to current flow, which is measured in ohms. Resistors rated above 5 watts have their resistance values stamped on them in plain English. Lower-wattage resistors have three or four (in the case of 1% resistors) colored bands on

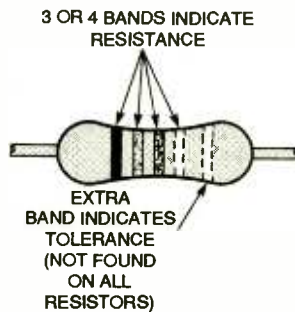


Fig. 1. Colored bands are used on a resistor to indicate its value in ohms and its tolerance.

their bodies (see Fig. 1) that indicate the resistance value. Most of the time, there is an extra band that indicates the part's tolerance (which we'll explain next time). Resistance-indicating bands can be one of ten colors; each color represents a digit, as shown in Table 1.

To see how the system works, let's take an example.

Say you pick up a resistor and it has three bands on it: yellow, violet, and orange. (Any bands of a color not found in Table 1 deal with tolerance, so we'll ignore them for now.) Using Table 1, we find that the bands indicate the digits 4, 7, and 3.

TABLE 1—
RESISTOR-BAND COLORS

Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

The first two digits indicate significant numbers (47), but the last digit (3) tells us how many zeroes follow the first digits. In that case three zeroes should follow the 4 and the 7. That gives us a value of 47,000 ohms.

Let's take another example, this time with four resistance-indicating bands of these colors found in Table 1: brown, red, green, red. The first three bands indicate significant figures, and from the table we can see that brown/red/green means 125. The last band, which tells us how many zeroes follow the numbers, is red. That tells us that 2 zeroes follow the number 125, so the resistor's value is 12,500 ohms.

What if the last band is black? That means that no zeroes follow the first digits. For example, if the resistor bands are white (9), brown (1), black (0), the resistor's value is simply 91 ohms, no zeroes follow. But right now

some readers' letters do follow:

MODEL-RAILROAD SOUNDER

The circuit that I have enclosed (see Fig. 2) can be used in model railroading to sound an electronic diesel horn when the train approaches a railroad crossing. I mounted the circuit in a 50-foot HO-scale box car, and placed the 8-ohm speaker, S1, behind the doors, which I now have to keep open. A longer cattle car would be a better enclosure because it is larger and has holes for sound to escape.

Reed switch S1, which I cannibalized from a Radio Shack reed relay, was mounted on the bottom of the car. When the "sound car" approaches the crossing, S1 is momentarily closed by a magnet that must be installed under the track, thus starting the timing cycle and sounding the horn.

Before you can use U2, the ISD 1000A record and playback IC (available at Radio Shack and elsewhere), you must first program it by breadboarding the circuit found in the applications data included with the IC. To record sound on U2, you'll need a sample of the sound that you want the IC to play. I called a local railroad yard to make an appointment to record the sound that I required. Another option is to stand near a railroad crossing holding a microphone, waiting for a train.

During construction of the playback circuit, save space by using single-turn trimmers for the variable re-

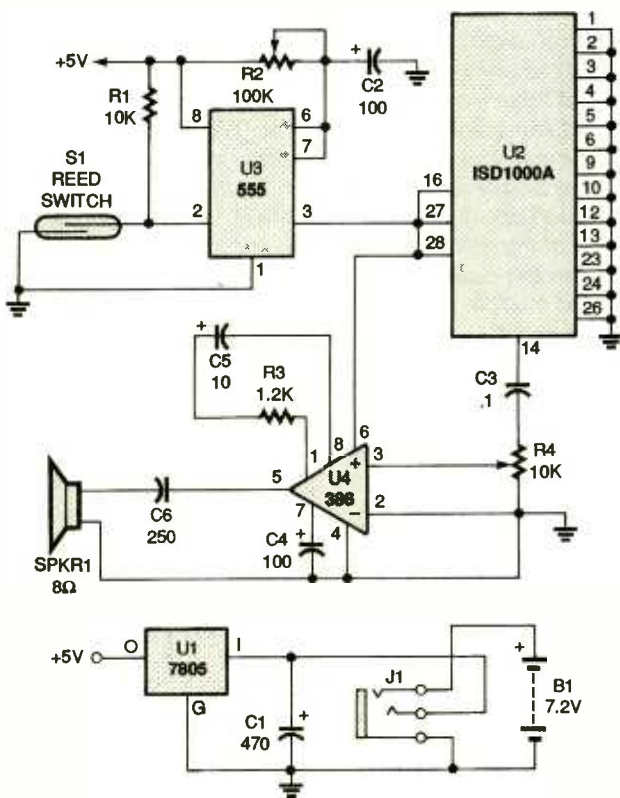


Fig. 2. This circuit can fit inside a model-train car and output any sound you record in the ISD1000A. Imagine a cattle car that moos!

sistors. To install U2, mount it on a low-profile socket. If you have an O or larger-scale railroad, you could use larger and louder speakers, an LM380 IC amplifier for more power, and another battery in parallel for extended use because of the extra space.

The phone jack, J1, which is mounted on the bottom of the car, serves two purposes. It serves as a means of charging B1, the 9-volt NiCd battery, and also provides a way to turn the circuit off. To charge the battery without disassembling the car, just wire a 9-volt battery snap to a male phone plug. Then just insert the phone plug into the car and the battery snap into your battery charger. The battery will last about 4 hours, depending on how many railroad crossings you have on your layout. When not in use, insert the phone

plug to turn off the circuit.

There are unlimited applications for the above circuit in model railroading. In addition to providing a horn for a train, it can be used to reproduce the sound of a ringing bell at a railroad crossing, or a police or ambulance siren. However it is used, the circuit is sure to make a

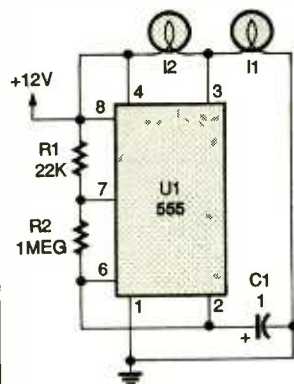


Fig. 3. This simple circuit can operate the incandescent bulbs in a railroad-crossing flasher.

model railroad heard as well as seen.

By the way, although I have been an avid reader of **Popular Electronics** for many years, I have no idea what book everyone is talking about in *Think Tank*. I would like to know what type of book you are sending to people who have their articles published in the column.

—Brian Couchene,
Escanaba, MI

Normally, when someone's letter appears here they are sent a *Think Tank II* book, which is a collection of circuits that have appeared in the past. If a reader already has one, or we are temporarily out of stock, they receive another book from our library, for example a *Circuit Circus* book.

By the way, I like your circuit a lot. The recharging

plug is a nice, practical touch.

CROSSING-GATE FLASHER

This circuit (see Fig. 3) is the solution for Bob Williams' concern in the October 1994 *Think Tank*. It works great as a crossing-gate flasher. The circuit contains only six parts, including the two incandescent lamps, and is cheap and easy to build. However, you do need a filtered power supply to run the circuit.

The two lamps, I1 and I2, flash back and forth at a rate of about 1 hertz. That flash rate is determined by the values of R2 and C1. You can alter the value of R2 for faster rates, and C1 for slower rates. Hope that helps you out.

—Paul Vandermyde,
Morrison IL
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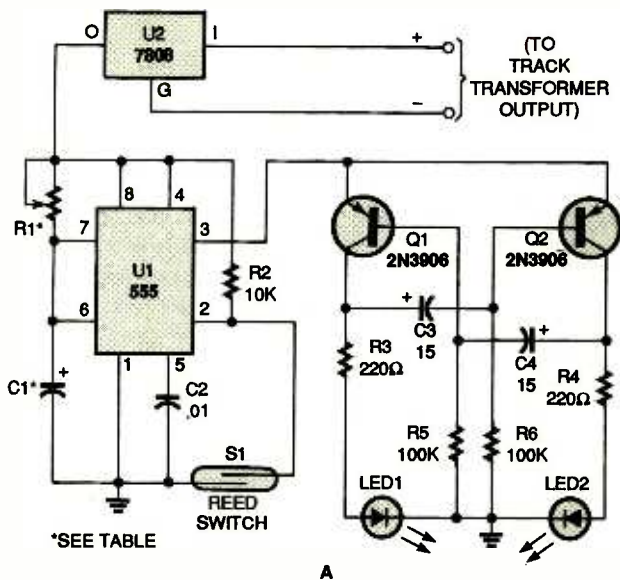
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*SEE TABLE

A

R1	TIME	
	C1 = 10 μ F	C1 = 100 μ F
100K	2 SEC.	16 SEC.
220K	3 SEC.	33 SEC.
470K	6 SEC.	70 SEC.
1MEG	15 SEC.	175 SEC.

B

Fig. 4. Featuring a reed switch operated by train proximity, this circuit (A) has everything you need to activate an LED-based crossing signal. To change the time period of U1, use these substitutions (B).

each other out. While you'll need a means to switch this circuit on and off, the reed-switch technique used in Fig. 2 should give you some ideas. By the way, because the 555 must source current part of the time, I recommend using a 555TLC, the CMOS version of the 555. The output from the lamps will be more even then.

FLASHER REVISITED

I am responding to your column in the October 94 issue about hobby circuits. I used a similar circuit (see Fig. 4A) in a crossing signal. It is a pretty-common timer circuit, based on a 555 timer IC (U1).

The monostable timer, U1, is triggered by a reed switch via a small magnet under the engine. When that happens, the output at pin 3 of U1 remains high for a time period determined

by C1 and R1. To alter that time period, replace C1 and R1 with components of the values in the provided table (see Fig. 4B). The output of pin 3 is connected directly to the flash circuit, which is a free-running multivibrator (in this case a flip-flop that triggers itself).

Resistors R3 and R4 limit current to the LEDs (which flash alternately). If desired, changing the values of C3 and C4 will change the

flash rate. Power comes from an extra set of outputs from the back of a train transformer via the 8-volt voltage regulator.

—Brian Rapp, Buffalo, NY

The power-supply feature is much appreciated. This is one of the few projects where the designer provided multiple parts values for a circuit. I would be very surprised if any of our readers wouldn't have some combination of junk-box parts to make the circuit.

TRACK-CONTROL SIGNAL

This circuit (see Fig. 5) is a variation of the track-control signal circuit printed in *Think Tank* in the October 1994 issue. It is used to indicate trains in hidden tracks, such as tunnels and holding tracks, and does not require modifying the trains themselves.

The circuit is based on a 555 timer IC, U1, and operates on 5-volts DC to make it usable with digital logic. The operating power of the circuit can be converted to 12 volts by increasing the values of R2 and R3.

Train detection is accomplished by photocell PC1, which should be mounted between the rails, flush with or slightly below the ties. A small light must be mounted directly above PC1 when used in any dark area. Resistor R4 is adjusted so that when a train covers PC1 the circuit triggers. Re-

sistor R1 reduces the current to U1 if R4 is set for minimum resistance.

Variable resistor R4 can also be adjusted so that each individual car in a train will change the colors of LED1, a bi-color unit, back and forth indicating train movement. That can be handy if 2 circuits are used, one at each end of the track block. It will indicate that the train has begun to move.

Mount LED1 on the control panel. The circuit is designed to indicate a green when no train is present. When a train covers photocell PC1, U1 switches LED1 to red, indicating the train is in position.

A 3-lead, bicolor LED could have been used to conserve power, but that would have meant one more wire running to the control panel.

—Robert Hartle, Tionesta, PA

To change the values of R2 and R3 to deal with 12 volts, double the values shown in the schematic, then jump to the next-highest standard value. For crowded control panels I recommend using ribbon cable to improve neatness. Start by hooking up the indicator furthest from the cable inlet with two adjacent conductors, then peel back the rest of the cable to the position of the next indicator, and trim. Connect that indicator and proceed in the above manner until a whole row of indicators is wired; then, run the cable out the panel. Also, take advantage of using common wiring (+V or ground) whenever possible.

Well, it's time to close. Till next time, please send in your creations and suggestions to me here at *Think Tank*, Popular Electronics, 500-B Bi-County Blvd., Farmingdale, NY 11735.

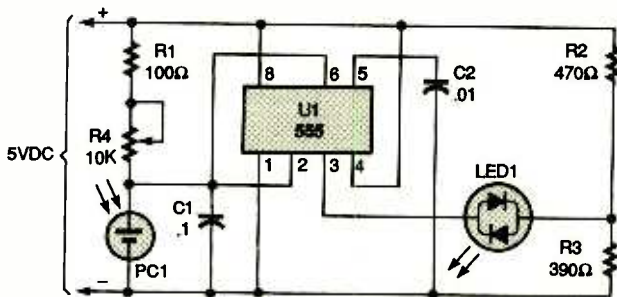
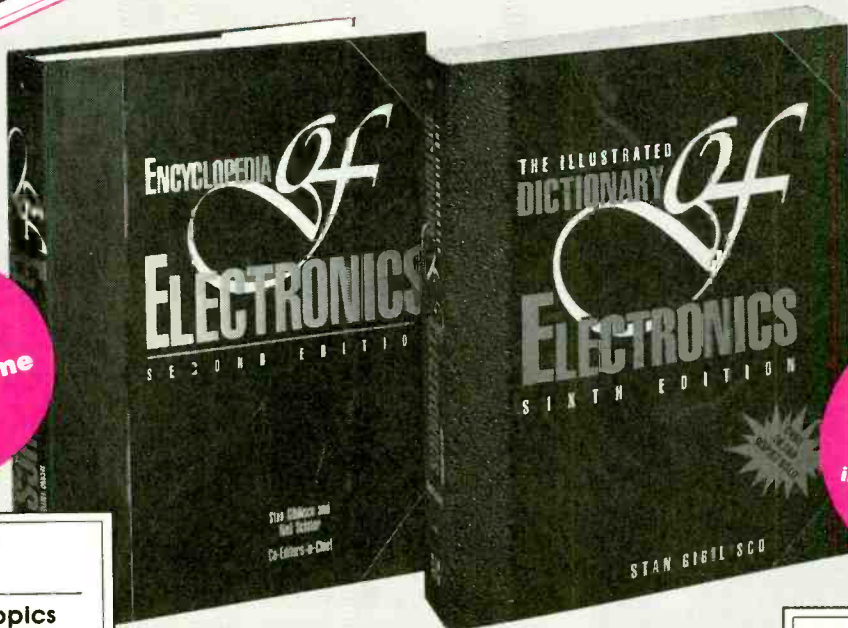


Fig. 5. Want a full-blown railroad-control panel? Try using multiple copies of this circuit to keep track of train positions.

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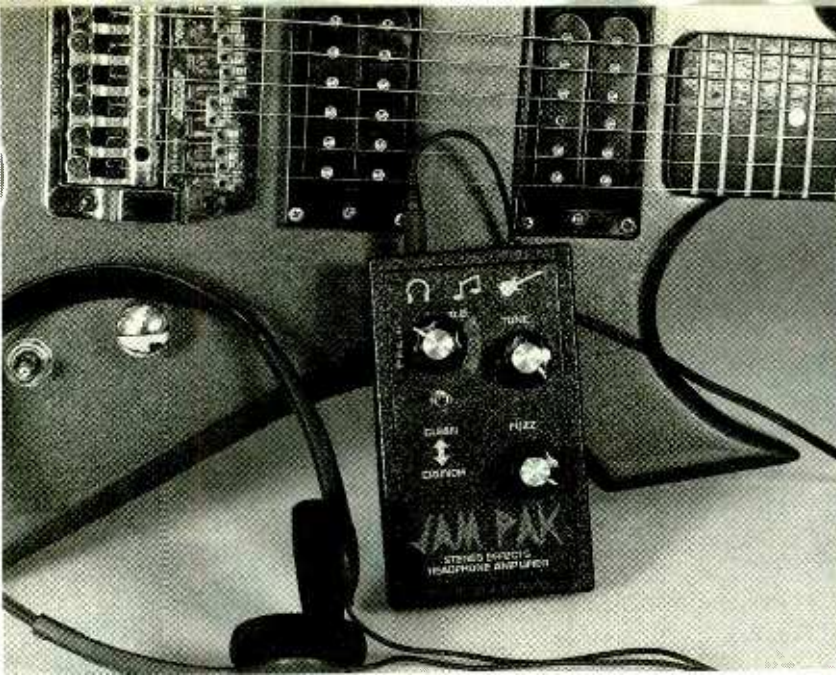
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7PC54



With this headphone guitar amplifier you can practice your guitar playing and prepare for a rock n' roll career, all without waking up the neighbors.

BUILD A HEADPHONE AMPLIFIER FOR YOUR GUITAR

Any electric-guitar player knows about the high cost of musical equipment. To purchase a small practice amp, one or two effects pedals, associated patch cords, and batteries and other power-supplies can cost at least a few hundred dollars. Not only is that equipment bulky and expensive, but to make things worse for the budding musician, there's always someone who doesn't appreciate a killer overdrive sound rattling the windows!

It's not easy becoming a rock 'n' roll superstar. However, with the *Jam Pak* headphone guitar amplifier described in this article, you will find it easier to practice. Simply plug in your "ax," put on the headphones, and crank it up as loud as you like. You can jam anytime, anywhere, without disturbing your family or neighbors. Similar headphone amplifiers available through music stores typically cost around a hundred dollars, but you can build the *Jam Pak* for under \$50!

The *Jam Pak* is a personal-headphone guitar amplifier featuring a unique stereo-imaging effect, and adjustable distortion, overdrive, and tone controls. It also has an auxiliary input that allows you to plug in any walkman-style tape- or CD-player and play along with your favorite

songs. That input can also be used with a keyboard or drum machine. The *Jam Pak* works with any stereo headphones and will operate for hours from a single 9-volt battery.

Circuit Description. Figure 1 is a schematic diagram of the *Jam Pak*. The main components in the circuit are two LM324 quad op-amp IC's (U1 and U2) and two LM386 power-amp IC's (U3 and U4). The inputs to U1 and U2 are biased to a little less than half the power-supply voltage by resistors R10 and R11. Capacitors C1 and C2 filter the power-supply and bias voltages.

There is no power switch in the circuit. Input-jack J1 turns on the *Jam Pak* when the input plug is inserted. When an audio signal from an instrument is input through J1, the signal is fed through coupling-capacitor C3 to the tone-control circuit composed of U1-c, R2, R4, and C4. Frequencies above 1 kHz are amplified or attenuated depending on the position of potentiometer R4, which is the tone control. Resistor R2 and capacitor C4 filter unwanted high frequencies.

Audio level and overdrive are controlled by potentiometer R9; with that level-control adjusted to full volume, the circuit's final amplifiers are over-

driven to produce a soft distortion effect. To prevent any unwanted DC "swishing" noise, a coupling capacitor, C8, is used.

Switch S1 toggles between the clean and distorted signals. When S1 is on the CRUNCH setting, diodes D1 and D2, and U1-d produce a distortion effect by clipping the amplified signal at 0.7 volts. Frequencies below 160 Hz are attenuated by R5 and C6. The amount of gain or "fuzz" is controlled by R7 and potentiometer R6, and resistor R8 adjusts the distortion level to match the tone-control level.

One of the reasons that the *Jam Pak* sounds great through a pair of headphones is its unique stereo-imaging effect. That is produced by a phase-shift circuit, composed of U2-a through U2-d, R20-R23, and C9-C12. Each stage shifts 90 degrees at the same frequency. The frequency of the shift at U2-a is:

$$f = 1/(2\pi RC)$$

where f is the frequency in hertz, π is equal to 3.14159, R is the value of R20, and C is the value of C9. For the frequency of the shift at U2-b-U2-d, use the values of R21-R23 and C10-C12, respectively (as Fig. 1 shows, those values are all equal). The four stages provide 360 degrees of phase-shift at 330

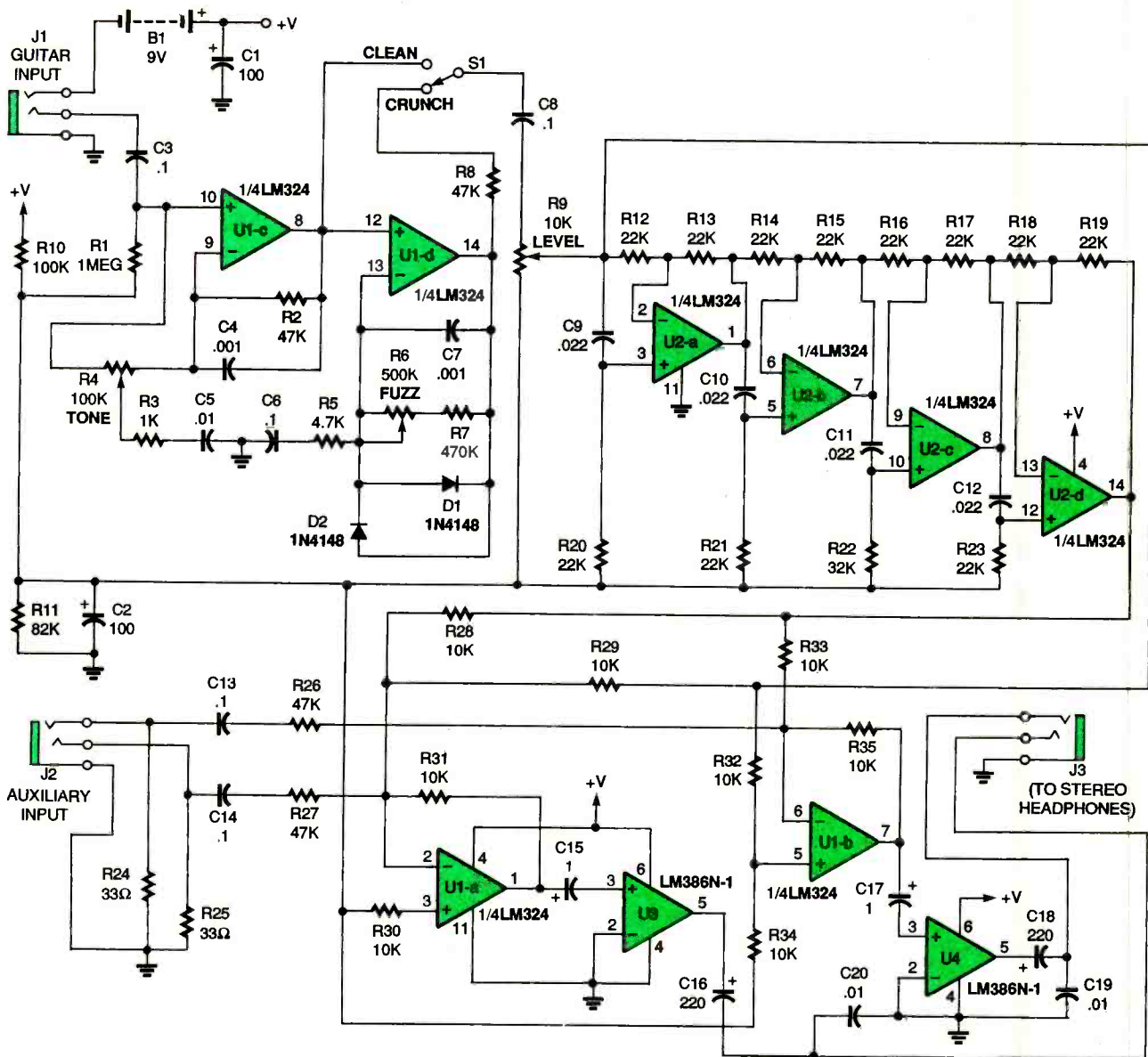


Fig. 1. From the hard distortion provided by U1-d and D1 and D2 to the stereo imaging accomplished by U2, the Jam Pak is a guitarist's dream come true. Note that there is no power switch in the circuit, as J1 turns on the unit whenever an instrument cable is plugged in.

Hz, which is about the center of the frequency range for guitars. At frequencies above and below 330 Hz, various degrees of phase shift occur. That phase-shifted signal is summed with the original signal for one channel (U1-a), and subtracted from the original signal for the other channel (U1-b). The result of all that is an interesting panning effect that is frequency dependent.

To play along with prerecorded music, or a keyboard or drum machine, you can feed the stereo signals from those sources into auxiliary-jack J2. Those signals are attenuated by R24 and R25, AC-coupled through C13 and C14, and mixed into the sum

and difference amplifiers through R26 and R27. Capacitors C15 and C17 provide AC-coupling of the sum and difference signals to U3 and U4, the final amplifiers.

Both U3 and U4 have a fixed gain of 20. With a supply voltage of 9 volts, they produce a power output of about 1/2 a watt into 8-ohm headphones. Capacitors C16 and C18 high-pass filter and couple the output to headphone-jack J3. Now, let's turn to building the amplifier.

Construction. The Jam Pak prototype was built on a double-sided printed-circuit board, which can be etched from the templates provided

in Figs. 2 and 3 or purchased from the source listed in the Parts List. There are a couple of good reasons why a PC-board is recommended for the project. One reason is to prevent the noise and self-oscillation problems that can occur in audio projects using other construction techniques. Also, using a PC-board simplifies construction and makes the finished product look neat and compact.

Most of the components listed in the Parts List are inexpensive and readily available from hobbyist sources and catalog distributors. Any enclosure of a suitable size can be used for housing the circuit board, jacks, and panel components. A pre-

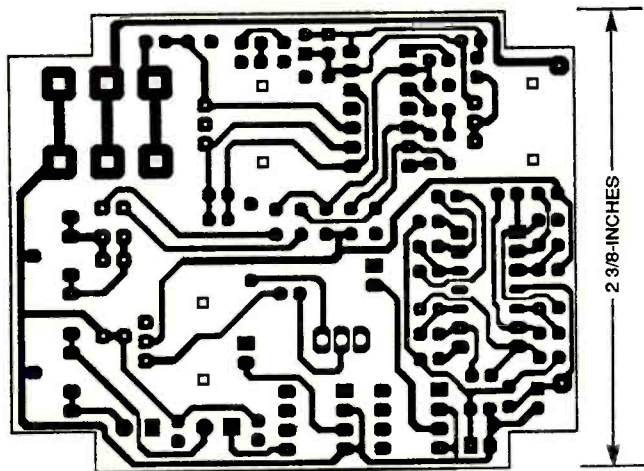


Fig. 2. Use this template to etch the component side of the printed-circuit board. The pattern is shown here in its full size of $2\frac{3}{8} \times 3$ inches.

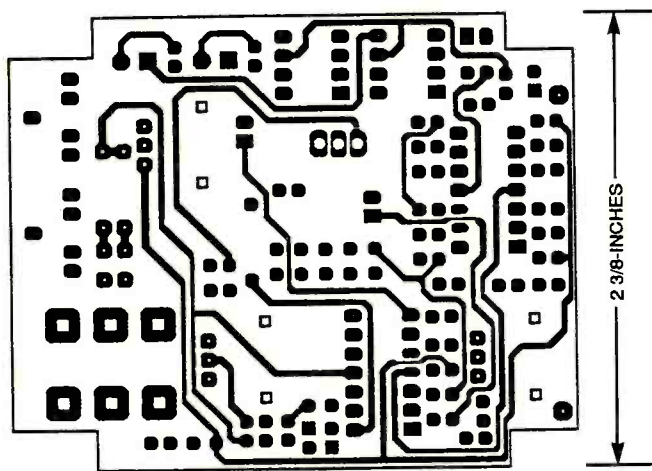


Fig. 3. This is the template for the solder side of the PC board. Like Fig. 2, it is also shown full size.

drilled enclosure with battery compartment, belt clip, and two-color silk-screening is available from the kit supplier.

Use the parts-placement diagram in Fig. 4 as a guide when building the Jam Pak, but keep the following in mind: To keep the circuit board small, most of the resistors are installed close together and standing up. To prevent a short, make sure that those part leads are not touching. Double-check your placement of integrated-circuits U1-U4 and the six electrolytic capacitors (C1, C2, and C15-C18) to make sure their polarities are correct. Also check to see if diodes D1 and D2 are installed with their banded ends facing in the directions indicated by the parts-placement diagram.

Install the IC's, jacks, capacitors, and fixed resistors on the component side of the PC board. The switch and the potentiometers should be mounted on the solder side of the circuit board (using PC-mount potentiometers eliminates the need for messy wiring, but panel-mounted units could be substituted if absolutely necessary). Make sure to solder on both sides of the circuit board whenever necessary. After you have installed all the circuit-board components, solder the 9-volt-battery snap in place, making sure that the polarity of the snap's leads is correct.

PARTS LIST FOR THE JAM PAK HEADPHONE GUITAR AMPLIFIER

SEMICONDUCTORS

U1, U2—LM324A quad operational amplifier, integrated circuit
 U3, U4—LM386N-1 low-power amplifier, integrated circuit
 D1, D2—1N4148, small-signal diode

RESISTORS

(All fixed resistors are $\frac{1}{4}$ -watt, 5% units)

R1—1-megohm
 R2, R8, R26, R27—47,000-ohm
 R3—1000-ohm
 R4—100,000-ohm, linear-taper potentiometer
 R5—4700-ohm
 R6—500,000-ohm, linear-taper potentiometer
 R7—470,000-ohm
 R9—10,000-ohm, linear-taper potentiometer
 R10—100,000-ohm
 R11—82,000-ohm
 R12-R23—22,000-ohm
 R24, R25—33-ohm

R28-R35—10,000-ohm

CAPACITORS

C1, C2—100- μ F, 10-WVDC, electrolytic
 C3, C6, C8, C13, C14—0.1- μ F, ceramic-disc
 C4, C7—0.001- μ F, ceramic-disc
 C5, C19, C20—0.01- μ F, ceramic-disc
 C9-C12—0.022- μ F, ceramic-disc
 C15, C17—1- μ F, 35-WVDC, electrolytic
 C16, C18—220- μ F, 10-WVDC, miniature electrolytic

ADDITIONAL PARTS AND MATERIALS

J1— $\frac{1}{4}$ -inch stereo phone jack, circuit-board mount
 J2, J3—3.5 mm stereo phone jack, circuit-board mount
 S1—SPDT, micro-miniature toggle switch
 B1—9-volt alkaline battery

Printed-circuit materials, enclosure, knobs, stereo headphones, 9-volt-battery snap with leads, wire, solder, hardware, etc.

Note: The following items are available from Lynn-Eren Electronics (17093 S. W. Lynnly Way, Sherwood, OR 97140; Tel. 503-625-2205): a complete kit of parts including an etched, drilled and plated-through PC-board with solder mask, and a pre-drilled enclosure with belt clip and two-color silk-screening, \$49; a fully assembled and tested unit, \$59; the PC-board only, \$15; stereo headphones only, \$10; a 72-inch auxiliary-input cable (3.5 mm stereo plug to 3.5 mm stereo plug), \$5. Please add 5% shipping and handling. Check off money order, VISA and MasterCard are accepted.

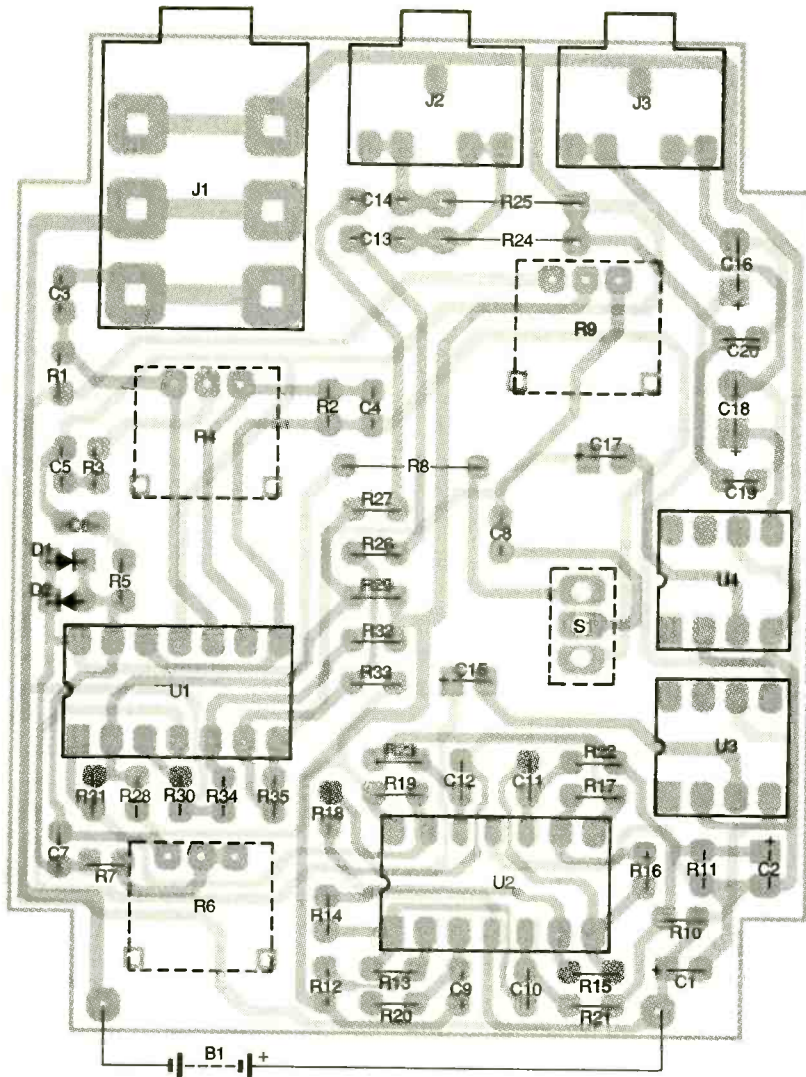


Fig. 4. Be sure to double-check the placement and polarity of your components with this diagram to avoid damaging any of them. Note that switch S1 and potentiometers R4, R6, and R9 mount on the solder side of the board.

