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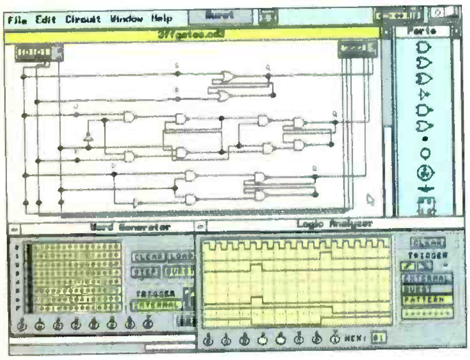

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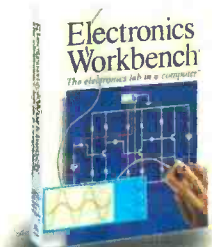

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SEPTEMBER 1994, VOLUME 11, NO. 9

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EDITORIAL

YOU CAN'T PLEASE EVERYONE

Sometimes you just can't win. A letter I received recently essentially trashed virtually everything about this magazine. The writer did not like our advertising ("too much"), consumer and computer coverage, our covers, and more. But one of his complaints really got my goat. That complaint involved projects using microcontrollers, or other relatively expensive ($18 by his definition) or hard-to-get parts.

Electronics is an ever-changing technology. Once upon a time, the only active components were vacuum tubes. Those gave way to transistors and other discrete semiconductors, and from those, integrated circuits of greater and greater complexity evolved. Microcontrollers and other LSI (large-scale integration) components are an extension of that evolution. They make possible projects that otherwise would be prohibitively expensive and complex to build. For example, try putting together the scrolling sign featured in this issue using discrete components. What's more, if you do not want to buy a pre-programmed controller, we always make the code available on our BBS or through the mail.

As for exotic parts, for the most part we insist on at least two sources for hard-to-get components. There are exceptions, of course, such as with the Universal Noise Reduction System in the July, 1994 issue. The availability of a key IC in that project was limited by copyright restrictions; however the source for the IC was selling it at a rather reasonable price. Why publish articles with hard-to-find parts? As with the example cited above, often there is no other way to present the project at all. It is a trade-off we must sometimes make, and we think that it serves the majority of our readers.

Don't get me wrong, there will always be a fair measure of simpler construction projects in this magazine. Each month, Circuit Circus and Think Tank present 6–12 projects built around basic, largely generic components. We also try to include some feature articles and projects that focus on more basic components in each issue. It's all part of our pledge to present a balanced view of the world of electronics.

Carl Laron
Editor

LETTERS

CLOCK CORRECTIONS

There are a few corrections to the "Build a Digital Clock" article that ran in the July 1994 issue. To begin with, the 7-segment displays should be of the common-cathode type. In Figure 2, a short was inadvertently drawn across 10-ohm power resistor R30; that short should be removed. In the same figure, U12-a has an unlabeled pin going to +9 volts; that should be labeled pin 16. Also, pin 2 of U12-a (not shown) should be connected to pin 14 of U12-b.—Editor

PROJECT SCORES AN A+

I am writing concerning John Yacono's article, "Build a Remote-Control Relay Station" (**Popular Electronics**, May 1994). I'd like to commend the author on that ingenious piece of equipment.

As of this writing, I am finishing up my first year in a two-year junior-college electronics program. Part of my final grade for this semester was to write a technical report and give an oral presentation to my classmates on anything dealing with electronics. I chose to build and do my report on the remote-control relay station for two reasons. First, it had a lot of solid-state components that I had been studying about and, second, the room where my TV and VCR are located is extremely long and is subjected to intense sunlight until about 10:00 AM.

I built the device and it worked the first time I applied power. My tech report was given an A+, and my oral presentation received a 99. Both of my instructors were highly impressed with the projects simplicity and versatility, and during my presentation they learned a few things about TV and VCR remote-control devices—namely, how they encode and transmit information. Two upper-classmen are also going to build the device for their own use.

P.J.V.
Coeur d'Alene, ID

HAVES & NEEDS

I'm looking for an operator's manual for an EICO DC wide-band oscilloscope, Model 460. I'll gladly pay for any copying and postage costs. Thank you in advance.

RAY BERKOSKI
General Delivery
APO AE 09601

I'm searching for owner's manuals and schematics for an Allied Radio Electronics Stereophonic AM/FM Receiver, Model A-380, and a Model A-2515 Communications Receiver from the same company. I will be glad to pay any postage and copying expenses. Thank you.

WILLIE C. MARTIN, KE6DKH
43528 Gadsden Ave, Apt. 306
Lancaster, CA 93534

I have a General Electric Radio, Model G-167, serial number 0194. According to its information plate, it consumers 180 watts of power, runs off a 105/125-volt 25-cycle power source, and was made in Canada. I am looking for a schematic diagram and possibly an owner's manual for the radio, as I would like to restore it. Anyone who can be of assistance is welcome to contact me. I am willing to reimburse any shipping and handling charges. Thank you.

RON NIEUWENHUIS
R.R. #1
Gowanstown, Ontario
Canada, N0G 1Y0

I recently acquired a Dumont 190 oscilloscope. The vertical-deflection amplifier output stage is defective. If anybody has schematics or service manuals for this scope, I will pay the necessary costs for photocopies and postage. A user manual would also be useful because this is my first scope and I have no papers on it.

I would also like to get in touch with people who build tube hi-fi equipment.

Thanks!

THOMAS DUNKER, LB2ZE
P. O. Box 2811
7002 Trondheim
Norway

I have been a **Popular Electronics** reader for some time now. I am looking for the schematics, calibration, and repair data for a Heathkit color bar and dot generator model IG-62 and an EICO model 324 signal generator. I will be grateful if any of your readers can help. I will gladly pay all costs.

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MULTIMEDIA WATCH

By Marc Spiwak

CyberMan at Your Command

This month I've got a mixture of hardware and software. Also, just to let you know, I've got a loaner Mac (a *Performa 600*) for about three months. I'm a PC man and don't get to play with Macs very often, so this is somewhat of a treat—or at least a change from my PC. The Performa 600 is about as fast as a 486 SX, so it's not nearly as fast as my 50-MHz PC. However, I am mostly interested in seeing how the Mac handles multimedia applications in general, and not so much in how fast it does them.

CyberMan, from Logitech, offers new dimensions in game control.

I have to say that a Mac really is very easy to set up and use. Without much Mac experience, I had no trouble setting it up and was quickly able to get things done with it. I don't think the same could be said of a Mac user trying to get things done on a PC. Anyway, I'm going to be comparing some multimedia applications that I have for both Mac and PC platforms, and I'll discuss what I find in a future column.

CYBERMAN.

I'm going to be looking at some new—and some bizarre—mouse/joystick substitutes during the next few months. One that I'd like to tell you about this month is the very unusual *CyberMan* from Logitech. CyberMan is sort of like a cross between a mouse, a joystick, and a trackball, with a few additional functions thrown in.

CyberMan offers three-dimensional control for every axis, including pitch, yaw, and roll. A stationary base with plenty of room to support your hand also supports a mouse-like assembly that is free to slide around within a square-shaped recess in the base. The mouse-like part has three buttons on top; the two outside buttons perform the same functions as on a regular mouse, and the middle button defaults to a left-mouse-button "double click." CyberMan is a little bit like a trackball in that its base doesn't move.

The mouse-like top performs X- and Y-axis movements just like a regular mouse. But if you push down on the entire assembly, you can control the Z-axis in the downward direction for times when you might have to "squat down." Likewise, if you lift up on the assembly, you move along the Z-axis in the upward direction for times when you might have to "jump." Twisting the assembly counterclockwise or clockwise controls yaw, allowing you to look, or turn, left or right. Roll occurs when you bend the assembly left or right: this lets you to move left or right or perhaps do a mid-air roll in a flight game. Pitch occurs when you bend the assembly forward or backward, which might move you forward or backward or raise or lower a plane's nose.

As if all that control wasn't enough, Logitech threw in one last feature: tactile feedback. If you either install two AA batteries or connect an optional AC adapter, CyberMan will vibrate at certain times (if you get shot at, for example) provided that the software you're using supports the feature. The feature is more bizarre than useful I think, but at least it invigorates your hand every so often.

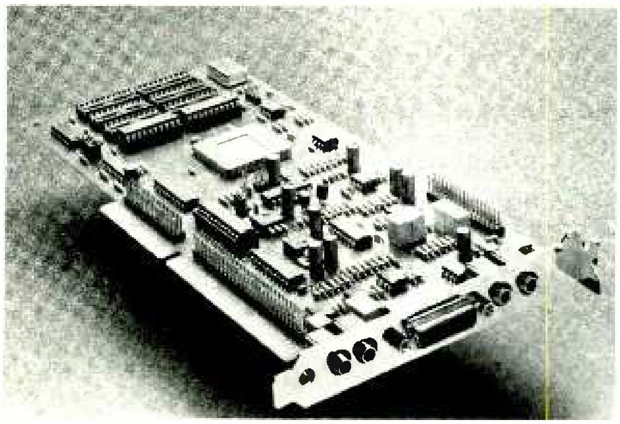
Special CyberMan functions (tactile feedback, pitch, yaw, etc.) must be built into the software you're using, or else CyberMan performs only the same functions as a regular mouse or joystick (more or less). A demo version of an amazing game called *Doom* is supplied with CyberMan. This version of the game provides full CyberMan support. In the game you are a commando on a mission to kill everything that exists on Mars. CyberMan lets you move in any direction and it vibrates when you're fired at.

Limited versions of Doom are actually distributed as shareware, and the idea is that you'll be impressed enough to buy the full-function game. The idea is right on target, as Doom has become one of the hottest games in town. Even the shareware version of this game (which just has fewer levels, but no less functionality) will blow your mind; the sound effects are wild and intense. If you've never played Doom, get your hands on a copy today.

Two other CyberMan-supporting games included are *Shadow Caster* and *The Terminator Rampage*. They are similar to Doom in the way they play, but they don't come close to the realism of Doom. Another program called *Body Adventure* is a fairly interesting multimedia adventure into the human body that doesn't benefit at all from the CyberMan. It was thrown in as a substitute for another game that wasn't ready to be shipped with the CyberMan.

A free serial port is required to use CyberMan. Software for the CyberMan makes it easy to use side by side with your regular mouse, provided you have a free serial port. If you don't have a free serial port, CyberMan will have to replace your mouse. That's not a problem because CyberMan works in DOS and Windows, although it does take some getting used to as a mouse substitute.

CyberMan has a list price of $129, but I've already seen it for sale at close to half that amount. I prefer to use my mouse for most mouse-like functions, but I'd rather use the CyberMan for certain games. If unusual controllers interest you, or if you think you have an application that would benefit from this very different controller, you'll want to get your hands on CyberMan.



The Gravis UltraSound is an inexpensive route to 16-bit wave-table synthesis sound.

GRAVIS ULTRASOUND.

I like to cover products that are as new as possible, but sometimes I receive demo products that deserve mention even though they aren't so new. The *UltraSound* 16-bit stereo sound card from Advanced Gravis, while not new at all, is an excellent sound card available at very reasonable prices—$199 list and around $130 on the street. The UltraSound's low cost should not be confused with low performance, however, as this card features wave-table synthesis and puts out some of the best sound available at any price—especially for MIDI applications.

One drawback with the UltraSound is that it's not the easiest card to set up in a PC. While I don't recommend the card for people unfamiliar with the intricacies of a PC, it's an inexpensive jewel of a sound card for people with higher PC knowledge. Because the card does not directly emulate a Sound Blaster, emulation software included with it must be run to provide Sound Blaster support. That was more of a concern when the card was new on the market, but most new games provide direct UltraSound support for some of the best sound effects you'll hear anywhere. Windows sound is fully supported.

A speed-compensating joystick port is built into the card. That kind of game port is a must for anyone with a fast PC, simply because the standard PC game port is too slow for today's PC's. A speed-compensating port will double your game-playing skills overnight. The speed-compensating port is available in a separate game-controller card from Gravis, but having this feature built into the sound card saves an expansion slot.

By itself the UltraSound is capable of 16-bit CD-quality audio playback, and only 8-bit recording. An optional daughter card adds 16-bit recording capability to the UltraSound. The daughter card mounts directly to the UltraSound board and it requires a unique IRQ and a DMA (different than those used by the UltraSound). The add-on provides full mixer support for Ultra-Sound cards that lack it—cards prior to version 3.7. The software bundled with the upgrade is an excellent addition to any audio hacker's collection. One drawback, though, is that the daughter card blocks an adjacent adapter-card socket. It also covers a connector on the UltraSound that's meant for a CD-ROM drive-card upgrade.

The UltraSound is to be replaced by the time you read this by a new card (the *UltraSound MAX*) that will have the daughter-card capabilities built-in, among other new features. I'll be checking out the new card very soon and I'll let you know what I think.

NEW STUFF.

I've been playing with two great CD-ROM's from Spectrum Holobyte: *Tetris Gold* and *Iron Helix*. Tetris Gold contains every version of Tetris ever produced for DOS, Windows, and the Mac. That includes Tetris Classic, Wordtris, Super Tetris, and more. Any Tetris fan will surely want this disc in their collection. Iron Helix for Windows, an enhancement of the original Mac version, is a fantastic interactive science-fiction adventure. The game takes place in a cold-war future where a deadly biological weapon threatens the entire galaxy. Your job is, of course, to save it. This is one of the neatest CD-ROM-based games I've seen as far as graphics are concerned.

Mad Dog McCree, available through IBM EduQuest, is an arcade-type shoot-em-up game with good live-action video. You play the "Stranger" who just entered town and must save the town from Mad Dog and his men. Readers who grew up playing old-west shooting games at the arcades will really get a kick out of this game.

Microsoft sent me some of their new CD-ROM's, including the 1994 editions of *Cinemania* and *Encarta*. Cinemania is an entertaining interactive movie guide. This disc will hold anyone's interest—anyone who likes movies that is, and who doesn't like movies? This disc makes it easy to search for movie information by title, topic, cast, category, and so on. Thousands of movies are reviewed on this disc. The disc also contains video clips, music, dialog, photos, and the complete text of several prominent printed movie guides. This disc is the perfect companion for any home-video collector.

Encarta is a great multimedia encyclopedia that includes video, pictures, sounds, music, readings, animations, and more. With the complete text of the 29-volume *Funk & Wagnall's* encyclopedia, and thousands of articles exclusive to Encarta at your fingertips, information on any topic is available in seconds.

If you like Schubert, in particular *The Trout Quartet*, check out Microsoft's *Multimedia Schubert, The Trout Quartet*. This illustrated, interactive musical exploration offers a unique way to study this piece of music bit by bit.

King Arthur's Magic Castle from New Media Schoolhouse is a place for children to explore a medieval castle or Merlin's magic-tower workshop, joust against menacing knights on brave steeds, or crawl through a maze of prizes and surprises in the Dungeon of Peril. For jousting, you get to choose your opponent and your horse. When exploring the castle, you can click on any part of the castle or the surrounding area to learn more about its function. The descriptions are spoken. Clicking on items in Merlin's tower activates animation sequences. In the Dungeon of Peril, you collect an inventory of items that prove to be useful as you proceed through a maze.

Capstone has come out with a neat set of kids' games on CD-ROM. The set consists of the games *Trolls* and *An American Tail*. If anything describes the Trolls set of games, it's the phrase "ultra-cute." All of its screens are filled with bright colors, fun animation, and interesting game scenarios. In classic 2-D arcade-game style (like Donkey Kong or Mario Brothers) you help a troll zip around collecting "good stuff" (balloons, yo-yos, and such) and avoid bad things (like naughty clowns and bad dice). There are seven lands (game themes) to visit—Fable land, Candyland, Toyland, Sodaland, Board Game Land, Fairground Land, and Medialand.

An American Tail is an interesting blend of adventure game and live animation. The object is to help Fievel Mousekewitz through a series of adventures in turn-of-the-century New York and the wild West to reach his family. Each screen is animated, but words appear on the screen instead of being heard. The user helps Fievel respond by selecting from a list of choices. This one's hours of fun for kids who can read. ■

Where to Get it

Advanced Gravis
1790 Midway Ln.
Bellingham, WA 98226

Capstone/IntraCorp, Inc.
Airport Corporate Center
7200 Corporate Center Drive,
Suite 500
Miami, FL 33126
Tel. 800-591-5900

New Multimedia Schoolhouse
P.O. Box 390
69 Westchester Ave.
Pound Ridge, NY 10576
Tel. 800-672-6002

IBM EduQuest
4111 Northside Parkway
Atlanta, GA 30327
Tel. 800-758-HOME

id Software
P. O. Box 538
Dallas, TX 75221
Tel. 800-IDGAMES

Logitech
6505 Kaiser Drive
Fremont, CA 94555
Tel. 510-795-8500

Microsoft Corporation
One Microsoft Way
Redmond, WA 98052-6399
Tel. 206-882-8080

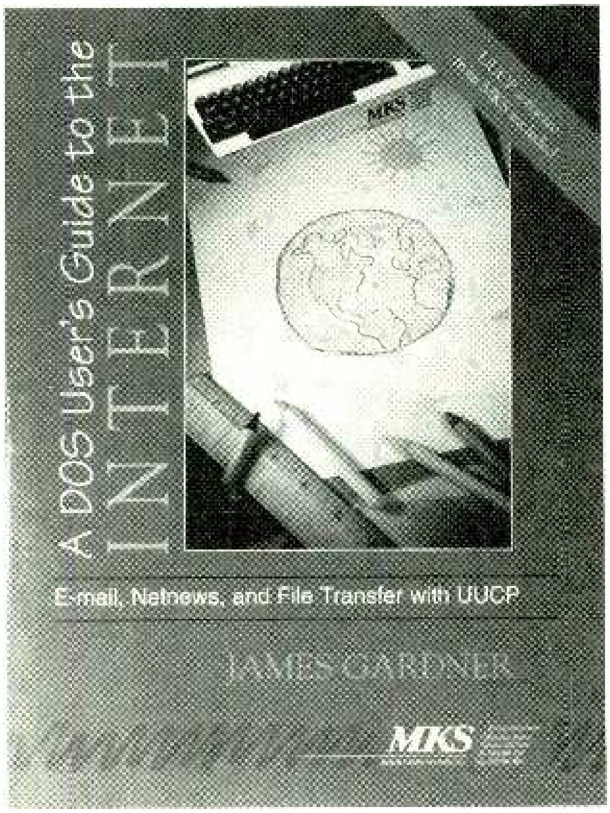
Spectrum Holobyte, Inc.
2490 Mariner Square Loop
Alameda, CA 94501
Tel. 800-695-GAME

ELECTRONICS LIBRARY

A DOS User's Guide to the Internet E-Mail, Netnews, and File Transfer with UUCP

by James Gardner

Bringing the riches of the Internet and the power of advanced UNIX communications software to MS-DOS users, this book provides detailed, hands-on instructions on how to access the Internet using the bundled UUCP software for DOS from MKS. The included software package, MKS UUCP from Mortice Kern Systems, lets DOS users sample various compatible Internet sites. Discount offers from three service providers encourage readers to "test drive" the services described in the book.



Using easy-to-follow examples, the book explains how to send and receive electronic mail across the Internet, how to receive and reply to any of the thousands of news groups on the Internet, how to transfer files over the Internet, and how to send and receive information between the home office and traveling business people. In addition, the book offers an overview and history of the Internet, a review of Internet mailing lists and new groups, and a discussion of "netiquette."

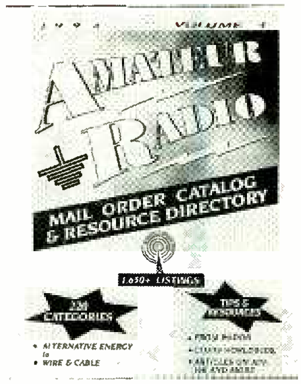
A DOS User's Guide to the Internet: E-Mail, Netnews, and File Transfer with UUCP, including diskette, costs $34.95 and is published by PTR Prentice Hall, 113 Sylvan Avenue, Route 9W, Englewood Cliffs, NJ 07632; Tel. 515-284-6751; Fax: 515-284-2607.

CIRCLE 99 ON FREE INFORMATION CARD

1994 AMATEUR RADIO MAIL ORDER CATALOG & RESOURCE DIRECTORY

from Resource Solutions

This 260-page book combines a catalog of the latest amateur-radio gear and a resource directory filled with valuable facts and articles. Designed to keep hams up to date on who's who in the mail-order business, the catalog contains more than 1650 listings of amateur-radio products from reputable vendors and manufacturers. Many of the 216 categories in the fourth edition of this catalog are new or revised, and every address and phone number has been verified. Categories include everything from bumper stickers, calendars, and ham-equipped bed-and-breakfast inns to antennas to meet any need, test gear, and computer-to-rig-interfaces. The resource directory lists catalogs, radio clubs around the world, bulletin board systems, books, museums, standards associations, worldwide QRP organizations, foreign amateur-radio magazines, and DX hot lines and help lines. How-to articles cover



getting your amateur-radio license, finding amateur-radio satellites, soldering, and ATV. Other articles discuss technical terminology, laser-printer tips, 160-meter antennas, and cable-television interference.

The 1994 Amateur Radio Mail Order Catalog & Resource Directory is available from Resource Solutions, 6050 Peachtree Parkway, Suite 340-228, Norcross, GA 30092; Tel. 404-448-9836; Fax: 404-242-9147.

CIRCLE 90 ON FREE INFORMATION CARD

THE PIRATE RADIO DIRECTORY, Sixth Edition—1994

by Andrew Yoder and George Zeller

Since the beginning of broadcasting, there have been unlicensed, "pirate" radio stations, and their numbers are rapidly increasing every year. Although they are illegal in North America, such pirate stations often provide some of the most interesting, and amusing, programming on the airwaves. Unfortunately, the erratic and sporadic nature of pirate transmissions make them difficult to tune in.