Checkout and Use. When the placement of all components has been thoroughly checked, you are ready to try out the Jam Pak. Plug a guitar, bass, or other unamplified musical instrument into input-jack J1, and plug stereo headphones into headphone-jack J3. Note, however, that the sound heard through the headphones might be surprisingly loud, so it is a good idea *not* to put them on just yet.

Connect a fresh, 9-volt alkaline battery to the unit. With switch S1 in the "clean" position and level-control R9 set at low to moderate volume, the amplifier should sound undistorted. Adjusting potentiometer R9 to a high volume setting should overdrive the amplifier and produce a soft distortion effect. Level controls on the guitar or other instrument might need to be turned up to achieve the overdrive effect.

With switch S1 in the "crunch" position, the amplifier should produce a hard distortion or fuzz sound, which can be adjusted using the "fuzz" control, R6. The tone control, R4, should adjust the treble of both the "clean" and "crunch" sounds.

Playing scales is a good way to hear how the Jam Pak amplifier's stereo effect works. As the frequency changes, the position or panning of the stereo channels also changes. The stereo effect will sound the fullest when playing chords or fast riffs with a wide frequency range.

To use the auxiliary input, connect any stereo walkman-type cassette- or CD-player, drum machine, or other amplified audio equipment to jack J2. That input has a low impedance, which is appropriate only for devices intended to drive headphones or speakers. Other high-impedance sources might be damaged if connected to J2.

The unit will operate for several hours on a good alkaline battery. Because the power switch is part of J1, it is a good idea to disconnect the plug from the input when the amplifier is not in use.

Once you get the Jam Pak working, you'll be able to practice any time of day or night you please, without irritating those around you. And who knows, with a bit of practice and some luck, rock n' roll stardom could be just around the corner! ■



This compact amplifier lets guitar players brush up on their skills without annoying others.

Glowing gas-discharge tubes were among the first electronic wonders. In the past, they were used as voltage regulators in tube circuits. However, even though gas-discharge tubes are still one of the easiest ways to regulate voltages higher than 75 volts, they are rarely applied to that task anymore.

What's a good use for a glowing tube? Well, because it is a source of faint light, a voltage-regulating gas-discharge tube makes a great nightlight. With just one of the tubes (which you can pick up on the antique-tube market for a buck or two), a couple of mirrors, and a few other components, you can build the *Novel Nightlight*, a truly unique project for the electronics-oriented household.

Voltage-Regulator Tubes. Voltage-regulator (VR) tubes are diodes; they have a plate and a cold cathode (i.e. one without a filament). During the manufacture of a VR tube, air is removed from the tube and the glass envelope is filled with small quantities of helium, neon, argon, or other gases at very low pressure. When enough voltage is placed between the plate and the cathode, the tube glows.

Let's take a look at how the tubes

work. A typical circuit using a VR tube is shown in Fig. 1. As long as the current through the tube is kept within the manufacturer's ratings (typically 5 to 40 mA), the voltage at E_2 will change very little, despite variations in supply voltage E_1 or in the load current.

The above circuit only has one resistor, R1. To find the value of that resistor in ohms, use:

$$R1 = (E_1 - E_2) / I_{max}$$

where I_{max} is the maximum tube current.

BY LARRY LISLE, K9KZT

Build this unusual nightlight in an evening or two, using an old, gas-filled voltage-regulator tube.

Build a Novel Nightlight

As you can see, the operation of a VR tube is simple. However, for this project we won't be using it to regulate voltages. We just want to make the tube glow!

The Circuit. Figure 2 shows the circuit of the Novel Nightlight. It's basically a transformerless, half-wave power supply that puts out enough voltage to keep V1, the OA3/VR75 VR tube, glowing. Because the circuit has no transformer, it's absolutely necessary for safety that all conductors be enclosed in insulated material!

In the event of component failure, fuse F1 will blow and interrupt the current flow. Resistor R1 limits the current through diode, D⁺, which rectifies the AC; capacitor C⁺ smoothes out the pulsations. The function of resistor R2 isn't immediately obvious but it is important. If R2 wasn't in the circuit, unplugging the nightlight would cause the voltage on C1 to discharge through R3 and V1. However, when the voltage dropped below 75 volts, V1 would go out and the 75 volts in the tube would just sit there waiting to zap someone. Even with a "bleeder" resistor like R2, it's always a good idea to short power-supply capacitors with an insulated screwdriver after unplugging.



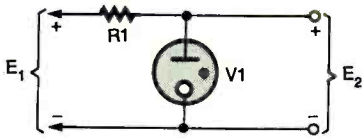


Fig. 1. This is the basic circuit for using a gas-discharge tube as a voltage regulator. In the nightlight project, however, we just want to make the tube glow!

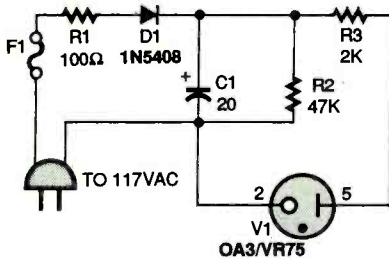


Fig. 2. The circuit for the Novel Nightlight is basically a transformerless, half-wave power supply that provides enough DC to light up V1, the voltage-regulator tube.

PARTS LIST FOR THE NOVEL NIGHTLIGHT

- D1—1N5408 silicon rectifier diode
- R1—100-ohm, 1-watt resistor
- R2—47,000-ohm, 2-watt resistor
- R3—2000-ohm, 5-watt resistor
- C1—20- μ F, 250-WVDC, electrolytic capacitor
- V1—OA3/VR75 voltage-regulator tube
- F1— $\frac{1}{4}$ -amp, fast-acting fuse
- $7\frac{3}{4}$ -inch square baseboard, 7-inch square pieces of glass (2), 7-inch square pieces of mirror (2), $7\frac{1}{4}$ -inch square piece of glass, rubber mounting feet (4), molding strips (8), power cord and plug, octal relay socket for tube (Potter & Brumfield 27E122 or equiv.), Fahnestock clips, fuse holder, epoxy glue, wire, solder, etc.

ging the circuit and before touching anything.

Construction. The method of wiring used to build the nightlight isn't critical. For the prototype, Fahnestock clips and some of the unused tube-socket terminals were used to make connections. If you do the same, be aware that pins 7 and 3 of the OA3/VR75 are connected internally.

The circuit should be mounted on a wood baseboard. In the prototype, that measures $7\frac{3}{4} \times 7\frac{3}{4}$ inches. Drill a hole in one corner of the board for the power cord to go through, but make

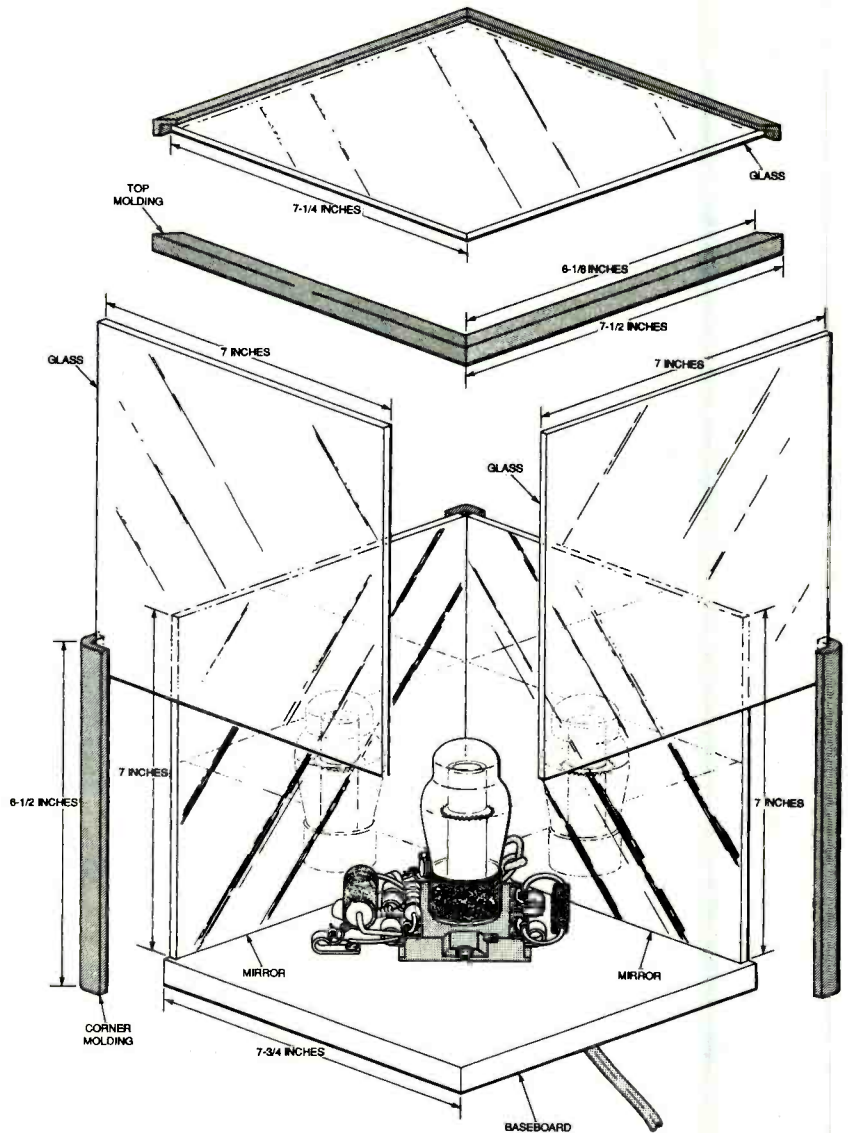


Fig. 3. Here is an exploded view of the nightlight-case assembly. The molding strips hold the pieces of glass and the mirrors together once they are glued. Note the 45° angles on the top molding which allow for a tight fit.

sure to tie a knot in the cord before inserting it, as that prevents strain on the wiring. To keep the unit from wobbling, attach four rubber feet on the bottom of the baseboard.

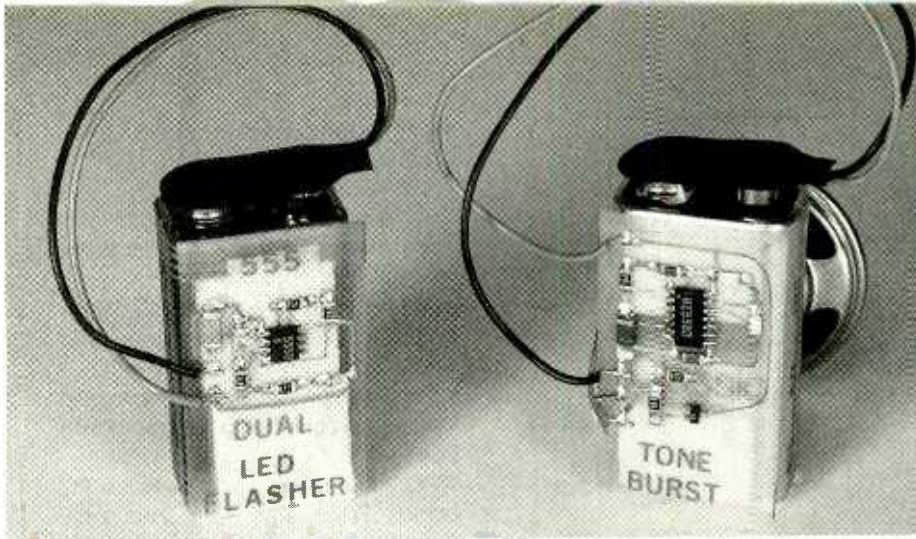
There are a few ways to adjust the brightness of the Novel Nightlight. First of all, you can change the value of R3. However, keep in mind that the current shouldn't exceed 40 mA (with the values shown in Fig. 2, it's about 31 mA). Also, other voltage-regulator tubes can be used instead, even though the OA3/VR75 was the brightest of the several that I tried. For a little variety, you could also add flashing neon bulbs with a capacitor and resistor for each, or an old mercury-vapor rectifier such as an 866.

Because of the high voltages present in the nightlight and the fact that the tube will get hot, once you have the circuit working, you should place it in some kind of enclosure or cover. An inverted food-preserving jar, an old aquarium, or a Plexiglas enclosure can be used. In the author's prototype, the enclosure was built as a 7-inch-on-a-side glass and mirror box (see Fig. 3). Two of the sides were made of mirror squares, so that when the unit is assembled and viewed at an angle, it looks as if there are four glowing tubes.

To duplicate the enclosure shown in Fig. 3, you will need two glass squares and two mirror squares, measuring 7

(Continued on page 96)

Getting Started in Surface Mount Technology



Two projects that will get you started in building with surface-mount components.

BY RONALD A. REIS

For most electronics hobbyists, the idea of hand-assembling surface-mount components (SMC's) into a working project seems ludicrous. After all, as most of us know, surface-mount technology (SMT) was developed with automatic assembly in mind. Finding, grasping, arranging, and somehow soldering those tiny, leadless SMT components by hand is ridiculous. Right? Wrong—delightfully wrong! Not only is it possible, but it can be accomplished easily, quickly, and, for the most part, with tools and materials you now have on your workbench.

As mentioned in the article "A Hobbyist's Guide to Surface-Mount Technology" (*Popular Electronics*, January 1995), SMT is a packaging revolution that attaches tiny, essentially "leadless" components to pads on the surface of a printed-circuit board (hence the name, "surface-mount technology"). That contrasts with traditional "insertion-mount technology" (IMT), which uses components with leads that are inserted through the PC board.

As you are about to discover, project-building with SMT is fascinating, fun, and, increasingly, inevitable. Even though today, for the most part, you still have a choice between traditional IMC's (insertion-mount components) and SMC's, tomorrow you might not; already, 50% of all the components in commercial electronic as-

semblies are SMC's. So, if you don't want to let a whole component-packaging revolution pass you by, learn to build the electronic projects of the near future, now.

SMT Project Building. To get you started in building tomorrow's electronic projects today, here are two fun, attention-getting, and, most important, easy-to-build SMT projects: the *555 Dual-LED Flasher* and the *Tone Burst*. Furthermore, to give you practice in fabricating SMT PC boards and soldering SMC's in place, a printed-circuit template for an SMT Practice Board is also included.

Both of the SMT projects presented here were chosen to give the begin-

ner the widest possible SMT project-building experience, using readily available, low-cost surface-mount components. Each project is built on a 1- x 1¾-inch PC board that is intended to be taped to the side of a 9-volt battery, its power source. The 9-volt-battery snap found in both projects, and the 8-ohm speaker in the *Tone Burst* are the only non-SMT components used.

Circuit Descriptions. The first project, the *555 Dual-LED Flasher*, alternately flashes a pair of tiny, surface-mount LED's at a rate of approximately 1 Hz. Figure 1 contains the schematic for that project.

The 555 timer, U1, is configured as an astable multivibrator (oscillator), the frequency of which is determined by the values of resistors R1 and R2 and capacitor C1. As C1 charges from ⅓ to ⅔ the supply voltage through R1 and R2, U1's output, pin 3, is high. As a result, LED2 is on (its anode is positive, its cathode, negative) while LED1 is off (both its anode and cathode are positive). When C1 discharges from ⅔ to ⅓ the supply voltage through R2, pin 3 goes low. As a result, LED1 turns on (now its cathode is negative and its anode is positive) and LED2 turns off (both its anode and cathode are negative). The duty cycle for the circuit is nearly 50 percent; therefore, each LED is on for close to an equal duration.

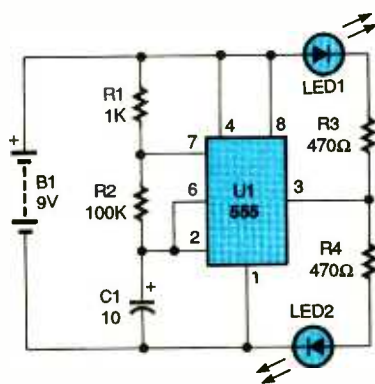


Fig. 1. Here is the schematic for the *555 Dual-LED Flasher*. The circuit alternately flashes LED1 and LED2, two surface-mount LED's, at a rate of approximately 1 Hz.

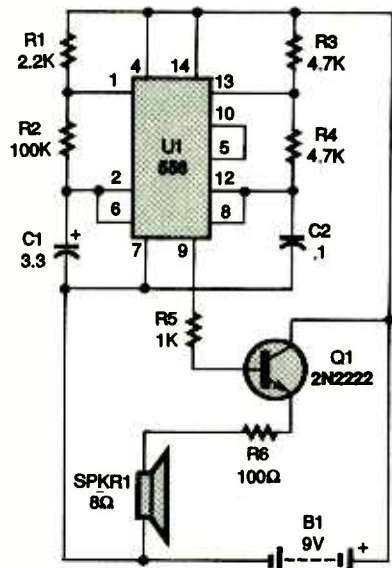


Fig. 2. The Tone Burst circuit puts out a 500-Hz tone, at a rate of 1 Hz, through an 8-ohm speaker, SPKR1. Besides the 9-volt battery and its connecting snap, SPKR1 is the only non-surface-mount component in the circuit.

The Tone Burst puts out a 500-Hz tone at a rate of 1 Hz. At the heart of the circuit is U1, a 556 IC, which is just two 555 IC's in one 14-pin package (see Fig. 2). Both "555's" are configured as astable multivibrators. The first, or low-frequency, oscillator, using resistors R1 and R2 and capacitor C1, turns on the second, or high-frequency, oscillator at a 1-Hz rate. The latter is alternately on and off for half a second. When it is on, it generates a 500-Hz signal, that value being determined by resistors R3 and R4 and capacitor C2. That signal is amplified by NPN transistor Q1, which drives the 8-ohm speaker.

SMT PC-Board Fabrication. The steps in fabricating an SMT printed-circuit board are identical to those used in etching a traditional, single-sided, IMT PC board. There are, however, two additional steps, or cautions, that should be observed when SMT boards are etched. We'll look at both in a moment, but first, here are the ten steps required to produce either an IMT or SMT PC board:

1. Clean the blank board with fine steel wool to get rid of contaminants and oily residue.
2. Spray a liquid photoresist onto the copper-clad board.
3. Dry the photoresist with a hair dryer.
4. Expose the sensitized board, with

- the artwork negative on top, to ultraviolet light.
5. Let the image develop.
6. Rinse and drip-dry the board.
7. Immerse the board in acid (ferric chloride is often used).
8. When etching is complete, thoroughly wash the board and then dry it with a paper towel.
9. Remove the remaining photoresist layer by lightly rubbing the board with steel wool.
10. Drill all necessary holes in the PC board. In an SMT PC board, only mounting holes might be required.

The PC-board template for the 555 Dual-LED Flasher is shown in Fig. 3 and the one for the Tone Burst is shown in Fig. 4. Note the small component pads and the extremely thin traces—in some cases, a mere 0.015-inches wide. When fabricating those and other SMT boards, two cautions are worth observing:

First, because you are dealing with

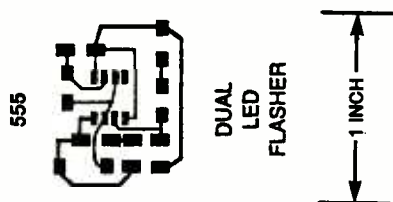


Fig. 3. This template for the 555 Dual-LED Flasher's PC board is shown in its actual size of only 1 × 1¼ inches! Note the small pads and extremely thin traces.

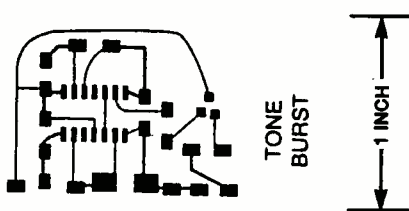


Fig. 4. The printed-circuit template for the Tone Burst is also shown here full size.

traces not much thicker than a line drawn with a pencil, it is a good idea to check the etching process frequently. Pull the board out of the acid bath often and examine it closely for acid undercuts. The narrow traces of an SMT board are delicate—leaving your board in the acid any longer than necessary to etch away unwanted copper might damage the traces.

Second, once the board is complete, check the PC-board pattern

with a magnifying glass. However, that might not be enough to locate any possible trace breaks, so you should check each trace (and pad) with a continuity checker (ohmmeter). That way you can be sure that the board is ready for the installation of surface-mount components.

Figure 5 is the template for an SMT practice board. By fabricating that board, you can gain experience in etching SMT PC boards with small pads and thin traces. Also, you can use the practice board to rehearse the SMC assembly techniques discussed later. For those reasons, etching the practice board before tackling either of the two SMT project boards is recommended.

Tools and Materials. In building either of the two projects presented here, you will need the right tools and materials. A full explanation of the items required was presented in "A Hobbyists Guide to Surface-Mount Technology" in the January 1995 issue of **Popular Electronics**. If you have a copy of that article, you might want to look it over.

Briefly, here are some tools you'll need: a soldering iron, a tweezers, a vise, and a magnifying glass. The soldering iron needs to be from 25 to 40 watts and should have a tinned tip with a conical shape, ¼ of an inch or less in diameter. The tweezers should have forceps-style tips. A small vise is ideal for securing the PC board while components are being attached. Because SMC's are so tiny, no matter

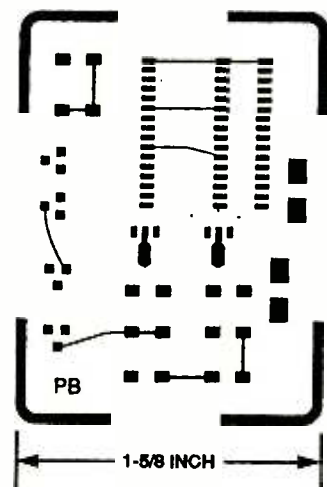


Fig. 5. Fabricating this SMT practice board will give you practice in etching an SMT PC Board, and in mounting SMC's. It is shown here full size.

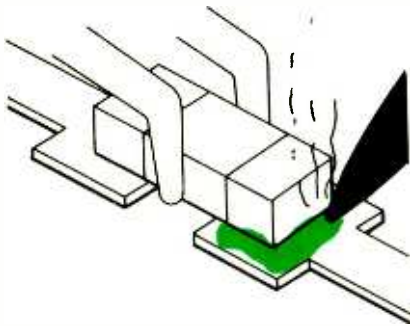


Fig. 6. To tag solder a two-terminal SMC in place, create a pool of solder on a pad, place the component above it, and reheat the solder so the SMC can "sink" close to the board surface.

how good your eyesight is, you'll want a magnifying glass close by. A desk-top illuminated magnifier, the kind that sells for around \$80, is ideal. At the very least, get yourself an inexpensive hand-held lens.

The materials you'll require are solder, liquid flux, a drop dispenser, a defluxer, and solder wick. The solder should have a 63/37 tin-lead mixture, and should be no greater than 0.020 inches in diameter. If you can find it, a 0.015-inch-diameter solder is even better. When purchasing a bottle of liquid flux, be sure it is of the noncorrosive type. To directly apply the flux where it is needed, you will want a drop dispenser. Also purchase a light-duty defluxer, in a spray can, which will be used to clean your assembled PC board of all contaminants. Finally, when choosing solder wick, select a width of 0.030 inches.

Attaching SMC's to PCB's. In building an SMT project, we suggest that you use the tag solder method discussed in the aforementioned article. Here is a review of the procedures for tag soldering various SMC's to a surface mount PC board:

To tag solder a two-terminal SMC to the surface of your PC board, first, using your drop dispenser, apply a dab of liquid flux to one PC-board pad. Then, using your soldering iron and solder, create a small pool of solder on that pad. Allow the solder to solidify.

Next, with the SMC held in your tweezers, rest the component on its PC-board pads and hold it in place. Then, using a soldering iron held in your other hand, reflow the solder so that the component "sinks" close to

the board surface (see Fig. 6). Remove the iron, allow the solder to cool again, and release the tweezers. With the component "held" in place, you're ready to solder the other terminal in a traditional manner.

To solder gull-wing leads on three- and four-lead components, proceed as above. Tag solder one lead and then solder the remaining leads in the conventional way (see Fig. 7).

When soldering DIP, gull-wing surface-mount IC's (SOIC's), first create a pool of solder on a corner pad in preparation for tag soldering. Then pick up the IC with a tweezers and

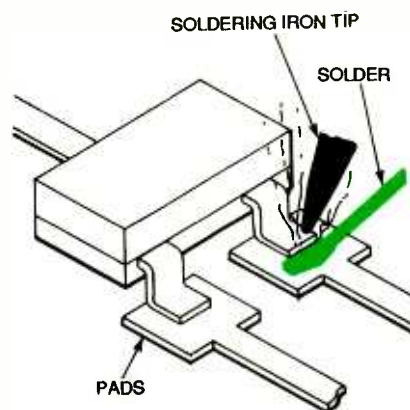


Fig. 7. To solder gull-wing leads to a PC board, use a 63/37 tin-lead solder that is 0.015 inches in diameter, and a conical soldering-iron tip that is 1/16 of an inch or less in diameter.

place it onto the copper pads, making sure to center the IC right-to-left as well as top-to-bottom. While holding the chip in place, apply the soldering iron tip to the pre-tinned pad. Keep the iron in place just long enough to flow the solder. If necessary, pivot the IC about the soldered pin to again align all pins with their respective pads.

To ensure the IC doesn't pivot, solder a second pin "kitty-corner" to the first. When doing so, don't forget to apply a small amount of liquid flux. When the chip is secure, "bathe" one line of pins with liquid flux and solder each pin, moving quickly to avoid overheating the IC. Then repeat the above step with the opposite row of pins. Finally, inspect your work under the magnifying glass, looking in particular for solder bridges.

At this point, you could continue directly to the assembly of your chosen project. However, if the procedures

just outlined seem a bit intimidating, you might want to practice a little SMC-placement first. That's where the SMT practice board, mentioned earlier, comes in. If you have etched the board, as suggested, you can now proceed to "stuff it" with surplus SMC's. As you will notice, pads to accommodate various sized two- and three-terminal SMC's, as well as thin- and wide-bodied DIP SOIC's, are provided.

Before actual component-placement and assembly begins, clean your PC-board traces and pads with steel wool. Next, mount the PC board securely in a vise. If you don't have a vise, you can try holding the PC board down by taping its corners to a flat surface with masking tape.

If you are using a desk-top magnifier, swing it into place and turn on the light. Place the rest of your tools, materials, and components nearby, within easy reach, and get comfortable. Pretend you're a surgeon about to perform a delicate operation. Then, just pick out a component location on the PC board, take a deep breath, exhale, and give it a go. You'll be a pro at SMT hand assembly in no time. Now, let's build our projects!

Construction. The parts-placement diagram for the 555 Dual-LED Flasher is shown in Fig. 8, and the parts-placement for the Tone Burst is given in Fig. 9. Whichever project you build, begin by attaching the integrated circuit. Note that in both projects the IC is placed so that pin 1 is on the top-left pad. Next, install any polarized capacitors (the positive terminal is indicated by either a colored bar or a

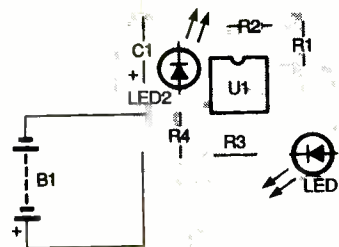


Fig. 8. Use this diagram as a guide when building the 555 Dual-LED Flasher. Because their markings are so small, polarized SMC's can be hard to work with, so be careful when aligning them.

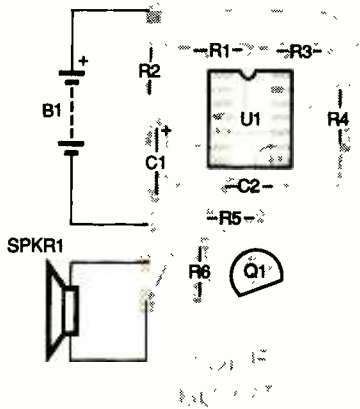


Fig. 9. This Tone Burst parts-placement diagram should make building the project a lot easier. Double check your battery- and speaker-wire connections to make sure they are correct.

PARTS LIST FOR THE 555 DUAL-LED FLASHER

- U1—555 timer, surface-mount integrated circuit
- LED1, LED2—Green LED, surface mount
- R1—1000-ohm resistor, surface mount
- R2—100,000-ohm resistor, surface mount
- R3, R4—470-ohm resistor, surface mount
- C1—10- μ F, 10-volt, electrolytic capacitor, surface mount
- B1—9-volt alkaline battery
- Printed-circuit materials, 9-volt-battery snap with leads, wire, solder, hardware, etc.

PARTS LIST FOR THE TONE BURST

- U1—556 dual timer, surface-mount integrated circuit
- Q1—2N2222 transistor or equivalent, surface mount
- R1—2200-ohm resistor, surface mount
- R2—100,000-ohm resistor, surface mount
- R3, R4—4700-ohm resistor, surface mount
- R5—1000-ohm resistor, surface mount
- R6—100-ohm resistor, surface mount
- C1—3.3- μ F, 10-volt, electrolytic capacitor, surface mount
- C2—0.1- μ F chip capacitor, surface mount
- B1—9-volt alkaline battery
- SPKR1—8-ohm speaker
- Printed-circuit materials, 9-volt-battery snap with leads, wire, solder, hardware, etc.

small marking). Proceed to install any non-polarized capacitors.

You can then place all the resistors. Because those components have no polarity, they can be installed in either direction. Do, however, solder them in place so that their resistance value is visible (for an explanation of how the values are read, once again refer to the previously mentioned article).

The 555 Dual-LED Flasher uses two LED's that are, of course, polarized. The cathode end is usually marked with a dot of green or red paint. If you're building the project, attach the LED's at this time.

The Tone Burst Project includes a three-terminal transistor. Because that tiny component can be placed on

"abuse," this is the time to find out. If your assembly techniques were good, the SMC's will hold.

Finally, attach a 9-volt battery. Your project should blink or beep, depending on which one you built. If the project fails to function correctly, make sure that you are using a fresh 9-volt battery. Then, check component placement and solder-joint integrity, and examine the project under your magnifier.

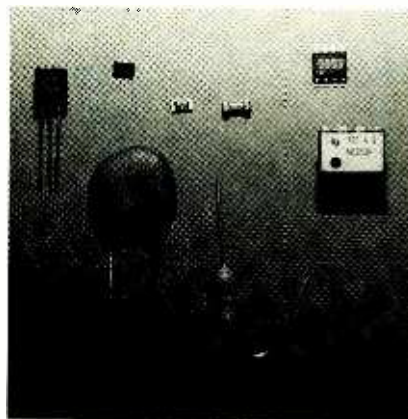
When your project is working, attach it to the battery with double-sided tape. For the Tone Burst, if you used a small enough speaker, you can affix the unit by taping it to the opposite side of the battery.

How to Get SMC's. You can purchase surface-mount components in single-lot (or "near-single-lot") quantities from a growing number of electronics distributors and retail outlets. First, check with your local electronics store. Second, look at the list of distributors presented in the aforementioned SMT article.

One of those sources, the Electronics Goldmine (P.O. Box 5408, Scottsdale, AZ 85261; Tel. 602-451-7454), has exactly what you need for either of the above two projects. In some cases you will have to purchase components in lots of anywhere from 5 to 20. That's practical, however, because you'll probably want to use the extras for solder practice or for building more projects.

Conclusion. Having built one or both of the SMT projects presented in this article, you have entered an entirely new realm of project building. In doing so, you have taken a leap not unlike that experienced by earlier electronics hobbyists when going from vacuum-tube-, to transistor-, to IC-based projects. You, too, are an electronics pioneer. But don't stop now.

SMT project kits are beginning to appear from a variety of sources. Purchase some of those kits and build them. Also, in the months to come, as you page through new issues of **Popular Electronics**, zero-in on the simpler IMT-based projects and try creating your own SMT versions of them. In no time at all, you will become an experienced pro at SMT project building.



Surface-mount components are much smaller and lighter than their insertion-mount-component cousins.

the PC board in only one correct direction, you can't get its placement wrong. If you are building the Tone Burst, install the transistor now.

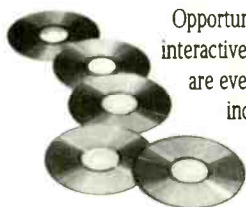
Tag solder the battery-snap wires directly to the appropriate PC board-pads. Be sure to observe correct polarity. Finally, if you are building the Tone Burst, attach speaker wires, approximately 2-inches long, to the correct pads on the PC board (see Fig. 9). Solder the other ends to SPKR1. For the sake of proportion, and to make an interesting assembly (more on that later), select a miniature unit for that speaker.

Checkout and Use. Before testing your project, spray it with the light-duty defluser. Then take a nail brush and scrub vigorously to remove contaminants. Don't be afraid that you'll scrape off an SMC or two. If the components can't stand the rubbing

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SIM-EQ: The Simultaneous-Equation Program

Let the silicon brain sitting in your den do some of the number-crunching on your electronics calculations.

BY JAMES E. TARCHINSKI

Everyone who works with electronics has their own reasons for choosing it as a career or a hobby. Some like the challenge of designing circuits, others take pleasure in building them, and a few enjoy the "pleasant" frustrations of debugging a circuit once it's built. There is even a group of people who enjoy electronics, at least in part, because of the mathematics involved. Yes, you read that last sentence correctly: It does read "because of" and not "in spite of" the math involved.