This book details how to find clandestine stations on the shortwave bands, including broadcasts originating from or-

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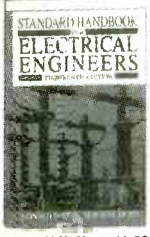

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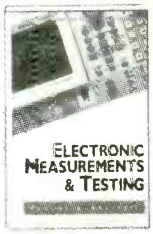

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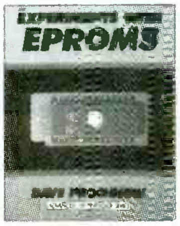

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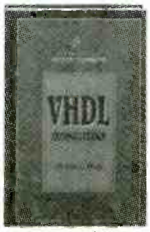

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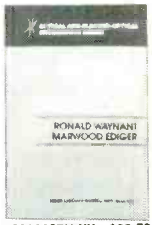

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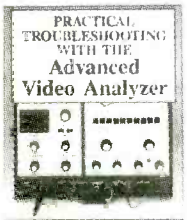

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Softcover

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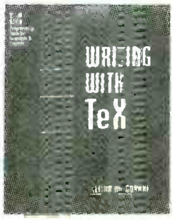
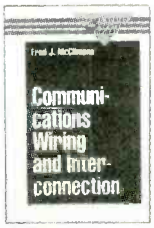


0252076P $29.95
Softcover

9255H-XXX $105.50
Counts as 3

0696217H $50.00



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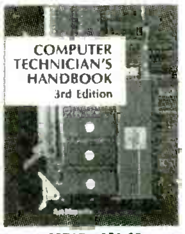
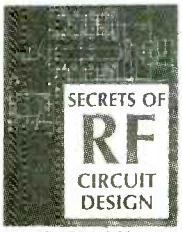
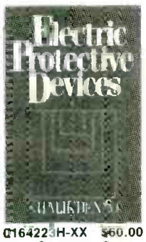


3279P $26.95
Softcover



3710P $19.95
Softcover



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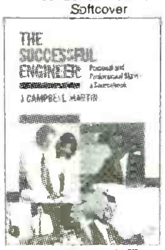
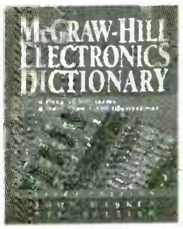


0407258P $30.59
Softcover



0404348H $49.50

028977H $49.00

0415250H-XX $61.50
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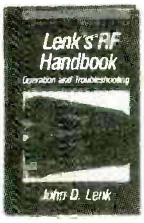
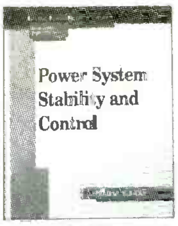


037504H $39.50

4228H $32.95



035958XH-XXX $95.00
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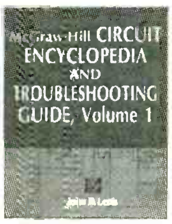

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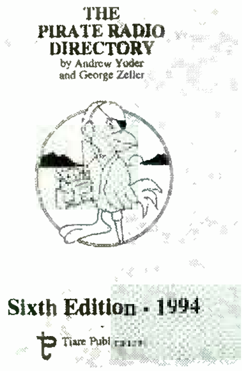


ganizations like the California Marijuana Growers Cooperative, businesses such as Friendly Freddy's Budget Burials, and even from someone in a leaky bathtub somewhere off the coast of North America. The book includes a witty introduction to pirate radio that explains how you can hear and QSL those stations on shortwave. The station section reviews dozens of pirate broadcasters who were active on shortwave last year, with details about their programming styles, relays, QSL addresses, and more. The book also includes a complete index of stations that have appeared in previous editions of the book.

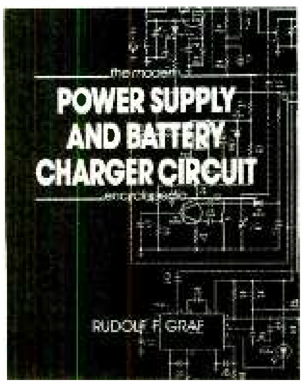
The Pirate Radio Directory costs $12.95 (plus $2 shipping and handling; $3 foreign) and is published by Tiare Publications, P.O. Box 493, Lake Geneva, WI 53147.

CIRCLE 91 ON FREE INFORMATION CARD

THE MODERN POWER SUPPLY AND BATTERY CHARGER CIRCUIT ENCYCLOPEDIA

by Rudolf F. Graf

This book provides readers with quick, easy access to more than 250 ready-to-use power-supply



and battery-charger circuit designs that represent up-to-the-minute circuit technology. It presents a selection of circuits that span the entire range of power supplies—fixed, high-voltage, variable, and more—as well as power-supply monitors and protection circuits. The battery-charger circuits are suitable for use with batteries of different voltages and chemistries. All of the circuits are arranged by applications for easy reference, and appear in their original form to prevent transcription errors. Each entry includes a schematic and a brief description of how the circuit actually works. For those who require more detailed information, listings of the original source for each circuit appear in the back of the book.

The Modern Power Supply and Battery Charger Circuit Encyclopedia costs $10.95 and is published by Tab Books Inc., Blue Ridge Summit, PA 17294-0850; Tel. 800-233-1128.

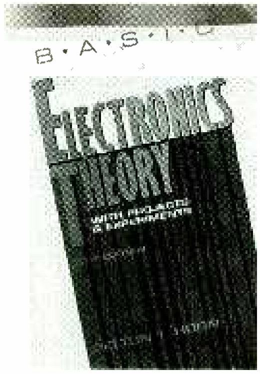
CIRCLE 98 ON FREE INFORMATION CARD

BASIC ELECTRONICS THEORY WITH PROJECTS & EXPERIMENTS; 4th Edition

by Delton T. Horn

Updated to keep pace with the rapidly growing field of electronics, the fourth edition of this book contains almost all of the material found in earlier editions, and a significant amount of new material. The sections on personal computers and troubleshooting have been expanded, and new chapters on TV's and VCR's have been added. Also new to this edition are discussions of computerized test equipment, laser diodes, VMOS transistors, logic-family interfacing, new computer microprocessors, Digital Audio Tape, and high-definition TV.

This combination introductory textbook and one-volume reference source functions as a complete, self-paced electronics course for hobbyists, students, and beginning-level technicians. Its focus is on the basics and some of the more important specialized areas of today's electronics. The book begins



with an introduction to those aspects of atomic physics and electrical theory that are relevant to electronics, and goes on to cover common electronic components, basic circuit types, and applications of modern electronics. To enhance the learning process with hands-on experience, several practical, do-it-yourself experiments are included. Tests at the end of each chapter help readers gauge their progress.

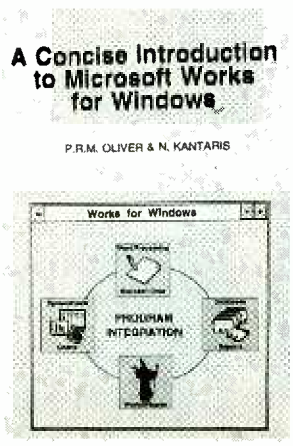
Basic Electronics Theory with Projects & Experiments costs $24.95 and is published by Tab Books Inc., Blue Ridge Summit, PA 17294-0850; Tel. 800-233-1128.

CIRCLE 98 ON FREE INFORMATION CARD

A CONCISE INTRODUCTION TO MICROSOFT WORKS FOR WINDOWS

by P.R.M. Oliver and N. Kantaris

Written with the novice user in mind, this book explains how to come to grips with Microsoft Works for Windows, with the least amount of time and trou-



ble. All functions and keyboard commands are detailed in the book. It is formatted in self-contained chapters, beginning with a look at how Works fits into the general Windows environment.

The book goes on to explain how to use the word processor to advantage to type, edit, enhance, print, and save documents; how to use Draw to handle graphics within documents; and how to build up simple spreadsheet examples and then edit, save, print, and retrieve them. The book shows how to generate, edit, and print single and multiple types of graphs. It also explains how to set up, sort, and search a database-management system, and how to use it to create top-quality printed reports.

A Concise Introduction to Microsoft Works for Windows (order number BP343) is available for $7.95 plus $2.50 shipping and handling from Electronics Technology Today Inc., P.O. Box 240, Massapequa Park, NY 11762-0240.

CIRCLE 97 ON FREE INFORMATION CARD

WINDOWS NT PROGRAMMING HANDBOOK

by Herbert Schildt

For those who would like to get started with applications development under Windows NT, this comprehensive volume can replace stacks of overly technical, confusing documentation and manuals. Opening with an overview of Windows NT and programming basics, the book then discusses such fundamentals as messages, bitmaps, menus, graphics, dialog boxes, and controls. The book also covers several functions unique to Windows NT, including consoles and multithread programming, as well as special conversion notes to help those programmers porting older 16-bit Windows applications to NT.

Windows NT Programming Handbook costs $29.95 and is published by Osborne McGraw-Hill, 2600 Tenth Street, Berkeley, CA 94710; Tel. 510-549-6600; Fax: 510-549-6603. ■

CIRCLE 92 ON FREE INFORMATION CARD

special project

READERS: TELL US WHAT YOU THINK ABOUT THIS ISSUE

Are you interested in helping us make this magazine as good for you as it can be? Then be one of the first to join the 1994 *Popular Electronics Reader Council*. Twice a year you'll be asked to complete a detailed questionnaire. It will tell us about the things in this magazine that are important to you and give us the information we need to make this your best possible reading.

If you would like to be considered for this special *Popular Electronics* project, take a few minutes to answer the questions on this page and return it to us.

While we cannot accept everyone, we will randomly select our participants, giving each one of you an equal chance of being selected.

Please mail the completed questionnaire no later than November 30, 1994, to:

Total Recall Research Group
Box 4079
Farmingdale, NY 11735-9622

Thank you, and I am looking forward to hearing from you!

Larry Steckler,
Editor-in-Chief

1. **Where did you get this magazine?**
   Subscription ☐ Newsstand ☐

2. **Are you:**
   Male ☐ Female ☐

3. **How old are you:**
   I am ______ years old

4a. **Highest education achieved?**
   Attended technical school ☐
   Graduated technical school ☐
   Attended College ☐
   Graduated College ☐
   Earned PhD ☐

4b. **Do you**
   Hold FCC license ☐
   Hold other license, Certif. ☐

5. **What is your total household income?**
   Total household income, before taxes is $ ______________

6. **Name the article in this issue that you liked the best.**
   ____

7. **Name the article in this issue that you liked the least.**
   ____

8. **Name the department or regular column in this issue that you liked the best.**
   ____

8a. **Name the department or regular column in this issue that you liked the least.**
   ____

9. **Do you earn your living working in the electronics industry?**
   Yes ☐ No ☐

10. **If you were the editor, would you make the articles:**
   More complex ☐
   Simpler ☐

   Longer ☐
   Shorter ☐

   More build it ☐
   Less build it ☐
   More how to ☐
   Less how to ☐

11. **What articles would you publish?**
   ____
   ____
   ____
   ____

12. **What new columns would you add?**
   ____
   ____
   ____
   ____

13. **What else would you change?**
   Use a separate sheet for your comments. Please give as much detail as possible.

Name ______________
Address ______________
City ______________
State, Zip ______________

NEW PRODUCTS

Palm-Sized World-Band Receiver

Whether you take frequent business trips, are planning a globe-trotting vacation, or prefer "armchair travelling" from the comfort of your own home, *Sony's ICF-SW100S* world-band receiver can help you keep up with news and events from around the world or around your town. The rugged, battery-powered receiver weighs just eight ounces, making it easy to take on the road. The ICF-SW100S can receive long-, medium-, and short-wave signals, as well as FM stereo. Its active antenna for shortwave reception helps pick up the clearest signal even in environments that typically have poor reception.

The receiver provides accurate information about time, broadcasting stations, and frequencies. Once the user inputs the local time, the built-in world clock can display the correct time of 24 major cities around the world. An LCD readout displays the names of broadcasting stations and their frequency numbers. Up to 50 different frequencies can be stored in the receivers memory, so the user can preset several different frequencies for each station and call up the most suitable one depending on the time or the season. The receiver's stand-by function has two timer settings so that favorite programs won't be missed.

The ICF-SW100S world-band radio receiver, complete with AC adapter, has a suggested retail price of $449.95. For more information, contact Sony, 1 Sony Drive, Park Ridge, NJ 07656.

CIRCLE 100 ON FREE INFORMATION CARD

"INFORMATION SUPERHIGHWAY" TELEPHONE

U.S. Order's PhonePlus is a multiservice telephone that lets people pay bills, shop from catalogs, and conduct banking transactions without leaving their homes. The devise is a speakerphone that has 256K memory, a 32-bit Motorola 68000 CPU, a full alphanumeric keyboard, and encrypted credit-card and ATM reader, Caller ID name and number display capability, personal-organizer functions, a 4-line by 20-character display with eight application "softkeys," and one-touch visual access to advanced telephone services such as Call Forward, Return Call, and Three-Way Calling. Personal-organizer functions include a visual and audible reminder for dates, appointments, and events; an integrated directory with autodial and storage for up to 250 names, addresses, and phone numbers; a call timer; and an available data back-up service.

PhonePlus users have password-protected access to services such as BankPlus and ShopPlus, which have a one-time activation charge and a monthly fee of less than $15. BankPlus is an electronic bill-payment service that also allows users to review their account activity and transfer funds by running their ATM cards through the built-in magnetic stripe reader. With ShopPlus, users can order from any catalog in print, and will receive a cash bonus with each PhonePlus transaction.

EmailPlus and InfoPlus will be added in the fourth quarter of 1994. EmailPlus will allow consumers to send e-mail notes through the Internet and to transmit faxes without using a PC or fax machine. InfoPlus will provide one-button access to sports scores, weather reports, stock-market reports, news, horoscopes, and trivia.

The PhonePlus telephone has a suggested retail price of less than $200. For more information, contact US Order, 13873 Park Center Road, Suite 230, Herndon, VA 22071; Tel. 703-834-9480; Fax: 703-834-9668.

CIRCLE 101 ON FREE INFORMATION CARD

OYSTER HANDHELD THERMOMETERS

Available for Type J, K, or T thermocouple inputs, *Extech's Model 43134* handheld thermometers feature an exclusive "Oyster"-design case. The rugged, impact-resistant Oyster case offers a half-inch LCD readout, an adjustable flip-up cover, and automatic shutoff when the cover is closed. The thermometers offer fast response times (0.25 seconds) and are accurate to 0.25% of the reading plus one digit. Measuring ranges are −60–1999°F for Type K, −60–1400°F for Type J, and −150–400°F for Type T. Each unit measures 3.7 × 4.2 × 2 inches and runs on a 9-volt battery or an optional AC adaptor. They can be used on the benchtop or for handheld applications, and the included

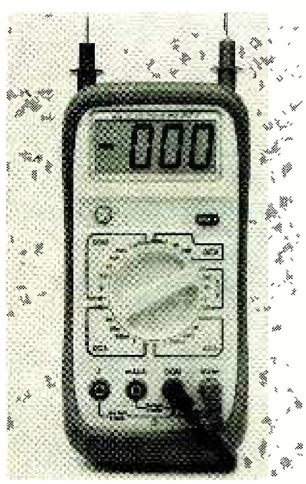
neckstrap allows hands-free operation. A bead-wire temperature probe is also included.

The Type J *Model 43134J* costs $89; Type K *Model 43134K* and Type T *Model 43134T* each cost $99. For further information, contact Extech Instruments Corporation, 335 Bear Hill Road, Waltham, MA 02154; Tel. 617-890-7440; Fax: 617-890-7864.

CIRCLE 102 ON FREE INFORMATION CARD

DIGITAL MULTIMETER

The *DM383* digital multimeter from *Universal Enterprises, Inc. (UEI)* measures up to 1000 VDC, 750 VAC, AC/DC current, resistance, diodes, and continuity. Its 200-mA range allows measurement of most flame safeguard systems. The DM383 offers a 0.91-inch, 2000-count LCD readout and a color-coded front panel. Other features include auto-polarity, data-hold, overrange indicator, low-battery indicator, an audible continuity buzzer, and a diode-check function. The digital multimeter was designed to meet UL and IEC safety standards and to withstand a 10-foot drop. A unique "boot" that allows the user to



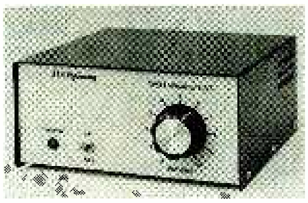
hang the DMM or position it on a flat surface with an adjustable tilt stand also serves as a probe and lead holder. Probes snap into the boot and leads wrap neatly around it for storage.

The DM383 digital multimeter has a suggested trade price of $49.95. For additional information, contact UEI, 5500 SW Arctic Drive, Beaverton, OR 97005; Tel. 503-644-8723.

CIRCLE 103 ON FREE INFORMATION CARD

WEATHER FAX PC INTERFACE

Available in kit form or fully assembled and tested, *A & A Engineering's Weather Fax* PC-compatible interface connects between the speaker of a satellite receiver (137 MHz or 1.69 GHz) or a HF SSB shortwave receiver and the computer's standard parallel printer port. Once connected, it will process HF ad satellite weather fax.



The interface consists of a satellite fax demodulator, a HF fax demodulator, a digitizer, a printer port, and a triple-output power supply. An optional 20-LED tuning indicator is available. The aluminum enclosure is pre-punched, painted, and lettered.

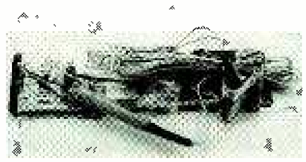
The included software will run on any PC/XT/AT/PS1/PS2-compatible computer with at least 640K of RAM and one floppy drive, parallel port, and a VGA display. To keep up with the satellite data stream in terms of real-time imaging, a 10-MHz 286 system or better is required.

The *WSH Weather Fax* interface costs $159.95 in kit form or $189.95 complete. The 20-LED tuning option adds $40 to the price. U.S. shipping charges are $6.50. For more information, contact A & A Engineering, 2521 West LaPalma, Unit K, Anaheim, CA 92801; Tel. 714-952-2114.

CIRCLE 104 ON FREE INFORMATION CARD

12-VOLT SOLDERING IRON

The *Antex MLXS* soldering iron from *M.M. Newman Corporation* is an industrial-grade, 25-watt iron that connects to any automotive or marine 12-volt battery to provide safe soldering without butane or flames. Two alligator clips connect to the battery terminals, and a 15-foot cord provides mobility. The heating element is located under the tip for optimum thermal efficiency, and heats up to 800°F in less than two minutes. The MLXS comes complete with a tip, solder, and a plastic carrying case.



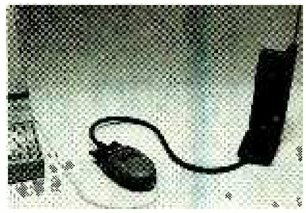
The Antex MLXS 12-volt soldering iron has a list price of $31.95. For additional information, contact M.M. Newman Corporation, 24 Tioga Way, P.O. Box 615, Marblehead, MA 01945; Tel. 617-631-7100; Fax: 617-631-8887.

CIRCLE 105 ON FREE INFORMATION CARD

INTELLIGENT CELLULAR/DATA LINK

ORA Electronics' Intelligent Data Equipment Adaptor (I.D.E.A.) allows any modem or fax machine to be connected to a portable cellular phone, automatically sending data or faxes as easily as by standard phone lines. The microprocessor-controlled system generates a dial tone, controls the functions of the cellular phone, and provides a standard RJ-11 interface for modem or fax connections. The system is completely transparent to the modem or fax machine and works with all popular communications and fax software packages. It does not require additional software and can be used with any modem-equipped computer or fax machine with an RJ-11 interface. The I.D.E.A. is powered by a 9-volt battery. To extend battery life, a built-in power-management feature shuts off the unit when not in use.

The system is available for most popular portable cellular



phones, including those built by AT&T, Motorola, NEC, OKI, and others. It comes with a phone-specific adaptor cable, a modular telephone cord, a 9-volt battery, and a user's guide. The modular design allows it to be used with other models of portable cellular phones by attaching an optional cellular-phone adaptor cable.

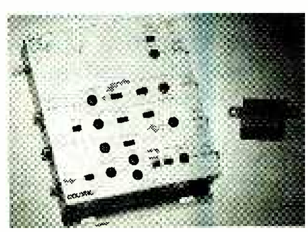
Suggested retail prices for the I.D.E.A. intelligent cellular/data link start at $249.95, depending on the phone model. For more information, contact ORA Electronics, 9410 Owensmouth Avenue, Chatsworth, CA 91311; Tel. 818-772-2700.

CIRCLE 106 ON FREE INFORMATION CARD

MOBILE ELECTRONIC CROSSOVER

The *XM-5e* mobile electronic crossover from *Coustic* provides a high degree of system flexibility, control, and fidelity. The two/three-way crossover uses an exclusive high-fidelity crossover slope technology said to provide dramatic improvements in staging and imaging abilities. The high-pass section uses an adjustable slope of 6 or 18 dB per octave, which allows the user to better tailor the response of the speaker. The low-pass section uses a fixed 18-dB slope to minimize the unwanted high-frequency content of the subwoofer while maintaining optimum phase and amplitude response characteristics.

The XM-5e offers subwoofer-enhancement features called Bass Drive and Bass Shaper. With Bass Drive, a remotely



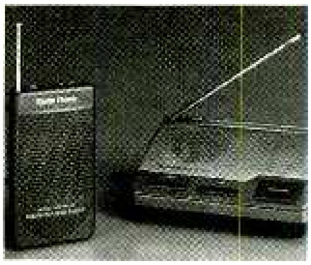
operated subwoofer level control allows the user to dial in the extra bass level needed to overcome the masking effects of road noise. The Bass Shaper allows the user to "customize" the sound of any woofer/enclosure combination with two controls for boosting any frequency from 25 to 250 Hz from zero to 12 dB. The XM-5e also offers a flexible bandpass section for three-way system designs, as well as a rear channel to enhance sound-stage ambiance. Other features of the crossover include a pulse-width modulated switching power supply, a frequency multiplier, and gold-plated RCA connectors for all inputs and outputs.

The XM-5e mobile electronic crossover has a suggested retail price of $249.95. For further information, contact Coustic, 4260 Charter Street, Vernon, CA 90058-2596; Tel. 213-582-2832 or 800-227-8879; Fax: 213-582-4328.

CIRCLE 107 ON FREE INFORMATION CARD

WEATHER RADIOS

Bad weather can be more than an inconvenience; Tornadoes, hurricanes, or floods can threaten your home or even your life. Two *Radio Shack Weatheradios* can keep you posted as to National Weather Service broadcasts throughout the United States. The radios monitor local forecasts, storm warnings, and traveler's advisories issued by the National Weather Service, 24 hours a day. Both the desktop and the portable, pocket-sized models feature an alert mode that sounds an alarm whenever the local weather station broadcasts a special signal indicating a weather emergency. If you are away from your Weatheradio, an alert lock provides a continuous tone to indicate that a weather bulletin was issued while you were out of hearing range. The desktop model operates on AC power with 9-volt battery backup (not included) for uninterrupted listening during a power failure. The pocket model uses three



"AA" batteries. Both models have built-in antennas.

The Weatheradios with alert mode are priced from $29.95 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

TRUE-RMS BENCHTOP DIGITAL MULTIMETER

For use in electronics service and production tests, *Wavetek's Model BDM40* 4½-digit, true-RMS digital multimeter features AC and DC voltage measurement in six ranges to 20 megohms and a diode test range. The true-RMS measuring circuit is pushbutton selectable for AC or AC plus DC coupling to assure accurate measurements. All functions and ranges are selected using interlocking front-panel pushbuttons. For user safety and convenience, input jacks are boldly labeled and the 2-amp jack is fully fused.

The Model BDM40 digital multimeter, complete with test leads, power cord, and a comprehensive instruction manual, costs $429. For further information, contact Wavetek Corporation, 9045 Balboa Avenue, San Diego, CA 92123; Tel. 619-279-2955. ■

CIRCLE 109 ON FREE INFORMATION CARD

A Hands-on Electronics® REPORT

ELENCO MM-8000 MICROPROCESSOR TRAINER

CIRCLE 119 ON FREE INFORMATION CARD

Learn how microprocessors work by building a computer from the ground up.

It can't be disputed that today, in order for someone to claim that they're proficient in the field of electronics, a general knowledge of microprocessors is a must. Microprocessors are found in more and more gadgets each day, and anyone considering a career in circuit design—or even just servicing—absolutely must be familiar with microprocessors.

Sometimes microprocessors end up in embedded applications such as in digital car stereos and microwave ovens. (Those microprocessors coordinate user inputs from switches on the device's front panel and inputs from various sensors inside the device.) Other times, microprocessors are used in more general-purpose computers that can perform many different tasks depending on the instructions they're given. Of course, their versatility and popularity are what make learning about them important.