Even the most devout mathematician, however, eventually grows tired of repeatedly performing a single sequence of calculations. An example of repetitive calculations is the solving of a series of simultaneous equations that is often necessary to analyze complex electronic circuits. The first few times you solve a group of simultaneous equations it's fun; after that it becomes drudgery and you start looking for some relief.

SIM-EQ.BAS can provide that relief. It is a BASIC program that can solve a series of up to 25 simultaneous equations with real, constant coefficients. Although the program was written for IBM-compatible PC's, it can easily be modified to run on any machine that supports BASIC.

But before you can use SIM-EQ to solve a series of equations, you need a series of equations to work with. Therefore, let's take a look at how to solve and obtain simultaneous equations, using a sample circuit for illustration.

There are two basic analysis approaches that can be used to solve complex electronics circuits: one based on Kirchoff's Current Law (KCL)

and the other based on his voltage law. (For more information on both types of analysis, refer to the article "Beyond Ohm's Law," by Paul Coxwell, in the May 1994 issue of **Popular Electronics**.) We will briefly look at the approach based on KCL, which is generally known as "Nodal Analysis."

Nodal Analysis. Kirchoff's Current Law states that the sum of all the currents flowing into a node of a circuit must equal the sum of all the currents flowing out of that node. To perform nodal analysis, all you need to do is write one KCL equation for each node of the circuit, not counting the ground node. That means that in a circuit containing a total of N nodes you will end up with a total of N independent equations. For example, in a three-node circuit ($N = 3$), you would have three equations.

The next step in nodal analysis is to replace every current variable in the equations you just generated with a term based on the node voltages of the circuit. For a resistive element, use Ohm's law to represent the current flow through the element in terms of its resistance and the voltages at the

two nodes to which it is connected. For current sources, that particular step does not apply because the current supplied is not a variable but a fixed number. Therefore, it is already in a form that is easy for a computer to deal with.

After completing those two basic steps you will end up with a total of N equations, within which there should only be references to the N node voltages of the circuit. Unfortunately, you can not solve those equations one at a time. All the equations need to be solved *simultaneously*, and hence mathematicians call those types of equations *simultaneous equations*.

Over the past few hundred years, several methods for solving series of simultaneous equations have been developed, but the best method was created about 40 years ago. That, of course, is to let a computer do it, which is precisely what the SIM-EQ program was written to do.

Program Operation. To demonstrate the use of SIM-EQ.BAS, let's use it to solve a series of three equations with three unknown values. To obtain those equations, we must first perform

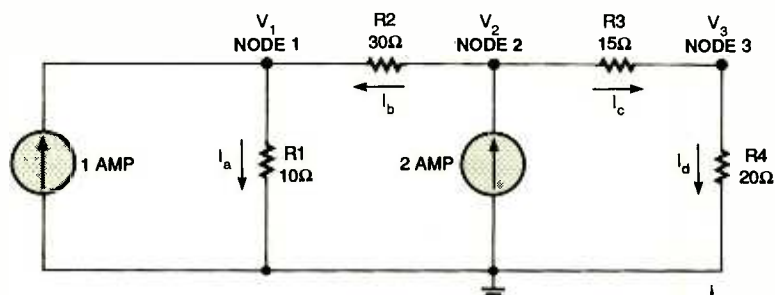


Fig. 1. Performing nodal analysis on this three-node circuit generates equations 10, 11, and 12. The SIM-EQ program can then be used to solve those equations to obtain node voltages V_1 , V_2 , and V_3 .

LISTING 1

```

100 CLEAR : DIM A(25, 26): KEY OFF
110 SCREEN 0, 0, 0, 0: COLOR 10, 0, 0: WIDTH 80: CLS
120 PRINT "SIM-EQ: The Simultaneous Equation Program"
130 PRINT "Copyright (c)1988-94 by James Tarchinski"
140 PRINT
150 PRINT "Enter the number of variables/equations"
160 INPUT "in the system you wish to solve (1-25): ", IN$
170 PRINT : N = VAL(IN$)
180 IF N > 25 OR N < 1 THEN PRINT "PLEASE ENTER A VALID NUMBER!": GOTO 140
190 N1 = N + 1
200 PRINT
210 '
220 '***** ENTER THE COEFFICIENTS *****
230 FOR I = 1 TO N
240 PRINT : PRINT "---- Column #"; I; " ----"
250 PRINT
260 FOR J = 1 TO N
270 PRINT "A("; J; ", "; I; ") = ";
280 INPUT "", IN$: A(J, I) = VAL(IN$)
290 NEXT J
300 NEXT I
310 PRINT
320 '
330 '***** ENTER CONSTANTS AND CORRECT ERRORS *****
340 FOR I = 1 TO N
350 PRINT "Constant of Row #"; I; " = ";
360 INPUT "", IN$: A(I, N1) = VAL(IN$)
370 NEXT I
380 '
390 PRINT
400 INPUT "Are all the values you entered now correct (Y/N)? ", IN$
410 IF IN$ = "Y" OR IN$ = "y" THEN 530
420 IF IN$ <> "N" AND IN$ <> "n" THEN PRINT "Please enter Y or N!": GOTO
390
430 '
440 INPUT "Row to modify: ", I
450 IF I = 0 THEN GOTO 530
460 IF I > N OR I < 1 THEN PRINT "Value out of range!": GOTO 440
470 INPUT "Column to modify: ", J
480 IF J > N1 OR J < 1 THEN PRINT "Value out of range.": GOTO 470
490 PRINT "Change A("; I; ", "; J; ") from "; A(I, J); " to: ";
500 INPUT "", IN$: A(I, J) = VAL(IN$)
510 GOTO 390
520 '
530 '***** GAUSSIAN ELIMINATION *****
540 CLS : PRINT "Calculating, please wait..."
550 FOR I = 1 TO N
560 HF = I
570 B = ABS(A(I, I))
580 FOR K = I + 1 TO N
590 T = ABS(A(K, I)): IF T > B THEN B = T: HF = K
600 NEXT K
610 IF I = HF THEN GOTO 650
620 FOR K = 1 TO N1
630 SWAP A(I, K), A(HF, K)
640 NEXT K
650 IF B < 9.9999E-20 THEN GOTO 870
660 T = A(I, I)
670 FOR K = I TO N1
680 A(I, K) = A(I, K) / T
690 NEXT K
700 '
710 FOR K = 1 TO N
720 IF K = I THEN 770
730 T = -A(K, I): A(K, I) = 0
740 FOR L = I + 1 TO N1
750 A(K, L) = A(K, L) + T * A(I, L)
760 NEXT L
770 NEXT K
780 NEXT I
790 '
800 '***** PRINT THE RESULTS *****
810 CLS : PRINT "The answers are:": PRINT
820 FOR I = 1 TO N
830 PRINT "X("; I; ") = "; : PRINT A(I, N1)
840 NEXT I
850 GOTO 880
860 '
870 PRINT "ERROR! - Equations can't be solved!"
880 PRINT : PRINT "Press any key to exit...";
890 IN$ = INKEY$: IF IN$ <> "" THEN GOTO 890
900 IN$ = INKEY$: IF IN$ = "" THEN GOTO 900
910 'End of Program Listing

```

a nodal analysis on the circuit of Fig. 1. As mentioned earlier, the first step in

nodal analysis is to write one KCL equation for each node of the circuit.

Doing that to the circuit in Fig. 1 yields:

$$\text{Eq. 1: } I_a = I_b + 1.0$$

$$\text{Eq. 2: } I_b + I_c = 2.0$$

$$\text{Eq. 3: } I_d = I_c$$

where I_a through I_d are the different currents in amperes. Equations 1, 2, and 3 are derived from nodes 1, 2, and 3, respectively.

Now that you have three KCL equations, use Ohm's law to replace each current term with terms based on the circuit's node voltages and resistor values. Remembering that the current through a resistor is equal to the voltage across it divided by its resistance, you get:

$$\text{Eq. 4: } \frac{V_1}{10} = \frac{(V_2 - V_1)}{30} + 1.0$$

$$\text{Eq. 5: } \frac{V_2 - V_1}{30} + \frac{(V_2 - V_3)}{30} = 2.0$$

$$\text{Eq. 6: } \frac{V_3}{20} = \frac{(V_2 - V_3)}{15}$$

where V_1 through V_3 are the different voltages in volts.

The next step is to eliminate the fractional elements in the above equations, which makes the equations easier to look at and deal with. To do that, multiply each equation by a constant value. For "real-world circuits" it is not always practical to perform that step, so instead, fractional components are often replaced with their decimal equivalents (for example, $\frac{1}{10}$ would become 0.1, $\frac{1}{30}$ would become 0.033333, etc.).

To eliminate the fractions in the three equations, multiply equations 4 and 5 by a factor of 30, and equation 6 by 60. In that same step, combine all like terms to give:

$$\text{Eq. 7: } 4V_1 = V_2 + 30$$

$$\text{Eq. 8: } 3V_2 - V_1 - 2V_3 = 60$$

$$\text{Eq. 9: } 7V_3 = 4V_2$$

To make it easier to enter the above equations into the simultaneous equation program, you need to write them in a standard format. That is accomplished by doing three things: First, rearrange the equations so that the unknown variables are lined up in columns on the left side of the equal signs, and the constants are in a column on the right side of the equal sign. Second, when a variable does

not have a coefficient explicitly listed in an equation, enter a zero value as a place holder. Third, write the row numbers in front of the equations and the column numbers above the unknowns. Note that you will always have one more column than you do rows, because of the constant terms on the right sides of the equations. Here is an example of the standard format, using the above equations:

	{1}	{2}	{3}	{4}	
Eq. 10:	(1)	+4v ₁	-1v ₂	+0v ₃	= 30
Eq. 11:	(2)	-1v ₁	+3v ₂	-2v ₃	= 60
Eq. 12:	(3)	+0v ₁	-4v ₂	+7v ₃	= 0

As far as SIM-EQ.BAS is concerned, all of the numbers in the above equations are known as A(r,c) coefficients, where r is the row number that the coefficient is in, and c is the column number of the coefficient. For example: A(2,3) is the coefficient in row 2, column 3, which is -2; A(1,1) has a value of +4; A(2,1) is -1; and A(3,4) is 0.

For clarity, numbers to the right of the equal signs have two different names. Besides being called A(r,c) coefficients, the terms are also called "constants of the row" for obvious reasons.

TABLE 1—SAMPLE OUTPUT

SIM-EQ: The Simultaneous Equation Program
Copyright (c)1988-94 by James Tarchinski

Enter the number of variables/equations
in the system you wish to solve (1-25): 3

---- Column # 1 ----

A(1 , 1) = 4
A(2 , 1) = -1
A(3 , 1) = 0

---- Column # 2 ----

A(1 , 2) = -1
A(2 , 2) = 3
A(3 , 2) = -4

---- Column # 3 ----

A(1 , 3) = 0
A(2 , 3) = -2
A(3 , 3) = 7

Constant of Row # 1 = 30
Constant of Row # 2 = 60
Constant of Row # 3 = 0

Are all the values you entered now correct
(Y/N)? Y

Calculating, please wait...

The answers are:

X(1) = 18
X(2) = 42
X(3) = 24

Press any key to exit...

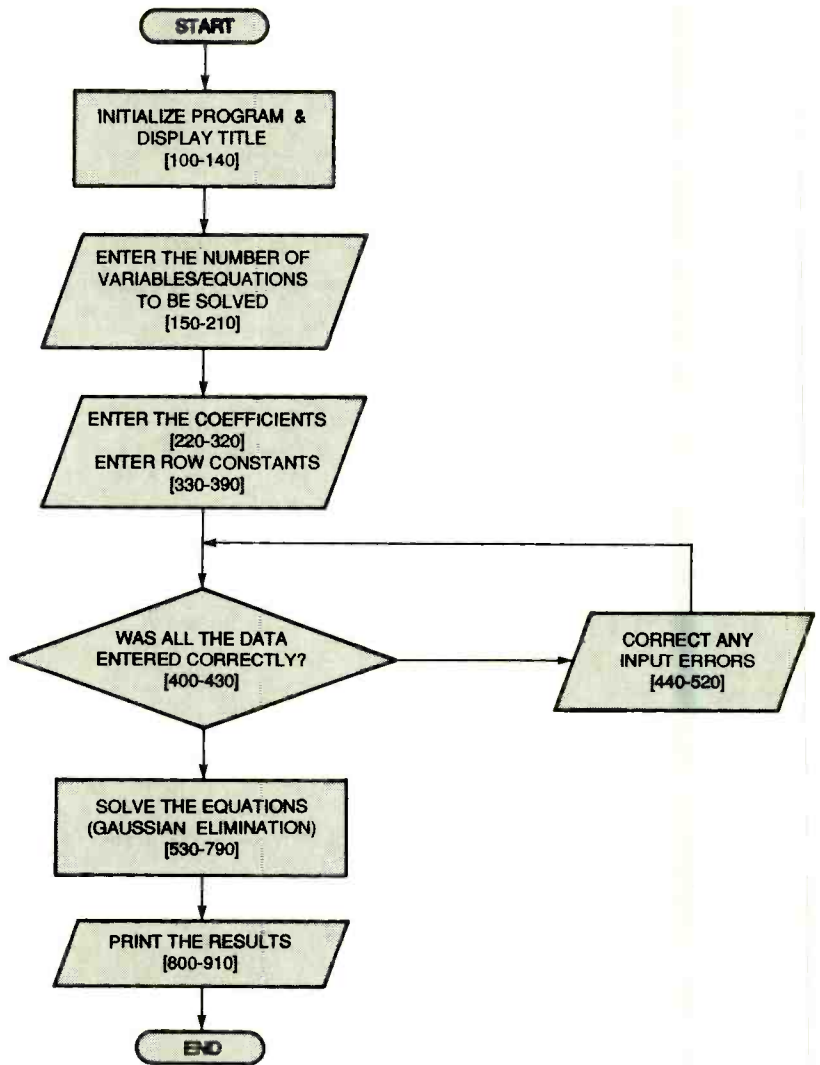


Fig. 2. This flow chart shows the sequence of logic in the SIM-EQ program. Note that the numbers given in square brackets refer to the corresponding line numbers in Listing 1.

Now that you have three equations in a standard format, and are familiar with the terminology the program uses, you are just about ready to use SIM-EQ.BAS to solve for node voltages V₁, V₂, and V₃. Loading the program into your computer is the only other step that needs to be completed.

If you've never entered a BASIC program into a computer before, you might need to consult your computer's instruction manual or your DOS manual for a complete description of the process. As given in Listing 1, the program will run on Microsoft-DOS based computers that utilize the BASICA, GWBASIC, or QBASIC implementations of the BASIC programming language. Users of other implementations, or users of other machines, might have to make some

minor modifications to the program, but the bulk of it should run as presented.

Once you've entered the program into your computer and have saved it to disk (as a precautionary measure), you are ready for the moment of truth—the solution of equations 10, 11, and 12. Run the program, and enter data as shown in Table 1. Be certain to look back at equations 10 through 12 while entering the data, so that you can see where the data originally came from. Note that in the table, all user input is underlined, while all computer-generated text is shown in normal type.

The program will solve the three simultaneous equations after only a few milliseconds of calculation, out-

(Continued on page 96)

Exploring the

IMAGINATION!



BY DONNA ROACH

Your computer comes alive with fun when you explore this very different on-line service.

How would you like to pilot your own plane in a heated dog-fight; gamble the night away in Las Vegas; play a friendly game of cards or 18 challenging holes of golf; or explore mazes while fighting monsters in a medieval land, without ever leaving the comfort of your own home? You can, over *The ImagiNation Network* (INN), an "entertainment network" that brings the world (via computer modem) to your doorstep. Log in and you will find thousands of friendly members from all over the country ready to enjoy this piece of cyberspace with you!

Before we go any further, let me introduce myself: I am INNTilli, and I am c sysop for the ImagiNation Network. Sysops, (short for systems operators), are the "social directors" of INN, devoted to helping all members enjoy ImagiNation.

Touring the Countryside. So that you can become more familiar with INN, let's take a little tour. You start by creating your own on-screen persona, complete with a face you design by choosing from a variety of features such as nose, hairstyle, eye color, etc. Once that's done, you can

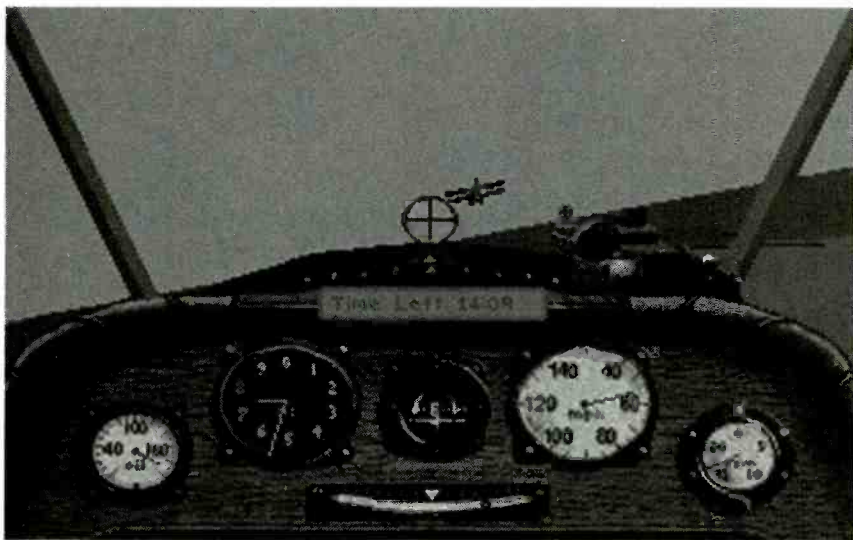
add information about yourself, including where you live, your hobbies and interests, etc., and you are ready to go!

Next, it's time to take a trip to ImagiNation! As you dial into the service, the scene on the monitor changes into a colorful picture of the "Sierra Mountains" as you watch a "signal" bounce off a satellite and connect. The scene changes again and you are looking down on the buildings of a small town. Created by Sierra On Line, Inc., the company that brought you games such as *King's Quest*, *Aces over Europe*, and the *Leisure-Suit Larry* series, ImagiNation Network consists of four separate and distinct "lands," each with its own character.

Let's start with the "Clubhouse," which you can enter with just a mouse click. There you will find many popular games, and plenty of friendly members to play them with. Chess, Checkers, Bridge, and Backgammon are available here, as well as Hearts, Spades, Euchre, Cribbage, Reversi, and Go. Those are all played live, in real time against real people. Select a room to play in, and you'll find yourself in a waiting area where you'll see names of other members who are on-



Anyone for a game of Bridge? In *The ImagiNation Network* you can play against opponents who range from beginners to champions.



Try your hand at *Red Baron*, a WWI flying game. Rather than a computer, your opponent is another network member.

line. You may talk to them, look at their picture (or "toon" as it's often referred to), and invite them to play a game with a simple click of your mouse. The game graphics are very realistic and colorful, and your opponents' toons appear on the screen in front of you as you play. Instant conversations are accomplished simply by typing messages during games.

But that's just the beginning! Enter the room in the Clubhouse named "INNUiversity," and you can take lessons in subjects ranging from C+ programming to learning how to play any of the games mentioned above. In the Chess Club you can find players ranging from beginners to world-class champions; and in the Bridge Club

(which ranks among the top ten in the nation for membership), ACBL-rated experts are often found tuning up for their next competition. Tournaments for all games are held frequently. You can also participate in live conferences on a myriad of subjects, and there are also over 175 (at last count) bulletin boards covering a wide range of topics to explore.

Click on the "Shopping Mall" to order Sierra games and other products like modems and hint books; or explore the Shopper's Advantage Network. Just above that is the Post Office, where unlimited E-mail may be sent or received between members. E-mail substations are available in the Clubhouse as well.

"SierraLand," (all decked out in pink), is where you can play *Red Baron* (a WWI flying game) and take part in "dogfights" against other pilots (real people and in real time, of course). There you can also find 18 holes of 3-D Golf, an incredibly realistic mini-golf game that's full of surprises, and NTN Trivia, where you can see your own scores and how you rank with other players around the country. SierraLand also contains games such as *Paintball*, *Rocket Quiz*, *Graffiti*, *Boogers*, and *Stratego*.

"CasinoLand" is where you'll find Poker, Slots, Blackjack, and Roulette, using "LarryBucks" for money. (Just make a little trip to "Nurse Clot" at the "Bloodbank" if you go broke!) Or relax in "Lefty's Bar" with a special friend, send her roses or kisses, and play *Veracity* or *Liar's Poker*. The atmosphere there is VERY adult as "community standards" are relaxed in this land. For that reason, the area is restricted to members 18 and over, and can be password-protected to prevent young family members from entering. If you are easily offended or shocked, but still wish to partake in the activities offered there, I recommend that you enter the room called "Polite Place." But if you enjoy a bawdy joke or two on occasion, the other rooms in CasinoLand can be loads of fun!

Looming up as a volcano in the distance is "MedievalLand," which contains two fantasy/adventure/role-playing games: *The Shadow of Yserbius* and *The Fates of Twinion*. Both are fascinating and tough to solve. There are over 30 mazes to explore in each, while fighting an assortment of creatures, ranging from Gargoyles to Manticores and Dragons. You must choose your best weapons, find proper keys for doors, go on various quests, etc., in order to complete them. But you don't have to struggle all alone, pitted against your computer. You can join a party of other members to explore the depths of the volcano. Experienced players are available to answer questions or help you find your way when you get lost.

Or you can ask me! That is where I do my work for ImagiNation. It's my job to greet new players and instruct them in the basics of playing. I tell them how to "walk and talk," how to arm themselves with weapons and
(Continued on page 92)

BUILD A FREQUENCY RESPONSE TESTER

BY RANDY CONSTAN



With it, you'll never again have to guess about the frequency response of an audio device.

Many off-the-shelf audio processors, such as equalizers, enhancers, and pre-amplifiers, alter audio signals even when in their so-called "pass-through" modes. The resulting frequency-spectrum losses often cause unwanted distortion, which can be very difficult to isolate if there are several components in an audio system. Therefore, a device that measures the frequency response of audio components should be a welcome addition to the toolbox of any audio-electronics enthusiast.

With the *Frequency-Response Tester* described in this article, you can directly view the frequency response of almost any audio gadget right on your oscilloscope screen, with a minimum of fuss. If any lumps and bumps appear in the signal of a device under test (DUT), the mystery of your sound troubles will be solved. Furthermore, the Tester will allow you to take corrective action, and quickly view the results.

The Tester works by generating two signals. The first is a linear-sawtooth sweep waveform that drives the horizontal input of your scope. Internally, that signal is transformed into a logarithmic waveform that spans three decades of voltage differential. That signal is applied to a function-generator IC to produce the second output, a sine-wave signal. The sine wave has a frequency that follows the log-

arithmic waveform, and has an amplitude that remains constant.

By connecting the DUT between the sine-wave sweep output and your scope's vertical input, the DUT's response to the entire frequency spectrum can be easily viewed. The logarithmic nature of the frequency sweep assures that the entire audio range appears as an ordered display, in which each $\frac{1}{3}$ of your scope's horizontal range depicts one decade of frequency span. In other words, the ranges are: 20 to 200 Hz, 200 to 2,000 Hz, and finally 2,000 to 20,000 Hz, from left to right. Because the unit also generates your scope's horizontal sweep, the scaling remains stable and repeatable no matter how you vary the sweep rate.

Frequency-sweep generators are not a new or unique idea, but unfortunately their cost can be somewhat prohibitive for the average hobbyist. However, you can build the Frequency-Response Tester for under \$50, depending on your junk-box supplies. Even though this project will save you some money, keep the following in mind: The circuit requires an initial setup and occasional calibration; also, accuracy beyond two digits is impractical unless your scope uses sophisticated on-screen digital readouts for frequency and voltage levels.

A plain, vanilla scope will work fine with the Tester, as long as its time base

and vertical amplifiers provide reasonable accuracy. A frequency counter is also recommended, at least for the initial setup.

Circuit Description. The schematic for the Frequency-Response Tester is shown in Fig. 1. The two quad op-amp sections, U3-c and U3-d, are configured as a linear-ramp generator. With switch S2 in the SWEEP position as shown, the output of U3-d is low. Zener diodes D2 and D3 limit that output to about -7 volts, which is the 6.2-volt reverse drop across D3, plus the forward drop of D2. The internal short-circuit protection of the op-amp limits the Zener current to several milliamperes.

Because the output of U3-d is negative, integrator U3-c generates a linear ramp in a positive direction, at a rate determined by the resistance of R4 and R29, and the capacitance of C5. A portion of that output is fed back to the noninverting input of U3-d via the voltage-divider network consisting of R2 and R3. Because U3-d is basically operating as a comparator with its inverting input grounded, its output will switch positive as soon as its noninverting input crosses zero volts. That will occur when the positive-going ramp reaches about $+5.8$ volts.

Once U3-d switches to a high-output state, the operation is repeated with the opposite polarity except that

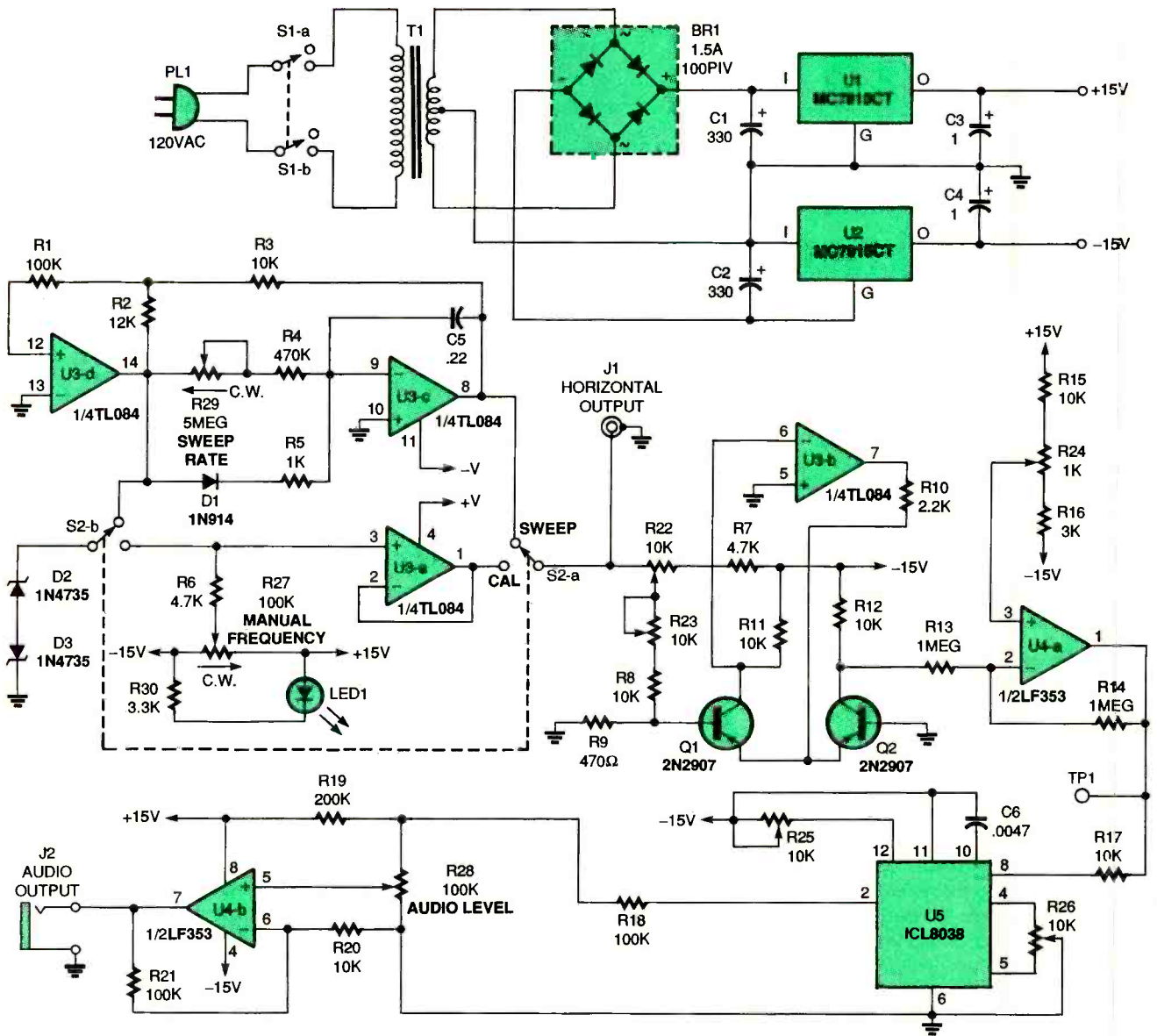


Fig. 1. As this schematic for the Frequency-Response Tester shows, there are five trimmer potentiometers, R22–R26, that are used for calibration. But don't worry, the process is not as hard as it might seem.

diode D1, now forward biased, allows an additional current path to U3-c via R5. Because the resistance of R5 is much less than the combined values of R4 and R29, the negative-going ramp time is almost negligible compared to the positive ramp, and the overall effect is to produce a sawtooth waveform with an amplitude of over 10-volts peak-to-peak. That is more than sufficient for just about any scope's horizontal input.

Next, the linear ramp undergoes a series of level and offset adjustments via resistors R7, R8, R9, R22, and R23, and is then applied to the base of Q1. The emitter-coupled transistors, Q1 and Q2, in combination with U3-b, produce an anti-log transfer function.

That means that when properly adjusted, the output at the collector of Q2 will be logarithmic with respect to the input, yielding a one-decade voltage differential for every few volts of input. To be more specific, if you divide the peak-to-peak voltage of the initial linear sweep by 3, the anti-log-generator output increases by a multiple of 10 each time the input voltage crosses another 1/3 milestone. That will all become much clearer when you see the logarithmic curve on your scope during the calibration phase discussed later in this article.

Next, U4-a inverts the polarity of the signal, so that it starts high and ends low. That is necessary because the output frequency of the 8038 function

generator, U5, is inversely proportional to its input voltage. In addition, U3-d's offset voltage is nominally set at about -7.5 volts by the combination of resistors R15 and R16, and can be trimmed precisely by the 15-turn trimmer potentiometer, R24. That shifts the logarithmic-sweep waveform to suit U5, which in our circuit receives its supply voltage from the ground and -15-volt source. Recall that our logarithmic sweep must span three decades of voltage differential, which means that if its final voltage were 5 volts, its initial voltage would be 1/1000 of that, or .005 volts. Tiny voltages like that have to be carefully controlled, which is why R24 is used for that critical adjustment.

Finally, we come to the heart of the circuit, U5. That relatively inexpensive ICL8038 function generator produces constant-amplitude sine waves, as well as triangle- and square-wave outputs, from 20 Hz through 20 KHz. Also, its output frequency is nearly a perfect inverse proportional to its input voltage, so driving its input with our custom logarithmic-sweep circuit will produce the balanced, three-decade frequency sweep we desire.

The sine-wave output from U5 is fed to the voltage divider made up of R18 and R19, which restores the DC offset to zero. That eliminates the need for any coupling capacitors in the output stage, which makes it possible for output level to remain independent of frequency. The voltage-divider output is then applied to potentiometer R28 for output-level control, and is subsequently routed to U4-b for a boost in both amplitude- and current-drive capability. Output can range from 0- to over 10-volts peak to peak, which is enough for testing almost any audio device.

The DPDT switch, S2, has another position called "CAL." In that position, potentiometer R27 controls the frequency of the sine-wave output for setup and calibration purposes. However, because the output of R27 is buffered by U3-a and routed through the anti-log circuit, the Tester can also serve as a simple stand-alone signal generator. Potentiometer R27 is also indispensable for "homing in" on a troublesome frequency during actual response testing.

Construction. The method chosen to build the Frequency-Response Tester is not critical; however, the easiest method is to use the single-sided PC-board layout provided in Fig. 2. If you're looking for a good PC-board project to try, the Tester PCB is an excellent choice because it is both single-sided and reasonably low in component density. When cut to the size shown, the board fits comfortably within the widely available metal enclosure noted in the Parts List.

If you choose to use a PC board, a parts-placement diagram is provided in Fig. 3. If you choose not to use a PC board, a perf-board approach with point-to-point wiring will work fine. Just remember that an oversized zero-volt ground bus, or the use of a

single-point grounding scheme is always recommended in circuits involving op-amps. In any case, a metal enclosure is recommended to reduce noise and provide stable support for output connectors. One important layout consideration is to place R24 near the edge of the board, so that an access hole drilled in the enclosure will allow occasional calibration.

Most of the components in the Tester are of easy-to-obtain values, with a few exceptions; for that reason some reasonable parts substitutions can be made. For example, power-transformer T1 does not have to be a single 36-volt, 300mA center-tapped type as shown. Two smaller single-output transformers may be wired with their outputs in series to yield the same result, as long as each output is at least 18 volts at 200 mA.