There are lots of different ways to learn about microprocessors, and many people turn to magazines like this one to learn what they can about them. However, the best way to learn about anything is with hands-on experience, and some of the best hands-on experience you can get with microprocessors is with the *Micro-Master MM-8000 Microprocessor Trainer Kit* from Elenco Electronics, Inc. (150 West Carpenter Avenue, Wheeling, IL 60090-6062; Tel. 708-541-3800).

The MM-8000. The MM-8000 is a complete computer system that you build from scratch. It teaches you how to write to RAM and ROM, and how to run an 8085 microprocessor. In these days of cheap 486 PC's, it's easy to forget that the Intel 8085 started it all when it was used in the first 4.77-MHz IBM PC's. The 8088 was later used in the "faster" XT's, then came the 286, the 386, the 486, and now the "586," or more precisely the Pentium.

The "lowly" 8085 performed many a task on many a desktop in its day, and you'd be surprised how many 8085's are still in use. In fact, while you wouldn't want an 8085 in a new computer, they're more than powerful enough for a microprocessor trainer. An 8085 can provide a great deal of insight into how the more complicated microprocessors in the lineup work. It's actually the ideal microprocessor for such an application.

The MM-8000 lets you write instructions for the 8085 microprocessor and store them in permanent memory. You learn about input and output ports, timers, how to scan displays and keyboards, and you eventually learn how to write machine-language programs. In addition to the 8085 microprocessor, the MM-8000 houses a 2816 EEPROM (electrically erasable, programmable read-only memory) and an 8156 2048-bit (2K) static RAM (random-access memory). The finished unit, which includes a built-in 5-volt power supply and a 28-key keyboard, is housed in a rugged black plastic case. Two empty DIP sockets on the board provide direct access to the I/O ports for various purposes. Also included are eight LED data-bus indicators, eight data switches, four control switches, and two 7-segment LED displays. A thick, well-written

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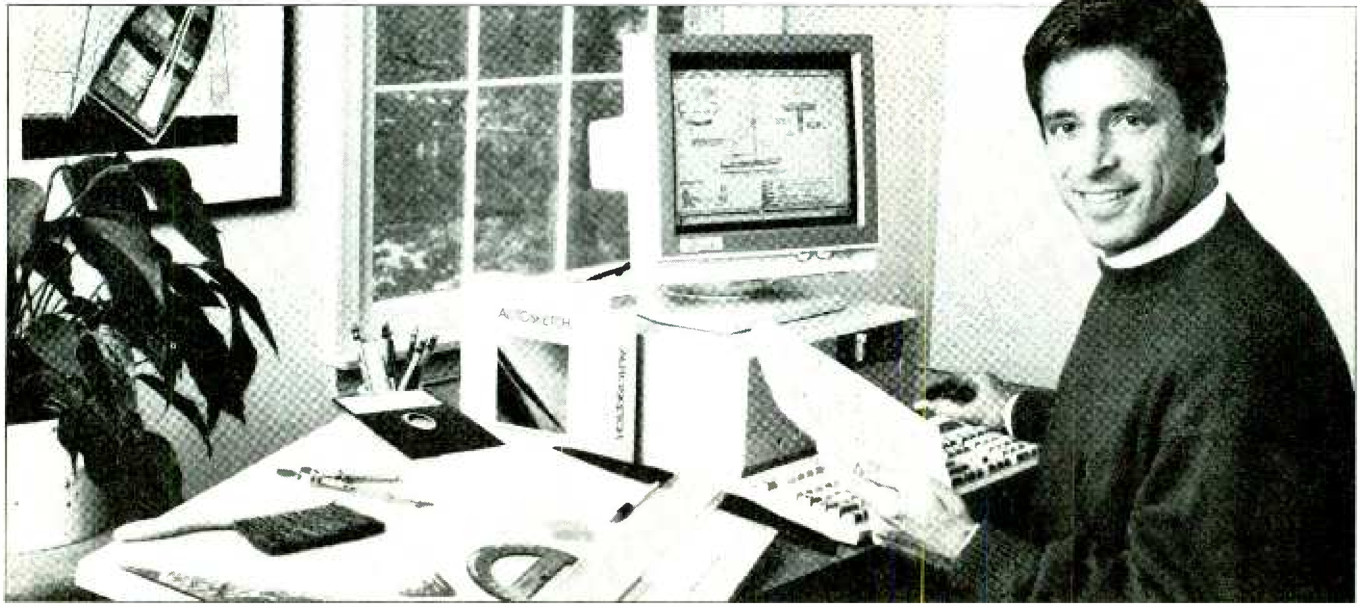

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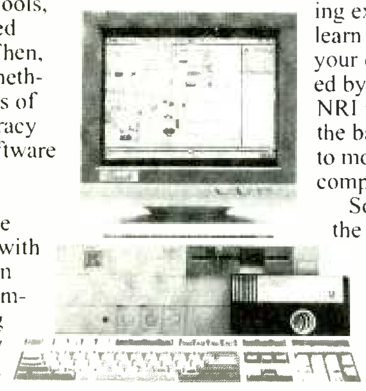

circuit boards — indeed, virtually anything you'll be called on to produce on the job — at the drafting table or your computer terminal.

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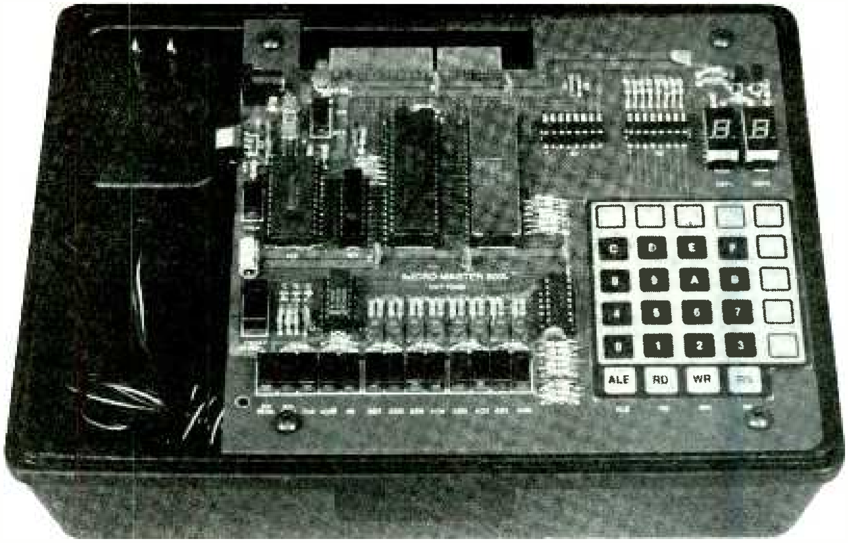


The keypad connects to the microprocessor, the microprocessor connects to the memory. Put all the pieces together and you end up with a working computer!

lesson/instruction manual and AC power pack completes the package—at a very reasonable price of $129.95.

A Hands-On Approach. What we found most interesting about the MM-8000 is its very effective hands-on approach that makes it easy to understand how microprocessors work. All you need to build the MM-8000 is basic assembly tools—a soldering iron, desoldering tool, needle-nose pliers, cutters, screwdrivers—and some experience building electronic kits, particularly ones containing IC's. A handful of IC's must be soldered onto a PC board, including two 40-pin chips, and careful soldering is a must. Anyone with no prior soldering experience should not learn how to do it with this kit. You'll also need many evenings of quiet concentration to fully understand the MM-8000, although the actual assembly time is only a few hours. What you don't need to build the MM-8000 is any prior knowledge of microprocessors or computers—that's what you learn by building it.

The operating theory behind the MM-8000 computer is discussed before any assembly begins. A page of soldering tips is also included in the lesson manual although, as we said before, one should already know how to solder before building this kit. The MM-8000 must be built in steps according to instructions. That's because each section of the circuit is explained, built, and tested, before continuing with the next. Certain jumpers are soldered in place in one step, only to be removed in another after their job is done. (A jumper's job is usually to let you manually test a feature that will later be controlled by the microprocessor.)

This step-by-step assembly technique is what makes understanding computer circuitry so easy and entertaining. For example, first the power-supply/distribution circuitry is discussed, installed, and tested. Next, memory is installed and manually tested. During testing, a section is operated manually so that the builder knows exactly what the microprocessor will have to do to perform the same task. This assembly process also increases the chances of finding and fixing any problems.

By the time all the parts are installed, the builder has an intricate knowledge of the MM-8000's circuitry and the 8085's complete instruction set. After that, more and more complex routines are covered until complete programs are up and running.

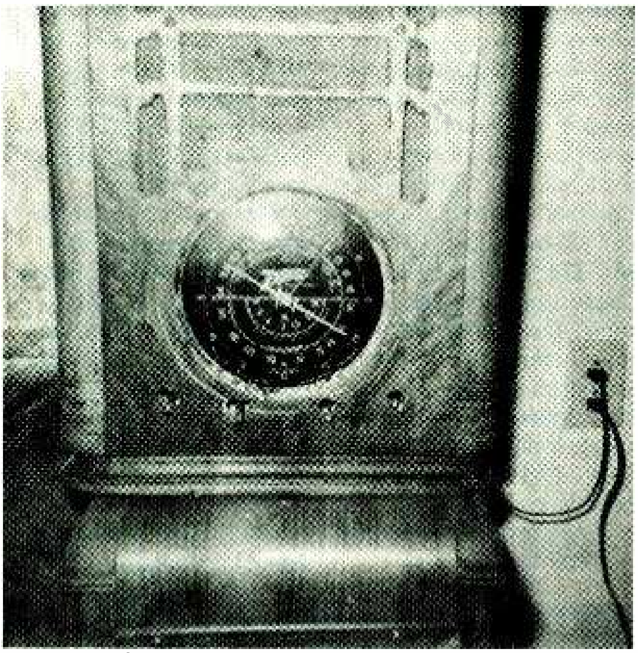
Anyone seriously interested in microprocessors and computers, and how they work, should look into this $129.00 educational bargain. The MM-8000 is an excellent way to obtain the hands-on experience that's so often lacking in theory-oriented microprocessor-training courses. If you'd like more information about it, contact Elenco Electronics at the address given earlier in this article, or circle No. 119 on the Free Information Card. ■

ANTIQUE RADIO

By Marc Ellis

Mailbag Time!

It has been many months since we've had the opportunity to give our readers the floor. I really hadn't intended to let so much time go by without a mailbag column. What probably threw us off schedule was my having broken into the crystal-set series earlier this year for a couple of impromptu columns on the Antique Wireless Association annual conference. Having interrupted the series once, I really hated to do it again.



Can anyone help Ivan Smith (see text) find the knobs he needs to complete this Zenith 5D127?

Last month's column, however, saw the wrap-up of the crystal-set project. At that time we were also able to cover most of the letters that had come in with comments relating to it. So let's go right on this month and work our way through the rest of the mail.

But before we get started, I'd like to take this opportunity to talk about how I handle communications from readers. First of all, let me assure you that every piece of mail I receive is valued and carefully read. Time does not permit me to respond personally to the many comments, questions, and requests for information that I receive each year. However, I do try to mention almost every letter I receive in the column, passing along the comments and requests for help to the readership at large.

Over the years, many helpful readers have responded to such letters—taking it upon themselves to send information and advice to those requiring it. To those generous souls, I'd like to pass along a hearty "thank you" on behalf of the folks who have benefited from your knowledge and resources. You are a credit to our hobby!

To those of you who've written me and are waiting for acknowledgment, please be patient! I wish it were possible to mention every letter in the month it was received, but the reality is that sometimes several months will pass before I have an opportunity to devote a column or two to the mail.

Now, without further ado, let's get started—beginning with those all-important requests for schematics, information, and parts.

WANTED: HALLICRAFTERS HELP

Tom Byers (1640 Timber Ridge Dr., Sedalia, MO 65301) seeks service data for a Hallicrafters S-40, as well as knobs for the band switch and BFO. An S-40 bandswitch knob is also needed by *Marvin E. Leisy* (5556 Beverly Ave. NE, Tacoma, WA 98422). By the way, if you need a schematic for a Majestic 90-B, Marvin has one and will send it to you for copying and mailing costs. Lucky scavenger *Chris Burke* (E.N.D. Auto Repair, 2801 Route 88, Point Pleasant, NJ 08742) found an SX-24 Skyrider Defiant in someone's garbage and is looking for schematics and service information.

Andre Pelletier (C.P. 1508, Fermont, Quebec, Canada G0E 1J0) needs an owners and/or service manual for an HT-40, and will gladly pay the cost of copying. *Bob Schaum* (R.D. #1, Box 1339, Carbondale, PA 18407) needs alignment data and a schematic for an S-16 Super Skyrider; he could also use some advice on correcting a low-sensitivity problem on the top two bands. How about some service info on the SX-100 for *Thomas Perepluk* (220 Beaverglen Close, Fort McMurray, Alberta, Canada T9H-2V3)? Finally, *Arturo Ortiz Pina* (AV Juarez 1006-A, Col. Centro, Pachuca, Hidalgo, Mexico c.p. 42060) is restoring an S-38 and an HT-40 and would like to get his hands on schematics for both.

WANTED: SCHEMATICS AND MANUALS

Schematics and/or service information for the following radio models are needed by the readers indicated:

Zenith Trans-Oceanic

Chassis -5H 40 (uses 1U4, 1L6, 1U4, 1U5 3V4); *Philipp Kotsias* (Kifisias 39, 151 23 Maroysi, Athens, Greece). Westinghouse radio/phono J904 with radio chassis V-2502-2 and power-supply/audio chassis P725891; *Frances L. Munsch* (22300 Mobile St., Woodland hills, CA 91303-2426). Deforest Crosley Type 7D 832, Model A 67615; Herb Turner (Site 121, Comp 2 RR 1, Sorrento, BC, Canada V0E 2W0). Blaupunkt TYP2500USA, Ser. G824852; Jim Ferrara (10 Eagle View Ct., Monsey, NY 10952).

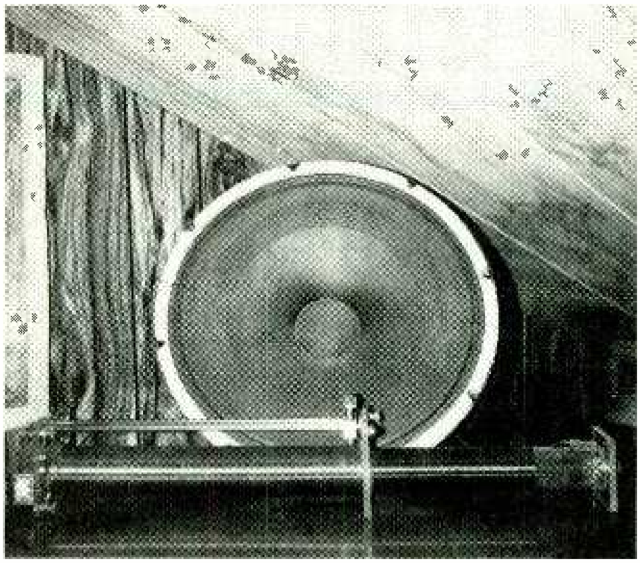
Operating manuals and, if possible, schematics for the following pieces of test equipment are needed by the indicated readers:

Heathkit IT-3120 Transistor Tester, Hickock 600A Tube Tester, Knight F-135 Signal Tracer, Knight F-119 Capacitor Checker, Sprayberry Academy of Radio 18 range VOM w/capacitor and resistor substitution boxes; *Ron Neely II* (2500 S. Rockport Rd., #403, Bloomington, IN 47403). Heathkit Signal Tracer Model T 2; *Jack Malone* (917 Torchwood Dr., Deland, FL 32724).

Craig Colboth (41190 N. Greenbay Rd., Zion, IL 60099) needs a schematic for a 1930's Echophone, but first he requires assistance in identifying the model number of that radio. It's a six-tube AC-operated cathedral-style set. The brass dial escutcheon is decorated with a graphic of a woman seated on our planet, and bears the legend: "Echophone—Echoes of the World."

WANTED: PARTS AND INFO

Albert J. Kelly (Amcor International Investigative Service, 7141 Marsden St., Philadelphia, PA 19135) is restoring an RCA Victor 45-RPM Victrola Model 45-EY-2.



James Knight's crystal set, which uses a carefully designed inductance coil (foreground), has been continuously driving a 14-inch speaker at comfortable room volume for 26 years.

He's looking for a set of tubes (35W4, 50B5, 12AV6), a new stylus (possibly a complete cartridge and stylus assembly), a schematic, and information on adjusting the changer. Albert would also like to know more about the history and manufacture date of that unit.

Larry Fritz (19899 Wayne Rd., Livonia, MI 48152) seeks an inexpensive source of antique telephones and parts, 1890–1920 vintage. *Roy Randall* (130 Palm Ave. #18, Jupiter, FL 33477-5133) needs a power transformer (Part #3-140) for a Sprague TO-6A Tel-Ohmike capacitor analyzer. *Ivan W. Smith* (HC72 Box 288, Glen Morgan, WV 258437-9714) sends a photo of his Zenith 5D127, which plainly would be improved by a set of knobs. Ivan is also looking for schematics and operating instructions for RCA WO-91A and Dumont 224-A oscilloscopes. Can anyone help?

From New Zealand comes an appeal for the pushbutton station and tone selector assemblies, as well as the white plastic volume and tuning knobs, for a Zenith shutter-dial set. Owner *Ross Paton* (56 Glengarry Rd., Aukland 7, New Zealand) tells us that the model-number label is missing, but the five-character model number starts with 9S3, and the tube complement is as follows: 6S7 (2), 6L7, 6J5 (2), 6F5, 6F6, 5Y4, 6U5. He could also use service information and a BFO/Q-multiplier coil for a Hammarlund HQ100. Readers needing service information on Phillips radios are invited to write to Ross, as he has quite a bit of data on hand.

R. Morrison (1597 Maquinna Ave., Comox, BC, Canada V9N 7B9) has forwarded many schematics to readers who requested them, but now he could use some help! Needed is a schematic for a Trio (Kenwood) 9R-4 receiver. The model was apparently made for sale in Japan, so not much service information has found its way onto this continent.

MISCELLANEOUS HAVES/NEEDS

Bob Zinck (118 Doull Ave., Halifax, NS, Canada, B3N 1Y9) has schematics for the following mostly 1950's-era Heathkit equipment (space permits mentioning only the model number): O-8, V-6, GD-1A, QM-1, C-3, T-3, SG-7, TC-1, TS-2, PS-2, IB-1B, AG-8, AO-1, SQ-1, AF-1, IM-1, AV-2, A-7, A-8, W-2M, WA-P1, BR-1, AR-1, FM-2, MI-11A, MI-41. Also available: Hewlett-Packard 401-B, 400-D, 200-AB. Send $1.00 per diagram for postage/copying.

If you need a radio schematic, chances are *Alvin Sydnor* (806 Meetinghouse Rd., Boothwyn, PA 19061) has it. Though retired from his service business, he held onto his collection of over 3,000 factory service manuals and schematics. Send a large SASE with your request. Al is also interested in hooking up with (or establishing) an antique-radio

Taking a drive down Radio Road in Tuckerton, NJ, reader Folkerts discovered what appear to be remnants of the original World-War-I-era German station.

club serving southeastern Pennsylvania and southern Delaware. Contact him if you have information.

Dr. O. A. Rinn (4402 Vance Jackson Blvd., San Antonio, TX 78230), at least as of several months ago, was looking for someone to restore his "Sorbor" battery-operated receiver (uses five type 32's and two type 30's) to working condition. And *James H. Lundsted* (211 SE Ridgeview Dr., Lee's Summit, MO 64063), again as of several months ago, was looking for reasonable offers on a Hallicrafters SX-111 Mark I ham-bands-only receiver. He'd like to place that radio in the hands of someone who would appreciate it.

THIS 'N THAT

In a very interesting letter too lengthy to quote in detail, *Don Lambert* (Auburn, IN) tells us that the recent NBS crystal-set series reminded him of his experiences building experimental crystal sets just before he was drafted into the army in 1944. Those were times of shortages and rationing, and Don had to "make do" for the parts he needed. For example, he recalls disassembling surplus transformers to salvage wire for winding coils.

Speaking of crystal sets, *James Knight* (Tulloma, TN) sent along a shot of one he built that drives a 14-inch speaker to comfortable volume when receiving a 250-watt station several miles away. And using an indoor antenna at that! James' radio has been operating more-or-less continuously for the last 26 years.

Just as this column was being "put to bed," we received a final NBS crystal-set note. *John Nix* (Foley, MN) tells us that the knurled binding-post nuts that the original 1920's constructors salvaged from No. 6 dry cells can be purchased in some hardware stores.

George Rath (Labour Market Services, 5th Floor, Phase IV, Place du Portage, Hull, P.Q., Canada, K1A OJ9) Is trying to locate Neil Carleton, formerly of Ottowa, Ontario. Neil holds the SWL call letters VE3DX2ZD. These "pseudo call letters" are similar to the "WPE" calls once issued by the original **Popular Electronics** magazine in the 1950's and 60's (and, in fact, may have actually been assigned by **Popular Electronics**). In any case, please contact George if you know how to get in touch with Neil.

In the November 1992 column, we mentioned a radio installation quietly built by the German government at Tuckerton, NJ just before our entry into World War I. It is thought that the order for the *Lusitania* sinking might have been given through that station. The station was confiscated by the our government and, after the war, was acquired by RCA.

After operating a shortwave transmitting facility at Tuckerton for decades, RCA sold the site to a developer in the late 1960's. Though no transmissions have been made from that location in many years, the street that originally gave access to the old station is still known as "Radio Road."

Last November, *W. Folkerts* (North Palm Beach, FL) had a chance to drive down Radio Road while visiting some relatives who live in Tuckerton. He discovered that three giant concrete blocks—possibly anchors for guy wires—were still standing near the station site. Mr. Folkerts sent us some nice shots of the blocks, and I'm including one here. ■

THINK TANK

By John J. Yacono

Education and Alarms

This month I'll continue to present letters on interesting alarm circuits, but first I'd like to follow up on something cut from last month's column. As you might recall, last month I discussed an educational course for beginners in electronics. I did that to help beginners and to bring up the topic of technical education.

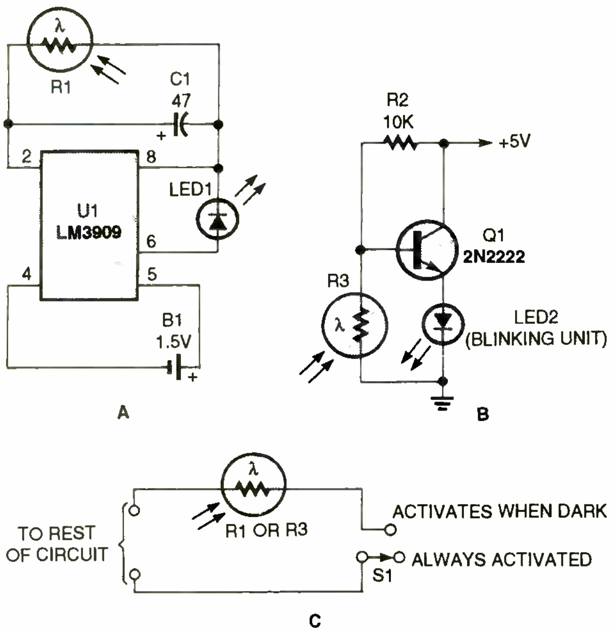


Fig. 1. The most inexpensive car alarm is no alarm at all, as the false alarms in A and B show. The circuit in A requires only 1.5-volts to operate, while the one in B requires more voltage, but fewer parts. In C we show a modification of the circuits for selectable daylight use.