On the more critical side, Q1 and Q2 must be a reasonably matched pair in order for the anti-log circuit to work properly. The 2N2907's specified are cheap, widely available, and have a lot of uses, so buy a few extra so you can look for a reasonable match. Using a DVM in diode-test mode, check the nominal voltage drop across the transistor's emitter-base junction. Two transistors that match up within or close to 3-digit accuracy are more than sufficient for the project. If your DVM does not have a diode-test function, make a temporary test jig with a 9-volt battery, a 10K resistor, and the base-emitter junction of the transistor. When the junction is forward biased (positive at the emitter for PNP devices), you can compare the voltage drops across the junctions of several transistors with an ordinary DVM set on its 0- to 1-volt range.

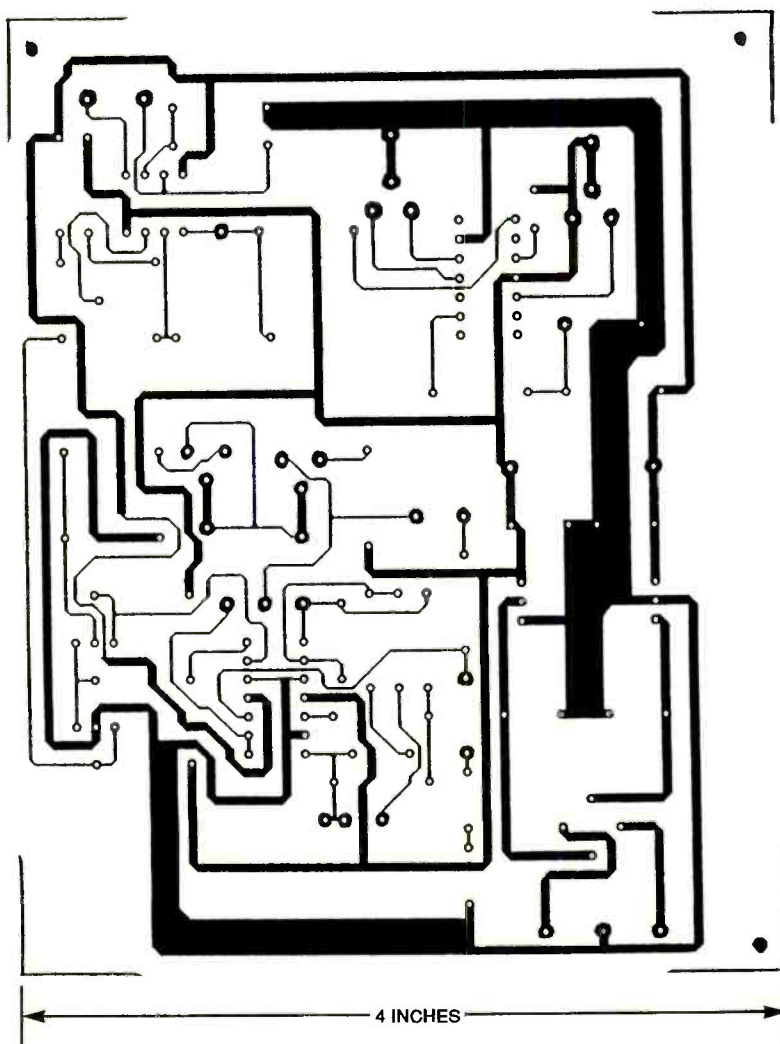


Fig. 2. The PC-board template for the Tester is shown here in its full size of 4 × 5 inches.

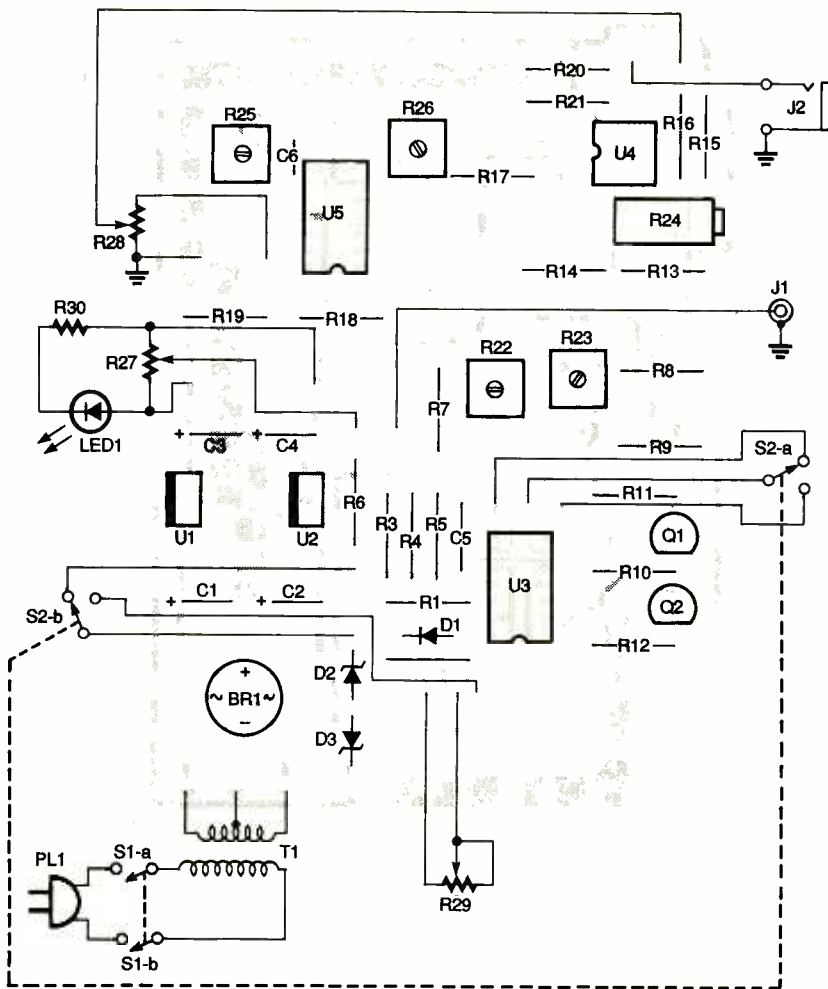


Fig. 3. Use this parts-placement diagram as a guide when making the various on- and off-board connections. Note that there is an off-board ground between a few of the components; connect those points and ground them to the metal chassis.

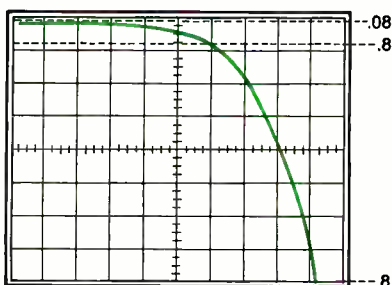


Fig. 4. Once calibrated, your Tester should display a three-decade logarithmic waveform that resembles this illustration.

Another critical item is R24, which must be a 15- or 20-turn trimmer potentiometer. It should also be obvious that even though normal component tolerances are not a problem, arbitrary substitution of seemingly "close" resistor values is unwise in the Tester circuit.

Here are a few things to watch for when using the parts-placement di-

agram in Fig. 3: Be careful when inserting Q1 and Q2, because the physical pinout of the transistors you obtain might not match the case style shown in Fig. 3. There, the emitter pad is closest to the edge of the board, and the base is the center pad. Also note that all pads that connect to off-board components such as potentiometers, switches, and outputs are slightly oversized for easy connection and identification. Some pads might not seem to be logically placed, which is a necessary sacrifice in maintaining a single-sided layout. Extra pads are provided for the center position of all trim pots except R24, to accommodate a wider physical variety of those parts. Socketing of all but the voltage-regulator IC's is recommended.

Potentiometers R27, R28, and R29 mount on the faceplate of the project case. Use insulated wires to connect them to the PC-board, as shown in Fig.

3. For best results, you might want to use coaxial cable for the connection to R28; if you do so, ground the cable and the off-board ground points shown in Fig. 3 to the metal chassis to provide shielding. Jacks J1 and J2, switches S1 and S2, resistor R20, LED1, and power-transformer T1 all mount off-board as well. Within the constraints of the enclosure, mount T1 as far from the board as possible.

Solder a small piece of stiff wire to the board at test point TP1. Make the wire just long enough to access later with your scope probe. Finally, when attaching the power cord to S1, use some kind of strain relief or grommet where the cord enters the case.

Check and re-check your connections before testing the project. The board itself can be mounted with some insulated stand-offs, but you might want to save that final mounting step until after initial checkout. In

PARTS LIST FOR THE FRE

SEMICONDUCTORS

- U1—MC7815CT 15-volt, positive-voltage regulator, integrated circuit
- U2—MC7915CT 15-volt, negative-voltage regulator, integrated circuit
- U3—TL084 quad op-amp, integrated circuit
- U4—LF353 dual op-amp, integrated circuit
- U5—ICL8038 function generator, integrated circuit
- Q1, Q2—2N2907, PNP transistor
- BR1—1.5-amp, 100-PIV, full-wave bridge rectifier
- D1—1N914 general-purpose silicon diode
- D2, D3—1N4735, 6.2-volt, Zener diode
- LED1—Red light-emitting diode

RESISTORS

- (All fixed resistors are 1/4-watt, 5% units, unless otherwise indicated.)
- R1, R18, R21—100,000-ohm
 - R2—12,000-ohm
 - R3, R8, R11, R12, R15, R17, R20—10,000-ohm
 - R4—470,000-ohm
 - R5—1000-ohm
 - R6, R7—4700-ohm
 - R9—470-ohm
 - R10—2200-ohm
 - R13, R14—1-megohm
 - R16—3000-ohm
 - R19—200,000-ohm
 - R22, R23, R25, R26—10,000-ohm, trimmer potentiometer, PC mount
 - R24—1000-ohm, 15-turn, trimmer potentiometer, PC mount

any case, plan to mount the board in such a way that a hole can be drilled to access R24 without opening the case. That is the only trim adjustment that you will occasionally need to touch up after initial calibration.

Calibration and Set-up. With all the trimmer potentiometers on the Tester's circuit board you might think that calibration is going to be a real nuisance, but that's not the case. The process is greatly simplified because you can use an oscilloscope to make almost all the adjustments visually. A separate frequency counter is also useful, but is not absolutely necessary. Another suggested tool to have on hand is a pair of walkman-type headphones. Hearing the frequency of the audio output is a good way of roughly gauging whether or not you're covering the entire audio range.

Start by centering all the trim pots,

FREQUENCY-RESPONSE TESTER

- R27—100,000-ohm, linear potentiometer
- R28—100,000-ohm, logarithmic potentiometer
- R29—5-megohm, linear potentiometer (see text)
- R30—3300-ohm, 1/2-watt

CAPACITORS

- C1, C2—330- μ F, 50-WVDC, radial-lead electrolytic
- C3, C4—1- μ F, 25-WVDC, radial-lead electrolytic
- C5—0.22- μ F, polyester
- C6—0.0047- μ F, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

- S1, S2—DPDT toggle switch
- T1—AC power transformer, 115-VAC primary to 36-VAC secondary, 300-mA center-tapped (Stancor P-8612 or equivalent, see text)
- J1—BNC jack
- J2—Phone jack
- PL1—2-conductor power cord and plug
- Printed-circuit materials, metal chassis (Radio Shack 270-253 or equivalent), insulated wire, solder, hardware, etc.

Note: A drilled and etched PC board is available postpaid from the author for \$20. Contact him on GENie at the E-mail address: R.CONSTAN for ordering information.

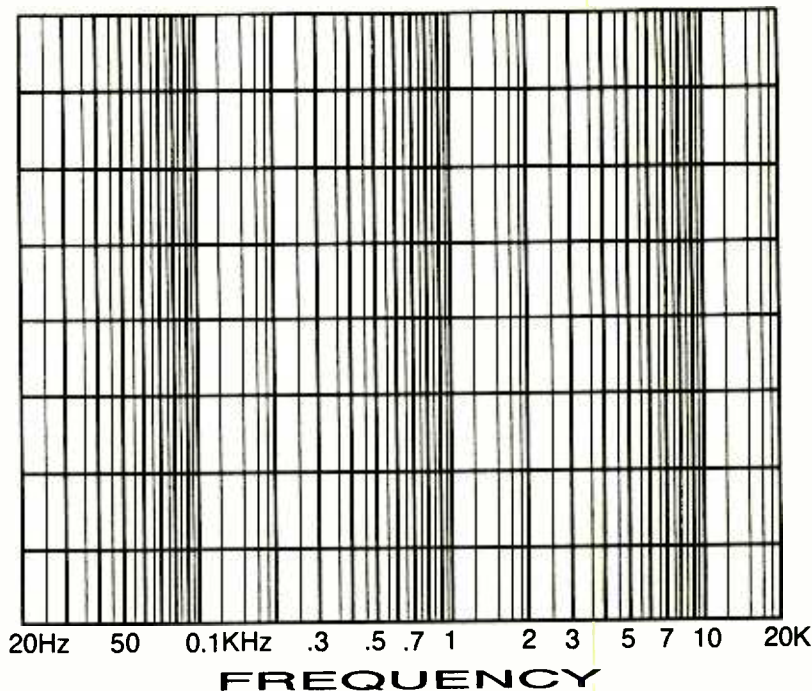


Fig. 5. By copying this scale to transparent film, you can create a custom reference graticule for your scope and greatly improve the visual accuracy of the display.

including R24. Before connecting any external equipment, power up the unit by itself to check that correct power-supply voltages are present in all the right places. Once you're confident that the circuit powers up correctly, you can proceed. Note that it is normal for the TL084 (U3) to run a little warm, and for both positive and negative regulators to become rather hot to the touch. If overheating becomes a concern, small heatsinks can be mounted on the regulators.

For your initial setup, connect the horizontal output to the horizontal input on your scope, and the audio output to your headphones. If the headphones are stereo, it is possible to hear through both right and left with an appropriate adapter. In the absence of headphones, a stereo-system auxiliary input will do, but be careful to keep the volume level down to avoid speaker damage.

Connect a probe to your scope's vertical input. Power up the scope, set the horizontal time base for external, and set both the vertical and horizontal amplifiers for DC measurement. With S2 in the SWEEP position and both R28 and R29 set to minimum resistance, power up the Frequency-Response Tester. The scope should display a horizontal sweep, the speed of which you can adjust using R29. For calibration purposes, use the horizon-

tal-gain and horizontal-position controls to produce a nine-division sweep deflection that is lined up with the left-most, vertical graticule line. Because nine divisions can easily be divided by three, setting up the three-decade logarithmic response we discussed earlier will be easy.

The next step is a bit tricky because it involves several coinciding adjustments. Connect the vertical input of your scope to the short wire you attached to TP1 earlier. If you turn up the AUDIO LEVEL control, R28, slightly, you should hear some kind of audio sweep that appears to follow the rate of the horizontal sweep (don't panic if that is not the case; the trim pots might just be too far out of adjustment). Flip S2 to the CAL position; the horizontal display will revert to a dot. Because the horizontal position of the dot is related to the audio-output frequency, refer to the screen display while using MANUAL FREQUENCY CONTROL R27 for calibration. Set R27 so that the dot once again lines up with the left-most, vertical graticule line on your scope. Then, adjust R24 to bring the audio-output frequency as low as possible. You will have to calibrate that more exactly later, but, for now, the lowest "bass note" you can hear without the audio dropping out is close enough.

Once the tone is established and set to the lowest frequency you can

detect, re-adjust R27 so that the dot moves exactly nine divisions to the right on your scope screen. The frequency should audibly rise. Adjust R22 at this time to a point just past the highest frequency you can hear. Repeat the process of "low" and "high" adjustment of R24 and R22 at least one more time, and then flip S2 back into the SWEEP position.

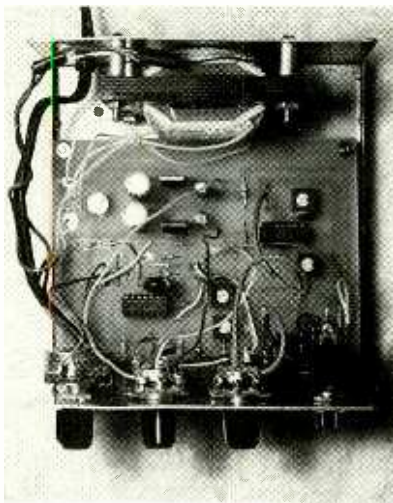
With the SWEEP RATE control, R29, set to maximum speed, you should be able to adjust your scope's vertical sensitivity and position until you can see a curve starting high on the left, and sloping downward on the right. Continue to adjust the position and vertical sensitivity, abandoning the "calibrated" setting on your scope as needed, so that the vertical deflection exactly fills the screen, from the highest vertical division available, to the lowest. That resulting curve is a logarithmic progression.

The next step is to contour the curve so that every three horizontal divisions correspond to a $\frac{1}{10}$ difference in vertical deflection. That is accomplished mainly with R23, which serves as a "decades/volt" adjustment for the anti-log network. Unfortunately, adjusting R23 is likely to affect the total vertical amplitude, so you might have to "see-saw" between R22 and R23 until the desired curve is obtained. Trim pot R24, which mainly affects the "top" portion of the vertical deflection, will probably not make much of a difference. In the end, your curve should resemble the one shown in Fig. 4 as much as possible.

The curve in Fig. 4 assumes that your scope graticule has eight major vertical divisions. Using the top line as a reference, note that the total deflection is eight divisions down at the right edge of the trace. Because the width of the trace has been set at nine divisions, you can easily divide the display into three sections. If you start at the right and move left, you'll see that the deflection from the top line is $\frac{1}{10}$ less each time we cross $\frac{1}{3}$ of the total width. So, the total deflection is 8, .8, and .08 vertical divisions at 9, 6, and 3 horizontal divisions respectively. Obviously, $-.08$ divisions is not really visible, and in fact, the start point of the curve should really be $-.008$ divisions, which is certainly not visible. Because the anti-log network defines the curve, we can assume that once one

decade is correctly "tuned," the others will all fall into place. By continuing to adjust the decades-per-volt trim pot, R23, along with the high log-level trim pot, R22, you should be able to approximate that curve.

The two remaining trim pots, R25 and R26, adjust the purity of the sine-wave output, and should be set as necessary before final calibration. Potentiometer R25 adjusts the duty cycle so that the top portions of the sine



As this internal view shows, the transformer in the Frequency-Response Tester should be mounted as far from the board as the project case allows.

wave equal the bottom half, while R26 is used to trim out distortion. Those controls do not treat all frequencies equally, so waveform purity must be optimized at a specific frequency. The author recommends a mid frequency of about 1000 Hz. Using your scope in its normal internal-sweep mode, set the tester to CAL, and observe the audio-output waveform while making the above adjustments. In the end, both controls should be somewhere near their initial center position, or the frequency span might suffer.

The final step in calibration is simply to repeat the setups of R24, R23, and R22, this time with a frequency counter added to the audio output. Instead of using your ears for the low- and high-frequency adjustments, use the frequency counter to obtain values of 20 Hz and 20,000 Hz. For that final calibration, make sure the unit has been on for a few minutes to allow it to stabilize.

If no frequency counter is available, you can use the scope as a frequency

counter by switching it back to internal sweep, connecting the audio output to the vertical input, and making calculations based on time/division. That is a bit of a hassle because it means doing a lot of switching, and you must remember to restore the horizontal gain to the original nine-division setup in between each measurement. If you have a dual-trace scope, you can set up one channel to represent the nine-division span of the Tester's horizontal output, and the other to monitor the audio output. You will still have to go back to the original setup at least once more to touch up the log curve with R23. Remember, you've already set up the unit to span from the lowest to the highest frequency you can hear, which is all that really matters. The good news is that once the Tester is set up, only the low adjustment, R24, will need an occasional touch up.

If you wish, use a photocopier that has a scaling capability to make a copy of the log scale in Fig. 5. By making the copy on a transparent sheet, such as the ones used for overhead projectors, you can make a custom reference graticule for your scope and greatly aid the visual accuracy of the display.

Using the Tester. For accuracy at the low-frequency range, always allow the Frequency-Response Tester to remain powered-up for a few minutes prior to running response tests. As we've seen, the Tester's entire first decade from 20 to 200 Hz depends on the stability of a very small control voltage, which usually takes a little time to settle. To test the response of an audio device, simply connect the Tester's audio output to the DUT's input, and the DUT's output to the vertical input of your scope.

(A note of caution is in order here: Some power amplifiers have outputs that cannot be ground referenced. In such cases, a dual-channel scope used in differential mode via both inputs is the only safe way to monitor the amplifier. Also note that power amplifiers usually require output loading for proper operation.)

When your test set-up is complete, switch S2 to CAL mode, and select a middle frequency using the MANUAL FREQUENCY control, R27. Then, adjust the

(Continued on page 93)

MAKING SQUARE WAVES AT HOME

Generating square waves is easy when you follow the simple "recipes" in this cookbook.

BY JOSEPH J. CARR

Square waves are among the most useful waveforms around. They are used to make qualitative tests of amplifier and passive-network circuits, and for radio troubleshooting. Square waves are even used as clocks in digital circuits.

Fortunately, square waves that are stable in both amplitude and frequency are relatively easy to generate using the following circuits. Let's take a look.

Types of Square Waves. Figure 1 shows five different types of square waves. For all five, the signal is inherently binary—it quickly jumps between two values ("high" and "low"). Because the square wave never permanently remains at just one level, it is said to be astable. For that reason, most square-wave generators are called "astable multivibrators."

A positive, monopolar square wave is shown in Fig. 1A. For that type of square wave, the two ideal voltage levels are zero volts and some positive voltage ($V+$). In transistor-transistor logic (TTL), the low level is anything below 0.8 volts and the high level is anything from 2.4 to 5 volts. Non-TTL-based square waves of that type might use different voltage levels. For example, while CMOS chips can generate TTL-compatible voltage levels, they are often used in circuits with much larger high-level voltages.

Figure 1A also shows the time relationships of a positive, monopolar square wave. A total cycle consists of

one high and one low, each of equal length. The total period required for the square wave cycle is:

$$T = t_1 + t_2$$

while the frequency (f) is:

$$f = 1/T$$

A negative, monopolar square wave is shown in Fig. 1B. The negative square wave is similar to the positive one shown in Fig. 1A, but in the negative square wave, a high is defined as 0 volts, while a low is some negative potential ($-V$).

Another square wave is the symmetrical, bipolar square wave of Fig. 1C. In that type of square wave, the high and low voltages are equal potentials above and below the voltage axis. A variation on that is the offset, bipolar square wave of Fig. 1D. That wave has a DC offset voltage that prevents it from being symmetrical around the voltage axis. The square wave shown has a positive DC component added to it, but that offset voltage could be negative instead.

Figure 1E shows another asymmetrical square wave. In that case, however, the lack of symmetry is not across the voltage axis but in the relationship between t_1 and t_2 — t_1 does not equal t_2 . The percentage of the time the wave is high, or:

$$100\% \times t_1/(t_1 + t_2)$$

is called the "duty cycle" of the square wave.

One of the things that make square

waves so useful for testing purposes is that they contain a large number of harmonics, or integer multiples of the fundamental frequency. Because the symmetrical, bipolar square wave has both baseline and time symmetry, it produces only even-order harmonics—harmonics with frequencies that are even multiples of the fundamental—as shown in Fig. 2. Theoretically, those harmonics extend to infinity, but in reality, a good, sharp, clean square wave has even-order harmonics out to about $1000f$.

Square waves can be generated by digital TTL and CMOS IC's, 555-timer-based circuits, and operational amplifier ("op-amp") circuits. Let's look at each in turn.

TTL Generators. TTL integrated circuits have a 74 or a 54 as the first two digits of their part numbers. They are powered by a 5-volt DC supply. Because a high level in TTL IC's is anything from 2.4 to 5 volts, a TTL signal is said to change state when it crosses a 2.4-volt threshold.

Normal TTL chips operate at speeds of up to 18 MHz, with some cooking along at 25 MHz. Special types go up to 80 MHz or more.

The inverter is a basic element in TTL-based square-wave generators.

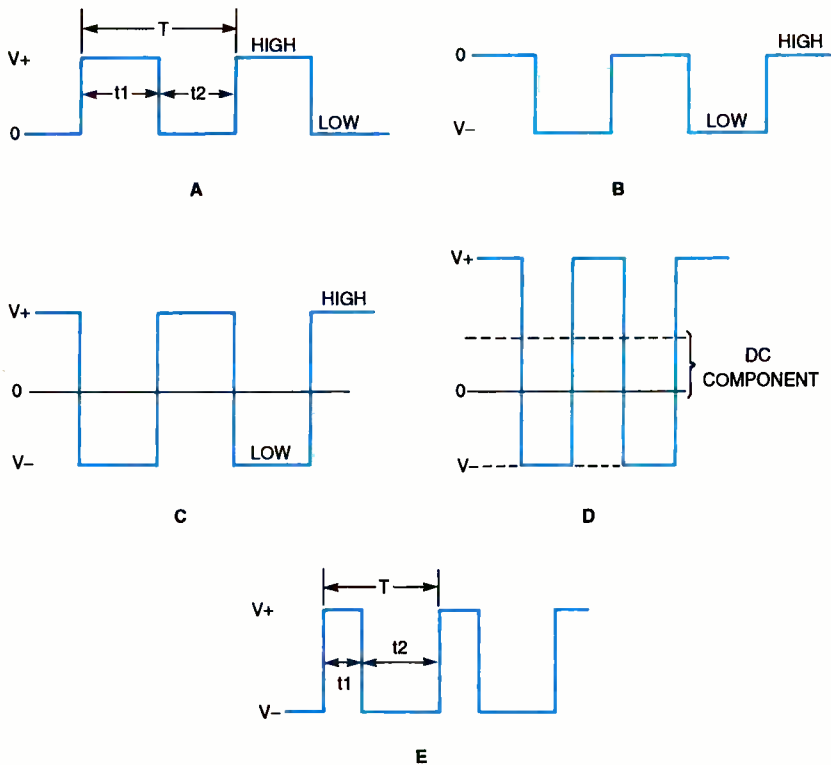


Fig. 1. Here are the five main types of square waves: positive monopolar (A), negative monopolar (B), symmetrical bipolar (C), asymmetrical bipolar (D), and time asymmetrical (E).

Those components can be either discrete inverters (such as the 7405), or NAND gates (like the 7400) or NOR gates (for example, the 7402) with their inputs tied together to form an inverter. Figure 3 shows a typical TTL ring oscillator that will produce square waves in the 500-kHz to 10-MHz range. In that form, it is made from three sections of a 7405 hex inverter chip.

The circuit's frequency is set by the values of C1 and R2. The value of C1 should be in the range of 390 pF to 0.005 μ F, while R2 can vary from 1 to 3.9k ohms. It is common to use a circuit like the one in Fig. 3 to generate a frequency that is higher than the one needed, and to then divide the frequency with a series of TTL counter circuits cascaded together.

CMOS Generator Circuits. The CMOS family of digital integrated circuits operates at lower frequencies than the TTL family, but in return, CMOS IC's consume less power. While a typical TTL device might dissipate milliwatts of power, an equivalent CMOS device dissipates microwatts. Like TTL IC's, CMOS devices can also be powered from a 5-volt supply, and depending on the situation, might be TTL

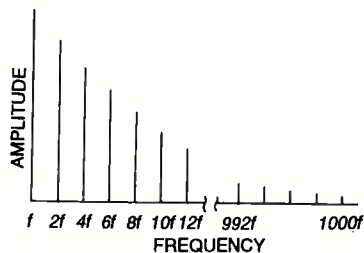


Fig. 2. The frequency spectrum of symmetrical square waves consists of the fundamental frequency and a large number of even harmonics.

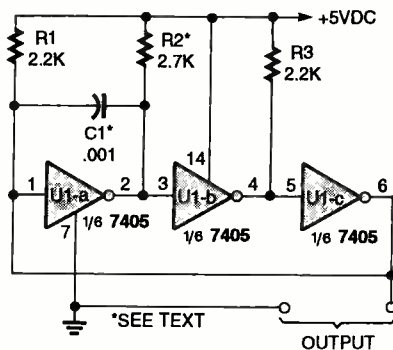


Fig. 3. A TTL ring-oscillator circuit uses an odd number of inverters in an astable configuration.

compatible. However, many CMOS devices can be powered at higher voltages.

For a typical CMOS chip, a signal is said to change state when it crosses the voltage half-way between the supply voltages. For example, when a +mi12-volt supply is used, the threshold is 0 volts, and when a single 12-volt supply is used, the threshold is 6 volts. The first digits in a CMOS-chip number are generally 4 or 45.

A Schmitt trigger is a special circuit that obeys slightly different rules than do other forms of digital gates. For example, when the 4584 hex inverting Schmitt-trigger IC is operated from a 5-volt power supply, the output state will change on positive-going input signals at 2.9 volts, and on negative-going input signals at 2.3 volts. The difference between the 2.9- and 2.3-volt signals is called the "hysteresis band."

Figure 4 shows a 4584 inverter (1/6 of the total 4584) used in a very simple square-wave oscillator circuit. Because the 4584 is an inverter, a low at input pin 1 produces a high at output pin 2, and consequently, a high input produces a low output. When power is initially applied, capacitor C1 is discharged so the input sees zero volts (it is low); the output is therefore high, allowing C1 to charge from the output voltage at a rate limited by the time constant R1C1. When the voltage at the input reaches the Schmitt trigger's positive-going trip point, the 4584's input sees a high. That results in a low output, which causes C1 to discharge through R1 until the voltage drops below the negative-going threshold. The capacitor will continue to charge and discharge between those two levels at a frequency of approximately $0.72R1C1$.

Figure 5 shows a CMOS square-wave oscillator based on inverters (or NAND or NOR gates wired to act like inverters), which is similar to the ring oscillator shown previously. Unlike some CMOS inverter-based circuits, the one in Fig. 5 will produce a square wave

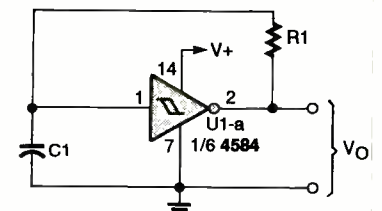
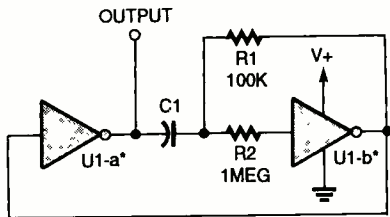


Fig. 4. A CMOS, inverting, Schmitt-trigger square-wave oscillator requires very few components to function.



*SEE TEXT

Fig. 5. This CMOS, inverting square-wave oscillator can be varied over a wide range. Note that R2 should be ten times the value of R1, as shown.

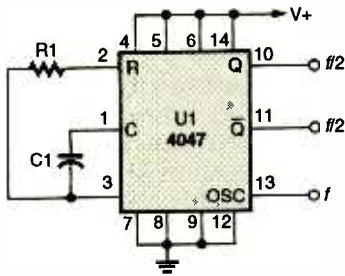


Fig. 6. This square-wave oscillator, based on the 4047 CMOS device, has complementary half-frequency outputs.

that has a 50% duty cycle. There are two resistors used in that circuit; R1 is used to set the operating frequency and R2 is approximately 10R1. Typical values for R1 and R2 are 100,000 ohms and 1 megohm, respectively. The value of C1 is less than 1000 pF. The operating frequency can be from 0.1 Hz to 1 MHz, depending on the values of R1 and C1, and is determined from:

$$f_o = 1/(2.2R1C1)$$

where f_o is in hertz, R1 is in ohms, and C1 is in farads.

Another CMOS square-wave generator is shown in Fig. 6. That circuit is based on the 4047 multivibrator circuit, which can be used for either monostable ("one-shot") or astable applications. In the configuration shown in Fig. 6, the 4047 is an astable multivibrator. There are three outputs from the 4047. The first is the oscillator (OSC) output, which is connected directly to the internal oscillator circuit. The other two outputs, Q and \bar{Q} , are complementary to each other and operate at one-half the frequency of the internal oscillator.

The output frequency is set by timing components R1 and C1, as in the last equation, but the Q and \bar{Q} outputs obey:

$$f_o = 1/(4.4R1C1)$$

The value of R1 should be between

10,000 ohms and 1 megohm, while the value of C1 should be 100 pF or more (the maximum capacitance is not limited theoretically, but a practical limit exists when the leakage resistance of C1 is of the same order of magnitude as R1).

555-Timer Oscillators. The 555 timer, with the possible exception of either the 741 operational amplifier or some microprocessors, is probably the most popular IC. That is because the 555 is versatile, low-cost, and behaves itself (which means that designing 555 projects is relatively easy).

The 555 is used to make monopolar square waves that can be either TTL compatible (V+ must be 5 volts DC), or CMOS compatible. Any power-supply voltage from 4.5- to 18-volts DC can be used, as the voltage sets the value of the high state.

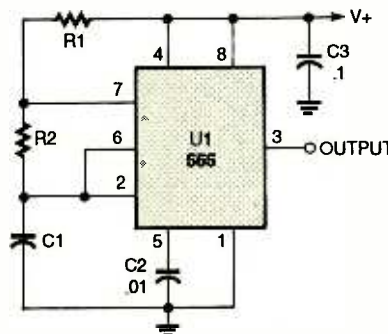


Fig. 7. Of course, the old 555 timer can be used as an astable multivibrator to generate square waves. However, for the circuit shown, they will not be symmetrical.

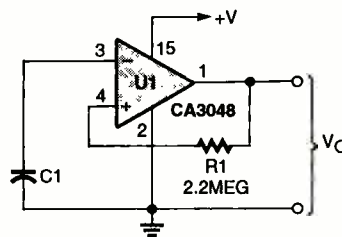


Fig. 8. An operational transconductance amplifier, square-wave generator circuit looks much simpler than it sounds.

The 555 can be connected in either monostable or astable configurations, but for continuous square waves, the astable version is used (see Fig. 7). The square-wave signal appears at pin 3 of the 555, while timing signals are processed at pins 2, 6, and 7. The output frequency of the 555 astable multivibrator is found from:

$$f_o = 1.44/((R1 + 2R2)C1)$$

The duty cycle of the 555's square-wave output is determined by the relationship between R1 and R2, and is given by:

$$\text{Duty Cycle} = (R1 + R2)/R2$$

Linear IC Generators. Several types of linear integrated circuits can be used to make square waves. The simplest of those is the operational transconductance amplifier (OTA). The only components in the simple circuit shown in Fig. 8 are a CA3048 OTA, a feedback resistor (R1), and a timing capacitor (C1). The output frequency is approximately given by:

$$f_o \approx 1/(2\pi R1C1)$$

Timing resistor R1 should be from 1 megohm to 3.9 megohms. When R1 is of a greater value, the circuit sometimes stops oscillating, depending upon the specific CA3048 used.

Operational-Amplifier Generators. The operational amplifier is one of the most useful linear ICs made. When introduced in the late 1940's (in vacuum-tube form), the op-amp was intended for performing mathematical operations in analog computers. Very rapidly, however, designers realized that the op-amp could be used for a wide variety of applications other than computing. The transistor soon introduced more people to the op-amp, but it wasn't until the advent of the integrated circuit that the complexity of the op-amp became an internal affair. The result was a simple amplifier in which the transfer function was set by manipulating the feedback.

Figure 9A shows a common op-amp square-wave generator circuit. It uses two feedback paths: one sets the DC level at the noninverting input (+), while the other is the RC timing network (R1C1). In general, if the feedback constant (β) is:

$$\beta = R3/(R2 + R3)$$

the output frequency is set by:

$$f_o = 2R1C1 \ln((1 + \beta)/(1 - \beta))$$

But, as with many circuits, a simple assumption can simplify the equation quite a bit. If we assume $R2 = R3$, then the equation reduces to:

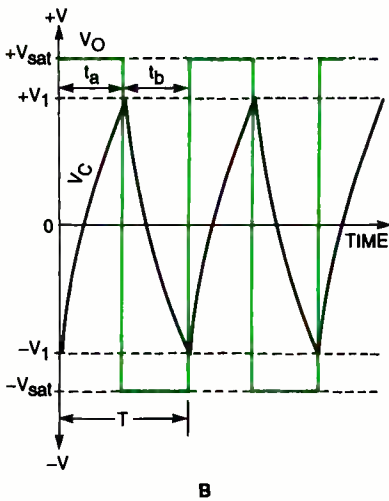
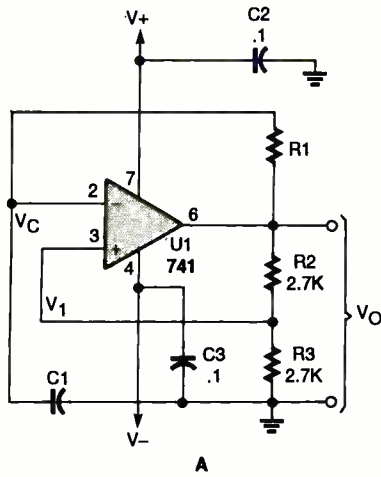


Fig. 9. This operational-amplifier square-wave generator (A) produces a 50-percent duty-cycle signal. That is because both the charge and discharge current for C1 flow through R1. The resulting charging and output waves are shown in B.

$$f_o = 1/(2.2R1C1)$$

Figure 9B shows the annotated timing waveform for the above circuit, with the capacitor charge/discharge curves superimposed on the output waveform. Because the op-amp is powered from a bipolar supply, output voltage V_o jumps between $+V_{sat}$ and $-V_{sat}$. The noninverting input is biased to voltage V_1 , which is a fraction of output voltage V_o according to:

$$V_1 = V_o \beta = V_o R3 / (R2 + R3)$$

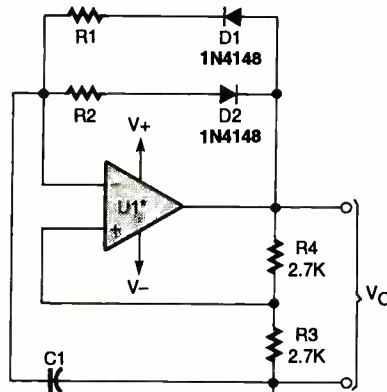
Since $R2 = R3$:

$$V_1 = V_o / 2$$

The rules for the operational amplifiers used in the above nonlinear circuits are simple: If the inverting input is less positive than the noninverting input,

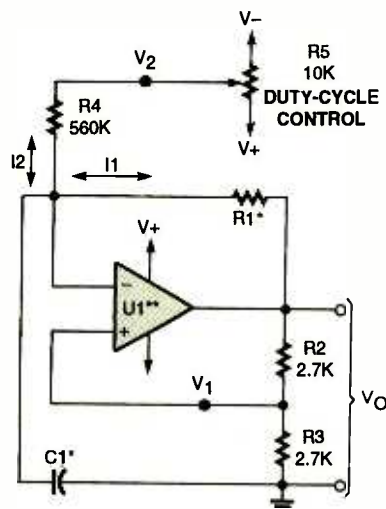
then the output is high; if the inverting input is more positive than the noninverting input, then the output is low; if the two inputs see the same potential, then the output is zero.

Assume on initial turn-on that the capacitor is discharged, so capacitor voltage V_c is zero. According to the rules for operational amplifiers, that forces a high output. Capacitor C1 can now charge under the influence of $+V_{sat}$ and the R1C1 time constant. After time t_a expires, the capacitor voltage V_c reaches $+V_1$, so the output snaps low to $-V_{sat}$. At that time, the low segment of the output waveform begins, and C1 begins to discharge under the influence of $-V_{sat}$. It then recharges under the opposite



*CHOOSE YOUR OWN OP-AMP

Fig. 10. Here is an op-amp-based square-wave generator that uses diode switching to produce a fixed duty cycle other than 50 percent.



*SEE TEXT

**CHOOSE YOUR OWN OP-AMP

Fig. 11. Use R5 to adjust this variable-duty-cycle square-wave generator. That potentiometer controls I_2 to vary the timing.

polarity. The process then repeats itself. The high time is t_a and the low time is t_b , while the total period is:

$$T = t_a + t_b$$

and the output frequency is $1/T$.

The circuit shown in Fig. 9A produces a time- and voltage-symmetrical square wave. We can alter that time symmetry by making either of the following two modifications to the circuit.

The first modification is shown in Fig. 10. That circuit uses two resistors in the timing network, and a pair of PN-junction diode switches to select which resistor is used at any given instant. Diodes D1 and D2 are backwards with respect to each other, so they conduct on alternate polarities of output voltage V_o . When the output is high, D1 is forward biased and D2 is reverse biased. As a result, R1 is used with C1 to time the circuit. When the output state changes to low, D1 is reverse biased and D2 is forward biased. In that case, R2 times the circuit. Because R1 and R2 are not equal to each other, their timing is different, so the output waveform's highs and lows are not equal.

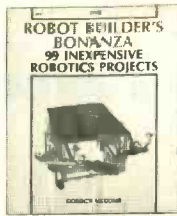
A limitation on the circuit in Fig. 10 is that the duty cycle of the output square wave is fixed. The second modification to the circuit in Fig. 9A is the variable-duty-cycle square-wave generator shown in Fig. 11. That modification uses a DC-offset circuit (composed of R4 and R5) to inject a second current (I_2). Because of that bias, the half cycle when I_1 and I_2 have the same polarity is shorter. When R5 is set to the mid-point, the value of V_2 is zero, and the output waveform has the usual 50% duty cycle of the unmodified circuit.

The circuit shown in Fig. 11 can be modified to perform pulse-width modulation. For that, one end of R5 is grounded and the other end is connected to a source of triangle, sawtooth, or sinewaves that modulates the duty cycle of the square-wave signal. The modulating signal should vary over a substantial portion of the $V+$ to $V-$ voltage range (but not more than those values) in order to produce maximum duty-cycle variation.

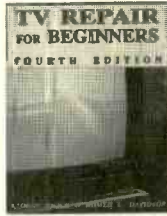
Square-wave generator circuits are easy to design, easy to build, and are extremely useful for a wide variety of applications in electronics. ■



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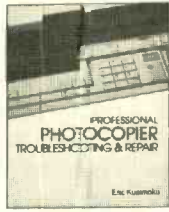
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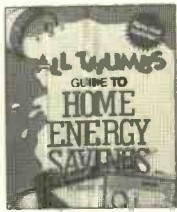
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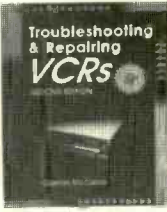
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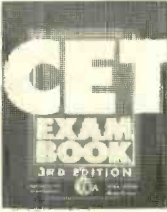
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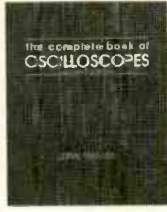
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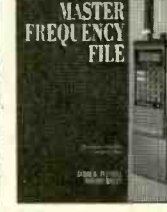
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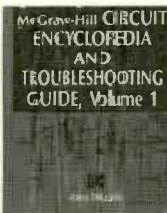
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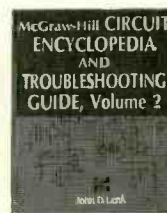
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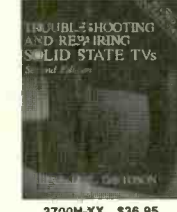
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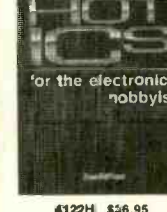
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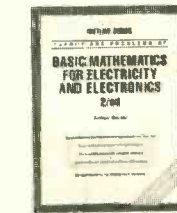
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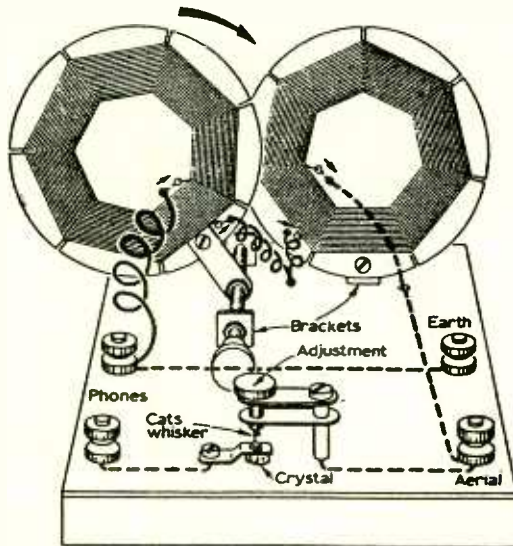
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ANTIQUE RADIO

By Marc Ellis

Mailbag Time Again!

It's time once again to give our readers the floor. Receiving mail from you is certainly one of the most enjoyable parts of this job! It's instructive, it's fun, and it keeps me in touch with your interests—which is a great help in planning the column.



Here's a pictorial of the reproduction 1922 British crystal set built by reader D.B. Millar from plans in *Practical Wireless* magazine. The set was tuned by swinging the front pancake coil over the back one.

My way of responding to your letters is to acknowledge them on these pages. If I tried to respond personally, particularly to the many requests for schematics, technical advice, and other information, I wouldn't have time to write *Antique Radio*.

So instead I share the letters, referring the questions and requests to the readership at large and passing along the many interesting tips and other pieces of information. For maximum impact, and in order not to interrupt the flow of ongoing projects or stories, your letters are

saved up and put together, in a special column or two, three or four times a year.

Since it does take another couple of months after I write a column for the magazine to hit the streets, it can be six months or more before you see your request or comment in print! So please be patient.

CRYSTAL SET COMMENTS

The series of articles on the NBS crystal set drew a lot of attention, and I'm still receiving comments from readers on that subject. Let's start with one from *Rudolf Mangold* (Penn Valley, CA), who remembers building crystal sets with his dad in the early 1920's. Even though the NBS set was designed to be scratch-built, Rudy doesn't understand why a capacitor wasn't used across the phones. The phones act as an RF choke, attenuating the flow of current through the crystal unless bypassed. "If we would show a crystal set without a capacitor at

our radio club, we would be laughed at." Rudy and his dad made their own phone capacitors by sandwiching alternate layers of metal foil and tissue paper.

D.B. Millar (Annapolis, MD) built a kind of British equivalent of the NBS set from vintage plans published in the UK magazine *Practical Wireless* (September, 1972). It was offered as a means for listening to the BBC 50th anniversary program (November, 1972) commemorating the first broadcast in 1922. That set didn't have a phone capacitor either, but (using a

formula from Ghirardi's *Radio Physics Course*) Millar built one from aluminum foil and masking tape—rolling up the "sandwich" into a neat cylinder.

Many folks who don't have the patience to fool with a cat's whisker (myself included) like to substitute a modern semiconductor diode for the galena while experimenting with crystal-set circuits. *George H. Haby* (Altadena, CA), who is 88 years old, goes us one better by using *four* diodes hooked up as a standard full-wave rectifier. The input terminals are connected where the crystal normally goes; the output terminals to the headphones.

Vincent Bashore (San Ysidro, CA) received his first crystal set as a birthday present in 1928, then got into building them. He once gave up school lunches for a week to accumulate parts money for a set using a coil wound on a maple rolling pin and tuned by a brass slider.

A photo received from *Robert S. Davey* (Frankfort, IN) shows a set he built from plans in *Popular Mechanics* (January, 1977). The published set used a 3½-inch-diameter, cylindrical salt container as a form, but Bob seems to have used some other kind of tube. For flexibility in experimentation, he substituted clip-lead coil connections for the permanent ones suggested in the article.

A. Ross (1926 Hafor Circle, Iowa City, IA 52246) is looking for two of the references I mentioned during the NBS set series: *How to Build Your Radio Receiver*,



Robert S. Davey's version of the "salt box" crystal set described in Popular Mechanics for January 1977. Clip leads make it easy to experiment with coil taps.

edited by Banning and Cockaday (Popular Radio, Inc. 1924), and *Radio for Everybody* by Austin C. Lescarboua (Scientific American Publishing Co., 1922). I've seen the former offered as a reprint but, unfortunately, don't recall the source.

M. DeLuca (E. Setauket, NY) requested the address of James Knight, who built the speaker-volume crystal set shown in the September, 1994 mailbag column. It's 222 Greenfield Ave., Tullahoma, TN 37388.

Finally, several folks are looking for copies of certain installments of the NBS set series. M.R. Angermiller (1239 Yale St., Houston, TX 77008-6959) needs January and May 1994. Gerry Hoye (Department of Civil Engineering, 220 Civil/Electrical Engineering Building, University of Alberta, Edmonton, Canada T6G 2G7) needs May and June. Cliff Stearns (803 W. Malone Dr., Connersville, IN) would like all the issues (January 1994 and April through August 1994). All those individuals offer to pay copying costs.

Here's a suggestion to anyone looking for back issues. If you need only a copy or two, they most likely

are available (the cost is reasonable) from the **Popular Electronics** Bookstore. Write them directly (not through this column) and inquire. If you need several issues, try your local library. Many subscribe to **Popular Electronics**, and most have copy machines.

HELP WANTED

Mrs. Tonya Dejong (1453 Garvin St., Prince George, BC, Canada V2L 3Z1) is looking for service info on a Vicking (could this be Viking?) N.A. 95. Larry Stanley (RT 1 Box 166, Delta, AL 36258) is looking for someone to repair his Zenith 9H081. John H. Rodriguez (123 Colonels Lane, Weymouth, MA 02189) needs help repairing the drive-motor circuitry (will not run on high speed) of his Akai Model M-7SP reel-to-reel tape player.

Could a Crosley expert give Randall Thacker (4216 East Hano St., Phoenix, AZ 85044) a hand? He's working on a Model E-15WE and is having trouble getting the knobs to stay on their shafts. It seems that the triangular plastic inserts are worn. Randy would like to find some used or reproduction replacements.

Randy also recently ac-

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CIRCLE 154 ON FREE INFORMATION CARD

quired an Echophone EC1, and wanted to review my July through October 1987 restoration series on that set. Randy couldn't find 1987 copies of **Popular Electronics** in his library. (Here's a hint, Randy: Back then, this publication was known as *Hands-on Electronics*!)

Anyone care to share their methods for (1) removing rust from chassis and transformers and (2) repairing large holes in speaker cones? Please contact *Glenn Woodward* (4003 Pine Hill Blvd., Racine, WI 53403). A schematic and service info for a Hallicrafters S-38C are being sought by *Howard Cummings*, 4700 Morris NE, Albuquerque, NM 87111. Howard could also use some restoration advice on that set. Please get in touch with *George B. Henley*, WA7GSN if you have information and/or schematics on the following test equipment: a Knight TEN-2 CB Checker, and an EMC (Electrical Measurements Corp. of New York, NY) Model 801 Resistance-Capacitance Comparator Bridge.

Christian Nielson (233



This grand-looking Pilot G-104 console was recently purchased by Christian Nielson, who seeks information on its rarity and value.

Eagle Ave., West Hempstead, NY 11552) sent us a shot of his recently purchased Pilot G-184. He'd like any information he can get on the set, especially an estimate of its rarity and market value.

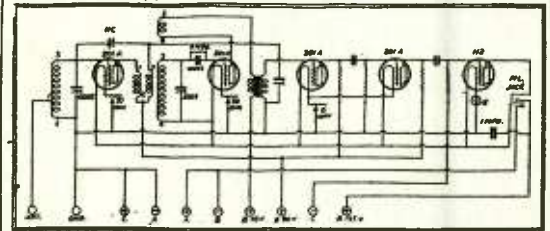
Craig Fiedler (22253 Pheasant Court, Hutchinson, MN 55350) needs an instruction book and calibration information for a Sprague Tel-Ohmike Model TO-6 Capacitor Analyzer. He found a 1968 date stamped inside the instrument and wanted confirmation that the analyzer could be so recent. All I can say is that it makes sense to me! The earlier Model TO-4 that I restored on these pages a few months ago was a late 1950's instrument.

THIS 'N THAT

Speaking of the TO-4 restoration, *Harry Atenik* (Hawthorne, CA) writes that he found it helpful in restoring his somewhat earlier TO-3. After replacing all the caps, including the filters, he fired it up and was quite pleased with its performance. Harry says that the TO-3 is more accurate than his Heathkit Digital L-C bridge or his EICO model 950 B.

Keith L. Fender (Mount Vernon, WA), who signs himself "Your Antique Reader," remembers starting his career in electronics with a "Quaker Oats" crystal set in the early 1920's. He sent a schematic and parts list of an AC-operated TRF—with Meissner tuning capacitor and coils—that he originally built (I would guess) in the late 30's. He's used it regularly over the years, making modifications and improvements from time to time. For example, the original grid-cap tubes were changed to single-ended types, and the set now sports a low-distortion de-

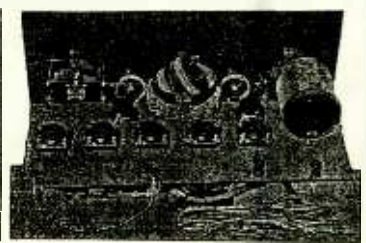
Schematic Diagram and Assembly of the "Ireland Five"



to not "too high and in slight; therefore, avoid voltage gain of the transformer coupled stage to produce the voltage gain of a pentode in a single stage. When general purpose tubes (12, 6BD6 or equivalent) are used in each.

Audio System
The filter, choke, and transformer to couple the detector tube to the first audio amplifier tube since the transformer distortion on one stage is so small that it cannot be readily detected, and the gain in signal voltage is very desirable. The audio system from this point to the output is a resistance coupled.

Black Mix tubes may be used to very great advantage in the two, three, or more, and with a power tube in the output, a good speaker may be specified with maximum volume and the quality is generally all that can be desired. A C battery for the output tube is imperative for the results and for



Sent in by reader John Lombardi, the radio section from a 1927 Sunday paper conveys some of the excitement of the 1920's radio craze.

sector from the *ARRL Handbook* and a "Poor Man's Williamson Output Stage" from a 1950's *Radio News*.

When renovating his home, *John Lombardi* (sorry, I don't have John's location) came across some newspapers stuffed in the wall as insulation. Included were a couple of pages from the radio section of the *Philadelphia Public Ledger* (February 27, 1927), and John was kind enough to send copies. Looking at those old-time large pages stuffed with ads, program listings, and radio-related news, you can really get a feeling for the "Radio Craze" of the 20's. Come to think of it, if you'd like to get an idea of what those radio pages look like, check the computer section of the business pages in your current Sunday paper!

Thanks to *Robert Fleischer* (Lake Tahoe, CA) for the long note. I enjoyed reading about your career as a circuit designer and your "retirement" as a repairer/restorer of hi-fi sets, industrial gear, musical-instrument electronics, and antique radios. Thanks also

to *Terry Schwartz* (Shoreview, MN) for the latest set of photos of his collection. We'll run them soon, Terry! Another thank-you to *Robert Davey* who sent me some interesting photocopies from recently-acquired *Radio-Craft* and *Short-Wave Craft* magazines of the 30's and 40's. I particularly enjoyed the advertising material on Hallicrafters, Doerle, and Echophone sets.

Louis Duval (Quebec, Canada) gets a thank-you for sending info to reader, *Barry Stephens* (Austin, TX), who inquired about the Type XXL Loctal tube (and for including a copy for my files). And, finally, *Tom Byers*, WBYTG would like to express his appreciation to the several folks who responded to his inquiries for service info on the Hallicrafters S-40-A. He now has it working and is restoring several other communications receivers.

Do you have any questions or comments for inclusion in the next *mailbag*? Write me c/o *Antique Radio, Popular Electronics*, 500-B Bi-County Blvd., Farmingdale, NY 11735.

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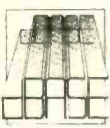


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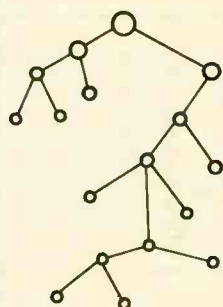
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By Jeff Holtzman

Objects



HIERARCHICAL TREE

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...		FAMILY
		GENUS
		SPECIES

DOS ANALOGY

BIOLOGICAL ANALOGY

Fig. 1. Hierarchical trees are a common way to represent relationships among families, types of animals, units of an organization—and computer software.

was one such concept that just kept getting pounded and pounded. Today, \$100 and a little shopping will get you a pair of Ethernet cards and a copy of Windows for Workgroups. Other concepts (e.g., artificial intelligence) made small inroads, but remain on the back burner, waiting for a good application.

Another over-hyped yet persistent (so to speak) idea is that of objects. Several years ago, you couldn't open a magazine or trade journal without being bombarded with object-this and object-oriented that. But then the Internet happened (that is, the general public became aware of it), and object lost its cachet. *Byte* magazine (in their May,

1994 issue) even proclaimed that objects were dead.

It may no longer be fashionable, but make no mistake: Object technology is important. Object technology is in fact alive and well, and flourishing in Silicon Valley, as well as software shops worldwide. All the influential software and computer companies are deeply committed to object-oriented technology. That includes IBM, Apple, Microsoft, HP Digital, Borland, and numerous others.

There are object-oriented operating systems (OpenStep, Cairo), object-oriented programming languages (Smalltalk, C+), a few object-oriented applications programs, and even object-oriented hardware devices (e.g., miniature sensors that operate on a network and provide feedback about the operational state of an automobile or manufacturing process).

If you're brand new to computers and programming, you may wonder what all the fuss is about. But if you've had any exposure to Basic, C, Pascal, FORTRAN, or most other programming languages, you have to adjust your thinking. And old timers, deeply immersed in traditional procedural languages such as COBOL, can have a really hard time.

Despite all of that, the concepts are not difficult. This month I want to give you a basic sense of what object technology is all about; next time, we'll look at things a bit more rigorously.

HIERARCHIES

Let's start with hierarchies; see Fig. 1. If you understand how to organize files under DOS, you understand the concept of a hierarchy. In DOS, the root directory might contain multiple subdirectories, each of which could contain multiple subdirectories, and so on. Under DOS, any given directory can have multiple subdirectories. On the other hand, a given subdirectory can belong to only one directory.

We use the hierarchical structure to organize our work. For example, off the root directory, we might have subdirectories for storing text files, finances, games, utility programs, and so on. Some of these might be further subdivided according to year (1990, 1991, . . .), and so on. And outside the computer world, we're surrounded by many different hierarchical structures, even though we don't normally think of them as such.

For example, families are hierarchically structured. If you're like most people, you can easily trace your family back through three or four generations; if you're lucky, perhaps more. Corporations are often structured hierarchically. So is the military. When we speak of the animal kingdom, we're really talking about a hierarchy. There are many species of dogs, and cats. Dogs and cats are both mammals. Mammals includes all dogs and all cats; it also includes human beings, apes, bears, and so on. The list of examples goes on and on.

Object technology (and

computer technology in general, for that matter) depends heavily on the concept of the hierarchy. Developing object-oriented software means building hierarchies. It means grouping like things together—dogs with dogs, cats with cats—grouping groups, grouping groups of groups, etc. Talent in object-oriented software design and development involves the ability to recognize and create consistent patterns among groups.

In the animal kingdom, a dog is real, but higher levels in the classification scheme are abstract. One of the key things about object-oriented technology is that it follows the same idea. It starts with a real object (a document, an inventory list, a video clip, a scanned photograph) and builds around it a hierarchy that

enables efficient computer processing.

That is in marked contrast to older, procedural ways of thinking about software. In those older ways, you neither started out nor ended up with something that directly corresponded to anything in the real world. A classic textbook is called *Algorithms + Data Structures = Programs*. The thinking symbolized by that title shows a computer-centric view of the world. By contrast, the modern way of thinking is to model the real world; that is, to represent it directly.

One thing that makes objects so exciting is the ability to use the hierarchical structure to create variations on a theme. By analogy, the class "dogs" includes Dalmatians, Sheep Dogs, German Shepherds, Scottish Terriers, Poodles, Chihuahuas, Dachshunds,

Irish Setters, Bulldogs, and many more.

If you were going to design a new dog, you wouldn't have to go all the way back to hydrogen, oxygen, and carbon. You could start off with the group of characteristics represented by "dog" (e.g., walks on four legs, omnivorous, gives live birth, is domesticated), and customize just those features necessary for your particular dog.

That is how object-oriented software works. Take an object, customize a few features to meet your needs, and that's it. Well, not quite. Things can and do get complicated. But the point is that object-oriented technology starts and ends with the real world. That fact alone gives the software a higher chance for success than would otherwise be the case.



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CIRCUIT CIRCUS

By Charles D. Rakes

Controller Circuits

It's show time, and are you ready for some circuitry fun? Good! Make yourself comfortable and get ready to share a few electronic control circuits.

Over the last two decades, U.S. manufacturers have steadily moved away from slow, and often unreliable, relay-control circuitry to the faster and more reliable microprocessor-based programmable controllers. The majority of those programmable controllers were designed to be placed in service by electricians who, in many cases, had little or no electronic training but were experi-

troller circuit, see Fig. 1, uses two hexFET's and half of the inverters in a single IC to perform a simple two-function operation. The heart of the controller circuit is a set and reset latch circuit made up of two inverters.

When the input (pin 3) of the U1-a is grounded via S1, the output (pin 2) goes high, driving the input of inverter U1-b high as well. That forces U1-b's output low, latching the input of U1-a low. In that latched condition, the output of U1-c is high, turning on Q1 and operating the motor. At the same time, the low output of U1-b keeps Q2 turned off.

The circuit remains in that state as long as switch S2 remains open. When the motor has completed its function, the stop switch, S2, can be manually closed. That forces the input of inverter U1-b low, and its output high which causes the output of U1-c to go low, turning off the motor. At the same time, the high at the output of U1-b turns on Q2, allowing a second load to operate. Although that load is shown as a solenoid in the schematic, it could be a relay, another motor, etc.

The circuit will remain

latched until S2 is opened and S1 is closed. Note that S2 must be opened before the cycle is restarted via S1; as long as S2 is closed S1 will have no effect on the circuit.

FOUR-OUTPUT TIMER

Our next controller, see Fig. 2, offers up to four timed outputs that can be used to operate motors, air valves, solenoids, relays, etc. Two dual, retriggerable monostable IC's and a few support components are all that's required for the circuit. The timer sections are cascaded so that as one timer times out, it triggers the next timer, and so on until the last timer times out.

The intended application for the controller required a two-sensor input that would only start when both inputs occur simultaneously. Note, however, that the start-signal logic could be modified to accommodate a combination of any number of input sensors, or even a single switch closure. The controller also includes an inhibit circuit that keeps the sequence from re-starting before a cycle is completed.

Here's how it works. At rest,

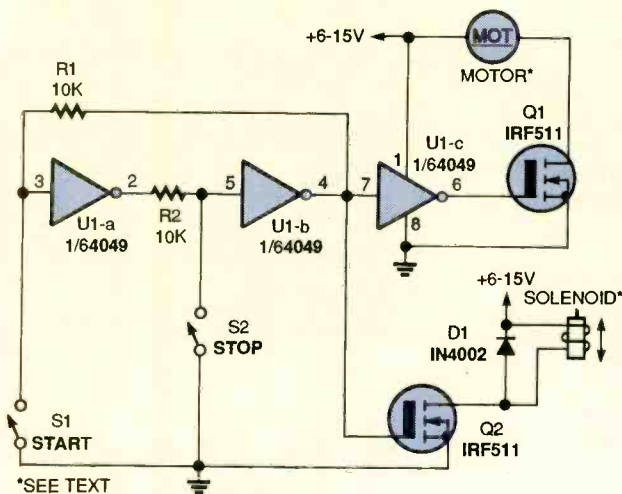


Fig. 1. This two-function controller operates a motor when started, then energizes a solenoid, relay, etc. when stopped.

enced in relay-ladder logic.

Since it's so easy to program and use those controllers, many are used to perform simple functions that often could be done as well or better with a simple shop-built circuit.

TWO-FUNCTION CONTROLLER

Our first electronic con-

PARTS LIST FOR THE TWO-FUNCTION CONTROLLER (Fig. 1)

SEMICONDUCTORS

U1—4049 hex inverting buffer, integrated circuit
Q1, Q2—IRF511 hexFET transistor
D1—IN4002 silicon diode

ADDITIONAL PARTS AND MATERIALS

R1, R2—10,000-ohm, 5%, 1/4-watt resistor
S1, S2—SPST switch
Motor (see text), solenoid (see text), wire, solder, etc.

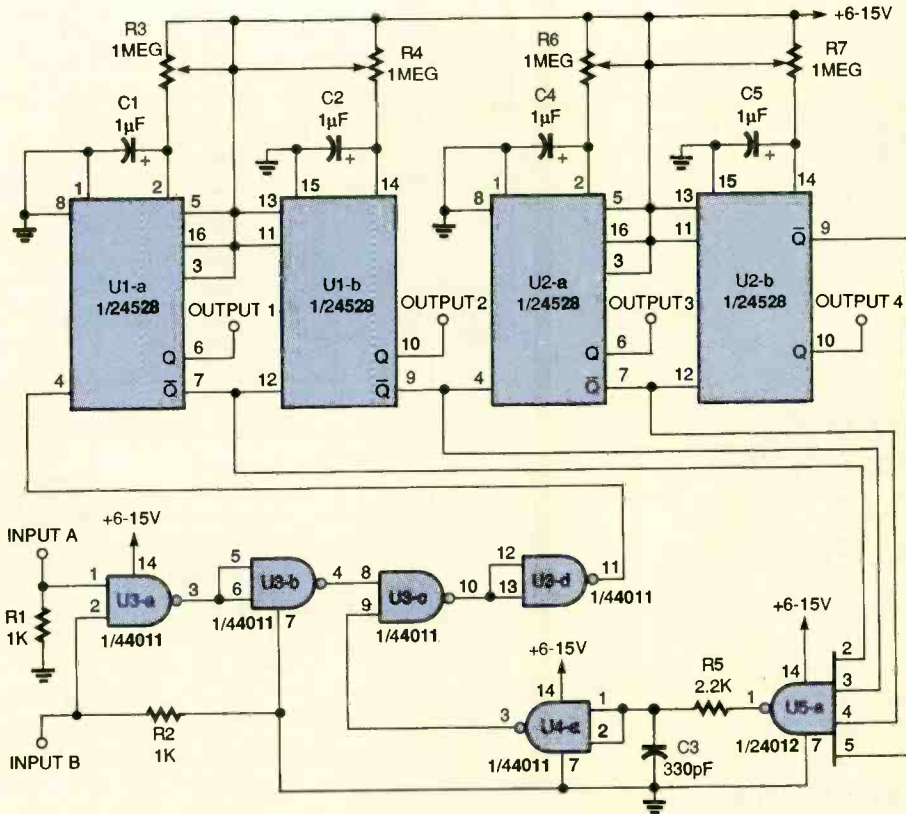


Fig. 2. This four-output controller features an inhibit circuit built around U5-a.

As soon as U1-a triggers and goes into its timing cycle, the \bar{Q} output (pin 7) goes low and the Q output (pin 6) goes high; the Q output is available at output 1. Those outputs remain in that state for the duration of the timing period determined by R3 and C1. At the end of the timing period the outputs change state, with the rising edge of the \bar{Q} output triggering the next timer, U1-b, and so on.