You see, I'm very distressed over the numerous reports in electronics trade journals that our youth can't cut the technical mustard. According to the reports, some American high-tech firms are having a heck of a time filling their more advanced positions from within America. I *do not* want to enter the debate over whether there's an education problem or companies are looking to save money by hiring overseas help. My point is that even if those reports are a tiny bit true, they should scare us.

I'm not so young that I can't remember the time when hiring from overseas would have been unheard of. When it was accepted, without debate, that our youth would be the technical leaders of tomorrow. Now, our own companies are looking elsewhere for talent; that's a big change in attitude to be just a simple economic trend.

Not being one who simply complains about the weather, I want to help change this destructive trend in whatever way I can. For that, I need to hear more from teachers and amateur electronics and science groups out there. Write and tell me what you'd like to see here in the coming months, what circuits your participants have built, etc. If I receive enough submissions from a given school or group, perhaps I can devote a column to their work. Perhaps we can work out the makings of an electronics fair fashioned after science-fair competitions. I can even work up some course material and present it here to help educators. Nothing would make me happier than to hear from you and do what I can to help out, so please write to me at the address given at the end of this article.

Let's now turn our attention to this month's correspondences. I think you'll like the alarm circuits they contain.

POOR MAN'S ALARM

Looking for an inexpensive vehicle-alarm simulator that's portable and can easily fool anybody? Then you can use either the circuit presented in Fig. 1A or the one in Fig. 1B. Although they are fake alarms, they give people the impression that there is indeed an alarm system installed in the vehicle.

Both circuits use a cadmium-sulfide photocell and they are activated (the LED's start blinking) when the surrounding environment is dark. You can also have the LED's blink in daylight by inserting a miniature on/off switch in series with the photocell (see Fig. 1C.) That approach, however, is not recommended since the glow of an LED is not very visible in bright light.

My personal favorite is the circuit presented in Fig. 1A. It operates on a single 1.5-volt AA battery, which can last for more than two months in continuous operation. In the circuit of Fig. 1B, the transistor is used as a switch. It switches on a blinking LED when no light hits the surface of the photocell.

Nothing is too critical in the circuits, and all materials are readily available from Radio Shack. It does not take more than a few minutes to set those circuits up and you can even use your imagination to add a realistic appearance to them. For example, I have assembled the circuit of Fig. 1A on the back of a ten-key matrix keypad that I purchased from All Electronics for a little over a dollar. My project now truly resembles a real alarm. In a friend's version, I added one green and one yellow LED in addition to the original red one (all connected in parallel, of course.)

Well dear John, I hope that those projects meet the requirements of your column and that they deserve a book.

—*Georgios Kilitzirakis, Astoria, NY*

In fact both circuits deserve a book, mainly because they perform a useful function in a very simple way. I like the fact that you used the often-overlooked blinking LED in the second design. I wish I had a dime for every circuit I've seen that contained a driver to blink an LED instead of taking the easy, less-expensive way out and just using a blinking unit. Of course, a driver is needed for your first circuit to power the LED off such a meager supply.

DOOR AJAR UNIT

I came up with a circuit to help a friend who owned a meat market. He wanted a short tone to sound when the front door was opened to announce a customer.

The door had a standard magnetic alarm switch (normally closed when near its magnet), so I used it as shown in Fig. 2A. When the door and switch are opened, the base of Q1 goes high, applying power to the 555 oscillator/timer. The IC is wired as a power-up one-shot and sounds the piezo sounder for about ½ a second. The circuit will not sound when the door is closed.

With the values shown, the circuit draws only 0.3 mA with the door closed and 11 mA when sounding. I used a 12-volt plug-in supply for power, but a 9-volt battery can be used if less volume is acceptable. By replacing the sounder with a relay and driver transistor (see Fig. 2B), the circuit can be used to sound a standard doorbell. That arrangement, however, requires that the supply be heavy enough to handle the relay's coil current.

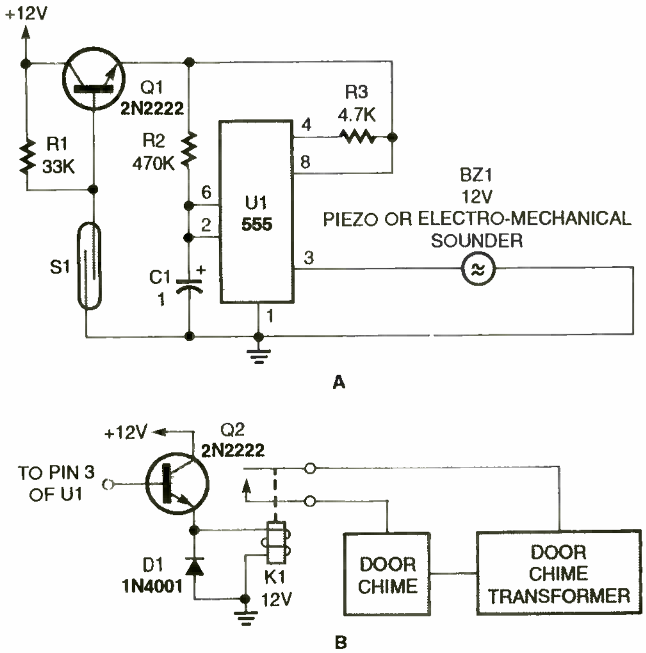


Fig. 2. This simple sounder (A) makes a good door annunciator. If the buzzer is replaced with the circuit in B, the annunciator can be made more pleasant to the ear.

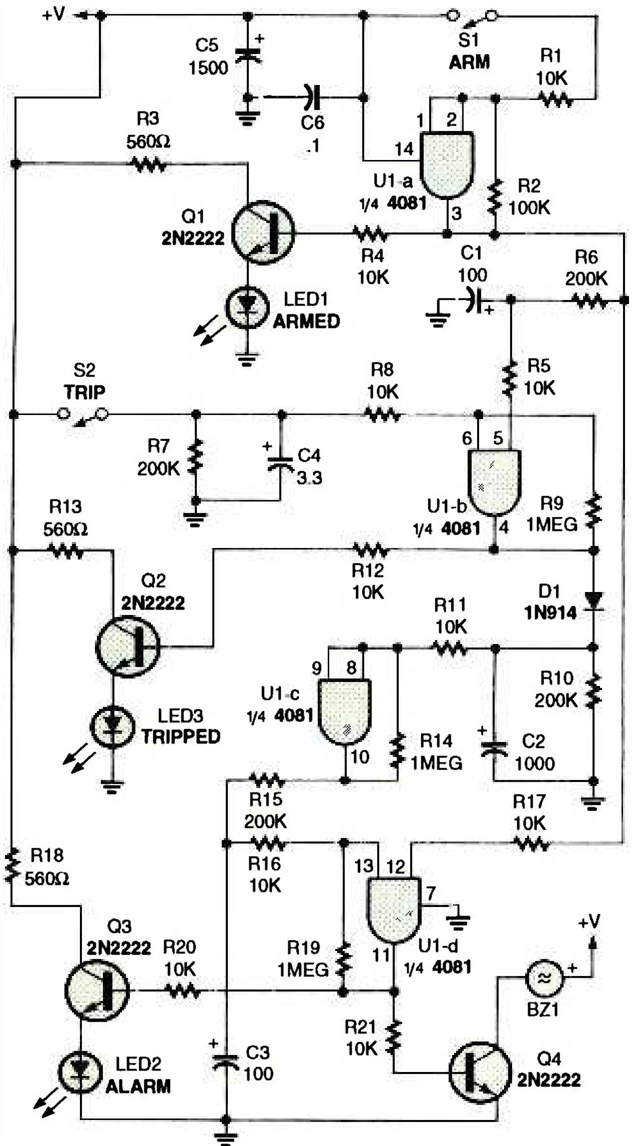


Fig. 3. If you want an alarm with all the standard features (exit/entry delay, automatic reset, status indicators, etc.) then this circuit is worth a look. For all its features, it only uses one simple IC.

—Ed Baumgarten, Stewardson, IL

Thanks for sharing that circuit with us. Remember folks to select the transistor in Fig. 2B to handle the relay's coil current, and the relay contacts should be rated for whatever they activate.

LOGICAL CHOICE

Here is an alarm circuit that I built around a single 4081 (CMOS) quad AND gate (see Fig. 3). It offers an exit and entry delay (around 20 seconds), and will automatically reset 2 minutes after tripping, provided that the trip input is not left high.

The arming switch must go high to arm or low to disarm. After arming, U1-a begins to charge C1 via R6. Around 20 seconds later (after the exit delay), C1 has a sufficient charge to produce a high at the pin-5 input of U1-b. Also, when the circuit is armed, Q1 is turned on to indicate arming, and one input of U1-d is brought high.

After the exit delay times out, if the trip input opens, it causes an output on gate U1-b. Transistor Q2 is turned on, lighting the trip indicator (LED3), C2 instantly charges, and the output of U1-c goes high. At that point, C3 begins charging to provide the entry delay.

After 20 seconds, C3 has sufficient charge to produce a high at pin 13 of U1-d. That forces U1-d's output high, turning Q3 and Q4 on, which activate the alarm indicator (LED2) and sounder (BZ1), respectively. If disarmed after a trip pulse, but before the 20-second entry delay times out, pin 12 of U1-d goes low, so the gate's output does not go high and there's no alarm.

Components C2 and R10 hold U1-c on for around 2 minutes and 20 seconds to provide the 2-minute alarm. After C2's charge drops below ½ the supply voltage, U1-c's output goes low, awaiting another trip pulse to set it off again.

Resistors R2, R9, R14, and R19 give the gates some snap when changing states. Capacitor C5 holds enough charge after power down to let all timing capacitors discharge before the supply drops. That prevents damage to the gates.

I hope that you at **Popular Electronics** enjoy putting this one together, I sure did.

—Douglas Miller, Alliance, OH

A very professional circuit. Anyone trying out the circuit should remember that electrolytic capacitors are not accurate timing components. Their tolerance is high and, more importantly, their leakage current drains charge off during charging cycles. That makes their charge times hard to predict, so expect some variation in the time periods you experience.

ALARM-CLOCK ADAPTER

This simple but very useful circuit (see Fig. 4) consists of a few inexpensive parts

(Continued on page 92)

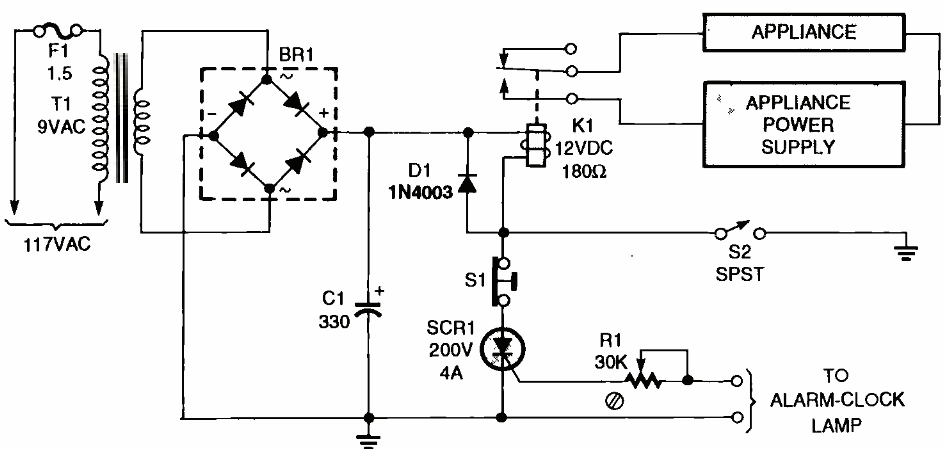


Fig. 4. Turn your alarm clock into a specialized timer with this simple circuit. The clock used with the circuit should be the kind that turns on a little lamp when the alarm is activated.

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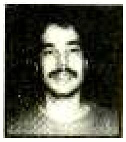

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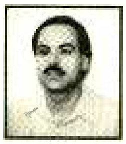

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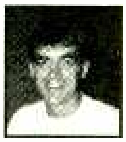

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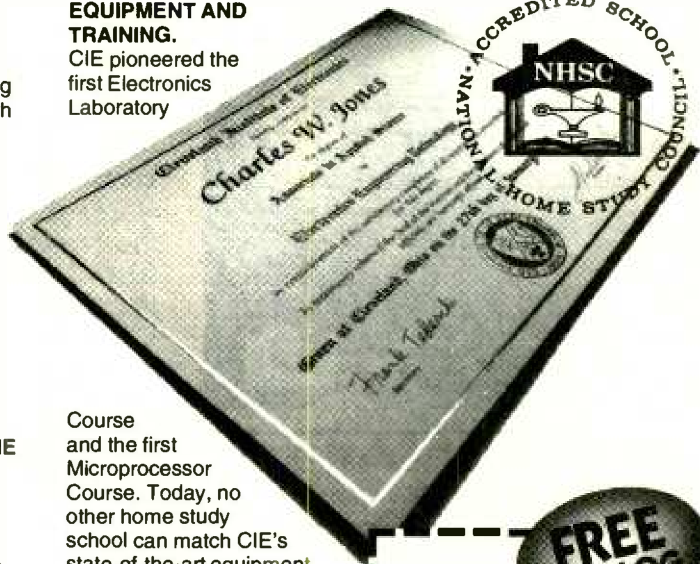

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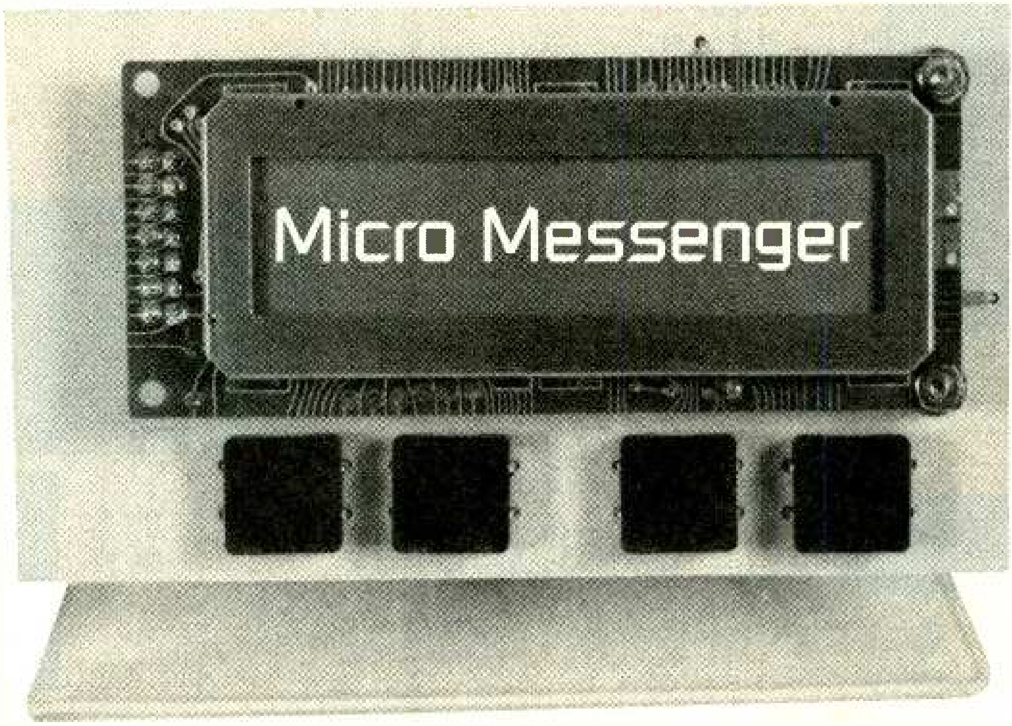


BY SCOTT EDWARDS

Put your thoughts into words and share them with the world using this scrolling marquee-like display.

Here's a project to help you communicate. It's not a phone, fax, radio, pager, or satellite dish. It's a sign. A very small electronic sign. Dubbed the *Micro Messenger*, it combines a sharp liquid-crystal display (LCD) with an inexpensive microprocessor to produce the world's smallest scrolling sign. It can be programmed via the front-mounted pushbuttons, or through a temporary serial connection to a PC. Once the Mirco Messenger is programmed, it will broadcast your opinions, tell your jokes, or just startle passersby for days using just a single 9-volt battery.

The Micro Messenger is easy to build. As an added bonus, you'll gain experience with LCD's, custom microprocessors, surface-mount components, RS-232 communications, and electronic assembly. Using the Micro Messenger will probably improve your spelling, too.

Circuit Description. Figure 1 is a schematic diagram of the Micro Messenger, which consists of a power supply, microcontroller, LCD module, and various resistors, switches, and connectors. Because most of the device's operation depends on U2, we'll start the circuit description with that microcontroller—a PIC16C54 made by Microchip, Inc.

The PIC16C54 is an inexpensive computer-on-a-chip that is often used in PC peripherals, such as mice and trackballs, or control systems like antilock brakes. Like other computers, its operation is determined by a set of program instructions that reside in internal read-only memory (ROM). Once programmed, it cannot be erased.

As computers go, the PIC is not very powerful, having only 32 bytes of random-access memory (RAM) and enough ROM for up to 512 instructions. It has a limited instruction set that allows a program to input and output data through its two ports; do simple arithmetic, like addition and subtraction; compare values and make IF/THEN decisions; and perform logical operations such as AND, OR, and NOT (inversion).

The PIC occupies the middle ground between full-blown microprocessors (like the ones in desktop computers) and logic IC's (like the 74xx or 4xxx series chips). It is called a microcontroller rather than a microprocessor because it is essentially self-sufficient. It doesn't need external RAM, ROM, or peripheral chips in order to do its job; those features are built in. The PIC's job in the Micro Messenger is to read inputs from switches S1 through S4 and the serial port (J1), and display them on the LCD.

Driving the LCD is not too different from driving a printer. The PIC must follow a strict format for communicating with, initializing, and controlling the LCD. Control codes tell the LCD to turn its cursor on or off, clear the screen, shift data left or right, and use a particular font.

Figure 2 is a flow chart of the Micro Messenger's PIC program. It begins by checking to see whether a computer is connected to the serial port. If a

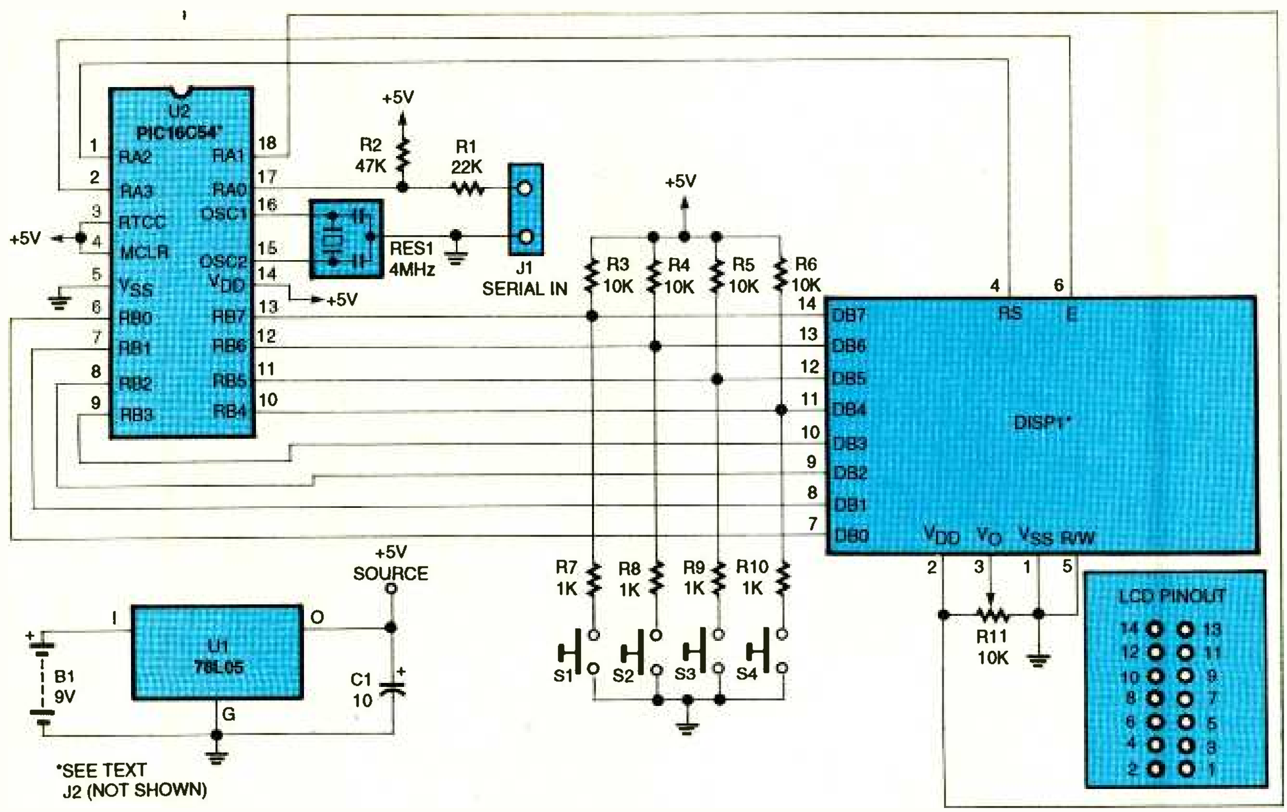


Fig. 1. The Micro Messenger consists of a power supply (U1, C1), microcontroller (U2, RES1), LCD module, and various resistors, switches, and connectors.

computer is connected to the serial port, the program assumes that you want to enter your message through the computer. If not, it prepares to accept a message through the buttons.

The program handles serial input by receiving one byte (equivalent to a character of text) at a time, displaying it on the LCD, and checking to see whether the maximum number of characters (70) has been received. If so, it begins scrolling the display, ignoring any further input. If not, it prepares to receive the next character.

Handling manual input is more complicated. The program initially displays a capital letter A in the center of the LCD screen. If you click S4, the display changes to B. Holding S4 down causes the display to rapidly scan through B, C, D, E, etc., until you release the button. If you press S1, you get the opposite result; the program progresses backwards through the characters. Arcade-game fans may recognize that style of "typing." It's the way that many games use a joystick or pair of buttons to let the high-scorer add his or her name to its "hall-of-fame list."

Once you have the letter you want displayed, clicking S2 causes the display to shift to the left, letting you pick the next letter. If you want to change a previously entered letter, pressing S3 moves the display to the right. Each time the display is advanced, the program checks to determine whether the maximum message length has been reached. If it has, the program stops accepting input and begins scrolling the display.

Some Questions and Answers. Now that you know how U2 works, you may have some questions about Fig. 1. For Example:

- I thought that receiving RS-232 signals required special components to shift the voltage levels and interpret the bits. How come this circuit has just a couple of resistors?

That's possible because an RS-232 computer port sends one bit at a time by switching a voltage between −10 and +10 volts relative to ground. A −10-volt signal represents a high bit (1), while +10 volts represents a low bit (0). Most computers use two peripheral chips to receive that signal; the first changes the ±10-volt signal to standard 5-volt levels and inverts it so that +5 volts represents 1, and 0 volts represents 0. The second chip collects the single-file bits, and outputs them eight (one byte) at a time to the microprocessor.