An inhibit function is provided by U5-a. When each timer's Q output goes low, that low is fed to one of U5-a's inputs. Whenever any of the inputs is low, the gate's output goes high, causing the pin-9 input of U3-b to go low. When U3-b is in that state, the sensor inputs are unable to trigger U1-a. To allow for pulse transition time between timers, R5 and C3 add a slight time

PARTS LIST FOR THE FOUR-OUTPUT CONTROLLER (Fig. 2)

SEMICONDUCTORS

U1, U2—4528 dual retriggerable monostable timer, integrated circuit

U3, U4—4011 quad 2-input NAND gate, integrated circuit

U5—4012 dual 4-input NAND gate, integrated circuit

RESISTORS

(All fixed resistors are 1/4-watt, 5% units)

R1, R2—1,000-ohm

R3, R4, R6, R7—1-megohm, potentiometer

R5—2,200-ohm resistor

ADDITIONAL PARTS AND MATERIALS

C1, C2, C4, C5—1- μ F, 35 WVDC, electrolytic

C3—330-pF, ceramic-disc

Wire, solder, etc.

and before the cycle starts, the four inputs of U5-a, one half of a 4012 dual-input NAND gate, are all high. That produces a low output, which is passed to the inputs of U4-a, 1/4 of a 4011 quad two-input NAND gate. As a result, the output of U4-a is high; that high signal is fed to one input (pin 9) of U3-c. Two sensors connect to the circuits via inputs A

and B. When both sensors go high, the output of U3-a goes low. Gate U3-b inverts that signal, and passes the resulting high to the other input (pin 8) of U3-c. When both inputs of U3-c are high, the output of that device goes low. That input is then inverted by U3-d and the resulting high is used to trigger the first sequential timer, U1-a.

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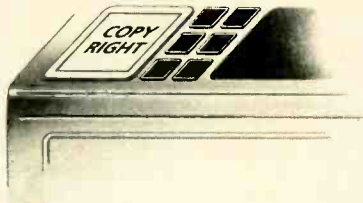


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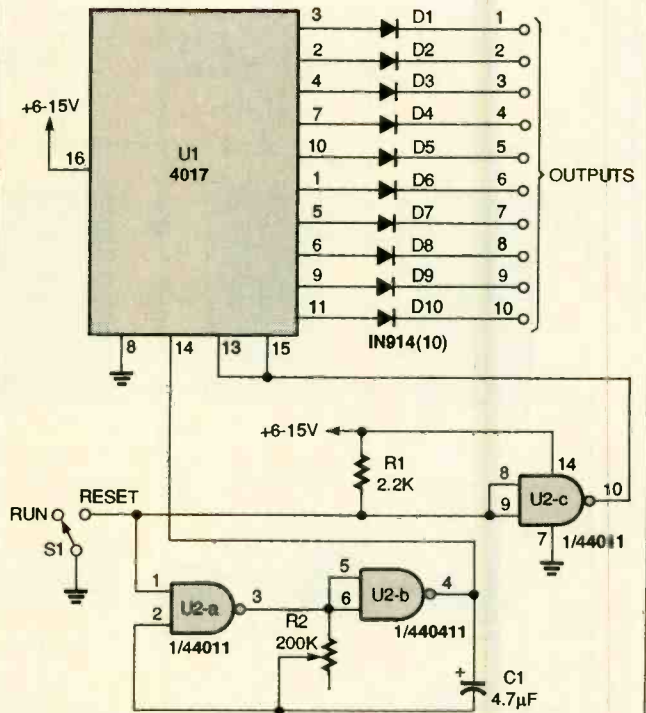


Fig. 3. Adjacent outputs of this 10-step counter can be combined to produce longer on times.

PARTS LIST FOR THE 10-STEP COUNTER (Fig. 3)

SEMICONDUCTORS

- U1—4017 counter/divider, integrated circuit
- U2—4011 quad 2-input NAND gate, integrated circuit
- D1-D10—1N914 silicon diode

ADDITIONAL PARTS AND MATERIALS

- R1—2,200-ohm, ¼-watt, 5% resistor
- R2—200,000-ohm potentiometer
- C1—4.7-µF, 16 WVDC, electrolytic capacitor
- S1—SPDT switch
- Wire, solder, etc.

delay to the inhibit gate's output.

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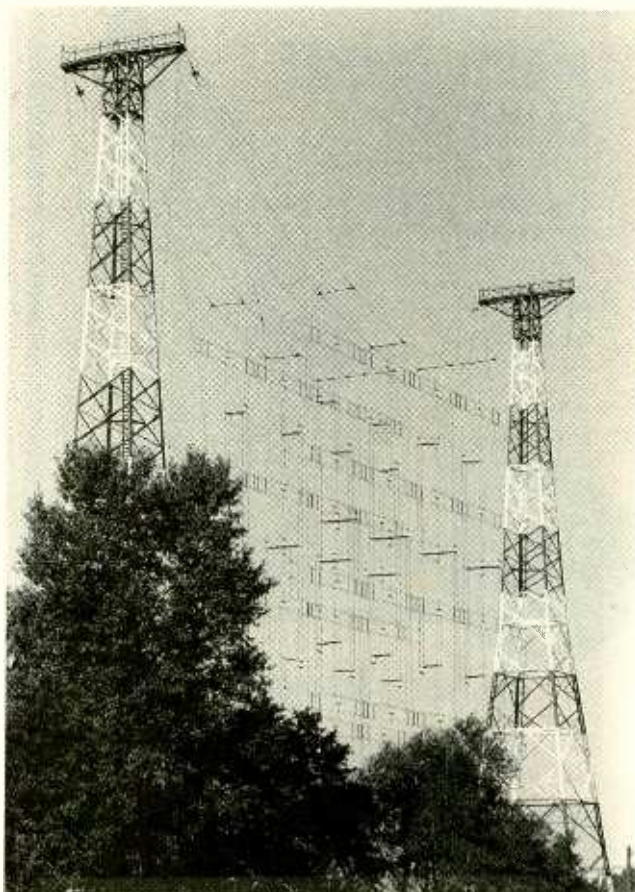
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By Don Jensen

Shortwave from Austria



This is part of Radio Austria International's elaborate shortwave-antenna system at Moosbrunn.

Shortwave is, of course, the classic, and oldest, means of international broadcasting. In the late 1920's, a number of nations began experimental transmissions on the SW frequencies. In central Europe, Austria was one of those shortwave pioneers.

As early as 1929, experimental programming was being aired by that country. In those days, high-powered transmitters were not available, nor, in those times of relatively little interference from other stations, were they needed to reach listeners overseas.

World War II ended all of

that, and it wasn't until the mid-1950's that Austria began planning and preparing for a major shortwave-broadcasting center. Then, in 1959, a foreign shortwave service began operating at Moosbrunn, some 25 kilometers southeast of the Austrian capital, Vienna.

Today, there are a pair of high-powered 500/300-kilowatt transmitters, plus two 100-kilowatt units, operating from Moosbrunn. With various directional broadcasts, sometimes operating in parallel in more than one language, *Radio Oesterich International* (*Radio Austria International*) transmits more than 80 hours of programming a day.

Since March 1989, some programs directed to North America are sent via satellite to *Radio Canada International's* transmitter facility at Sackville, New Brunswick, for relay. In return, the Austrian transmitters are used to relay some of RCI's shortwave broadcasts. In addition, English programming of Radio Austria International can be received in the United States on the C-Span audio network.

Since it began broadcasting to overseas audiences, the Austrian broadcaster has gained in importance. Production and studio facilities are located in the ORF Center in Vienna, where six well-equipped studios are used for producing programs. Radio Austria International has about 100 staff members and freelance employees providing language service, administration, and engi-

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The station's daily "Report from Austria" program includes world, European, and Austrian news, and reports on political developments, economics, the arts, current affairs, and sports. Austrian music adds an unmistakable flavor to the station's SW programming.

The program segments aimed at North America are aired at 0130 UTC on 9,655 kHz; at 0530 and 0630 UTC, relayed from Canada, on 6,015 kHz; and at 1130 UTC on 13,730 kHz. In addition, English transmissions beamed to South America can be received in the U.S. at 0130 UTC on 9,870 and 13,730 kHz.

For SWL's who want to write Radio Austria International, the address is Wurzburggasse 30, Vienna A-1136, Austria.

IN THE MAILBOX

James Wright, Houston, TX, writes with several questions.

"Will there ever be a shortwave-radio station in the state of Oklahoma? Seems like there would be in Tulsa, or Oral Roberts.

"What about Radio Australia? I never hear them anymore. And how about Hawaii? Why isn't there any SW station there?"

I can't say for sure, Jim, if there will ever be a shortwave broadcaster in Oklahoma. I've heard of no plans by the Oral Roberts organization to establish a station. Right now religious groups have no difficulty

buying air time on existing U.S. shortwave stations.

It shouldn't be too difficult to hear *Radio Australia*. You indicated that you listen mostly during the evening hours. Try these Radio Australia channels: 17,795 and 17,860 kHz, at 0030 to 0600 UTC; 9,860 and 11,910 kHz, at 0630 to 0730 UTC.

Finally, Jim, there is now a Hawaiian shortwave station, *KWHR, World Harvest Radio*, at Naalehu. Its schedule is: 0000 UTC on 17,555 kHz; 0200 UTC on 17,510 kHz; 0600 UTC on 9,930 kHz; 1600 UTC on 7,425 kHz; 1800 UTC on 13,625 kHz; 2000 UTC on 13,720 kHz; and 2200 UTC on 17,510 kHz.

A letter from Oscar Naimi of Mukilteo, WA, asks about shortwave receiving antennas. "I'm not using a serious antenna at the present time, just my bed frame (It may sound funny, but it's ok). I'd like to hear about suggestions on how to improve my antenna?"

Your bed may function as an "ok" antenna, Oscar, but you'll wake up your SW reception with a decent skywire. Fortunately there are a number of good reference books on SW antennas. Here are a few titles available:

Receiving Antenna Handbook, by Joseph J. Carr (\$19.95 + \$2.50 S&H, Grove Enterprises, P.O. Box 98, Brasstown, NC 28902); *The Antenna Handbook*, by Clem Small (\$12.95 + \$2.50 S&H, Grove Enterprises); *The Easy Wire Antenna Handbook*, by Dave Ingram (\$9.95 + \$1 S&H, Universal Radio, 6830 Americana

*CREDITS: Brian Alexander, PA; Marie Lamb, NY; Harold Levison, PA; John MacDonald, WA; William McGuire, MD; David Morasco, WV; Ed Newbury, NE; Betsy Robinson, TN; North American SW Association, 45 Wildflower Road, Levittown, PA 19057.

Parkway, Reynoldsburg, OH 43068); *Easy Shortwave Antennas*, by Frank Hughes (\$9.95 + \$2 S&H, Tiare Publications, P.O. Box 493, Lake Geneva, WI 53147); and *Limited Space Shortwave Antenna Solutions*, by Frank Hughes (\$10.95 + \$2 S&H, Tiare Publications).

You should find the answer to your antenna problem in one or more of those books, Oscar. Catalogs describing those and other shortwave-related titles are available from the firms mentioned above.

DOWN THE DIAL

Your shortwave loggings, with times, frequencies, and program descriptions, are wanted. Drop me a line at DX Listening, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735.

Here are some SW catches recently reported by listeners.


CONGO—4,765 kHz. *Radio Congo* has been noted in French around 0515 UTC with identification, African music, and rhythmic drums, followed by a newscast. The station operates in parallel on 5,985 kHz.

HUNGARY—9,835 kHz. *Radio Budapest* is heard with Hungarian ethnic music at around 0220 UTC. After an interval signal of trumpets and station identification, English programming begins at 0300 UTC.

INDIA—13,750 kHz. *All India Radio* is reported here with Indian music at 0020 UTC. That is followed by English news.

PARAGUAY—9,735 kHz. *Radio Nacional de Paraguay* broadcasts from one of the more difficult to log South American countries. Try for it at around 2230 UTC. It has been noted in Spanish with *futbol* news and Paraguayan music. ■

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HAM RADIO

By Joseph J. Carr, K4IPV

Some Antenna Topics

Antennas are near and dear to the hearts of ham operators and more advanced shortwave listeners. This month we will take a look at a couple of antenna topics, including an antenna project.

THE G5RV ANTENNA

The G5RV antenna was designed several years ago by Louis Varney (G5RV), a ham operator in the United Kingdom. The G5RV antenna is not terribly popular in the U.S., but if you read the ham magazines from Europe, you'll find that it's much more common "over there."

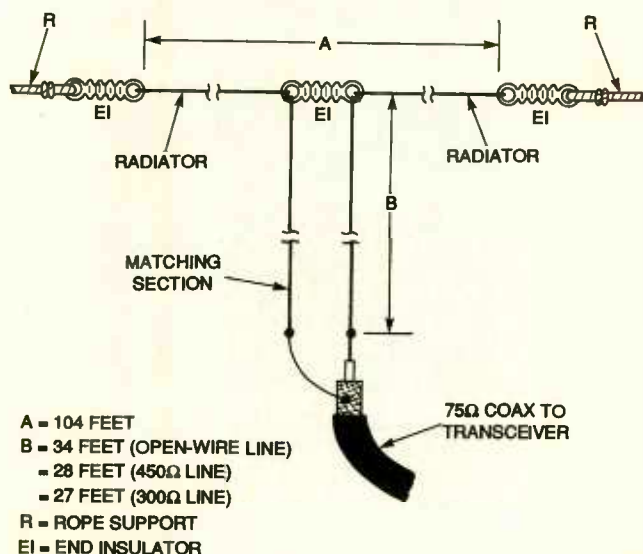


Fig. 1. The G5RV antenna is an interesting multiband ham antenna, but an antenna-tuning unit is a must for good results.

I've known several hams who've used the G5RV, and I've used one myself. The results are mixed, and I suspect the difference is in how well the design is implemented. It is significant, for example, that one chap who claimed the G5RV did not work well failed to use an antenna tuner between

the output of his transceiver and the feedline to the G5RV; as we will see, that's a critical mistake.

Although the dimensions of the G5RV have been subject to some controversy, for the high-frequency (hf) ham bands (80–10 meters) the G5RV dimensions have been pretty well-established by experiment and trade-off. As shown in Fig. 1, the two horizontal radiator elements are 52 feet long, or a total of 104 feet overall. The length of the matching section depends on which type of transmission line is used: If you prefer 450- to 600-ohm parallel open-line feeders, the length is 34 feet; if you prefer 450-ohm twin-lead, the length is 28 feet; and if you prefer 300-ohm twin-lead, the length is 27 feet.

The G5RV antenna is fed by 75-ohm coaxial cable, although the feedpoint impedance can vary quite a bit from 75 ohms. That's the reason why an antenna-tuning unit is needed!

The G5RV is built much like a dipole, using the same kind of wire and insulators. The rope supports (R), at either end, are connected to standard end insulators (EI), which are available at most radio-supply stores. The center insulator can be another end insulator (which will work well), or it can be a special center insulator. Make sure that the center insulator is not actually a BALUN transformer. While the BALUN is used extensively for dipole antennas, it is not appropriate with the G5RV.

The G5RV works differently on different hf

bands: On 3.5–4.0 MHz, the antenna works as a slightly folded, foreshortened dipole. On 7–7.3 MHz, it acts as two half-wave radiators fed in-phase. On 10 MHz, the antenna acts as a collinear antenna with two in-phase half-wave radiators (but its load is more reactive than on 7 MHz). On 14 MHz, the G5RV acts like a $\frac{3}{2}$ -wavelength dipole (i.e. like using a 40-meter dipole on 15 meters). At 18 MHz, the antenna is two full-wave radiators fed in-phase. On 21 MHz, the antenna acts like a $\frac{5}{2}$ -wavelength long-wire antenna. Finally, on 28–29.7 MHz, the G5RV acts like a $\frac{5}{2}$ -wavelength long-wire antenna, but with a much lower feedpoint impedance than on 21 MHz. Because of those differences in operation, the G5RV antenna will have a different feedpoint impedance at different frequencies. Again, that's why an ATU is a must!

RECEIVE OR TRANSMIT ANTENNAS?

One of the attributes of radio antennas is the property of reciprocity. That means antennas work the same on receive as they do on transmit. In other words, the azimuth pattern of a half-wavelength dipole is the same on both transmit and receive.

Reciprocity is a fact of life on antennas. Attempts to prove cases of non-reciprocal antennas have, thus far, always been based on a false premise or two. For example, one fellow attempted to prove that antennas are not reciprocal on the hf bands

because there are ionospheric conditions that are not bidirectional.

It is a well-known phenomenon that sometimes, especially in the late afternoon or evening on 40-meters, European stations are heard in the U.S., particularly on the east coast; but we cannot be heard by them. That is due to anomalies in the ionosphere that causes propagation in one direction to be different from propagation in the opposite direction. That difference is not a failure of antenna reciprocity, but an indication that the ionosphere sometimes isn't the same in both directions.

Another argument against antenna reciprocity is the operation of the Beverage antenna. The Beverage is a receive antenna that works best on the lower frequencies. The Beverage works best over a poor ground, except at the end far from the feedpoint. The best Beverage antenna is said to be one that is largely over desert or beach (which is a poor ground), with the termination resistor at the far end grounded in a brackish or salt-water swamp! The claim for non-reciprocity results from the fact that the Beverage is a very inefficient antenna, so it is not a good choice for transmitting. However, the patterns and impedances, and all other elements on which we characterize an antenna, are the same for both receive and transmit for the Beverage.

That brings up another issue: Is it true that the best receive antenna is also the best transmit antenna? Reciprocity would seem to say so, but that's a false notion. Why? The attributes of a good receive antenna are not the same as those of a good transmit antenna.

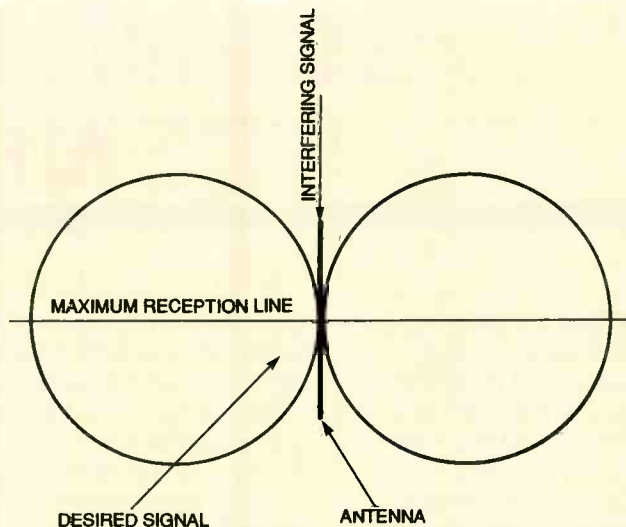


Fig. 2. For best results, a half-wave dipole should be oriented so that its deep side nulls point in the direction of an unwanted signal.

An ideal transmit antenna should be designed to maximize the gain in the direction in which one wishes to transmit. That way, we can take advantage of the inherent gain of the antenna for "free" power or signal strength. For example, if the antenna has a gain of 8 dB over a dipole (as is claimed for many 3-element beams), then a 1,000-watt transmitter will have the same signal strength at a distant point as a 6,300-watt signal fed to a standard half-wave-length dipole.

Another advantage of using an antenna with gain for transmitting is that it protects stations off-axis. In other words, while gaining a few dB of signal strength in the direction of interest, you also keep others from being clobbered by your signal in directions that are of no interest. That's good spectrum management, and good manners.

The receiver antenna, on the other hand, might have different goals than the transmitting antenna. Sure, we can use the gain of the antenna to boost received signals. But that is not usually a problem with modern

shortwave and ham-band receivers. With only 0.1 to 0.5 μV needed to produce a 10-dB signal-to-noise ratio, most receivers don't have to worry too much about getting enough signal. Of far greater importance is the signal-to-noise ratio (SNR) of the receiver system.

The SNR should typically be 10 dB for comfortable listening, although skilled operators can detect signal with a considerably worse SNR. In the case of the receiver system, the SNR includes not just internal white noise "hiss," electrical noise, and lightning static (snaps, crackles, and pops), but also undesired stations on the same or adjacent channels. When you are trying to copy a station through lots of co-channel or adjacent channel QRM (man-made interference, typically other stations), those QRM'ing stations are pure noise.

In the case of a receiver system, a good antenna might be one that has sharp nulls or notches, such as a half-wave dipole (see Fig. 2). Consider two signals, one the desired signal and one the interfering signal.

For best results, the antenna should be oriented so that the deep side nulls point in the direction of the undesired signal. While we don't pick-up the desired signal as strongly as we might if the maximum signal line was aligned with the signal, the ratio of the desired to undesired signal is maximized.

While it is true that most ham antennas are useful on both receive and transmit, that is not always the case. I've seen situations on the crowded 75/80- and 40-meter bands where a dipole was used as the transmitting antenna and a rotatable small-loop antenna was used as the receive antenna. The loop has an azimuth pattern similar to that of Fig. 2, but the axis is opposite (the nulls are broadside to the antenna, not off the ends as in the dipole).

Another example is the case of using a vertical antenna on transmit and a loop or dipole on receive. I've known one ham who had a 40-meter vertical plus two 40-meter dipoles at right angles to each other. He could select any of the three antennas for either transmit or receive, as needed. If transmitting east-west, for example, he might use the east-west dipole for the transmitter, and the north-south one for the receiver. Similarly, if transmitting on the vertical, for receive he selected whichever dipole reduced the interference the most.

Fortunately, some receivers allow separate receive and transmit antennas. If yours does, it will have a second rear-panel SO-239 connector marked for a receive antenna. Otherwise, you will need to build some type of system to switch between two antennas.

SCANNER SCENE

By Marc Saxon

PC-Powerful Scanning

Here's an exciting way to expand the capabilities of the already excellent *Realistic PRO-2005* and *PRO-2006* scanners. It's a product called the *OptoScan 456* system, which includes hardware and software for full computer control of all scanning functions. In addition, unlike all other radios, the *OptoScan 456* includes CTCSS ("PL tone"), DCS code, and DTMF (telephone touchpad) character reading, integrated with the software scan and log functions.



Put the power of a PC behind your *PRO-2005* or *PRO-2006* with the *OptoScan 456* interface system from Optoelectronics.

The hardware can sense when a computer interface is established. It then places the scanner's micro-processor into stand-by mode. Control over all radio functions passes on to the computer. A cable is provided for direct RS-232C interface with a computer's serial port.

Custom *OptoScan 456* introductory software for the PC is provided. All you have

to do is provide the scanner. The software is the OEM version of Scan*Star, which supports tone, code, and touchpad character decoding as well as received signal level. The power of the *OptoScan 456* is realized by the scanning software used. The professional versions of the ScanCat and Scan*Star software both support *OptoScan 456* with upgraded features, such as a spectrum display. Windows-based and Mac software are under development by independent organizations.

The *OptoScan 456* interface assembly can be installed in your scanner without cutting, drilling, or soldering. It's done with detachable cables, which are provided. The installation manual uses photos and step-by-step instructions. The entire installation should take the average scanner owner about two hours using simple hand tools.

With the *OptoScan 456* on the job, the scanner operates at high speed (50 channels per second) and has nearly unlimited memory. Even when you're not there, your scanner can continue to search out those frequencies that you want to check out, and can record them into a virtually unlimited number of memory channels. It relentlessly pursues and searches for elusive or infrequently used channels. The software makes scanning easier than the radio's front-panel controls. Software menus al-

low complex store, search, and scan features to be easily accessed.

The complete *OptoScan 456* installation kit includes the assembled and tested controller board, mounting hardware, cables, software, and installation manual. It costs \$299. For more information, write to Optoelectronics Inc. at 5821 N.E. 14th Avenue, Ft. Lauderdale, FL 33334, or call 1-800-327-5912 or 305-771-2050.

LOOK, UP IN THE SKY!

Readers often ask if it's possible to tune in directly to the space shuttle, and several times we have provided amateur radio, two-meter band frequencies that have been used. That isn't the only way, however!

For quite some time now, scanner owners have been advised that the space shuttle also has a (alternately reported AM or FM) "primary" frequency of 296.8 MHz, and a "secondary" frequency of 259.7 MHz. Those channels are, of course, in addition to the shuttle's main communications system, which operates at 2 GHz in a digital mode.

Actual use of the 200-MHz band by the space shuttle has been doubted, or at least questioned, by some monitors. Shall we say that reports of reception have not been abundant? We say, keep on listening!

I personally can attest to recent activity there. When astronauts Mark Lee and Carl Meade took their Ex-

travehicular Activity (EVA) space walk from the Discovery last September, I was able to directly monitor their communications on 259.7 MHz, in AM mode, as the craft was passing over my area.

That reception was accomplished using a PRO-2006 with a GRE Superamplifier hooked up to a MAX-225 UHF military aeronautics-band ground-plane antenna. Signals came through quite well, and were undoubtedly via an on-board repeater on the shuttle. The space suits transmit on 279.0 MHz, which must be the input for that repeater. Even so, the transmitter on 259.7 MHz probably wasn't running much power.

Keep 296.8 and 259.7 MHz, AM mode, plugged in during space shuttle missions. They are active frequencies, and good ones.

ALSO GOING UP

An interesting new satellite system will be using frequencies within the range of scanners. Leo One will have 48 low orbit (513 miles high) satellites circling the globe, with 12 satellites in each of four circular orbits. The satellites will be designed to support a variety of subscriber applications, including status monitoring, vehicle tracking, paging, E-mail, security monitoring and control, emergency alerting, etc. Leo One will provide store-and-forward data services.

Service is set to commence within two years. The satellites will have communications links with one another in the Ka-band (22 and 24 GHz), thus offering worldwide coverage.

Uplinks are all from 148.00 to 150.05 MHz. Transceiver downlinks are from 137.00 to 138.00 MHz, with

Gateway downlinks from 400.15 through 401.00 MHz.

IN THE MIX

Eugene W. McLees, of Madison, Connecticut, reports that his local police operate on 453.475 MHz, but complains that they scramble some of their transmissions. That is a grumble heard from readers in other areas, all of whom want to know if there is a scanner accessory available that will descramble and copy the transmissions.

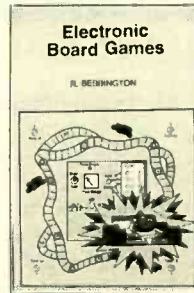
There was one, until about eight years ago, when the government forced the little gizmos off the market. Most police departments use a rather simple but effective form of analog scrambling. Analog scramblers are easy to crack. It's the same system used in today's 46-MHz cordless phones. Some clever "techie" might figure out how to adapt an analog-scrambled phone as a scanner accessory.

Analog scanning is vastly different from the digital scanning used in 900-MHz cordless phones and in the more sophisticated scramblers used by some federal-agency communications systems. Digital scrambling sounds like a hiss on a scanner. Thus far, it has never been possible for scanner owners to descramble digital scramblers.

An anonymous reader in Ohio passed along the Cuyhoga Falls trunked system in use for the past year. Police/Fire primary is 855.1625 MHz, with the secondary being 854.1625 MHz. Control or city services can be found on 853.1625 MHz, control or fire department on 852.1625, and city services or fire department on 851.3625 MHz.

That's all for now. See you again next month.

3 NEW BOOKS for the Project Builder

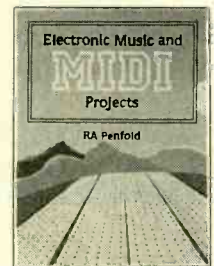


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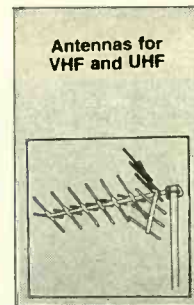
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Save cash by building the MIDI gadgets you need. Want a MIDI THRU box, program change pedal, Metronome, analog echo unit, MIDI patchbay or switcher? Over 16 practical and very useful music and MIDI projects—all in this book! The projects are explained in detail with full instructions on assembly.



BP301—ANTENNAS FOR VHF AND UHF\$6.00

From installing a TV or FM antenna to setting up a multi-antenna array for shortwave listening or amateur radio, this book explains the basics of VHF and UHF antenna operation and installation. The text describes in easy-to-understand terms the essential information about how antennas work, the advantages of different antenna types, and how to get the best performance from an antenna.



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ELECTRONICS LIBRARY

Giga Bites: The Hacker Cookbook 17th Edition

by Jenz Johnson

Hackers cannot live by computers alone—some physical sustenance is required as well. According to the author of this cookbook, food is often the only interruption tolerated by the dedicated (read: fanatical) hacker. Whether devoured over the keyboard or during a short break, the hallmarks of hacker cuisine (also known as "cyberchow" or "technogrub") are large portions, quick prep time, and unpredictable results. Although nutritional content is not a priority, none of the recipes in this book contain more than 6000 calories per serving—a real achievement when dealing with such culinary treats as "Twinkie Casserole," "Left-

includes pointers for guarding your keyboard from dip spills, preventing soggy chips, and cleaning your screen.

Giga Bites: The Hacker Cookbook costs \$9.95 and is published by Ten Speed Press, P.O. Box 7123, Berkeley, CA 94707; Tel. 800-841-2665 for orders or 510-559-1600; Fax: 510-524-4588.

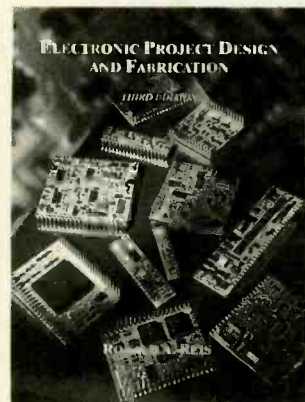
CIRCLE 80 ON FREE INFORMATION CARD

ELECTRONIC PROJECT DESIGN AND FABRICATION; Third Edition

by Ronald A. Reis

This book provides the real-life experience in project design, building, and documentation that every hobbyist and prospective electronics technician needs. It opens with a step-by-step guide through the prototype project design and fabrication process for the "sample project"—a variable power supply—and the "exercise project"—a three-channel color organ. Fifteen elective projects, including an audible logic probe, a digital temperature controller, a push-button combination lock, and a burglar alarm, are also presented in the book's first section, which concludes with an introduction to computer-aided design.

In Part II, project design and fabrication using surface-mount technology is covered in three chapters. An overview of the subject is followed by hands-on study of SMT component acquisition, circuit breadboarding, surface-mount PC-board design, and SMT project assembly using traditional hand tools. The third chapter explores the tools and techniques needed to re-work commercial products involving surface-mount circuits.



Part III is devoted to actual construction projects. It covers concepts, documentation, system diagrams, circuit design sketching, and packaging plans for 15 insertion mount technology (IMT) projects.

Electronic Project Design and Fabrication, Third Edition, costs \$45.00 and is published by Prentice Hall, Inc., Englewood Cliffs, NJ 07632.

CIRCLE 99 ON FREE INFORMATION CARD

THE VIRTUAL REALITY PROGRAMMER'S KIT

by Joe Gradecki

This book-and-software package provides everything that the computer user with no programming experience needs to produce virtual reality (VR) programs—including virtual cities populated with animated people, robots, or bizarre monsters—on his or her own PC. Readers who have a little knowledge of the C programming language will also learn to create multi-user worlds that work over modems; design labyrinths and VR games with sophisticated animation and 3D sound; and integrate projects from a companion book, *The Virtual Reality Construction Kit*, into original virtual worlds.



over Chinese Food Dip," and "Hacker Fondue with Pork Rinds." The microwave is the appliance of choice, and favorite ingredients include Cheez Whiz, Wonder Bread (usually squashed into bread balls), Spam, and anything that comes in a can. Along with recipes, the book



The package also offers tips for experienced C programmers, providing code to add advanced features to their creations. The four complete virtual-reality applications included on the disk can be explored as is or customized for unique VR experiences.

The Virtual Reality Programmer's Kit costs \$29.95 and is published by John Wiley & Sons, Inc., Professional Reference and Trade Group, 605 Third Avenue, New York, NY 10158-0012.

CIRCLE 88 ON FREE INFORMATION CARD

1995 ARRL HANDBOOK FOR RADIO AMATEURS

from *The American Radio Relay League*

The 72nd edition of this authoritative handbook is not merely a revision but an entirely rewritten book that supersedes all previous editions. It has been reorganized for easier reading and represents several years of research and revision. New sections cover digital signal processing and other evolving technologies that are shaping



amateur radio today and into the future.

The book is aimed at amateur radio operators, broadcast engineers, electronic hobbyists and professionals, science teachers and students, and anyone interested in communications technology. It features chapters on radio and communications theory, background information on assembling, setting up, and testing an amateur radio station; and a wealth of new projects for the home builder, from power supplies to transceivers and amplifiers.

The 1995 ARRL Handbook for Radio Amateurs costs \$30 and is published by The American Radio Relay League, 225 Main Street, Newington, CT 06111; Tel. 203-666-1541; Fax: 203-665-7531.

CIRCLE 82 ON FREE INFORMATION CARD

THE VISUAL GUIDE TO dBASE FOR WINDOWS

by Carl Townsend

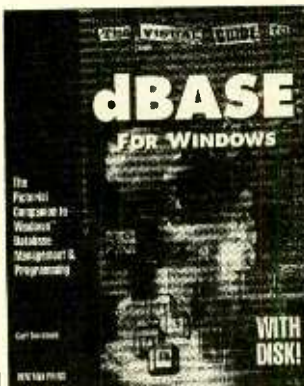
With tips for developers and designers at all levels, this book-and-disk package offers a comprehensive examination of effective, efficient database design for dBASE users. It provides a generously illustrated overview of dBASE for Windows, including version 5's fresh new interface and OOP language extensions.