The Micro Messenger takes a no-frills approach to do the same job. Resistor R1 limits the amount of current allowed to flow through the RS-232 connection, while diodes inside the PIC limit the voltage to 5-volt logic levels. The PIC program takes care of inverting the bits and arranging them into bytes. Resistor R2 (see Fig. 1) helps the PIC determine whether or not a computer is connected. If no computer is connected, R2 holds the serial input pin at 0 volts; if one is connected, the RS-232 resting state of +10 volts puts a high on the serial input pin, telling the PIC to expect serial input.

- The eight pins of port RB go from the PIC to the LCD, probably carrying bytes of data. How can the switches use the same pins without messing up the LCD?

The PIC is able to change the functions of its pins from input to output and vice-versa. To read the switches, the PIC disables the LCD by putting a

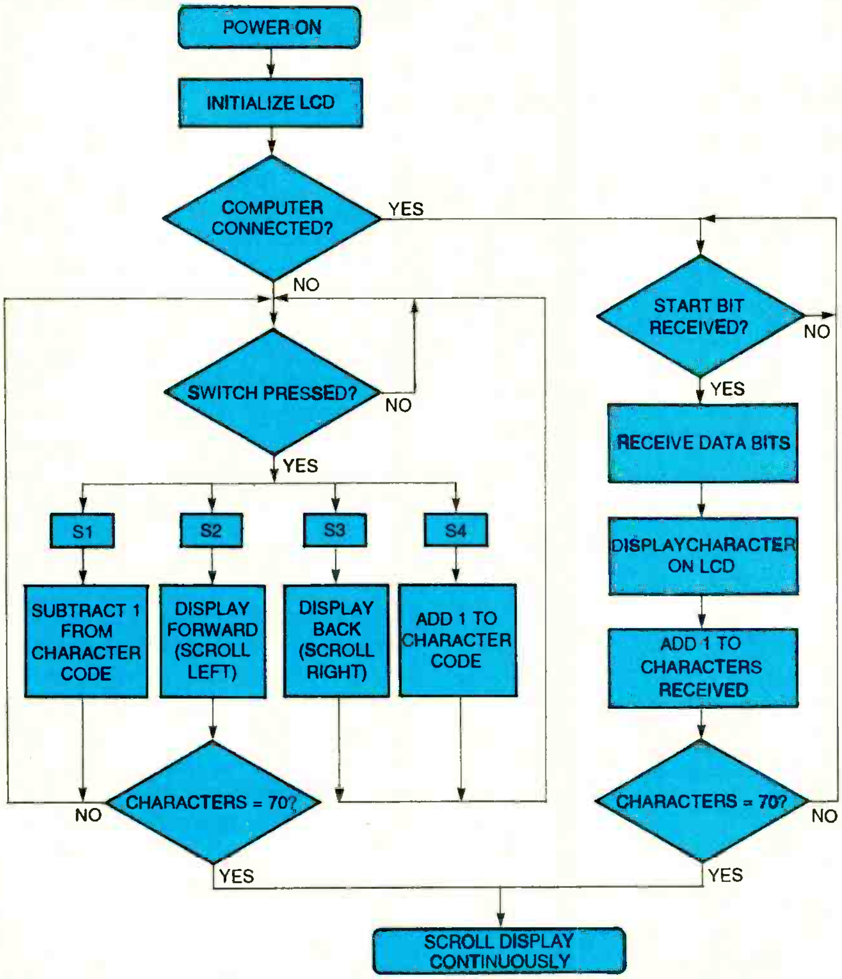


Fig. 2. This flow chart of the PIC program shows that the PIC begins by checking to see whether a computer is connected to the serial port. If a computer is connected to the serial port, the program assumes that you want to enter your message through the computer. If not, it prepares to accept a message through the buttons.

low on the enable line, and then puts the pins of port RB into the input mode. If no switch is pressed, 10k resistors (R3 through R6) hold pins RB4 through RB7 at +5 volts (high). When you press a switch, the corresponding pin of RB sees resistances of 10k to +5 volts and 1k to ground. The two resistors form a voltage divider, delivering about half a volt to the pin: 1k/(1k+10k) × 5 volts = 0.45 volts, which is low enough to be seen as a 0.

To talk to the LCD, the PIC puts the pins of port RB into output mode and puts a high on the LCD enable pin. If a switch is pressed while the PIC is transferring data to the LCD, a high on the corresponding PIC output pin has to push 5 mA of current through the 1k resistor (5 volts/1k) to ground. The PIC can supply up to 20 mA per pin, so that's not a problem. The PIC merely "overpowers" the switch input.

- What does RES1 do?

The ceramic resonator (RES1) performs a similar function to quartz crystals (which control timing in watches and frequency in transmitters); it is less precise but more rugged than its quartz counterpart. The resonator controls the speed of a clock oscillator that's built into the PIC, which, in turn, determines the rate at which the PIC executes instructions. The PIC executes an instruction every fourth clock cycle, so with a clock speed of 4 MHz, the PIC carries out 1-million instructions per second.

The PIC clock can be programmed to operate with a resistor and capacitor pair to set the clock speed. However, receiving RS-232 signals requires fairly precise timing, so a ceramic resonator was used in the circuit. A quartz crystal would also work, but could be larger and more fragile.

Construction. The author's prototype of the Micro Messenger was built on a printed-circuit board, measuring about 4 by $2\frac{3}{16}$ inches. A template of that printed-circuit board is shown in Fig. 3. Once you have etched your board, verified there are no shorts between traces or broken

PARTS LIST FOR THE MICRO MESSENGER

SEMICONDUCTORS

U1—78L05 100-mA, 5-volt voltage regulator IC (Digi-Key AN78L05)
U2—Programmed PIC16C54 microcontroller (see text)
DISP1—16 × 1 LCD module based on the Hitachi 44780 controller circuit (see text)

RESISTORS

(All fixed resistors are ¼-watt, 5% units, unless otherwise noted.)
R1—22,000-ohm
R2—47,000-ohm
R3–R6—10,000-ohm, ⅛-watt, surface mount
R7–R10—1000-ohm
R11—10,000-ohm miniature, PC-mount, trimmer potentiometer

ADDITIONAL PARTS AND MATERIALS

C1—10-µF, 16-WVDC, axial-lead electrolytic capacitor
RES1—4-MHz ceramic resonator (Digi-Key PX400)
J1—4-pin section of single-row stake header material (0.100 inch spacing, Digi-Key WM4002)
J2—14-pin section dual-row stake header material (0.100 inch by 0.200 inch spacing, Digi-Key S2072-14-ND), see text
S1–S4—N.O. momentary contact pushbutton switch (Digi-Key P8034S)
B1—9-volt transistor-radio battery
Printed-circuit materials, enclosure, 9-volt battery holder and connector, 4-contact IDC receptacle (0.100-inch spacing, Digi-Key A1902-ND), female DB-9 connector, 4 × 5-inch acrylic photo frame, hot glue, ¼-inch diameter standoff tubing, ½ inch, 2-56 machine screws and nuts, solder, tools, wire, solder, hardware, etc.

Note: The programmed PIC16C54 is available for $10 postpaid (check or money order) from Scott Edwards, 964 Cactus Wren Lane, Sierra Vista, AZ 85635. Arizona residents add 6.5% sales tax.

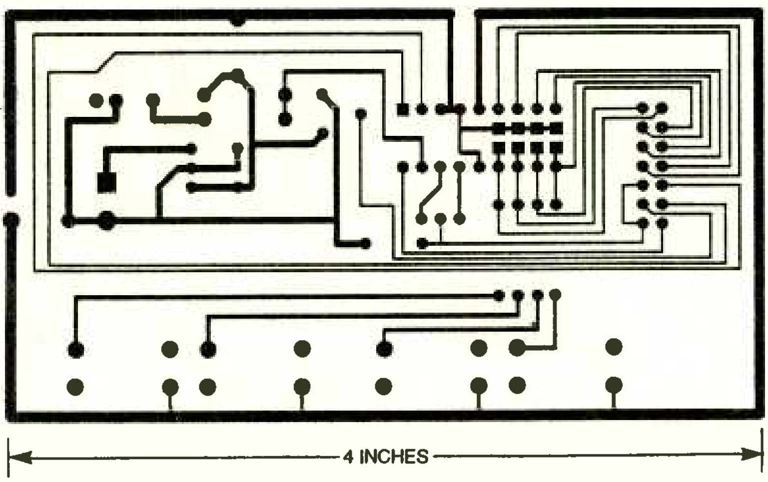


Fig. 3. The author's prototype of the Micro Messenger was built on a printed-circuit board, measuring about 4 by 2³⁄₁₆ inches. A template of that printed-circuit board is shown here.

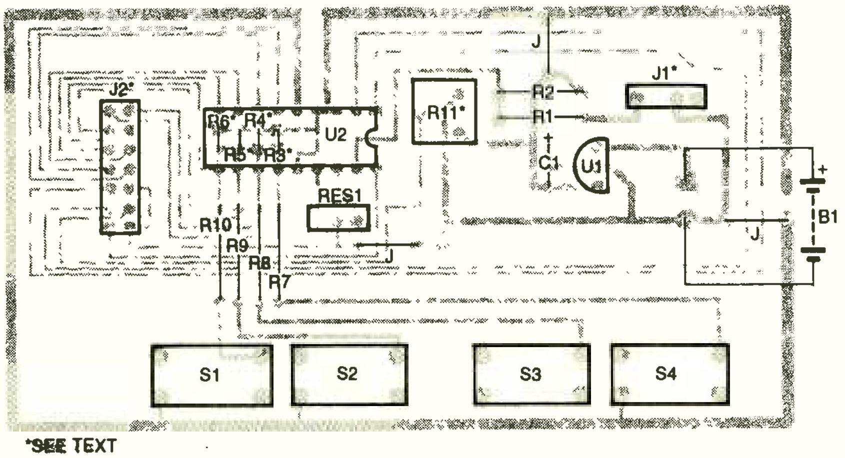


Fig. 4. Once you have etched your board, verified there are no shorts between traces or broken lands, and obtained all the parts listed in the Parts List, install them in the positions indicated in this parts-placement diagram.

lands, and obtained all the parts listed in the Parts List, construction can begin. An ohmmeter can be used to make continuity checks for land breaks. When drilling the board, be sure to use as fine and sharp a bit as possible. An oversize or dull bit may remove the pads entirely—so be careful.

The pin headers, J1 and J2, require some minor surgery before installation. Note that J2, the LCD socket, is not shown in the schematic (Fig. 1). Begin with J1, the serial-port header. Break off a four-pin piece of the single-row header material—a pair of wire cutters can be used for that; just snip the plastic at the notch between adjacent pins. Then use a pair of needle-nose pliers to pull the square metal posts completely out of the plastic block. The plastic may separate into two pieces. If it does, discard one piece. Now push three of the four posts back into the remaining block, leaving the blank one space from the end. Don't push the posts into the block very far; just until their ends are flush with the surface of the block.

Insert the modified header through the component side of the circuit board at the position indicated in Fig. 4. The pins should protrude from the foil side and the block should be flush to the board on the component side. Solder the pins carefully.

Next you'll perform a variation on the same trick for J2. Break or cut off a 14-pin section of dual-row header. A fine saw does the neatest job. Take a look at the header pins. They protrude approximately ¼ inch from one side of the plastic block, and ⅛ inch from the other side. Using needle nose pliers, push each stake further through the block until the short end protrudes only about ¹⁄₁₆ inch. That's just enough to stick through the circuit board and make a solder joint. The idea is to extend the pins' reach above the circuit board enough to mount the LCD over the other components. If you can find headers with pins longer than 0.5 inch overall, you can skip that step.

Once it's modified, mount J2 so that the long ends of the pins stick up on the component side of the board; just the opposite of J1. The trimmer potentiometer, R11, is mounted on the foil side of the board. Just push its pins through the board and solder it in place. Be careful not to touch the part's plastic body with the soldering iron.

Next install U1, all of the resistors other than R3 through R6, the switches, C1, and the wire jumpers where indicated in Fig. 4. Note that the tall components—U1, C1, and RES1—all must be bent flat to the board. The resonator's case should point toward U2's mounting area. When you are finished, connect a 9-volt battery connector to the board, apply power, and check the voltage across pins 5 and 14 of U2's still-vacant pads. If it reads something other than 5 volts, remove power and recheck your work. Do not install U2 until you measure 5 volts across those pins.

A pre-programmed PIC16C54 (U2) is available form the source given in the Parts List. If you have the ability and equipment to program your own PIC, the listing is available on the Gernsback BBS (516-293-2283, 8-N-1).

Before installing U2, make sure that you, your tools, and your work area are static safe. That means wearing cotton clothes and a ground strap, using a grounded soldering iron, and working on a wood or metal benchtop or a static-free pad. Although U2 is not particularly sensitive to static, it's better to be safe than sorry. Be sure to orient U2 correctly; pin 1 should be at the top of the board.

Before soldering U2 in place, lightly tin the square pads beneath U2. The surface-mount resistors go here. You want a fairly thin coating, one that just barely bulges above the pad. To install the resistors, pick one up with a pair of tweezers. Heat one of the pads with your soldering iron until the tinning melts. Press one end of the resistor against that pad, while aligning the other end with the opposite pad. Let the first pad cool a moment, then touch your iron to the other pad and the end of the resistor. Then the joint should flow together. If needed, you may touch up the joint with a bit more solder. Repeat the process with the other three surface-mount resistors, then install U2.

Finally, we come to the LCD module. Note the LCD module, DISP1, is a surplus unit that is available with slight variations from several parts dealers. The one used in the prototype is the 16 × 1 Hitachi LCD from Timeline, Inc. (23605 Telo Avenue, Torrance, CA 90505; Tel. 800-233-9977), priced at $8.33 (with a minimum $25 order requirement). An equivalent device (tested to work in the circuit) is the Densitron 4012 available (as part no. 25-210 ($9.95) from Hosfelt Electronics (2700 Sunset Boulevard, Steubenville, OH 43952; Tel. 800-524-6464). No minimum for credit card orders. Another source is B.G. Micro (P.O. Box 280298, Dallas, TX, 75228; Tel. 214-271-5546). Their DMC16207H (at $5.99) works, but requires a negative bias voltage as described in the sidebar. The DMC20171 (at $9.95) also requires a negative bias voltage, but provides a jumbo display, 6 inches wide with 0.42-inch characters. B.G. Micro has a $10 minimum order requirement.

Install the LCD module. The module has two rows of seven holes each that match the pins of J2. Fit the LCD to the pins, and then look to see whether any of the components on the circuit board are interfering with the fit. If they are, press them flatter to the board or adjust them as necessary to accommodate the display. Capacitor C1 is the most likely potential problem.

Before soldering the LCD into position, cut two pieces of ¼-inch diameter standoff tubing to a length of ¼ inch. Put a drop of glue (or hot glue) into each standoff and push ½-inch, 2-56 machine screws headfirst into the glue. Make sure that the threaded ends stick straight up. Set them aside on wax paper or any other glue-resistant surface. When they are set, push the threaded ends of the screws through the LCD's right-hand mounting holes and secure them with nuts. Apply a dab of glue to the other end of each standoff and install the LCD

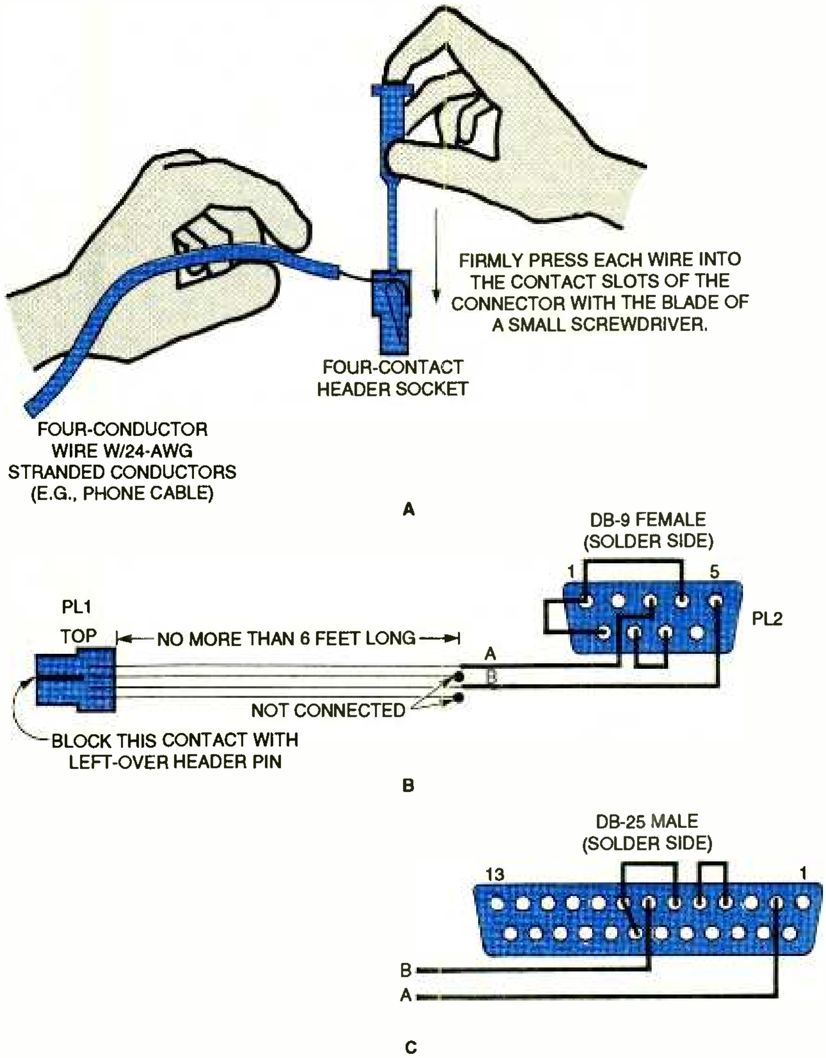


Fig. 5. If you plan to use the Micro Messenger with a computer, use this diagram (and the instructions in the text) to prepare the necessary interconnecting cable.

on its mounting pins. Press the sticky standoffs securely against the circuit board and solder the LCD into place.

Apart from connecting a 9-volt battery and (if desired) a power switch, you are done. The only issue that remains is a case for your project. I cut a 4- × 5-inch acrylic photo frame to size, drilled holes for J1, R11, and the power leads, and hot-glued the circuit board to the front of the frame. The clear plastic protects the foil side of the board from fingers, but shows off my handiwork. You can follow my lead, or dream up an entirely different mounting scheme.

If you plan to use the Micro Messenger with a computer, Fig. 5 shows how to make the cable. The interconnecting cable was make from a 6-foot length of 4-conductor stranded 24 AWG cabling (e.g., modular telephone-station wire), a 4-contact header socket, and a DB-9 or DB-25 connector. Begin by firmly pressing each wire into the contact slots (as

LISTING 1

```
OPEN "com1:2400,N,8,1" FOR OUTPUT AS #1
CLS
PRINT : PRINT : PRINT
PRINT "Type your message below: 70 characters maximum. "
PRINT
".........10.........20.........30.........40.........50.........60.........70"
LINE INPUT ; ""; A$
PRINT #1, A$
CLOSE : END
```

SURPLUS LCD BARGAINS

One of the most important skills an electronics hobbyist can develop is scrounging—the ability to recognize and use parts bargains. The Micro Messenger project is a prime example. Its LCD module can be quite expensive, up to almost $40 from some new-parts suppliers. The surplus sources specified in the Parts List sell it for less than $10; that's quite a difference.

Surplus buyers not only save money, they get an education, too. In the case of the Micro Messenger, the author found that the variety of LCD's using the same basic controller is staggering. Most work with the Micro Messenger chip, but a few do not. If you're the adventurous type and want to use a different LCD than the ones specified in the article, here are some guidelines:

The controller must be a Hitachi 44780, which interprets the commands that the Micro Messenger PIC sends to the LCD. If it's not a 44780, chances are the LCD won't respond correctly. (Don't worry if your LCD has additional letters and numbers to the part designation, like HD44780A00. It's still a 44780.)

In addition to the controller, the LCD should have at least one additional driver chip, either a Hitachi 44100 or an OKI 5259. At least one popular 16 × 1 LCD display, the Optrex 16187, lacks an extra controller IC. Without it, the LCD behaves like a two-line device with the lines arranged side-by-side. That results in scrambled text from the Micro Messenger. (Here again, additional characters in the part number are OK: HD44100H or M5259.)

Two-line displays (16 × 2) are generally a safe bet. They usually have both the 44780 and 44100/5259 to support their two-line display. Since the Micro Messenger is programmed to use the top part of the second line to display the descenders of letters like g, p, and y, the extra space isn't too noticeable.

Backlighting is optional. A backlit display will work fine without power to the backlight. If you do want to use the backlight, find out from the surplus dealer what type it is; electroluminescent (EL) or LED. If it's EL, find out whether the dealer has the inverter needed to convert a 5-volt supply to the 100 VAC/400 Hz required by the backlight. Do no connect the backlight to household AC power! That's not only dangerous, it's ineffective. The 60-Hz AC line won't light the panel properly. If the backlight is an LED, you'll see connections marked A and K for anode and cathode. Connect the anode to the +5-volt supply through a 220-ohm resistor and ground the cathode.

Different pin arrangements are common. As built, the Micro Messenger uses a two-row header to connect to the 14 pins on the LCD module. Many LCD's have their pins arranged in a single row along the top or bottom of the display. There's normally a mark to identify pin 1. To use that type of display, you'll need to use wire or ribbon cable to make the connection. Just make sure to observe the staggered arrangement of the two rows on the printed-circuit board. Unlike a 14-pin IC, whose pins are numbered 1–7 on one side and 8–14 on the other, these pins are numbered 1, 3, 5, 7, 9, 11, 13 along one edge and 2, 4, 6, 8, 10, 14 along the other.

Some LCD's require a negative supply. The LCD used in the project requires a low-biasing voltage at pin 3 (V_o) to control the contrast of the screen. At room temperature, R11 is adjusted to set the bias at about 0.5 volts DC. Some LCD's intended for use at extreme temperatures require a negative biasing voltage. For example, the Optrex DMC16207H and DMC20171 require −3- to −4-volt DC bias. The easiest way to supply that bias voltage is to disconnect R11 from the +5-volt supply. Connect a second 9-volt battery to the circuit. Ground the positive terminal and connect the negative terminal to the ungrounded terminal of R11. You can now adjust R11 to supply negative bias. ■

shown in Fig. 5A) of the header with the blade of a small screwdriver. Afterward block the contact-position indicated in Fig. 5B with the header pin that was left over from the board-mounted assembly, and snip off the excess. That way you'll have a socket that will only fit one way; the right way. Next connect the female DB-9 connector to the other end of the cable, and finally make the jumper connections between the connector pins, as shown. Figure 5C shows how to connect a DB-25 connector to the cable instead of the DB-9.

Operation. Connect a 9-volt battery to the circuit and adjust R11 until you see a capital letter A in the center of the LCD screen. At that point, you are ready to enter a message. Manual operation of the Micro Messenger is pretty well described in the circuit description above, but here are a few hints. To enter a space character, or move rapidly around the character set, press and hold S1 and S4 at the same time. The characters "space," capital "A," lowercase "a," and the number "0" will scroll by on the screen. Let the buttons go when you see the character you want. That helps speed up the two-thumb typing process.