The book defines dBASE basics, such as exploring the Navigator, Catalog window, Command window, tables, forms, and queries. It explains how to design dBASE databases, from analyzing your goals and needs, to using sound design concepts and techniques, to working with objects. The book provides hands-on practice in creating and modifying tables, organizing and moving data, indexing information, and correcting problems.

The book also explains how to design, create, and execute queries; create fast forms with the Form Expert; customize with the Form Designer and Crystal Reports; and use SpeedMenus and the Menu Designer to add menus, buttons, and SpeedBars. Finally, it shows readers how to develop

dBASE programs using dBASE for Windows' unique two-way tools. An in-depth index includes advanced administration and management information.

The companion disk features a tutorial software system that illustrates key techniques and features in programming. All of



the tables, queries, forms, reports, and programs needed for working with the examples in the book are on the disk, linked through a convenient menu system.

The Visual Guide to dBASE for Windows book with disk costs \$29.95 and is published by Ventana Press, P. O. Box 2468, Chapel Hill, NC 27515; Tel. 919-942-0220; Fax: 919-942-1140.

CIRCLE 83 ON FREE INFORMATION CARD

1995 TECHNICAL SUPPLIES CATALOG

from *Hub Material Company (HMC)*

HMC's full-line 1995 catalog is filled with the electronic tools, test gear, and technical supplies required for the assembly, testing, and repair of electronic products. The detailed buying guide features a broad selection of brand-name items at competitive prices, complete with large photographs, clear copy, and comparison tables of product features. The catalog includes test instruments, tool kits, soldering/desoldering systems, precision hand tools, work stations, industrial chemicals and adhesives, data communications and telecommunications equipment, PC-board handling equipment, and static-control products.



The 1995 Technical Supplies Catalog is free upon request from HMC, 33 Springdale Avenue, Canton, MA 02021; Tel. 617-821-1870; Fax: 617-821-4133.

CIRCLE 84 ON FREE INFORMATION CARD

SIMPLIFIED DESIGN OF LINEAR POWER SUPPLIES

by John D. Lenk

This one-stop guide to linear power-supply design is well suited for beginners, students, and experimenters, as well as design professionals. It feature step-by-step instructions and diagrams, and requires no previous design experience.

The book concentrates on the use of commercial IC regulators by discussing the selection of external components that modify the IC-package characteristics. A full chapter is devoted to heat sinks and other temperature-related design problems. Another chapter covers testing the linear supplies in both experimental and final form, and illustrates the connections of the completed supplies.

Operation of all circuits is fully detailed to provide a foundation for those who are totally unfamiliar with linear supplies and a refresher for professionals. All popular forms of linear supplies, including zener, three-terminal, feedback, current foldback, op-amp, series, shunt, and IC package, are covered in detail. In addition, the design examples can be put to immediate use as is, or can be modified to meet a specific design goal.

Simplified Design of Linear Power Supplies costs \$29.95

and is published by Butterworth Heinemann, 313 Washington Street, Newton, MA 02158-1626; Tel. 617-928-2500; Fax: 617-928-2620.

CIRCLE 85 ON FREE INFORMATION CARD

NET GAMES: Your Guide to the Games People Play on the Electronic Highway

by Kelly Maloni, Derek Baker, and Nathaniel Wice

By some estimates, more than half of online time is spent playing interactive games. At any hour of the day, millions of people worldwide are online playing games with each other in Cyberspace, where online camaraderie and competition rival the intensity of contact sports. The new breed of games takes advantage of the Internet and other computer networks to bring human rivalry and team spirit directly to your screen.

This book is a guide to more than 1500 of those new comput-



er games. It includes multi-player virtual scrimmages such as Air Warrior, Cyberstrike, Doom, and Bolo, which combine the local color of a hometown bowling league with the massive firepower of a Hollywood action movie. Traditional games, including chess, Go, bridge, and backgammon are also covered, as are play-by-mail classics like rotisserie baseball and Diplomacy. The book also covers MUD's, MOO's, and MUSH'es—participatory narrative adventures—in which players build and explore virtual worlds from the USS Enterprise to worlds based on Anne Rice's vampire chronicles.

Besides the games people play online, the book also covers the thousands of free computer games and demos that can be downloaded from online archives. It describes the clubs that share cheats, hints, and walk-throughs for mastering home and arcade hits ranging from Mortal Kombat to NBA Jam (and even the daily crossword puzzle).

Net Games: Your Guide to the Games People Play on the Electronic Highway costs \$19 and is published by Random House Electronic Publishing/Michael Wolf & Company, Inc.; Tel. 1-800-NET-1133.

CIRCLE 86 ON FREE INFORMATION CARD

MASTER CATALOG 1994-1995

from Jensen Tools

Jensen's latest catalog has been upgraded with larger pages, pictures, and type, to make it easier to use. The catalog offers a single source of tools and test instruments for the installation and maintenance of electronic equipment and systems. It features a full line of specialty tool kits and cases, as well as the latest portable field-test equipment from major manufacturers. Also included are hard-to-find tools,



static-control products, circuit-board accessories, lighting and optical aids, workbenches, soldering supplies, cables, connectors, LAN installation and maintenance products, shipping containers, and more. Jensen brand tools have a lifetime guarantee, and shipping is free in the continental U.S.

The Master Catalog 1994-1995 is free upon request from Jensen Tools Inc., 7815 South 46th Street, Phoenix, AZ 85044; Tel. 800-426-1195.

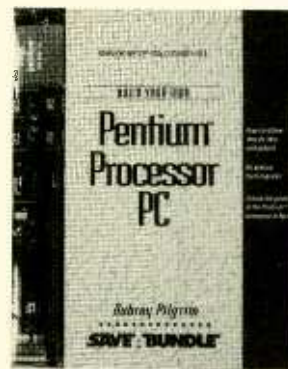
CIRCLE 87 ON FREE INFORMATION CARD

BUILD YOUR OWN PENTIUM™ PROCESSOR PC

by Aubrey Pilgrim

If you dream of owning a powerful new Pentium-processor PC, but can't afford to buy one at today's prices, this book is for you. Although a Pentium-based computer is much more powerful and expensive than most other commercial PC's, it isn't more difficult to assemble. This book explains how to construct an IBM-compatible Pentium computer out of mail-order parts and peripherals for a fraction of dealer prices.

After an overview of the Pentium processor and its capabilities, the book describes



in step-by-step, illustrated detail how to put together all the necessary components, including motherboards, floppy and hard drives, CD-ROM drives, printers, input devices, memory chips, monitors, graphics cards, fax/modems, and backup systems. It explains how and where to find the best components and peripherals at the lowest possible prices, and explains which software packages will best suit a variety of needs (including multimedia applications). The money-saving guide also contains a review of operating systems and a handy list of troubleshooting techniques, making it a valuable reference for those who are planning to

buy a Pentium-based PC instead of building one.

Build Your Own Pentium Processor PC costs \$19.95 and is published by Tab Books Inc., Blue Ridge Summit, PA 17294-0850;

Tel. 1-800-233-1128.

CIRCLE 98 ON FREE INFORMATION CARD

MINIATURE SATELLITE DISHES:

The New Digital Television

by Dr. Frank Baylin

Digital broadcasts from high-power satellites to 18-inch dishes are now being transmitted, and this book covers all aspects of the new direct broadcast satellite (DBS) industry, including the technology, the players, and the programming, as well as signal security and installation methods.

The book opens with an overview of DBS and also covers the underlying technology of satellites and receiver systems. Topics such as digital video compression, bit error rate, receiver design, and compatibility of large- and small-dish systems are studied. Next, the DBS players—DirecTV, EchoStar, PrimeStar, and USSB—are discussed, along with their satellites and systems. The book examines how DBS differs from large-dish satellite TV and cable TV, the origins of DBS, and DBS frequency allocations.

Subsequent chapters outline the encryption systems used for signal security and examine the program packages and prices offered by various players. The step-by-step procedures for installing both small- and large-dish satellite systems are presented in detail. The final chapter demonstrates the methods used to hook up and interface home-entertainment systems, including off-air antennas, stereos, and VCR's, with home satellite TV receivers.

Miniature Satellite Dishes: The New Digital TV is available for \$20 plus \$4 shipping and handling from Baylin Publications, 1905 Mariposa, Boulder, CO 80302; Tel. 303-449-4551; Fax: 303-939-8720.

CIRCLE 89 ON FREE INFORMATION CARD

Electronics Paperback Books



□ **BP88—How to Use OpAmps...\$5.95.** A designer's guide that covers operational amplifiers. Serving as both a source book of circuits and a reference book for design calculations. The text is non-mathematical and easy to understand by most readers.



□ **BP113—30 Solderless Breadboard Projects-Book 2...\$5.95.** Numerous hobbyist projects of useful gadgets and circuits using "Verobloc" breadboards. All the breadboard projects in this book are based on CMOS logic integrated circuits.



□ **BP177—Introduction to Computer Communications...\$5.95.** Details on types of modems and their suitability for specific application, plus details of connecting various computers to modems, and modems to the telephone system.



□ **BP276—Shortwave Superhet Receiver Construction...\$6.95.** Provides construction details, including coil winding, of a number of advanced-design receivers which should have performance levels at least equal to commercial sets of similar complexity.



□ **BP61—Beginners Guide to Digital Techniques...\$5.00.** Covers the basics of digital techniques—decimal, binary, octal and hexadecimal numbering systems are covered plus insights on weighted and non-weighted binary-coded-decimal codes and alpha-numeric codes. The basic building blocks of circuit logic, the common AND, OR, NAND, NOR and EXCLUSIVE-OR gates and bi-stables, are thoroughly covered.



□ **BP285—A Beginners Guide to Modern Electronic Components...\$6.50.** It is easy for newcomers to electronics to become confused. There are a great many different types of components available often with numerous variations of each type. This book presents the reader with a vast amount of invaluable parts information to enable the right component to be selected every time for repairs and projects.



□ **PCP103—Practical MIDI Handbook...\$9.95.** The Musical Instrument Digital Interface (MIDI) is surrounded by a great deal of misunderstanding. This book is aimed at musicians and technicians who want to explore the vast capabilities of MIDI. It covers MIDI-based equipment you can use: keyboards, drum machines, sequencers, effects units, mixers, drum pads guitars. There's also a section on computer music.



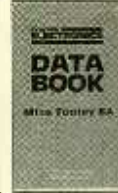
□ **BP90—Audio Projects...\$5.50.** Details the construction of preamplifiers and mixers, power amplifiers, tone controls and matching projects. All projects are fairly simple to build and include a number of board layouts and wiring diagrams.



□ **BP121—How to Design and Make Your Own PCBs...\$5.75.** Simple methods for copying printed-circuit board designs from magazines and books on to copper. Covers all aspects of simple PCB construction as comprehensively as possible.



□ **BP44—IC 555 Projects...\$5.95.** Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer integrated-circuit chip is one such device. Included are basic and general circuits used by most hobbyists.



□ **PCP109—Everyday Electronics Data Book...\$10.00.** An invaluable source of electronics information—the text contains sections that deal with the underlying theory of electronic circuits and a wide range of practical electronic uses for everyone.



□ **BP60—Practical Construction of Pre-Amps, Tone Controls, Filters and Attenuators...\$5.50.** The book offers practical designs and details thereof by enabling the project-builder enthusiast to construct, with the minimum of difficulty and expense, various audio pre-amplifier and tone control circuits, etc., which may be used with home-constructed audio equipment or even complex commercial gear.



□ **BP297—Loudspeakers for Musicians...\$6.25.** Contains all the information that a working musician needs to know about loudspeakers; the different types, how they work, the most suitable for different instruments, for cabaret work, and for vocals. It gives tips on constructing cabinets, wiring up, available fittings, finishing and how to connect multi-speaker arrays, etc. Includes ten enclosure designs with plans.



□ **PCP110—Electronic Power Supply Handbook...\$10.95.** All types of power supplies used for electronics purposes are covered in detail, starting with cells and batteries and extending by way of rectified supplies and linear stabilizers to modem switch-mode systems, IC switch-mode regulators, DC-converters and inverters. The devices, their operating principles and typical circuits, are dealt with in detail.



□ **BP254—From Atoms to Amperes...\$6.50.** Explains in crystal-clear terms the fundamentals behind the whole of electricity and electronics. Really helps you to understand the basis of the complex subject perhaps for the first time ever.



□ **PCP101—Practical Digital Electronics Handbook...\$9.95.** An introduction to digital circuits, logic gates, bi-stables, timers, micro-processors, memory and I/O devices. A special feature of the book is the section on digital test gear projects.



□ **BP315—Introduction to the Electromagnetic Wave...\$5.95.** A fundamental and easy-to-understand approach to a complicated theory topic. The beginner requires no more than elementary mathematics and basic knowledge of electronics.



□ **#228—Essential Theory for the Hobbyist...\$5.25.** Supplies to the hobbyist background knowledge tailored to the specific requirements of their activities. Relevant material is presented in a readable manner with a minimum of mathematics.

TEST EQUIPMENT SPECIALS

- **BP239—Getting the Most from Your Multimeter...\$5.95**
Covers analog and digital gear, component and gear testing.
- **BP267—How to Use Oscilloscopes & Other Test Equipment...\$6.95**
Get with the next step to proficient troubleshooting.
- **PCP111—Electronic Test Equipment Handbook...\$13.95**
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SUBSTITUTION GUIDES FOR HOBBYISTS

- **BP85—International Transistor Equivalents Guide...\$7.50**
The ultimate guide to replacing foreign and domestic transistors.
- **BP108—International Diode Equivalents Guide...\$5.95**
Rectifiers, Zeners, LEDs, OCIs, diacs, triacs...all hobby types.
- **BP140—Digital Equivalents and Pin Connectors...\$12.50**
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NEW PRODUCTS

"Perpetual Memory" CW Keyboard

The MFJ-452 "Perpetual Memory" CW keyboard from MFJ Enterprises features eight 250-character nonvolatile message memories, a 150-character type-ahead buffer, a two-line LCD readout, an RFI-suppressed keyboard, and a powerful Morse code trainer. Even the hunt-and-peck typist can send perfect CW messages, because the buffer smoothes out one's typing and gives him or her more time to compose. There is no computer to boot up, and no program to

keys for easy use. The MFJ-452 also features an iambic keyer for fast break-in—by plugging in an iambic paddle you can use it as a full-featured keyer.

The Morse code trainer allows the user to practice or teach in Farnsworth or normal code. Letters, numbers, punctuation marks, and prosigns can be selected in any combination for practice.

The MFJ-452 Morse AT101-compatible keyboard, which plugs into a compact interface, costs \$129.95. For more information, contact MFJ Enterprises, Inc., P. O. Box 494, Mississippi State, MS 39762; Tel. 601-323-5869 or 800-647-1800 for orders; Fax: 601-323-6551.

CIRCLE 102 ON FREE INFORMATION CARD

RADIO-TRANSMITTER DETECTOR

Aimed at the security, surveillance, law-enforcement, and hobby monitoring markets, the Scout from Optoelectronics is a handheld device for detecting radio transmitters in the near field.

For walk-by applications, the Scout can automatically detect and record 200 unique frequencies and up to 250 repeat hits on any that were previously recorded. When used with the miniature DB32 antenna, the Scout will fit in a pocket, operating in a completely automatic mode, and will signal the user with a pager-style vibration when a frequency is recorded. After recording, the Scout data can be downloaded into a computer using the supplied software and an optional TTL to RS-232C interface converter.

In drive-by mode, the built-in beeper signals when the Scout records a new frequency with a double beep. A single beep indicates a hit on a previously recorded frequency. Automatic operation allows the driver to monitor frequencies without

load. The device allows the user to save his or her messages and settings for up to 20 years without power or batteries.

The display simultaneously shows what is being typed on one line and what is being sent out on the other. The user can review stored messages and keyboard settings, and can spot and correct any typing errors.

Thanks to RFI suppression, the CW keyboard won't lock up or send unwanted characters. Single-touch function keys make it easy to store and recall messages; set speed, weight, and tone; set up serial numbering; and turn on and off the transmitter tune. Commonly used prosigns are assigned



being distracted. Reaction tuning a receiver in drive-by operation provides instant, hands-free monitoring of the detected transmissions.

To distinguish actual radio frequencies from background noise, Optoelectronics' patent-pending Digital Filter/Capture technology is used. The beeper and LCD backlight are switch-selectable on power up. A NiCd battery pack provides at least six hours of portable operation. An AC adaptor/charger is included; a 12-volt DC adaptor is optional.

The Scout radio-frequency detector, complete with AC adaptor/charger, 3.5-inch disk with PC-compatible utilities, and user's manual, costs \$399. The DB32 miniature VHF/UHF antenna costs \$29, and the CX12-to-RS-232C interface costs \$89. For more information, contact Optoelectronics Inc., 5821 NE 14th Avenue, Ft. Lauderdale, FL 33334; Tel. 305-771-2050; Fax: 305-771-2052.

CIRCLE 103 ON FREE INFORMATION CARD

SERVICE KITS

Two digital multimeter service kits from Fluke each include a rugged handheld DMM, along with the accessories and training materials needed to perform electrical measurements.



The *Fluke 23* kit provides the industrial, electrical, and HVAC technician with a Fluke Model 23 analog/digital-display multimeter, an 80i-400 clamp-on AC-current probe, a TL20 test-lead set, and a C17Y case. The kit also includes electrical and HVAC/R application notes and training materials for DMM users.

The *Fluke 87* kit provides the user with a Model 87 analog/digital multimeter, an 80i-400 clamp-on AC-current probe, a TL20 test-lead set, a C28Y case, and a video titled "Understanding Harmonics." Additional training materials in the kit include the "High-Performance Guide to DMMs" application booklet and electrical, harmonic, and HVAC/R application notes.

The list prices for the Fluke 23 and the Fluke 87 service kits



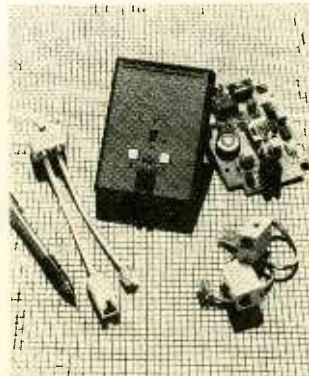
are \$309 and \$469, respectively. Those prices represent a 10% cost savings over purchasing the items separately. For further information, contact Fluke Corporation, P. O. Box 9090, Everett, WA 98206; Tel. 800-44-FLUKE; Fax: 206-356-5116.

CIRCLE 104 ON FREE INFORMATION CARD

TELEPHONE WIRETAP DETECTOR

With inexpensive, easy-to-use wiretapping equipment now readily available, both businesses and individuals are increasingly concerned about maintaining their privacy. As the threat of surveillance becomes obvious, businesses recognize the need to protect their information.

Security Call's SC1100 tele-



phone-wiretap-detector alarm system protects private phone lines from eavesdropping and tampering. The unit continuously monitors the phone line for suspicious changes in electrical characteristics, and alerts the owner with an audible tone when they occur. The small, microprocessor-controlled unit snaps easily into place and can be checked remotely.

The SC1100 wiretap-detector system costs \$139. For additional information, contact Security Call, 15425 Los Gatos Blvd., Los Gatos, CA 95032-2541; Tel. 408-356-6509 or 800-334-0074; Fax: 408-356-0758.

CIRCLE 105 ON FREE INFORMATION CARD

PROTOTYPE BOARDS AND COMPATIBLE BOXES

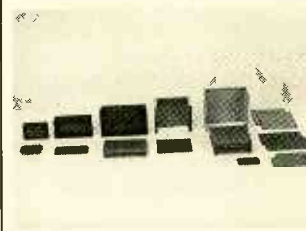
Jameco's line of 15 printed-circuit boards and 15 matching boxes features ABS speedy boxes, die-cast aluminum enclosures, sheet-metal aluminum boxes, and heavy-duty instrument cases. The compatibility between boards and boxes give electronics enthusiasts a quick start on their projects.

The pre-cut boards also allow the builder an immediate start on prototyping circuits. Each board has two or four mounting holes and is compatible with Jameco's PC-board mounting hardware. The 1/16-inch-thick boards are made of laminated glass epoxy, are copper-clad, and have a solder mask on one side.

The boxes are designed for convenience and durability. The ABS speedy box, for instance, can be used to enclose and protect the boards inside, as

well as to house the switch that activates the boards' circuitry. The number of boards that can be stacked is limited only by space, and the boards can be interconnected. The box has mounting slots on all four sides. The die-cast aluminum enclosures come with channeled walls for easy board mounting. Because the lid forms an effective screen against RFI, they are ideal for RF circuits. The sheet-metal aluminum boxes, consisting of two pieces that slide together, allow the builder to access the prototype boards from two sides as well as from the top.

The metal cabinets are de-



signed to suit a large variety of electronics projects. Slots are located on the sides of the cases for cooling purposes. The heavy-duty instrument case splits apart so that the builder can access the prototype boards from all sides. Four plastic feet secure the case in place on a desk or table. The case accommodates various board-mounting positions.

Prices for the prototyping boards range from \$3.95 to \$14.95. Prices for the boxes range from \$2.25 to \$9.49. For more information, contact Jameco Electronics, 1355 Shoreway Road, Belmont, CA 94002; Tel: 415-592-8097; Fax: 415-592-2503.

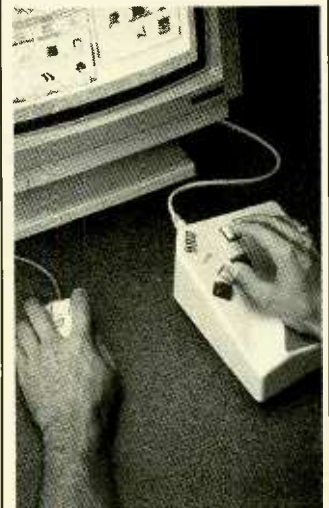
CIRCLE 106 ON FREE INFORMATION CARD

MACRO KEYBOARD

The *BAT (Biomechanical-Automated Technology) Personal Keyboard* from *InfoGrip, Inc.* compresses all the capabilities of a traditional keyboard into a seven-key unit that can be used with one hand. Its battery backup stores macros so they don't have to be reactivated every time the keyboard is turned off. The *BAT* keyboard can be used with several different PC-com-

patible computers—at the office, home, or on the road—without having to download your macros to floppy. The device weighs just 16 ounces and fits in a briefcase.

The user can quickly type any letter, command, or function with one hand by pressing key combinations of one to five fingers, similar to playing chords on a piano. *ChordEasy* software allows a library of macros and shorthand "WordChords" to be



created to save time and reduce errors. Frequently used phrases and commands of up to 250 characters can become macros that can be entered with just two chords. Those features make the *BAT* keyboard popular with the physically and visually impaired as well as with programmers, desktop publishers, and CAD and graphic designers who need to keep one hand free for using a mouse.

Letter and number chords can be learned in about an hour. To enter the letter "A," for example, the user simultaneously keys the thumb and first three fingers. Typical typing speeds reach 25 to 45 words-per-minute with one hand.

The *BAT* keyboard with battery backup, including custom carrying case, costs \$199. A 10-minute video demonstration costs \$2.95; the price of the demonstration video will be applied toward the purchase of a keyboard. For more information, contact *InfoGrip, Inc.* at 800-397-0921.

CIRCLE 107 ON FREE INFORMATION CARD

LIGHT-UP REMOTE CONTROL

Late-night TV viewers won't have to fumble in the dark for the right remote-control buttons with *Radio Shack's Light-Up remote*. The keypad lights up on command. The most frequently used controls (volume and channel up/down) are brighter than the others, making it easier to quickly find the correct button.



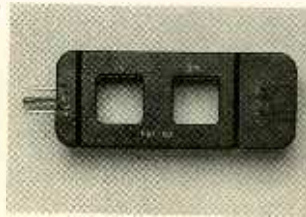
The Light-Up remote can be used to control a TV, VCR, cable box, and one other device. It is programmed to operate your specific equipment by entering the three-digit codes for your models. The owner's manual includes a list of codes for hundreds of models. The remote also works with Radio Shack's Plug 'n Power modules to control lights and appliances around the home.

The Light-Up remote sells for approximately \$29.99 at Radio Shack stores nationwide. For additional information, contact Radio Shack, 700 One Tandy Center, Fort Worth, TX 76102; Tel. 817-390-3300.

CIRCLE 108 ON FREE INFORMATION CARD

LINE SEPARATOR

You can safely monitor AC line current with the *Model 480172 line separator* from *Extech Instruments*. It allows easy access to a two- or three-wire power cord, so that a standard clamp meter then can be used to easily and safely record line



current. The device separates the hot/live conductor from the neutral (and ground) wire. Two- or three-prong plugs can be tested by placing the line separator between a standard wall outlet and a power cord. A $\times 10$ multiplier range allows precise measurements of low current levels.

The *Model 480172 line separator* costs \$15. For additional information, contact Extech Instruments Corporation, 335 Bear Hill Road, Waltham, MA 02154-1020; Tel. 617-890-7740; Fax: 617-890-7864.

CIRCLE 109 ON FREE INFORMATION CARD

HF ANTENNA TUNER

The *Tucker T-1000* antenna tuner operates from 1.8–30 MHz and matches any transceiver or receiver to almost any antenna with up to 300 watts of power-handling capability. It features a large, lighted cross-needle meter that simultaneously measures forward or reflected power and SWR. The metering system measures both peak and average power. A built-in 300-watt dummy load uses a special ceramic construction that actu-



ally becomes more resonant as it heats up.

The T-1000 has an eight-position front-panel switch that allows the user to alternate between two coax-fed antennas (either directly or through the tuner); a balanced line or wire antenna; a bypass position that allows switching directly to the antenna, thereby bypassing the

tuner; two positions that bypass the antenna tuner but keep the SWR/Power meter active; and two positions for the built-in dummy load (tuned or direct). Using the tuned dummy-load position allows the user to preset the tuner for the band in use without causing on-air interference. The tuning system itself uses two large, conservatively rated, continuous-rotation capacitors and a 12-position switched inductor. A heavy-duty 1:4 balun is built-in, along with binding posts for long-wire antennas and SO-239 connectors for coaxial-fed antennas.

The T-1000 antenna tuner has a list price of \$149.95. For further information, contact Tucker Electronics and Computers, 1717 Reserve St., Garland, TX 75042-7621; Tel. 1-800-527-4642.

CIRCLE 110 ON FREE INFORMATION CARD

INSULATION-TEST METER

The *Model DI-2000M* insulation-test meter from *HC Protek* measures insulation resistance as well as AC voltage and continuity. The rugged, easy-to-use meter has a built-in megohm meter with a range of 2–2000 megohms ($\pm 2\%$) at a terminal voltage of 500 volts. The meter measures AC voltage from 0 to 750 volts with $\pm 1\%$ accuracy. Resistance measurements range from 0 to 200 ohms at 0.1-ohm resolution and $\pm 1\%$



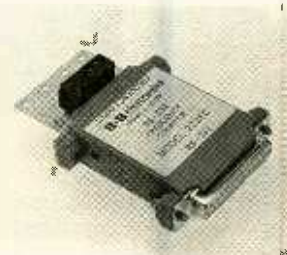
accuracy. Continuity checks are aided by a built-in buzzer. The tester measures $7.5 \times 4 \times 1.75$ inches and weighs approximately 1.3 pounds. It is powered by six "AA" batteries.

The *Model DI-2000M* insulation-test meter, complete with test leads, batteries, strap, and carrying case, costs \$120. For additional information, contact HC Protek, 154 Veterans Drive, Northvale, NJ 07647; Tel. 201-767-7242; Fax: 201-767-7343.

CIRCLE 111 ON FREE INFORMATION CARD

RS-232 FREQUENCY COUNTER

Powered from the RS-232 port handshake lines, the *Model 232FC* frequency counter from *B&B Electronics* allows you to make frequency measurements of TTL-level signals through your RS-232 port. If the handshake lines are not available, a 12VDC external supply can be used to power the converter. The 232FC makes frequency measurements from 5 Hz to 2 MHz and duty-cycle measure-



ments from 5 Hz to 50 kHz. Simple commands allow you to make measurements with your own program. The device is shipped with software that logs and plots frequency and duty-cycle information, and also displays histograms. Sample code in BASIC, Pascal, and C that demonstrates the 232FC commands is provided.

The 232FC frequency counter costs \$69.95. For further information, contact B&B Electronics Manufacturing Company, 707 Dayton Road, P.O. Box 1040, Ottawa, IL 61350; Tel. 815-434-0846; Fax: 815-434-7094; BBS: 815-434-2927.

CIRCLE 112 ON FREE INFORMATION CARD

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Note: Issues prior to November 1988 are "Hands-on Electronics"—the predecessor of Popular Electronics.

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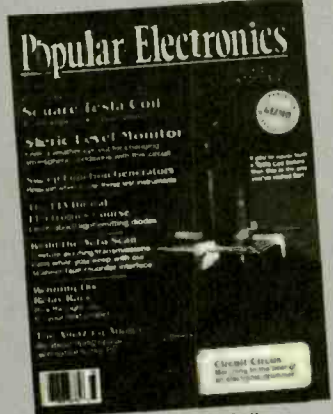
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August 1989

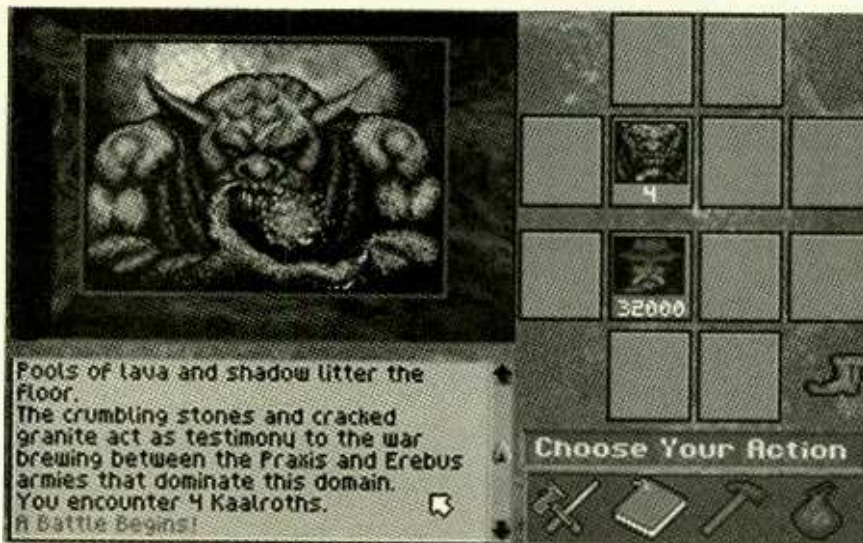


Take a chance on our Dice-Roulette project—
April 1989

THE IMAGINATION NETWORK

(Continued from page 50)

equipment, and how to fight battles. I also answer questions about other aspects of the network, monitor a portion of the bulletin boards to ensure that community standards are maintained, and deal with an occasional troublemaker. We have members from 8 to 80, and INN is first and foremost a family place.



If you are a fan of adventure/role-playing games, you'll love what you will find in MedievalLand, one of the lands in INN.

INN takes great pains to ensure that an enjoyable time can be had by all. If you should, by chance, receive a message from another member that you find offensive, you have the option to click a "complain button." That button records the exact message along with the offender's name and account number for INN personnel to review, and the staff will take action on it, if warranted. Occasionally, something improper gets posted after our daily monitoring, or a member becomes exceptionally unruly, in which case the offending post (or even the member) will be removed when called to our attention.

Some Background. The ImagiNation Network's cyberspace community is continually being expanded and upgraded. It was conceived by Ken and Roberta Williams, the founders of Sierra On-Line Inc. Folklore has it that Ken's grandmother was a person who loved to play cards, but because of her advanced years found it in-

creasingly difficult to get together with her friends for a game. He thought how wonderful it would be if she, and others like her, could always find friends for a game of cards, without needing to leave the comfort of her own home. Based on that concept, INN, (originally called The Sierra Network) was created.

In 1993, AT&T and General Atlantic Partners both invested in The Sierra Network and the name was then changed to The ImagiNation Net-

work. The interest of those larger companies was generated by their intent to use INN as a showcase and testing ground for a variety of on-line computer games, from Sierra and other companies. Many exciting things are planned for the future, but we'll keep those as surprises for now!

I may be biased, but I think that The ImagiNation Network is closer to "virtual reality" than any other computer network that I've explored. It's simple enough for the youngest child to enjoy, yet diverse enough to challenge even the most competitive adult. INN has grown rapidly from just a few hundred members in 1991, and is quickly approaching the 200,000-member mark as this article is being written.

If all that sounds like fun, you can call 1-800-Imagin-1 to obtain the software, which costs \$5.95 and includes a free trial. The basic membership package is \$9.95 monthly with 5 hours of on-line time included. Give the ImagiNation Network a try; I think you will enjoy it immensely. ■

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FREQ.-RESPONSE TESTER

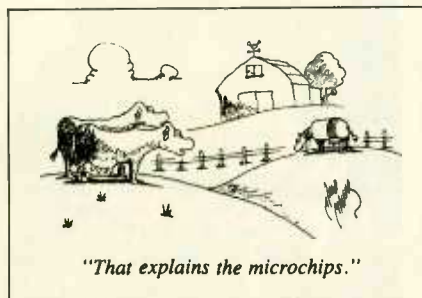
(Continued from page 56)

AUDIO LEVEL control using your scope as a waveform monitor with internal sweep, to make sure no clipping occurs. Switch S2 into SWEEP mode, and set your scope to external sweep as you did during calibration. If you made your own log scale using Fig. 5, set your horizontal gain to match its width. By adjusting the vertical gain, you should be able to see the DUT's response over the entire frequency spectrum.

Here are a few hints: Although the response display seems most easily viewed with SWEEP RATE control R29 set to maximum, the low-frequency portion of the display (the left side) will not be very accurate with that setting. The Tester's lowest output frequency is about 20 Hz. Because that frequency is constantly being modulated, if the frequency increases significantly before a single 20 Hz-cycle is completed, then your test at 20 Hz is invalid. For that reason, the slowest sweep rate should be selected when seriously examining low-end response. A storage scope is of course ideal for that.

Note that the vertical display of your scope simply reads peak-to-peak voltage, which is very different from the decibel scale normally used for audio. To put things in perspective, a 50 percent dip in vertical deflection corresponds to a -3-dB drop when monitoring power amplifiers, and a -6-dB drop when testing almost any other audio device.

Finally, you might wish to occasionally touch up the low-frequency calibration via the access hole you drilled for R24. As before, leave the Tester powered-up for a few minutes before proceeding, and then perform the calibration procedure as previously described. ■



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ELENCO TRAINER

(Continued from page 24)

puts to "see" multiple switch transitions instead of a single one. The logic-switch outputs are conditioned so that only one transition is generated at the output for each throw of the switch.

Also included are 8 LED readouts that can indicate the status, high or low, of up to eight points in a circuit—an 8-bit data bus is one example. The digital section also includes a built-in clock. The clock output is a 5-volt peak-to-peak square wave that can be set from 1 hertz to 100 kilohertz.

All of that is housed in a case that measures about 12 by 16 inches. The case includes a molded well that can be used to store loose parts, and a cord holder is built into the lid.

As you can see, the XK-525 is an invaluable aid in designing circuits. However, as it is a kit, it must be built before it can be used. Let's see what's involved in doing that.

Building the XK-525. As you might

imagine from the above discussion, there's quite a bit to this unit. As a result, building the kit requires quite a bit of work—too much to be completed in just one evening—even a long evening, at a frantic pace. Fortunately, the kit is built in sections that can be done at a leisurely pace, one section per evening, for example. That also makes it ideal for educational situations, as the kit is perfect for electronics students to build one section per class, per week, per course, or whatever.

The assembly instructions, which are clear and easy to follow, are laid out in an order that's designed to catch errors on the way and lead to a properly working unit when finished. Two separate PC boards must be assembled. Neither of the boards are a large project in themselves, and either could be built in one evening. However, one of the boards is built in two stages, and fully tested after each stage.

After that part of the construction is finished, the bulk of the work in assembling the XK-525 is in wiring the different components together. Everything mounts on the back side of a metal front panel, and wires connect things together. It's a lot of work, but well worth it in the end.

While putting together the XK-525 is a big job, it's the kind of activity that many of our readers enjoy. When complete, the result is a very useful instrument for the hobbyist who put it together. Building the XK-525 involves a little bit of everything, from PC-board assembly, to wiring, to mechanical assembly. It's actually a very good kit for someone who's starting to get more serious about his or her electronics hobby; it helps the user brush up on building skills and yields a versatile platform for future digital- and analog-circuit design. For more information on the XK-525 Digital/Analog Trainer, contact Elenco Electronics directly at the address given in the box below, or circle no. 119 on the Free Information Card. ■

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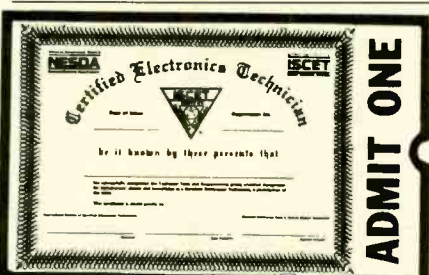
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SIMULTANEOUS EQUATIONS

(Continued from page 48)

putting numerical values for variables $X(1)$, $X(2)$, and $X(3)$. Those numbers are the solutions to the original equations. They represent the unknowns that were located in the first, second, and third columns (respectively) of the standard equation format. Because we were solving for the three node voltages of the circuit in Fig. 1, the computer's output shows us that:

$$\text{Unknown of column 1} = X(1) = V_1 = 18$$

$$\text{Unknown of column 2} = X(2) = V_2 = 42$$

$$\text{Unknown of column 3} = X(3) = V_3 = 24$$

Your version of SIM-EQ should output numbers very close to those listed above, but they might not be *exactly* the same. The reason for that is that every type of computer tends to round-off numbers in a slightly different way during its calculations. After several successive calculations, the amount of the round-off error increases, and hence one computer might output a value of exactly 42, while another might output 41.9996. That is completely normal and is not an indication that you entered the program incorrectly.

Program Description. The SIM-EQ.BAS program consists of five main sections of code that are delimited by asterisk-enclosed comment lines in the program listing. Each of those sections will be discussed below. Also, as an additional aid to understanding how the program works, Fig. 2 is a flowchart of its sequence of logic.

The first section of code in SIM-EQ, which includes lines 100 through 160, initializes the program and prints a brief introductory screen. It also prompts the user to input the number of unknowns in the series of equations to be solved. As indicated, the entered number must be within the range of 1 to 25.

After the number of equations (which is the same as the number of unknowns) is entered, the user is asked to input the values of the coefficients associated with the unknowns. That occurs in lines 220–320. It is important to note that the coefficients are en-

tered by *columns*, top to bottom, and then left to right. If you accidentally enter those numbers by rows you are guaranteed to get incorrect results!

The entering of the "constants of the rows" (i.e. the numbers to the right of the equal signs in the standard equation format) takes place in lines 330–390. After the user enters those numbers, the program then inquires if all the numbers, both coefficients and constants, were entered correctly. If you respond to that question with an "N" or an "n," the program will then prompt you to correct your mistakes. Otherwise, it will continue to the next section of the program.

The heart of SIM-EQ lies in lines 530–790. In that section, a process known as Gaussian Elimination is used to solve the simultaneous equations. Depending on the speed of your machine and the number of unknowns in the equations, that section can take up to several minutes to complete. You might need to be patient.

Once all the Gaussian Elimination calculations are completed, the program proceeds to execute lines 800–900, where the final results are displayed. On occasion, the program might need to print the error statement of line 870, which reads: "ERROR! - Equations can't be solved!" That indicates that either there was a mistake made in inputting the coefficients or constants, or that there are contradictions within the equations you are dealing with.

The following example of a series of "contradicting" equations illustrates the type of problem that would result in an ERROR statement. If you look closely at the following two equations, you will see that they do not agree with one another. One of these equations is obviously incorrect:

$$\begin{aligned} V_1 + V_2 &= 6 \\ 2V_1 + 2V_2 &= 20 \end{aligned}$$

If you ever see the ERROR message, try running the program again on the same data. Then, if you get the ERROR message again, take some time to determine if your original equations are correct. While it might be annoying to get an ERROR message after entering a multitude of numbers into the computer, it's better than solving five or six equations manually, only to discover that your original equations were incorrect! ■

NOVEL NIGHTLIGHT

(Continued from page 38)

× 7 inches each, for the sides of the nightlight. The top is a 7¼-inch square of glass. You will also need to cut four pieces of top molding and four pieces of corner molding, using the dimensions given in Fig. 3.

To assemble the nightlight cover, apply epoxy glue to the inside edges of each piece of molding that you are ready to attach. Carefully fit together the pieces of glass and the mirrors that make up the sides of the box (the mirrors should be adjacent), and hold them firmly in place to allow the glue ample time to dry. When the sides are assembled, glue the top square of glass to the pieces of top molding. After that has fully dried, glue the assembly to the top of the glass box.

The glass cover should be secured to the baseboard, especially if the Novel Nightlight will be used by young children. That can be accomplished in a number of ways. On the prototype, a piece of wire is connected between two small screws on opposite corner moldings. Sliding the wire under the baseboard prevents the cover from being lifted. If you prefer, you can attach small latches on opposite sides of the project, instead.

With the case assembled, you can safely plug in and use the Novel Nightlight. So, put an antique VR tube to good use, and brighten up your evenings while you're at it. ■



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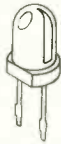
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0.75" diameter X 0.63"

6-32 set screw. CAT # KNB-73

\$1.00 each • 25 for \$ 18.75

3 FLUTE DESIGN W/SKIRT
AND INDICATOR LINE

Alcocnob # KS 500B1/4

0.5" dia. knob with 0.75" dia.

skirt. 0.63" high. 6-32 set screw.

CAT # KNB-75

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7 Vdc MOTOR

Matsushita

MMX- 7AC O 8A

1.25" diameter x 1.25" high

motor. Prepped with 1.61"

diameter flywheel, pulley

and fiberglass mounting

board.

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Special purchase of these 8 ohm, 1 watt speakers allows us to sell quantities at very special low prices. Mounting frame is 2.6" square. Overall depth, 0.75."

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These 6" X 6" glass enclosed photovoltaic panels produce 9 Vdc at 60 ma. Ideal for charging batteries and powering small devices. Put two or more together for more current and voltage. Includes hook-up instructions.

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Projects a bright red spot up to 100 meters. An excellent business or educational aid. Settings for continuous or flashing beam. LED Indicator. Low battery indicator. Includes 2 AAA batteries. Hi-tech ergonomic gun-metal gray and black case.

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Hitachi # LM215B

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13.18" X 4.93" X

1.2". Inside

the housing

and easily

removable

is a stan-

dard Hitachi

480 X 128

graphic and

alphanumeric

display with built-in drivers. Requires an external

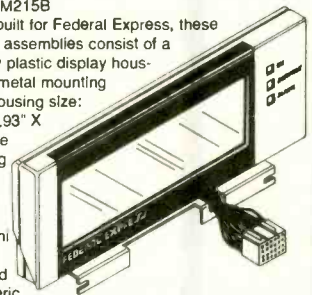
controller (HD61830 or equiv.). Display area is 9" X

2.71." Module size is 10.6"

X 4.33". Includes spec.

and hook-up sheet.

CAT # LCD-24



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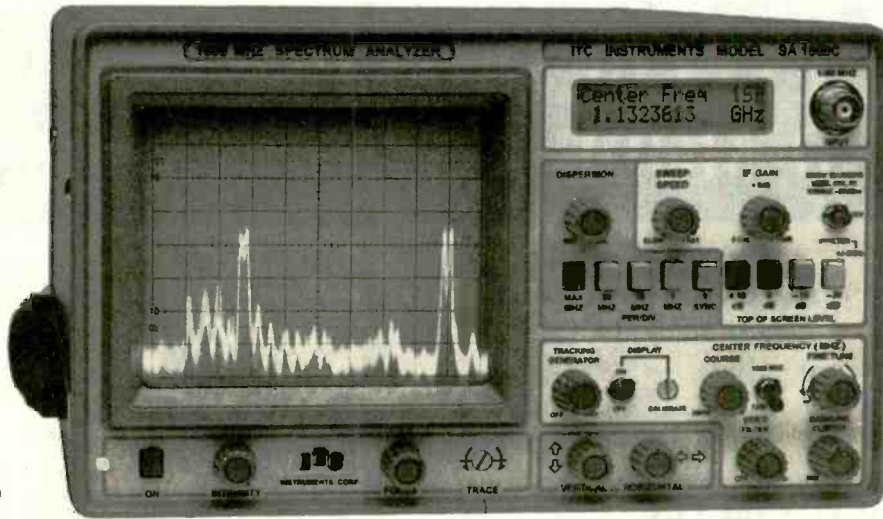


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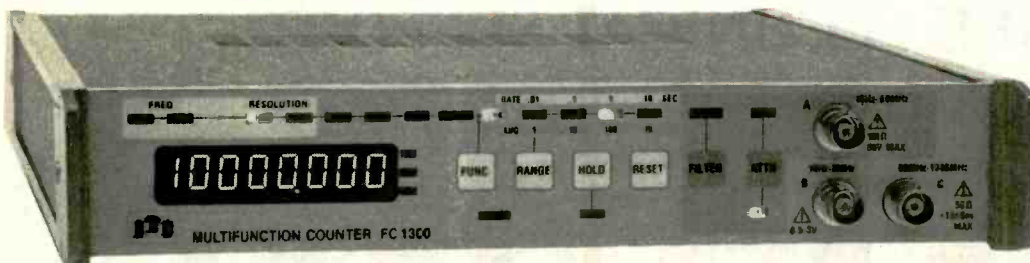
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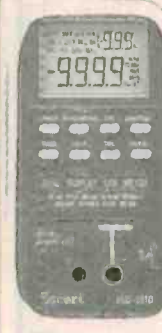


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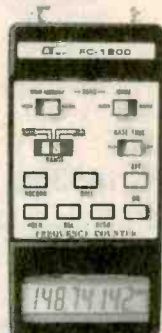
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Most Advanced LCR
Dual display L/C or C/D
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adapter, Sound level meter,
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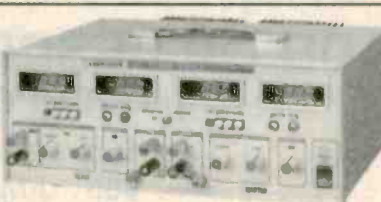


20 MHz Oscilloscope with Delay Sweep PS-205 \$429.95
Dual Trace, Component test, 8" CRT, X-Y Operation, TV Sync, Z-Modulation, CH2 Output, Graticule Illum, 2 probes each has x1, x10 switch. Best price with delay sweep.
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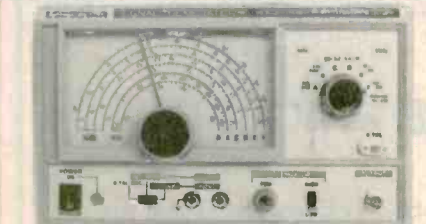
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100 kHz-150MHz sinewave in 6 ranges
RF Output 10CmVrms to 35 MHz
Internal 1kHz, External 50Hz-20kHz
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Audio output 1 kHz, 1 Vrms

AUDIO GENERATOR AG-2601A \$119.00
10Hz - 1MHz in 5 ranges
Output 0-8Vrms sinewave
0-10Vp-p squarewave
Synchronization: ±3% of oscillation frequency per Vrms
Output distortion:
0.05% 500Hz - 50kHz
0.5 % 50Hz - 500kHz
Output Impedance: 600 ohm

FUNCTION GENERATOR FG-2100A \$169.95
0.2 Hz - 2 MHz in 7 ranges
Sine, square, triangle, pulse and ramp
Output: 5mV-20Vp-p
1% distortion, DC offset ± 10V
VCF: 0-10V control frequency to 1000:1



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Generates RF signal same as SG-4160B
6 digit frequency counter 1Hz - 150 MHz for internal and external source Sensitivity <50mV

AUDIO GEN./COUNTER AG-2603AD \$229.95
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INCLUDES
2 AAA Batteries
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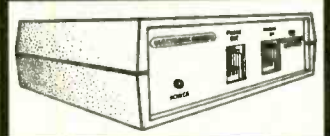
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The Exciting New TELEPHONE MONITOR



Monitors your phone system, See how accurate your phone company really is!

- RECORDS OUTGOING CALLS :**
 - Date & time of each call.
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 - How many times phone rings.
 - If answered the length of call.
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 - Detects any tone on line sent by phone company or any other source.

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EASY TO INSTALL

- Connects to parallel port
- Phone line in.
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All software included!

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TM-1 ONLY KIT

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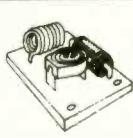
WIDE BAND PREAMP

The ideal preamp for scanners, hand held radios, frequency counters. Amplifies low level

(weak) signals. If the signal is extremely low 2 amps can be used in series. 1MHz to 2.5MHz @ 2.8dB nF 1dB compression = +0 dBm gain: 1MHz-20dB to 2.5Hz-6dB Requires 12VDC @ 16Ma

WBA-6

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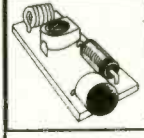


MICRO-MINIATURE PHONE TRANSMITTER

We haven't seen a smaller phone transmitter than the MMPT2 kit. Powered by the phone, it requires no battery. Transmits both sides of a phone conversation to an FM radio up to a 1/4 mile away. Tunable from 88 to 108MHz FM. Attach it to one phone or add it to the line to pick up all incoming calls. The MMPT2 is undetectable if properly installed. Unit has surface mounted parts, you install the leaded parts. Size .45"x.6"

MMPT2

\$29.95



MICRO-MINIATURE WIRELESS MIKE

So small you could hide this one on some real bugs! It's the smallest we've ever seen. With it's super sensitive mike it transmits a whisper or a room of conversation to an FM radio, tunable from 88 to 108MHz FM. With a proper antenna & 9v it transmits about 1 mile. The kit is made with surface mounted parts, we have already mounted these parts. You install the leaded parts. Can operate on 6 to 12v DC. Size .35"x.9"

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WIRELESS FM MICROPHONE

Small but mighty this little jewel will out perform most units many times its price. It really

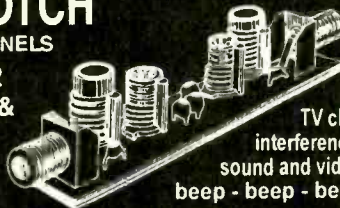
stomps out a signal. The WM-1 kit is a buffered wireless mike that operates from 80MHz to 120MHz FM, the frequency of any broadcast FM radio. Includes a mini-electret mike. SIZE: .8"x1" 6 to 12VDC

WM-2

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2 thru 22 SNOOP & BULLET



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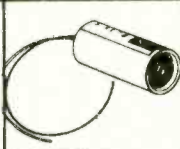
DF-222 Kit

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Own your own FM radio station. Any stereo signal you plug into the FMST-100 will be transmitted to any FM radio tuneable from 76 to 108MHz FM. Transmit a wireless link through an auditorium, from your car to your camper, listen to your cd's while mowing the lawn, Play music on one channel sing on the other. Clarity is excellent, approx. 40dB stereo separation. Length of antenna determines the distance of transmission. Complete with stereo input level controls, & crystal for stereo separation. 9v battery operation

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LDM-5

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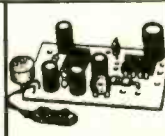
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The robot follows
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Preassembled PCB



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5 pc Solder Ease Kit
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from .1pf to 20,000µf



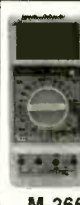
**Digital
LCR Meter
LCR-680
\$79.95**
3-1/2 Digit
LCD Display
Inductance
1uH to 20MΩ



**Function Generator
GF-8026
\$239**
Int/Ext
Operation
Sine, Square, Triangle, Pulse
Ramp, .2 to 2MHz, Freq Ctr



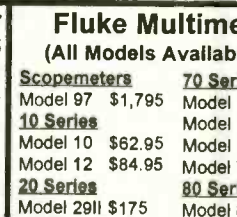
**3-3/4 Digit Multimeter
BK-390
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0.1% DCV acy
Analog bar graph
Auto/manual ranging
Capacitance meas
Temperature probe



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Multimeter Kit
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Full function 34 ranges
Ideal school project
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**Fluke Multimeters
(All Models Available Call)**

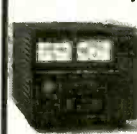
Scopemeters	70 Series
Model 97 \$1,795	Model 7011 \$69.95
10 Series	Model 7311 \$97.50
Model 10 \$62.95	Model 7711 \$149
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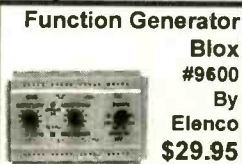


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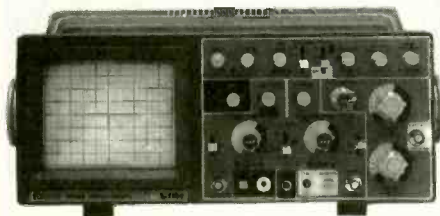
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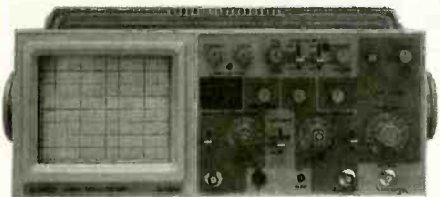
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- 3 1/2 Digit LCD Display
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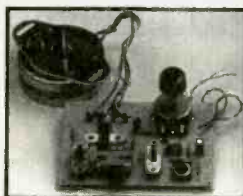
This little gem comes with many fancy features considering its compact size! Light weight and hand held, this unit also tests batteries and diodes. Great for the technician, student and hobbyist alike! SPECIFICATIONS: DC Volts: 2-500V, AC Volts: 200-500V, DC Current: 200mA, Resistance: 2K-OHMS-2MEG.OHMS, Diode Test: 3.2V Max 1=1mA (Diode), Battery Test: 1.5V AA (40mA) - 9V (24mA)



CAT# DM-01 **\$19.95 each**

STEPPER MOTOR CONTROLLER KIT

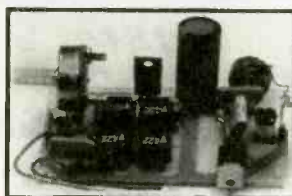
This kit allows you to adjust the speed and direction of a stepper motor. You can move the motor in one step increments or rotate it at a constant speed. There are a set of visual indicators that show the sequence of motion. Includes stepper motor, pc board, parts and instructions. (12vdc power source not included.) CAT# SMK-1



\$25.00 each

STROBE KIT

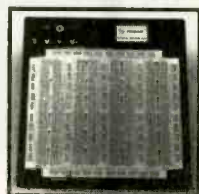
This kit allows you to vary the rate of strobe flashes 60 to 120 flashes per minute. Operating voltage is adjustable depending on how you wire the kit. It will work on 4.5, 6 and 12 VDC. Includes pc board, parts and instructions.



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They were recorded on once and played only a few times. Made by a major brand name manufacturer. Professional series metal tapes. Includes plastic jewel box.

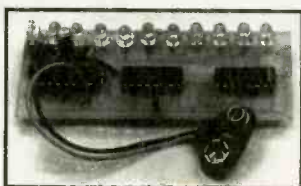


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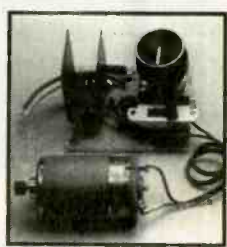


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Easy To Build!

This kit allows you to control the speed and direction of a 6 to 12 volt motor. It is easy to build and includes pc board, motor, parts and instructions.



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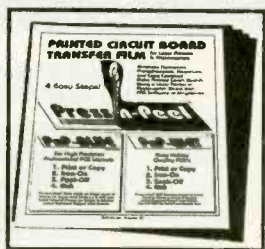


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COMES COMPLETE WITH YELLOW HOLSTER, PROBES, BATTERY, FUSE, STAND

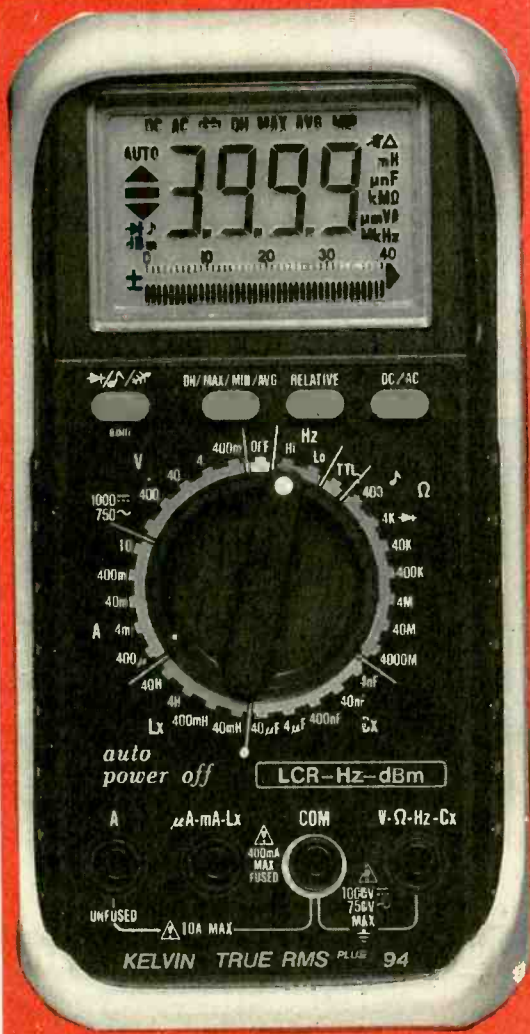
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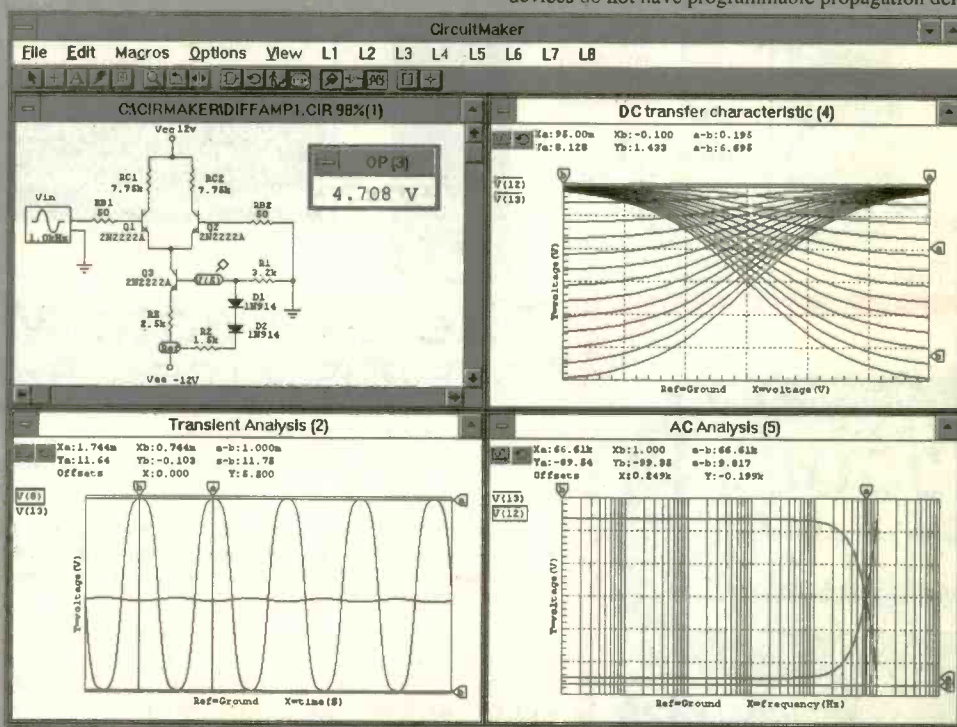
CircuitMaker's analog simulation results are shown in graph windows that provide powerful, interactive analysis options. You can plot multiple waveforms by clicking on the desired nodes and can select linear or logarithmic axes. Horizontal and vertical cursors facilitate quick and accurate measurements. You can also zoom in on any portion of the graph to obtain additional detail.

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Electronic Workbench has no interactive logic probe or Trace capability and no Hex or ASCII keys. Their "word generator" is limited to 16 words. EWB does not have tri-state devices and digital devices do not have programmable propagation delays.



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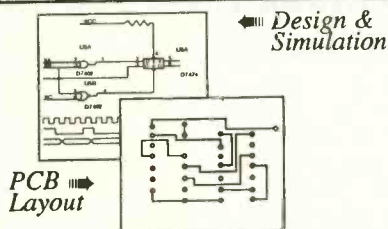
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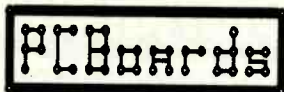
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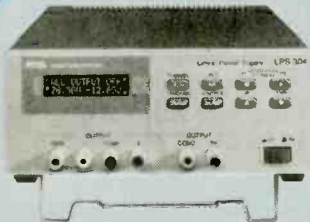
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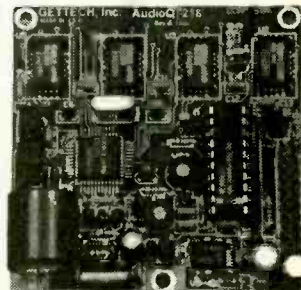
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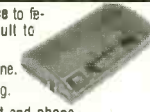


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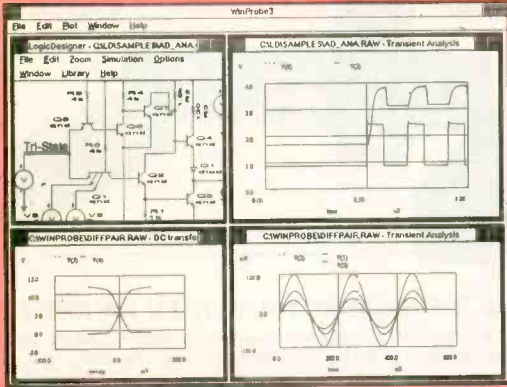
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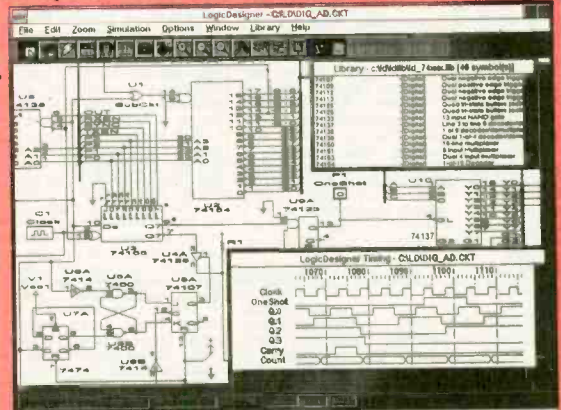
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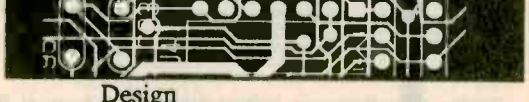
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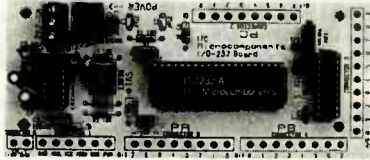
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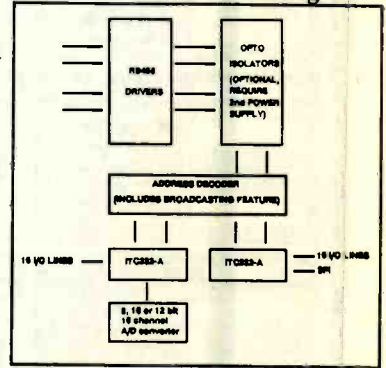
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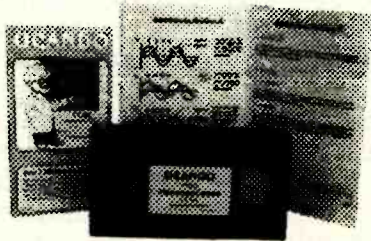
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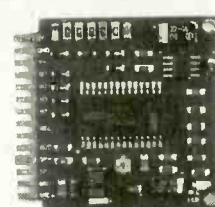


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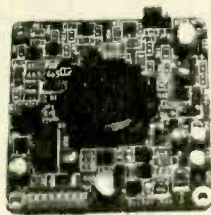
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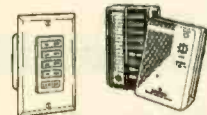
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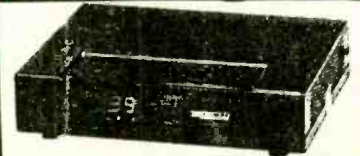
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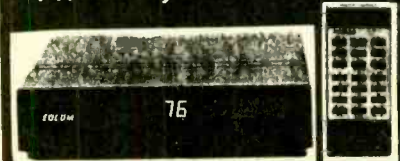
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You know that the Russians secretly installed countless microphones in the concrete work of the American Embassy building in Moscow. They converted

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Stolen Information

The open taps from where the information pours out may be from FAX's, computer communications, telephone calls, and everyday business meetings and lunchtime encounters. Businessmen need counselling on how to eliminate this information drain. Basic telephone use coupled with the user's understanding that someone may be listening or recording vital data and information greatly reduces the opportunity for others to purloin meaningful information.

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Bugs of a very small size are easy to build and they can be placed quickly in a matter of seconds, in any object or room. Today you may have used a telephone handset that was bugged. It probably contained three bugs. One was a phony bug to fool you into believing you found a bug and secured the telephone. The second bug placates the investigator when he finds the real thing! And the third bug is found only by the professional, who continued to search just in case there were more bugs.

The professional is not without his tools. Special equipment has been designed so that the professional can sweep a room so that he can detect voice-activated (VOX) and remote-activated bugs. Some of this equipment can be operated by novices, others require a trained countersurveillance professional.

The professionals viewed on your television screen reveal information on the latest technological advances like laser-beam snoopers that are installed hundreds of feet away from the room they snoop on. The professionals disclose that computers yield information too easily.

This advertisement was not written by a countersurveillance professional, but by a beginner whose only experience came from viewing the video tape in the privacy of his home. After you review the video carefully and understand its contents, you have taken the first important step in either acquiring professional help with your surveillance problems, or you may very well consider a career as a countersurveillance professional.

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