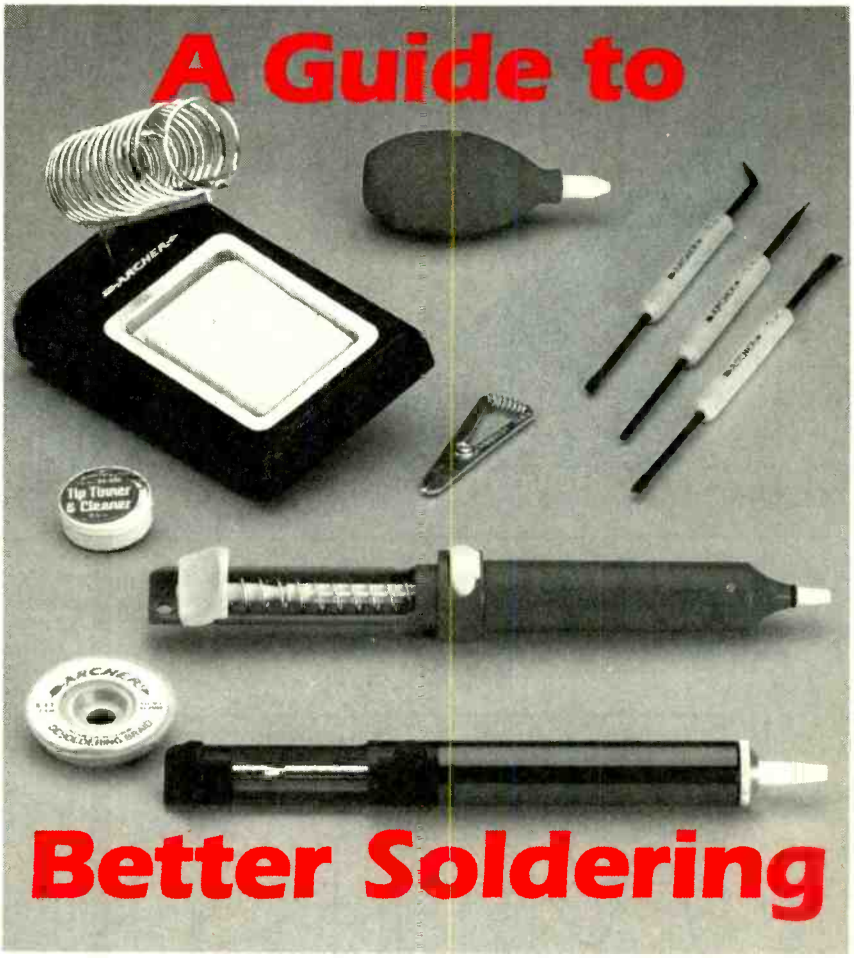
If your message is shorter than 70 characters, put a space on the screen, then press and hold S2. That will enter a string of spaces to pad the rest of the 70-character memory. Feel free to explore the character set of the LCD; there are many pleasant surprises. For example, past the lowercase Roman alphabet are Japanese Kana characters, Greek letters, and special symbols. Even if you don't have a particular need for those characters, you can throw a few in to give your messages an international flavor.

Using the Micro Messenger with a computer is almost as easy. With the Messenger turned off, connect the cable between the Micro Messenger and the computer's serial port. Turn the computer on and boot your terminal software. Set it for 2400 baud, eight data bits, no parity, with one stop bit. Afterward, turn on the Micro Messenger and type in your message. When the Micro Messenger has received 70 characters, it will begin scrolling. As with manually entered messages, you may pad the message with spaces to reach the 70-character point. If you don't have a terminal program, enter and run the BASIC program in the Listing 1, and use it to download messages to the Micro Messenger.

Once you have programmed the Micro Messenger, you can take off the programming connector. Doing that won't disturb the Micro Messenger's memory once your message has begun scrolling.

Conclusion. Now that you have this powerful new means of communication, what do you want to say? I have a theory that the first million or so cellular phone calls were exactly the same, "Hi Joe. Guess where I'm calling from—my car!" If you want to avoid that trap with your Micro Messenger, try quoting song lyrics. Mine frequently says, "I wish I were in Dixie, away, away" or "She's filing her nails while they're dragging the lake." (Not too many readers can identify that second song, I'll wager.) If you are really stuck for ideas, you could always leave practical messages like "Gone to lunch, back by 1:00." Whatever you decide to say, have fun! ■

A Guide to Better Soldering



Here's all you'll ever need to know about the art, craft, and science of soldering.

BY KARL T. THURBER, JR.

There's nothing too difficult about soldering. Many failed construction projects suffer from nothing more than poor soldering. However, it doesn't take much time to learn good soldering techniques, nor does good soldering require expensive tools. If you stick to a few guidelines, you'll consistently produce good, permanent electronic connections.

This article presents some tips to help your electronic projects look and work better through improved soldering. The tips include discussions of solder, flux, soldering tools and accessories, the role of cleanliness, preparing connections, knowing what a good soldering job looks like, avoiding component damage, desoldering techniques, and common soldering problems. The article also covers handling special soldering jobs and practicing good soldering techniques.

The Solder. Solder is a tin-lead fusible alloy, although small amounts of other metals such as antimony, bismuth, or silver may be included to enhance its characteristics or make it suitable for a special purpose. Solder flows at a fairly low temperature, around 360–370°F. Because of its relatively low melting point, solder can form a metallic union or "joint" of two metals at a temperature well below their own melting points. So solder can easily be melted by home-workshop soldering irons, guns, and pencils to make connections between metals.

Solder is usually identified by its tin-to-lead composition. If you look at a solder roll, you will probably find the figures 40/60, 50/50, 60/40, or 63/37. Those are the ratios of tin-to-lead, given in percent. Solder with a higher tin content melts at a lower temperature, and is usually desirable.

Since solder adhesion depends on a solvent or metallurgical action, the process breaks down if the solder itself is of poor quality, or of the wrong composition. When tin is added to lead, the melting point of the lead decreases along a known composition/temperature line (see Fig. 1). When lead is added to tin, the melting point of the tin is lowered along another such composition/temperature line. The intersection of these two lines is known as the "eutectic" point.

The so-called "eutectic alloy" of 63% tin and 37% lead has a melting, or eutectic, temperature of 361°F. That composition is the standard for electronic purposes, being approximated by 60/40 solder, and has a pronounced melting point. Other solder compositions have a flexible or plastic range running from the 361°F eutectic temperature up to the melting points of either pure lead (621°F), or pure tin (450°F).

Solders with a 63/37 or 60/40 composition are the most free-flowing kinds and are particularly good for working on delicate printed-circuit boards. That is especially the case if you use solder in thin, 16- or 18-gauge wire form; avoid thicker solders, which are difficult to control in terms of quantity and usually don't flow quickly enough.

Another important quality is strength. A nice looking solder connection is worthless if it won't take a little stress and strain. Since tin is a more active metallic solvent than lead, the quality of the joint is very closely related to its tin content. Taking a look at Fig. 2, note that solder with less than about 30% tin content is inferior in stress-handling ability. The alloy quality curve reaches its peak with about 60% tin, which approximately corresponds to the composition of the eutectic alloy we described.

Use the Right Flux. Most solder contains flux inside its core, so the flux is automatically applied when you heat the solder. When it flows over the connection, it removes oxides from the metal surfaces. Any oxides are suspended in the flux, allowing good metal-to-metal contact to promote the metallurgical process. The action

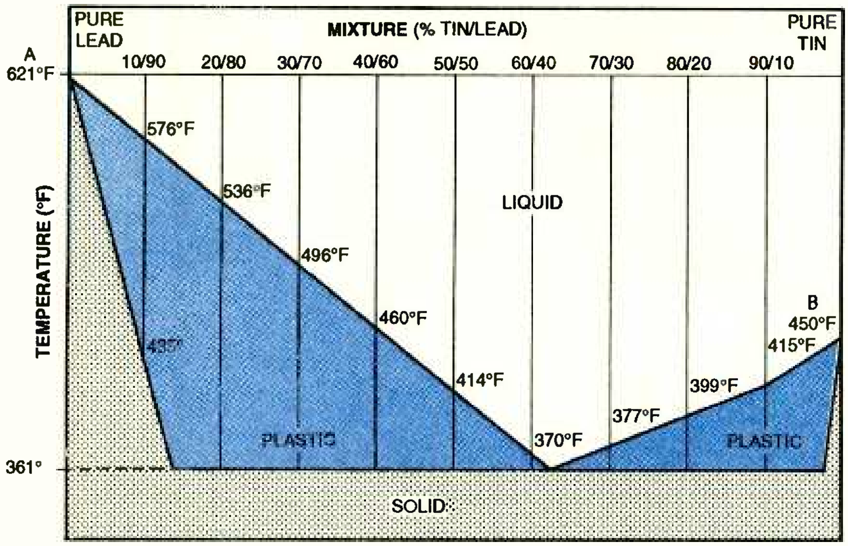


Fig. 1. When tin is added to lead, the melting point of the lead decreases along a known composition-temperature line. Likewise, when lead is added to tin, the melting point of the tin is lowered along another composition-temperature line. The intersection of these two lines is known as the eutectic point.

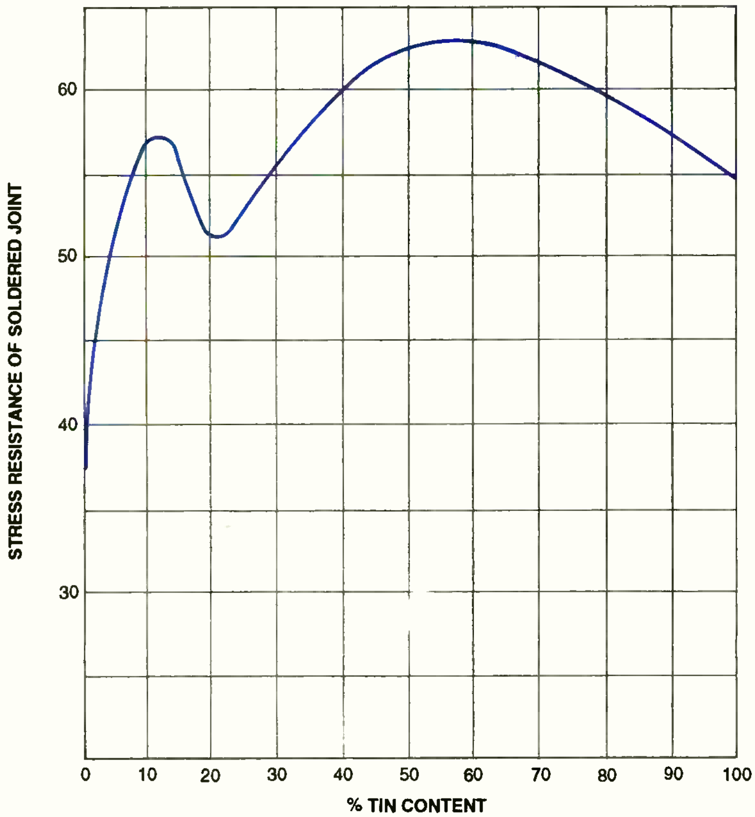


Fig. 2. Shown here is the change in joining quality of tin-lead solders with an increase in tin content, based on the resistance of the joint to stress. As shown, solder with less than about 30% tin content is inferior in its ability to take stress.

of the flux is known as "wetting the metal;" after soldering is complete, the oxides lie inert on the surface of the solder joint.

There are three basic types of soldering fluxes: organic acid or chloride, organic, and resin or rosin. Resin flux is the only kind that's usable in electronics construction and repair work. In that category, the safest and most reliable type of flux is pure rosin with no additives, rather than "active-rosin" fluxes. Active fluxes can cause salt migrations, called "dendrites," between pathways on the PC board. Later, that can cause "phantom failures" in electronic equipment.

Organic-acid and chloride-salt fluxes are highly corrosive since they attract moisture. They have no place in electronics. Using acid or salt type fluxes is almost sure to lead to circuit problems. So, read the label closely to ensure that what you have isn't an organic-acid type.

Use the Right Tools. The state of the soldering art has progressed over the years, along with the rest of the electronics field, and has spawned many new tools and aids. There now are a large number of soldering and desoldering tools available for general and special applications, including soldering irons, guns, pistols, and variations on these tools. As a rule, irons and pencils are light- and medium-duty tools; guns are for medium- to heavy-duty work, while pistols are available in light, medium, or heavy-duty models.

Looking first at the iron, it's usually low in cost, keeps a fairly uniform temperature, and doesn't have to be turned on each time you solder a connection. Irons vary in size and heat capacity from about 15 to 500 or more watts, but an iron of 20–30 watts is all you need for most electronics work. A 15-watt pencil iron is good for PC boards and tight places. A 100-watt-plus iron is good for heavy-duty electrical work, but not for working on PC boards.

Arguably, the tip is the most important part of the iron; the size of the tip greatly affects the initial heating and heat-recovery times. Tips are made of various types of metal, though coated copper is generally used. A simple, straight tip with two flat faces (like a wedge) is most often used for general-purpose irons. Very slim, pointed tips are frequently used for delicate PC-board work. Several tip-face styles usually are available for most popular irons.

Depending on what you're working on, you might find a soldering gun suitable. Although a gun must be activated each time it's picked up, a gun heats quickly, often has a dual heat selection, and doesn't need a stand. A gun has a noteworthy advantage over an iron: fast heating. It has a built-in transformer that provides high current directly to the tip, causing the tip to come up to full heat almost instantaneously.

However, that feature is a two-edged sword: some users complain that a gun is hard to handle, heavy, and fatiguing to use. A gun is typically more useful for repairs and when only a few connections must be made.

With the features of both a soldering iron and a soldering gun, a soldering pistol might be more advantageous. It combines a gun-type heating element and step-down transformer with the iron's soldering tip, so it heats almost instantaneously.

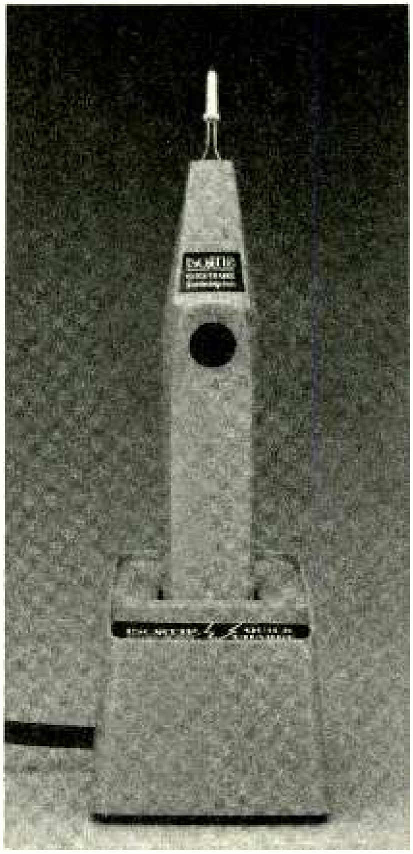
One of the most useful soldering tools of recent years is the rechargeable cordless soldering iron. It allows completely portable operation—it is not tied down to an AC source like a conventional iron, gun, or pistol. The typical cordless unit has a self-contained, rechargeable battery that yields from 100 to 175 solder joints per charge. The tip usually comes up to operating temperature in 5 to 8 seconds.

Many units have batteries that can be brought up to a full charge in an hour or so after completely discharging. The more advanced models allow for continuous charging when not in use, and have LED indicators that indicate when charging is complete; others can be left plugged in at all times, and can't be overcharged.

Many multipurpose units have provisions for interchangeable tips and other accessories, including small PC-board drills. Wahl has a novel PC mini-drill attachment for their ISO-TIP rechargeable iron; it temporarily replaces the tip of the iron, and obtains power from the unit's battery pack.

Accessories. We'll assume you're equipped with appropriate electronic workbench tools, such as needle-nose pliers, screwdrivers, knives, wire strippers, and the like, in addition to a suitable soldering iron or gun. Besides these, many other soldering accessories and gadgets can make building and repair work a great deal easier.

Some soldering accessories you'll find useful are a brush, scraper, probes, and spare tips. A clip-on heat sink to protect delicate components is a must, although it need not be a commercially manufactured item. You could use a paper clip, a clamp, or pliers to grip components that need protection from excessive heat.



This Wahl Quick Charge ISO-TIP iron recharges completely in 3 to 4½ hours and can't be overcharged. A fully charged unit can make up to 125 electrical joints per charge. The kit contains the cordless soldering iron, wall plug transformer, two tips, and instructions. (Photo courtesy Wahl Clipper Corporation.)

Something to clean up the iron and keep its tip shiny is a must. That can be a sponge, rag, or washcloth. An illuminated magnifier is handy for examining connections, working with small components, and performing delicate PC board repairs.

Anyone who has had the experience of having a hot soldering iron inadvertently come in contact with c component, PC board, or cabinet, thereby causing heat damage, will want to use an iron holder to keep the iron in a safe place. Some iron holders even have built-in sponges for tip cleaning.

Keep the Soldering Tool Clean. If there's a basic rule about soldering, it is: keep it clean! The tip itself must be clean, with its surface lightly coated with solder to prevent its deterioration from oxidation. That is called tinning, and it facilitates transfer of heat from the tip to the connection. You should clean and tin the tip of the soldering tool with solder after purchase.

Wear on the tip is not due to erosion or to the flux. Instead, it's due to the effect of the molten solder on it. Some manufacturers coat their copper tips with iron; this makes them less efficient for heat transfer, but it increases their lifetime. Besides the tip, the terminals and components to be joined must also be clean. "Well cleaned is already half soldered," is what old hands say.

The tip should be cleaned frequently during lengthy soldering sessions. This can be done by lightly running a wash cloth or rag across its surface, particularly when it is only moderately hot. Don't let the cloth remain in contact with the tip for an extended period, or it will char or even catch fire. Specially treated cleaning pads and sponges can also be used.

This Wahl butane-powered soldering iron and torch is for heavy-duty electrical jobs—not for delicate PC-board work. Ideal for hobbyists and technicians, especially in outdoor applications, the cordless and refillable iron features an aluminum body and even-flow valve for a uniform flame. (Photo courtesy Wahl Clipper Corporation.)

Don't be concerned if the tip becomes pitted since this is a result of normal soldering action. You can lightly file the iron's tip to remove the black spots of oxidation, and then retin it. If your iron has a detachable tip, you should periodically dismantle it from the heating element, to prevent its permanently bonding itself in place. Some builders like to store the heating element and handle with the tip removed.

Prepare the Connection and Solder. For solder to properly adhere to a connection, the metals must be clean and free of all nonmetallic matter. While rosin flux removes oxides from metal surfaces, it won't remove grease, dirt, or other foreign matter. If need be, you must do that yourself with a brush or cloth. You can clean a dirty lug or component lead with a small steel-bristle brush designed for the purpose, and you can use a strip of emery cloth or a file to remove stubborn particles. You also can use a solvent such as alcohol.

Once the components and terminals to be soldered are clean, they should be connected together to form a good mechanical and electrical joint before soldering. However, don't always rely just on solder to physically hold the work together. If parts fit too loosely, a weak joint will be the result, or even no joint at all if the gap is too wide for the solder to bridge.

The iron or gun should be hot enough to allow soldering to proceed quickly, but not so hot that the solder "burns" and free flux on the tip forms black flakes. If your iron or gun is adjustable, try different settings to determine which is best.

Now, to solder the connection. The idea is to apply the tip to the connection and almost simultaneously apply the solder to the junction between the tip and the connection. You want a small amount of solder to flow between the iron tip and the wire or component, which aids in transferring heat to the connection. The connection becomes hot enough for the solder to flow onto it, forming a solder fillet between all of the parts.

When soldering, place the tip of the soldering iron directly against the connection to be soldered, and at the same time apply the solder to the point where the iron touches the two pieces of metal. Allow the connection to be heated enough so that the solder melts quickly and spreads evenly and almost immediately to every part of the connection.

Keep the soldering iron against the connection long enough to "cook out" any flux residue, but not so long that the solder "burns up." The time for the entire operation should be very short, just a matter of seconds. Don't let the solder run down the tip, or try to heat up the whole area first. Apply just enough solder to fill the gaps, and no more. Why? Excess solder will flow into places where it's not needed, or where it can cause a short.

To complete the process, remove the solder first, then the tip, being careful not to allow the connection to move while the solder is solidifying. Resist cooling the joint by blowing on it and also overcome the temptation to "test" the physical connection prematurely. If you do, you'll set up tiny fractures within the joint, seriously weakening it. Note, too, that you should clip excess leads before soldering, not afterwards—doing so afterwards weakens the connection.

Names and Numbers

Elenco Electronics, Inc. (150 W. Carpenter Ave., Wheeling, IL 60090; Tel. 708-541-3800) offers a number of electronic kits, including the SP-1 Soldering Practice Kit, several analog and digital multimeters, a diode/transistor tester, a combination AM/FM radio kit and training course, power supplies, and several other educational kits particularly suited to beginners.

Radio Shack Corporation (1500 One Tandy Center, Fort Worth, TX 76102; Tel. 817-390-3011) sells through its more than 7000 stores a good selection of soldering and desoldering tools and accessories. Necessary test equipment, including several multimeters, also are offered.

Solder-It Company (P.O. Box 20100, Cleveland, OH 44120; Tel. 261-721-3700) markets a variety of specialty soldering pastes and tools. Their products aim to make soldering coaxial-cable fittings, aluminum tubing, antenna set screws, and other often difficult-to-solder materials less troublesome.

Wahl Clipper Corporation (2900 Locust Street, Sterling, IL 61081; Tel. 815-625-6525) sells a variety of soldering and desoldering tools. They feature the ISO-TIP line of cordless rechargeable soldering irons and accessories, including PC-board mini-drill attachments. ■

It's best not to use water to clean any solder joint that uses a rosin flux, as it can cause a corrosive chemical reaction. The rosin residues can be left in place with no danger of corrosion, or they can be removed with a rag or a brush and special solvents.

How Good Soldering Looks. What does a good solder connection look like? A good connection is one where the solder has uniformly flowed over all the surfaces to be connected, following their contours. The connection appears bright, shiny, and smooth, with all wires in it appearing well soldered. However, if the connection is rough, grainy, or flaky looking, or if the solder formed into little round blobs, or has ridges or sharp points, redo it. Take the time to visually check the connection with those points in mind.

If the joint is a "cold" connection, caused either by insufficient heat, a wire moving, or foreign matter (such as oxides) getting into the connection, the cure is simple and direct: reheat the joint and apply a little more solder. If that would place too much solder on the joint, you will have to remove the solder (as we'll describe shortly) before trying again.

Avoid Component Damage. Place heat sinks on the leads of particularly heat-sensitive components such as transistors, integrated circuits, small capacitors, diodes, and the like, to divert heat from them. Also keep in mind that components such as integrated circuits and field-effect transistors, can be destroyed by static or stray electricity. For that reason, many of these devices are furnished with the leads jumpered or shorted together by a ring of fine wire or special conductive foam. Leave the short on the leads as long as possible to prevent damage during handling.

Know How to Desolder. It's tricky to repair a mistake on a PC board without damaging the board and its components. The board is delicate: the base material can be charred or melted, and the metal foil can be pulled up from the base and broken if you're not careful. If you replace a component, use as little heat as possible. Excessive heat can damage it, adjacent components, and the board itself.

For correcting mistakes and for PC board repairs, you'll need a low-heat desoldering tool, bulb, station, or wick. A soft wire brush and illuminated magnifying glass might also be handy. Most of these inexpensive items are available in desoldering tool sets from Radio Shack and other electronics suppliers. It's worthwhile to have the proper desoldering tools, since a construction mistake and a messy, inept attempt at PC-board repair can ruin a whole project in a twinkling.

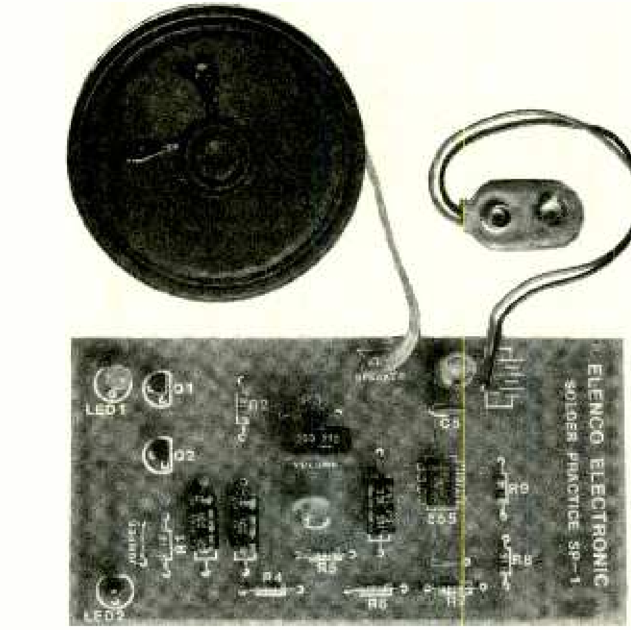
Nasty Problems. Most electronic kits returned to the factory for repair don't have anything wrong with them except bad solder connections. The biggest problems arise from poor soldering techniques, resulting either in cold, ineffective solder joints or massive blobs of solder running across contacts and terminals shorting them out. Many of these problems can be traced to not applying the right amount of heat to a joint, moving it too soon, using too much solder and not watching where it flows, applying the soldering iron tip to the solder rather than to the joint, and working with dirty soldering tools.

Problems due to cold solder joints are difficult to diagnose. They tend to blend into regular electronic malfunctions, making them difficult to spot. They can appear as open, intermittent, high-resistance, or even apparently normal connections. They can trick you into suspecting other components, such as resistors, transistors, capacitors, and IC's.

If you're having problems with an electronic project, closely examine all solder connections for dull, loose, or flaky joints and for "solder bridges" between adjacent components. A good magnifying glass and a sharp eye helps spot them. Usually, reapplying heat to all connections will solve most such problems.

Special Solder Jobs. Some metals are just not solderable (at least in their natural states); they don't have an affinity for conventional solder. Therefore, you need to first consider the metal or materials to be soldered—some of the problem ones being magnesium, chromium, tantalum, silicon, and aluminum.

That doesn't mean it's impossible to solder to them; it's just more difficult. Aluminum and other metals can be soldered, for example, if you use a special flux. To solder some of the difficult metals, they must be plated with a solderable metal.



The Elenco Electronics SP-1 Soldering Practice Kit is designed for the beginner, being a simple and inexpensive project that exposes you to proper soldering techniques. (Photo courtesy Elenco Electronics, Inc.)

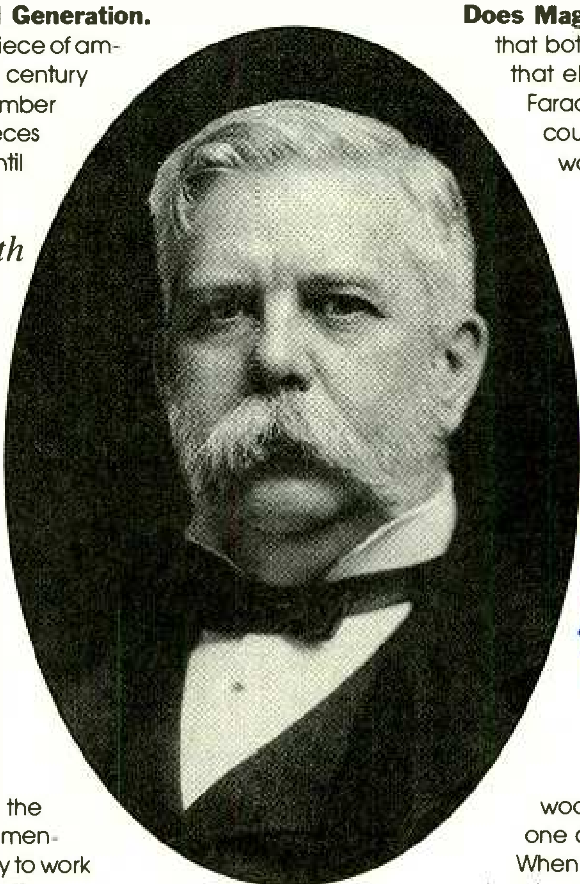
Solder-It Co., markets a variety of specialty soldering pastes and tools to handle some of the difficult metals. The main product offered is The Solder Kit. The kit contains the necessary fluxes for silver, aluminum, copper, and pot metal (for zinc die cast and white metals), plus a pencil butane soldering torch. The $59 kit includes four solder-paste syringes, a refillable butane pencil, and a vinyl storage pouch.

The special fluxes are packaged in special no-mess applicator syringes for one-hand-free soldering. Professional results, including neat, clean soldered joints and excellent electrical conductivity, and continuity, are results claimed by the manufacturer for its products.

Sometimes, especially in heavy outdoor projects, you need soldering tools heavier than the small, low-power guns and irons we have focused on here. Wahl, for instance, makes a butane-powered soldering iron and torch, the Model 7980, for heavy-duty use by hobbyists and technicians, and so it's especially useful for big outdoor jobs. As an iron, it offers up to 100 minutes of continuous soldering per refill; adjustable tip temperatures range up to 1067°F. Used as a torch, the unit provides up to 60 seconds of continuous flame per refill; adjustable temperatures up to 2372°F can be obtained. The Wahl unit is $47.

Practice Makes Perfect Do you need some electronic soldering practice before digging into a real project? The February 1994 issue of **Popular Electronics** favorably reviewed the Elenco Electronics SP-1 Soldering Practice Kit. Designed for the beginner, it's a simple and inexpensive ($8.25) project that exposes him or her to various soldering techniques. While the project's warbling alarm and flashing LED's might not be something you really need, it may be perfect for the first-time electronics builder. The kit is like any other electronic kit, but the SP-1 manual places more emphasis on learning and practicing proper soldering techniques than it does on the circuit itself.

That's really all there is to good soldering. With a little practice and keeping these few guidelines in mind, you can do a professional soldering job each and every time. ■



AC or

In the late nineteenth century, George Westinghouse and Thomas Edison took opposing sides in the spirited debate to determine whether AC

Thomas A. Edison is quoted as saying: "My personal desire would be to prohibit entirely the use of alternating currents. They are as unnecessary as they are dangerous." His futile attempts to have the establishment of alternating current (AC) power systems outlawed seemed to be centered around the issue of "safety." It is likely, however, that not all his motives were altruistic.

While Edison did have a great fear of high voltages, he also had a major business interest in the development and manufacture of direct-current (DC) generation-and-distribution systems. Not surprisingly, he attempted to use his popularity as the greatest scientific celebrity of the late 19th century to rally public support against the competition posed by George Westinghouse's high-voltage alternating-current system.

The History of Electrical Generation. Thales of Miletus rubbed a piece of amber with a cloth in the sixth century B.C. and found that the amber would then attract light pieces of matter. From that time until Alessandro Volta produced the first battery in 1800, experimenters only had static electricity to work with. Rotating static-electricity generators developed in the 17th century were used to charge Leyden jars (capacitors), but they could only provide current flow for very brief periods while they discharged.

Volta's batteries produced a unidirectional flow of electrons, but were expensive and could not produce substantial currents for extended time periods. That mattered little, however, as electricity was merely a poorly understood scientific curiosity in 1800.

A major scientific breakthrough was made in 1820 when Hans Christian Oersted noticed that a battery current flowing through a wire caused a nearby compass needle to deflect. His discovery established that electricity and magnetism are somehow related.

Andre Marie Ampere, upon learning of Oersted's observation, conducted experiments that resulted in his finding that closely spaced, current-carrying parallel wires either attract or repel each other depending on whether the currents flow in the same or in opposite directions. He determined that the magnitude of the attractive or repulsive force is directly proportional to the product of the two currents and inversely proportional to the square of the distance separating the wires. Ampere also discovered that a current flowing through a spiral wire or solenoid produces the same type of magnetic field as does a bar magnet.

Francois Jean Dominique Arago soon discovered that an iron core greatly increases the strength of the magnetic field produced by current flow through a solenoid. He also found that some residual magnetization remains in the iron core after the current flow stops.

Does Magnetism Produce Electricity? Knowing that both Oersted and Ampere had established that electricity produces magnetism, Michael Faraday attempted in 1831 to see if magnetism could be used to produce electricity. He wound two separate coils on a block of wood and then made a current flow through one coil.

When the current through the one coil was started or stopped, and only then, a galvanometer connected to the second coil indicated the momentary flow of current. Suspecting that the changing magnetic field was responsible, Faraday then showed that this "mutual induction" effect, as he called it, was much more pronounced when the two coils were wound on an iron ring (see Fig. 1). He had discovered the principle of "transformer action."

Faraday discovered another important electrical principle shortly thereafter. He found that a current can be made to flow by moving a conductor through a magnetic field. In Faraday's experiment, current flowed between the axis and rim of a copper disk that was rotating between the poles of a strong horseshoe magnet. These two observations would be crucial in the development of electrical generators, motors, transformers, and other energy-conversion systems.

Joseph Henry, working simultaneously and independently in the United States, also discovered the principle of mutual induction. In addition, he discovered that the ratio of the number of turns on the two coils determined the magnitudes of the voltage and current in the second winding relative to the corresponding values in the first winding.

It was now known that electricity produces magnetism and that, conversely, magnetism produces electricity. Some ten years earlier, Faraday and Ampere each had independently found that a current-carrying conductor can be made to rotate in the fields produced by bar magnets.

Necessary Principles Now Known. In 1831, all the scientific principles needed for the development of large-scale electrical generators, transformers, and motors had been established. It would be many years, however, before the advantages of using such devices would be fully realized and the practical problems associated with building them would be solved.

Faraday's rotating disk was capable of producing only very small voltages. The greatest attention, therefore, was soon directed toward developing the other principle he had discovered for producing voltages: induction.

Changing the magnetic field around a conductor is accomplished rather easily by wrapping a coil of wire around a cylindrical "armature" and then rotating that armature in a magnetic field. The voltage generated is proportional to the strength of the magnetic field, the speed of the armature's rotation, and the length of the wire comprising the rotating coil. Increasing any one of these quantities will increase the voltage produced.

One important problem to be overcome was that of maintaining continuous electrical contact with the rotating coil of wire. The solution devised was to connect the ends of the coil to "slip rings" that rotate with the coil and that rub against stationary "brushes" to make the needed electrical contact (see Fig. 2).

The voltage produced by rotating a coil in a magnetic field is not constant. The angle that the magnetic field makes with the plane of the coil changes as the coil rotates. That results in a change in both the magnitude and polarity of the voltage produced.

DC?

power systems were safe enough to supplant those using DC.

BY JAMES P. RYBAK

The voltage generated and, hence, the current flowing through a connected load vary sinusoidally with each revolution of the coil. That is precisely the output produced by the alternators or AC generators used today. What was wanted in those days, however, was a voltage that was constant with time like that produced by a battery. No one at that time knew of a use for "alternating" voltages.

Direct Current Produced. A "split-ring commutator" was developed in 1832 by Hippolyte Pixii in France to provide unidirectional current from a generator. He connected the ends of the rotating coil to the opposite sides of a metal slip ring that had been split lengthwise to form two half-cylinders (see Fig. 3). The two segments of the split slip ring were insulated from each other and each was connected to the ends of the coil that rotated in the magnetic field. The stationary brushes were positioned so that as the voltage generated by the coil changed polarity, the section of the split-ring commutator coming into contact with each brush also changed. This commutator action caused the voltage delivered to the load to always have the same polarity although it was still not constant in magnitude. Nonetheless, a DC generator had been achieved. Later DC-generator designs had additional coils spaced symmetrically around the armature with each connected to its own pair of commutator segments. These produced more nearly constant DC voltages.

Other improvements in the operation of the DC generator soon were made by a number of experimenters. It was noticed that increasing the number of loops of wire on the rotating coil resulted in greater voltage output. A larger diameter wire allowed greater currents to be delivered to the load. Positioning a number of separate coils around the rotating cylindrical armature and segmenting the slip-ring commutator into a corresponding number of segment pairs provided a DC output that was more nearly constant in magnitude.

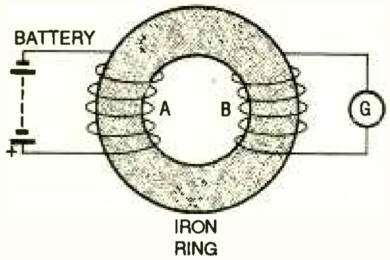


Fig. 1. Faraday discovered the "transformer effect" when he observed that causing a current to start or stop in coil A produced a momentary deflection of the galvanometer connected to coil B.

The horseshoe magnet that had provided the magnetic field through which the armature coils rotated was soon replaced by an electromagnet powered by a battery. Much greater magnetic field strengths and, hence, greater generator output now could be obtained.

In 1866, it was discovered that the residual magnetism of the electromagnet's iron core produces a small output from a generator even if the battery is not connected. Connecting the electromagnet's own coil to the output terminals of the generator slightly strengthens the magnetic field produced by the electromagnet. That, in turn, increases the output of the generator. The increased generator output further strengthens the magnetic field and results in the generator output being further increased.

This "bootstrapping" action quickly results in the generator reaching full output. Generators operating on this principle became known as being "self-excited" and the windings on the electromagnet became known as the "field" windings.

Generators Go Commercial. The first major comrnercial use for machine-produced electricity came in the early 1870's when DC generators began to replace the costly batteries used in industrial-electroplating processes. In addition to never needing replacement, the generators provided a more constant voltage than did batteries. Other commercial uses for generators quickly followed.

Generator-powered electric-arc outdoor lighting was developed simultaneously in both the United States and Europe in the late 1870's. The first carbon-arc lights were inefficient and had a relatively short lifetime, but produced significantly greater amounts of light than gas lamps.

Arc-lamps required high currents at relatively low DC voltages. Typically, as many as 65 lamps were connected in series in circuits operating at up to 3500 volts. The light produced by these arc-lamps, however, was too intense to be used indoors.

Edison's Contributions. Thomas Alva Edison developed his first commercially successful incandescent lamp in 1879. He then designed several types of DC generators to power his lighting systems in factories, public buildings, and steamships.

In 1882, the newly formed Edison Electric Illuminating Company of New York began building a central power-distribution system to provide indoor incandescent lighting for the main business district of the city. Six "jumbo" generators, each capable of powering twelve-hundred 100-watt lamps, were built by the Edison Machine Works and used together with more than fourteen miles of underground power mains.

Edison had designed his incandescent lamps to operate at a voltage ranging from 110 to 125 volts DC. That was considered to be the maximum safe voltage for use inside commercial buildings and homes. The voltage produced by the power generating stations, was therefore 125 volts since parallel operation of the lamps was desired and no efficient way to reduce higher DC voltages was available. As a result of this low utilization voltage, the power mains had to handle very large currents.

The design of the underground distribution systems presented numerous problems. The high currents necessitated that both large conductor cross-section areas and short conductor lengths be used to keep the voltage drops from being excessive.

Soon, Edison improved the load capacity of his distribution systems somewhat by connecting the outputs of two 125 volt generators in series. He used a three-wire distribution system to deliver the correct 125 volt electric potential to each lamp. The generating stations, however, still had to be located relatively close to where the power was to be used.

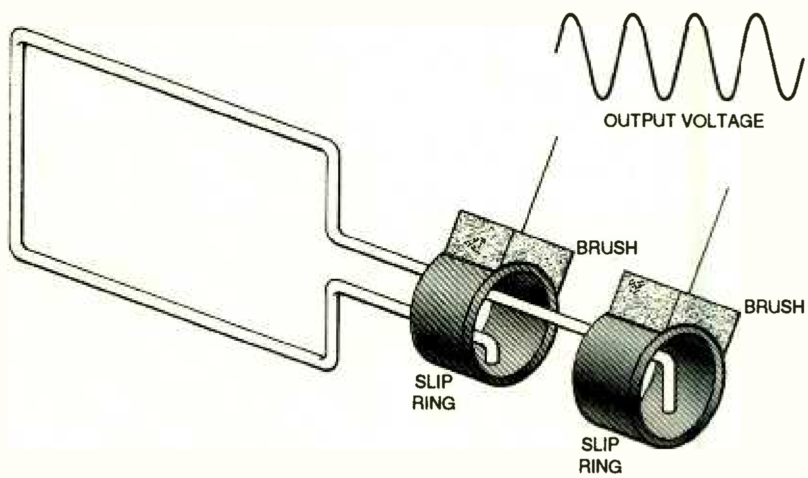


Fig. 2. The "slip-ring" and "brush" made possible the development of rotating electrical generators.

The DC power-generating and distribution systems designed and produced by Edison were quickly adopted by hundreds of cities, both large and small, throughout the United States. Because of the limitations of the distribution networks, these Edison systems were characterized by the use of numerous small central generating plants.

The success of the incandescent lamps manufactured by the Edison Lamp Company increased the demand for electrical power. Ironically, this increased demand helped hasten the demise of the municipal DC generation and distribution systems Edison had developed.

The short distribution systems necessitated by the low utilization voltage and high currents meant that the central power stations had to be built in dense population areas where the cost of real estate was high. In addition, the actions of overseas copper cartels in the late 1880's dramatically increased the cost of that metal, which was required in great amounts for the distribution systems (see Fig. 4). Direct-current systems were at a distinct cost disadvantage compared with the alternating-current systems George Westinghouse was beginning to develop.

Alternating-Current Generators. The first true AC generators capable of producing significant amounts of power were built the 1850's and 1860's. The builders recognized that AC generators (or alternators) had the advantage of inherently simpler design due to their lack of a commutator.

Creating a demand for AC power met with little success initially. Interest in AC power increased, however, when it was found in the 1870's that arc-lamps functioned better when operated from AC rather than from DC voltages.

Ganz and Company was established in Budapest in 1880 and became one of the European pioneers in the development of alternating-current systems. Their first major contribution was a 60-volt, 2800-ampere alternator capable of operating 1600 of the incandescent lamps developed by Joseph Swan in England.

The Ferranti Company began building AC equipment in England at approximately the same time. In 1883, that company built a 200-volt alternator capable of powering 5000 incandescent lamps.

The advantages of electrical transmission at high voltages became apparent to many in the late 1870's. It was estimated, for example, that copper conductors 3 inches in diameter would be needed to transmit the electrical equivalent of 1000 horsepower a distance of 30 miles. Increasing the potential to 80,000 volts, however, would permit 21,000 electrical horsepower to be transmitted 300 miles using only ½-inch diameter copper wires.

Low-voltage alternating current, on the other hand, provided no advantages in overcoming distribution problems, however. So what was apparently needed were high-voltage AC generation and distribution systems coupled with the yet-to-be-invented transformer.

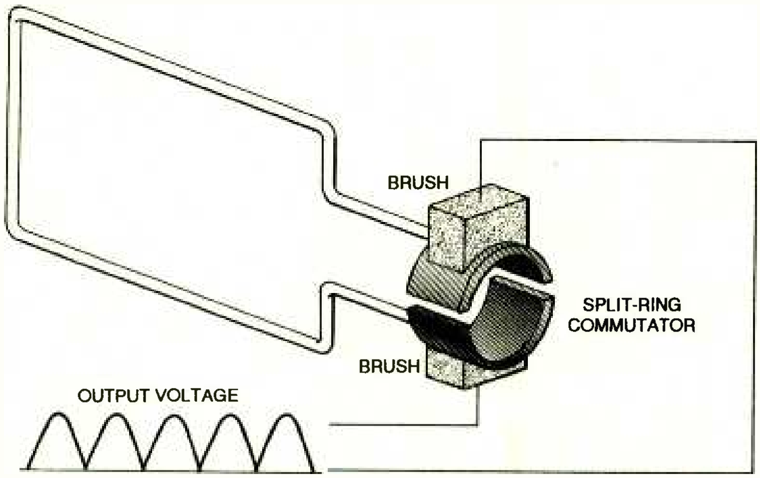


Fig. 3. The "split-ring commutator" made the generation of a pulsating, unidirectional flow of electricity from a coil rotating in a magnetic field possible.

The Transformer Evolves. The transformer has as its ancestor the induction coil, which experimenters have used since the 1830's to generate high-voltage pulses. The induction coil of that time had a bundle of iron wires as a core over which a primary coil, consisting of a few turns of heavy-gauge insulated wire, was wound. A secondary coil, consisting of many turns of fine, insulated wire was wound over the primary coil. A battery connected to the primary winding caused a large current to flow. When this current was abruptly interrupted, a high-voltage pulse was produced across the terminals of the secondary winding.

A number of people recognized that the induction coil might be modified to produce a continuous high-voltage output when connected to an AC generator. It was Lucien Gaulard and John D. Gibbs, however, who were the first to produce a convincing demonstration.

These two engineers constructed a modest but highly successful display at the 1883 electrical exhibition at Westminster Aquarium in London. They clearly showed that the use of what they called "secondary generators" (today we would call them "transformers") would enable electrical-energy producers to supply AC energy to a distribution system at the most economical potential, while permitting the users to obtain that energy at the potential that best suited their needs.

In 1884, Gaulard and Gibbs installed an electrical transmission line with secondary generators to supply AC power to arc lamps and incandescent lighting at a number of passenger stations of the London Metropolitan Railway. That same year, they produced another impressive demonstration at the Turin (Italy) Exhibition. For that, they built a transmission line with secondary generators that powered electric lights from the line's origin at Turin to the terminus at Lanzo, some 25 miles away.

Gaulard and Gibbs' secondary generators were configured much like an induction coil. A bundle of straight soft-iron wires was used to form an "open" core around which the primary and secondary windings were wrapped. Pulling in or pushing out the core controlled the voltage produced at the secondary terminals. The fact that the primary windings were connected in series severely limited the degree to which the secondary voltages could be independently varied.

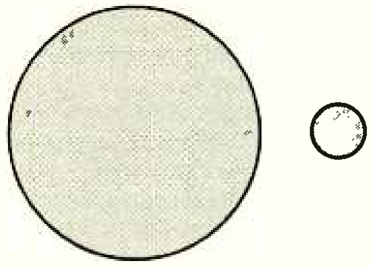
The demonstration caught the attention of three Hungarian engineers (Max Deri, Otto Blathy, and Karl Zipernowsky) who were in attendance at the Exhibition. The three visitors immediately concluded that a better secondary generator design was possible. In only a few weeks after returning home, the Hungarians produced their first 1400-watt "transformer," as they called it, with iron wires forming a "closed" core. Seventy-five of these transformers with their primary windings connected in parallel were used in conjunction with 1067 of Edison's incandescent lamps to light the 1885 Hungarian National Exhibition in Budapest.

Westinghouse Likes What He Sees. Despite the shortcomings of the Gaulard and Gibbs design, their demonstration at Turin earned for them the gold medal and cash prize awarded by the Exhibition's organizers. George Westinghouse was impressed with what he saw at the Exhibition and purchased the American patent rights to the Gaulard and Gibbs equipment. He had several of the secondary generators immediately shipped to Pittsburgh for study.

Westinghouse, already famous for the invention of the railway air brake, had recognized the opportunities offered by electrical power. A year earlier he had assembled a group of the best "electricians" available to develop commercially profitable electrical products. To this group he now added a man who had worked with Gaulard and Gibbs. With both the patents and the technical knowledge that the Gaulard and Gibbs enterprise had developed, Westinghouse began manufacturing transformers.

The Westinghouse transformers used stacks of thin, T-shaped plates of soft iron for the magnetic circuit rather than the bundles of iron wire Gaulard and Gibbs had used. Connecting the transformers' primary windings in parallel was recognized from the onset by the Westinghouse engineers as far superior to a series connection.

AC Competes with DC. The first experimental Westinghouse AC distribution system was installed at Great Barrington, Massachusetts during the winter of 1885–86. The system served only about 150 incandescent street and store lights, but was so successful, Westinghouse began to manufacture and sell AC equipment for powering incandescent lighting. By November of 1886, Westinghouse had installed his first commercial AC-distribution system in Buffalo, New York and had orders for twenty-seven additional systems.



A B

Fig. 4. The relative amounts of copper required by Edison's 220-volt three-wire DC distribution system and Westinghouse's 1000-volt AC distribution system are indicated here by circles A and B, respectively.

Initially, Westinghouse used AC generators built by Siemens and Halske in Germany. Later, the Westinghouse firm would manufacture its own alternators.

Thomas Edison quickly became aware of the Westinghouse successes. Of concern to Edison was the fact that the Westinghouse AC-generation and -distribution systems not only provided reliable service, but were more economical to install than were Edison's own DC systems.

Power in the Westinghouse AC systems was usually distributed at a potential of 1000 volts in contrast with the 240 volts used in the Edison DC systems. Transformers then stepped-down the potential to the 50 volts needed to power specially designed incandescent lamps.

The high voltage used in the AC distribution systems allowed the use of small conductors because of the proportionately lower current levels needed for a given amount of power. The large copper conductors needed for Edison's low-voltage distribution systems, together with the small area over which each of his generating plants could provide service before voltage drops became excessive, put the DC systems at a substantial cost disadvantage.

There was really no way that the cost of installing a DC system could be reduced. The voltage drops dictated by Ohm's Law and the cost of copper were outside of Edison's control. Clearly, other tactics would have to be used if Edison was to avoid the threat of financial ruin posed by Westinghouse's AC systems.

Edison knew that he needed to have public support if his DC systems were to survive. If Edison could convince the public that AC systems posed unacceptable safety risks, it might be possible to get them outlawed.

AC Called "Damnable." Harold P. Brown, a virtually unknown electrical consultant and inventor, joined the battle against AC systems in May of 1888 when he wrote a letter to the *New York Evening Post* in which he claimed that, from a safety standpoint, alternating current should be described by "no adjective less forcible than damnable." Brown, who had no formal schooling in electricity, claimed that the danger due to electrocution lay not in the amount of voltage present, but in whether the current flow was "wavy or pulsating" (AC) as opposed to "continuous" (DC).

Books and Articles

"The Comparative Value of the Alternating Transformer and Continuous Current Systems for Central Station Lighting," by F. B. Badt, *The Electrical Engineer*, July, 1888, pp. 305–308.

"Experiments with Electric Currents on Dogs," by Harold P. Brown, *The Electrical World*, August 11, 1888, pp. 72–73.

"The New Instrument of Execution," by Harold P. Brown, *The North American Review*, vol. 149, November, 1889, pp. 586–593.

A Streak of Luck, by Robert Conot, Seaview Books, New York, 1979.

"The Dangers of Electric Lighting," by Thomas A. Edison, *The North American Review*, vol. 149, November, 1889, pp. 625–634.

"Transformer Invented 75 Years Ago," by A. A. Halacsy and G. H. von Fuchs, *Electrical Engineering*, June, 1961, pp. 404–407.

The Rise of the Electrical Industry During the Nineteenth Century, by Malcolm MacLaren, Princeton Univ. Press, Princeton, NJ, 1943.

"The Damnable Alternating Current," by Terry S. Reynolds and Theodore Berstein, *Proceedings of the IEEE*, vol. 64, September, 1976, pp. 1339–1343.

"Alternating Current Versus Direct Current," by Lewis B. Stillwell, *Electrical Engineering*, May, 1934, pp. 708–710.

"A Reply to Mr. Edison," by George Westinghouse, Jr., *The North American Review*, vol. 149, December, 1889, pp. 653–664.

Chicago had already severely restricted the use of AC for power distribution and Brown urged that the New York City Board of Electrical Control adopt similar regulations. Brown's recommendation that no AC-distribution networks be allowed with potentials exceeding 300 volts would have eliminated the economic advantages AC held over DC.

Brown then went to the West Orange, New Jersey laboratory of Thomas Edison to obtain the use of specialized equipment needed to conduct experiments he hoped would confirm his assertions concerning the dangers of AC. Edison had not known Brown previously, but agreed to the latter's request, obviously hoping that Brown would be successful.

Brown's plan was to show that AC was more dangerous than DC by subjecting live dogs to electric shocks of both types. The series of experiments he conducted in the summer of 1888 was both inhumane and somewhat macabre, at least by today's standards.

The gruesome details of Brown's experiments are best left undiscussed here, but his conclusions concerning the relative dangers of AC and DC are important. Brown claimed that dogs subjected to direct current shocks as great as 1420 volts "yelped but (were) unhurt," while those to which AC shocks of as little as 200 volts (and less) were applied died "without a struggle."

Frederick Peterson, a medical doctor who assisted Brown with the experiments and then performed autopsies on many of the dogs that died, proposed an explanation concerning the apparently greater lethal effect of AC. In essence, he felt that a DC voltage produces a damaging shock to the body only twice; once when the circuit is first closed and once again when the circuit is opened. No shock, he claimed, occurs with DC during the interval between those events.

Dr. Peterson maintained that AC produces a damaging shock to the body each time the current changes direction; *i.e.*, twice each cycle. The effects of ohmic heating produced in the body by both AC and DC current were apparently not taken into account, or else were considered unimportant, by Peterson.

A New Mode of Execution. The next stage in the verbal battle between the proponents and opponents of AC developed almost immediately as the State of New York undertook a search to find a means of executing criminals that would be more humane than hanging. Edison suggested that electricity, specifically alternating current, be used. Edison's recommendation was supported by Elihu Thomson who headed the Thomson-Houston Company, a major manufacturer of alternating-current equipment.

Edison opposed the principle of capital punishment, but felt that, if executions were to be conducted, electrocution would be the most painless method. George Westinghouse opposed the electrocution of criminals because he feared adverse public reaction to his alternating-current systems.

The New York State Legislature enacted legislation calling for the electrocution of criminals convicted of committing capital crimes on or after January 1, 1889. The type of electricity was not specified, but the Legislature requested that the New York Medico-Legal Society determine the best way to carry out the new law. The chairman of the commission established by the Society was Dr. Frederick Peterson who utilized (not surprisingly) the services of Harold Brown in his work.

The two men prepared a report for the Medico-Legal Society based on additional experiments in which animals, including two calves and a horse, were electrocuted. Most of the experiments took place at Edison's West Orange, New Jersey laboratory. The much publicized report recommended (not surprisingly) that alternating current be used to execute criminals.

Brown then was given the responsibility of purchasing the equipment for performing executions by electrocution at New York's Auburn, Sing Sing, and Clinton penitentiaries. As Brown was convinced of the greater lethal power of AC, he wanted to purchase three Westinghouse alternators. George Westinghouse, not wanting his alternators associated with death, refused to sell Brown the machines. Brown, however, finally did obtain the Westinghouse alternators on the used-equipment market.

Westinghouse knew full well that Peterson and Brown's work was threatening the public's acceptance of alternating current. He challenged the conclusions drawn by Brown and Peterson as well as their objectivity. Westinghouse also suggested that Brown was deliberately serving the business interests of Edison for pay. Westinghouse urged that an unbiased person independently investigate the relative dangers of AC and DC.

Brown responded by challenging Westinghouse to a contest best described as a game of electrical "chicken." The proposal was that Brown would submit himself to DC electrical shocks while Westinghouse would be given AC electrical shocks. The voltages would be increased in 50 volt increments between successive shocks. The contest would continue until one of the men cried "enough" and publicly admitted the error of his position concerning the relative dangers of AC and DC.

Wisely, Westinghouse declined Brown's challenge. The contest, at best, would have proven nothing scientifically and, at worst, could have resulted in serious injury or death to one or both of the men.

Probably relieved that Westinghouse had declined the challenge, Brown nonetheless tried to use the refusal to his advantage. Brown reminded the public that Westinghouse was "willing to endanger the public, but not himself," with alternating current. The fact that Westinghouse used direct current in his own home did not go unnoticed or unmentioned by Brown.

Edison is Heard From. Thomas A. Edison became more directly involved in the controversy in November of 1889 when he wrote an article entitled "The Dangers of Electric Lighting," which appeared in a widely read magazine of the day. In that article, Edison stated that DC at a potential not exceeding 200 volts is "harmless, and can be passed through the human body without producing uncomfortable sensations." He also claimed that alternating current of 1000 volts and greater (such as Westinghouse's distribution systems used) "through any living body means instantaneous death."

The "father" of the incandescent lamp and the person generally recognized by the public as the greatest expert concerning things electrical was adamant in his stand. He maintained that "There is no plea which will justify the use of high-tension and alternating currents, either in a scientific or a commercial sense."

Edison urged that DC be restricted to no more than 700 volts (well above the voltages used in his DC distribution systems) while stating: "As for alternating current, it is difficult for me to name a safe pressure." He went on to say: "My personal desire would be to prohibit entirely the use of alternating currents. They are as unnecessary as they are dangerous."

George Westinghouse lost no time in responding to Edison's claims. In an article entitled "A Response to Mr. Edison" published in the same magazine, Westinghouse convincingly refuted Edison's principal assertions concerning the dangers of AC.

Westinghouse challenged Edison's claim that DC "can be passed through the human body without producing uncomfortable sensations" quite dramatically. He invited the readers to place a thick piece of beef between a metal pan and a metal grid, both of which make contact with the beef and are connected to the two wires of one of Edison's residential DC electrical systems. Westinghouse assured the readers: "I have witnessed the roasting of a large piece of beef by a direct continuous current of less than one hundred volts within two minutes."

In reference to the lethal effects of AC on dogs, Westinghouse claimed knowledge of an experiment in which: "A continuous current of 304 volts was applied (to a dog) for thirty seconds, and then an alternating current of 100 volts for sixty-five seconds; yet the dog was unhurt." Westinghouse further attacked the validity of Brown's experiments on dogs by claiming that the "alternating current" used in these experiments wasn't true AC, but was actually DC made alternating using a "polechanger" that produced a dangerously high voltage transient by partially discharging the field magnets of the generator.

Unlike Edison's DC system, wherein the wiring in buildings was connected directly to the distribution system, the step-down transformer used in the AC systems isolated the customer's wiring from the distribution system. This, claimed Westinghouse, made the use of AC far safer than using DC. Furthermore, the 50-volt potential used for lighting in his AC systems enabled the use of lamps that were "far more durable and give a better light, with much greater economy, than the 100- or 110-volt (DC) lamps" according to Westinghouse.

A Law is Sought. Edison and the other advocates of DC made their final major attack on AC by attempting to have high-voltage distribution systems outlawed legislatively. When a bill to outlaw any electrical potential exceeding 800 volts was proposed in Virginia, a committee of 15 state senators was appointed to hold public hearings.

Edison testified at the hearings, but his deafness made it frequently necessary for the questions to be repeated. As a result, his testimony was both disjointed and unconvincing.

The proponents of AC had several expert witnesses who were able to explain the advantages of alternating current eloquently and in terms that were both convincing and soothing to the senators. As a result, the proposed bill was defeated.

Legislation to prevent the use of alternating current was introduced in numerous other locations in the United States and Canada, but the results were the same. The advantages of AC were recognized and officially sanctioned.

Edison's Control Slips. Edison had a brilliant mind for inventing but he lacked the interest and ability to manage the finances of his, by now numerous and large, manufacturing companies. Edison had accepted payments in stock and bonds, rather than in cash, from many electric-utility companies who purchased his equipment. He also had allocated more cash to operate his research laboratory and to pay his personal salary than the manufacturing operations could comfortably afford. Business was thriving, but the cash needed to expand the companies was lacking.

By 1889, a wholesale corporate restructuring of the Edison companies was needed. A syndicate of U.S. and foreign bankers supplied the funds needed to combine Edison's diverse corporations into the Edison General Electric Company. Edison was given over one million dollars in cash, but now held only a relatively small percentage of the stock in the new company. He received a salary and a research budget, but they, together with the control of the Company's destiny, now were determined by the new corporate directors, not by Edison himself.

Edison soon began putting all his time and energy into the development of a magnetic technique to concentrate low-grade iron ore. Setback after setback could not convince him that the project was doomed. When investors refused to put more money into what was clearly becoming a hopeless cause, Edison sold off large blocks of his stock to raise the necessary cash. His holdings in the Edison General Electric Company soon were reduced to nearly nothing.

Lacking both an AC system and up-to-date DC streetcar motors to market, the Edison General Electric Company was being outpaced by its competitors. When the Company's managers tried to steer Edison's efforts away from his mining folly and toward the development of a competitive AC power system, he stubbornly replied "The use of alternating current instead of direct current is unworthy of practical men." Edison, once the brilliant pioneer of electrical equipment, was now out of touch with the industry that people identified with his name.

By 1892, the Edison General Electric Company's directors and bankers knew that it was necessary to act decisively. Without Edison's knowledge, a merger with the Thomson-Houston Company was negotiated. Thomson-Houston was already a leader in the manufacture of AC equipment and wanted to increase its position in electric lighting.

The new company was to be called simply "General Electric." Edison was deeply shocked that his name no longer would be part of the Company's identity. General Electric soon became a world leader in developing equipment that produced and utilized the alternating current its forbearer, Edison, detested. ■

GIZMO®

A CHRONICLE OF CONSUMER ELECTRONICS

Living the Good Life

A Look at the World of Whole-House Entertainment

There's a hot new trend in consumer electronics—but you won't find it at your local Circuit City or Nobody Beats The Wiz store. In fact, you might not even be aware that it exists outside the pages of glossy magazines depicting the homes—and the audio/video systems—of the mega-rich.

We're talking about custom installation (a.k.a., whole-house entertainment or custom design): the process of incorporating home electronic equipment into the architectural and interior design of a room, several rooms, a house, or an entire residence (including the house, outdoor living spaces, "out buildings" such as guest cottages or garages). The electronics need not be limited to audio and video; custom designs can incorporate telephone and security systems, as well as lighting, heating and cooling systems, and even appliances if you wish.

In this Gizmo special issue, we examine custom installations from several different perspectives. First, we answer some frequently asked questions: What type of systems are available? Who designs and installs those systems? How much does it all cost? And could custom design and installation represent a new career choice for you?

Next, we take you on tours of two distinctly different installation sites. One is a luxury home built from the ground up by a team of professionals to be a showcase for whole-house entertainment, security, and communications. The other is a retrofit of a modest existing home, an installation that we designed and installed completely on our own. Also included are hands-on reviews of the equipment that was used in our own installation.

WHAT IS CUSTOM INSTALLATION?

Many tasks fall under the general heading "custom installation." A custom installer might be called-in just to install some in-wall speakers. But a more typical custom-design/installation assignment might be to create a home theater in one room—designing a system that includes several audio and video sources, surround-sound decoding, and all the necessary speakers. Although it's possible to buy all that gear retail, a professional custom installer will help ensure not only that the system is properly connected and calibrated, but that the homeowner knows how to use it, and that it complements the decor of the room.

At the high end of the custom-installation spectrum are jobs that entail distributing the audio and video outputs from that main system to various zones located throughout the house and property, and even integrating communications and security equipment.

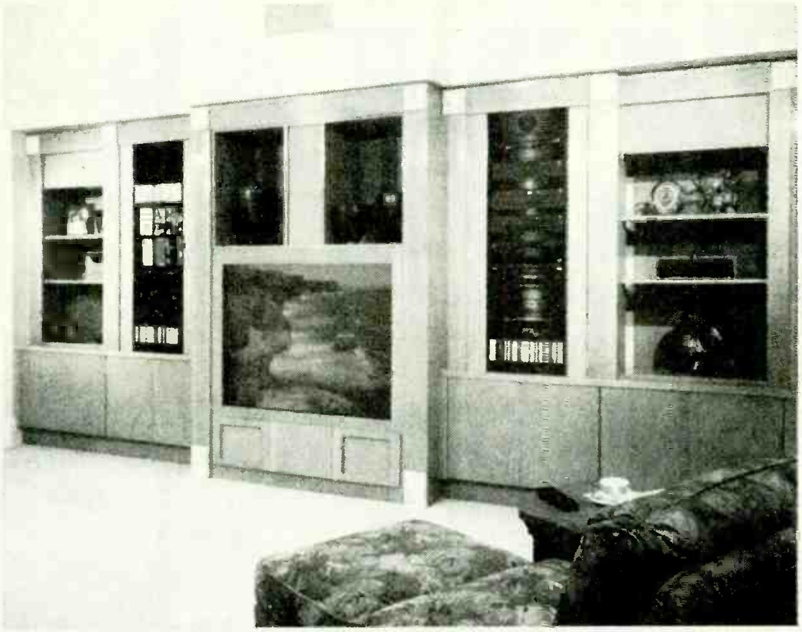
Let's take a look at how much use a typical family might get from just such a whole-house system over the course of a summer evening.

GEE WHIZ-ARDRY

It's 6:00 pm, and the Smith family just got home from work, school, and day care. Mom is watching a cooking show on The Learning Channel (source: cable TV) on the small TV in the kitchen as she prepares dinner, while Dad catches up with world events on "All Things Considered" (source: FM radio) in the study. Meanwhile, their teenage son listens to Smashing Pumpkins (source: CD player) while splashing around in the pool with some friends, and his little sister is kept occupied with a tape of *Barney* (source: VCR) in the family room.

After dinner, Dad listens to classical music (source: CD player) as he cleans the kitchen, while Mom clears up some paperwork in the study with her favorite radio station playing. Their son is closeted in his room doing homework while watching MTV (source: cable TV), and their daughter falls asleep to the soothing sounds of her favorite Rafi tape (source: tape deck).

Later, chores completed and baby tucked in, the rest of the family gathers in the family room to watch a laserdisc movie on their home-theater system.

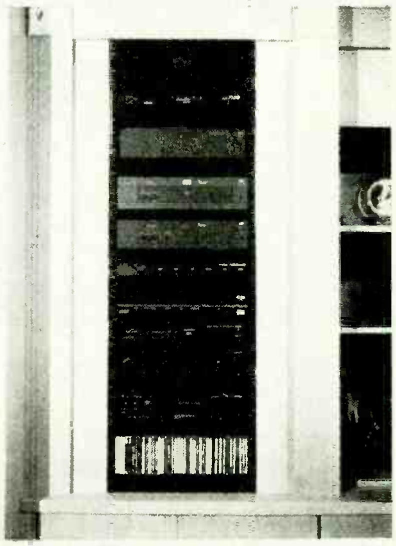


A custom installation usually includes a home-theater, like this one and the one shown on page 49, both designed by Behrens Audio Video of Jacksonville, Florida.

You might think that the above scenario closely resembles a typical evening in your own home, but keep in mind that in the Smith home all of the source components are neatly, centrally located in one spot—the family-room entertainment center. Each of the other zones—kitchen, bedrooms, and even the back yard—is equipped with only a pair of speakers, perhaps a television set, and a wall-mounted pad that controls the functions of the source components.

There are other differences between the Smith house and a typical home. For instance, if the phone rang at the Smiths', all audio/video sources would temporarily mute until the call was picked up; then only the zone in which the call was received would remain muted until the call was ended. If the doorbell rang, the chime could be heard in all zones. A surveillance camera mounted at the front door would allow the homeowner to view the visitor on a TV in any zone, while a built-in intercom would allow two-way conversation between the homeowner and the guest. Other surveillance cameras would allow parents to keep an eye on the kids in the pool or the baby in the nursery.

The Smith family's whole-house system can also turn on or off lights, heating, air conditioning, and appliances at specified times. It can even, at the push of *one* button, dim the family-room lighting, lower black-out shades at every window and skylight in the room, roll out a projection-TV screen, and turn on all the components needed to watch a movie on laser disc, complete with surround sound.



Custom cabinetry stores source components, as well as a CD collection, with a minimum of clutter.

HOW DOES IT WORK?

At the heart of any whole-house custom installation is a component, or group of components, that provides multi-source, multi-room operation; in other words, it allows different entertainment sources to be enjoyed in different locations at the same time. The main audio and video components are wired directly to that multi-room controller. The source and control units are typically located in the family or media room, although it is possible to keep the controller in a separate, less obtrusive spot. Also hard-wired to the multi-room controller, but mounted in other rooms (or "zones"), are keypad controllers and speakers that allow remote control of some functions of several audio and video components. Each keypad controller features an infrared eye that allows the functions to be accessed using a hand-held remote.

Although multi-room controllers are now being produced by a number of manufacturers, most are not available directly to consumers, but only through dealers and installers. One of those is Square D's Elan Home Electronics Network, a modular system that can include whole-house music and video distribution, paging, security cameras, and more. In fact, the Smith family's system described above closely resembles an actual installation built around the top-of-the-line Elan Series HD. That system is covered in detail elsewhere in Gizmo.

Regardless of size and complexity, all custom installations have two things in common: aesthetics and ergonomics. Each system is designed to merge seamlessly with the decor of the home, and with the lifestyle of the homeowner. No matter how sophisticated the system, control of each and every component must be simple enough for every member of the family to operate. Before a single piece of equipment is brought onto the site of a custom installation, the family's listening and viewing needs and preferences—present and future—are considered, as are their decorating tastes. The components should not overwhelm the house, and using them should not overwhelm the homeowners. All functions should be obvious, almost second nature to the users.

Achieving those results is an exercise in problem-solving that demands knowledge of several disciplines, including electronics, construction, carpentry, and home design. In other words, for most homeowners it's time to call in a pro.

WHO DOES CUSTOM INSTALLATIONS?

That professional is a specialized home contractor, called a custom installer or custom designer, who offers several related services. Using his (or her) familiarity with the technologies and products currently available, along with extensive input from the client, he designs the entire system. He determines what capabilities it will offer, what equipment will be used, where each piece will be placed, how it will all be connected, and how it can be expanded in the future. He (or his compa-

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ny) then performs the actual installation, from pre-wiring the home to fine-tuning each piece of equipment. If the installation requires custom cabinetry, the custom installer either does the work himself, subcontracts it, or supervises the craftsperson hired by the client. The installation is not considered complete until all the finish work is done, and all the components are operating smoothly.

Even then, the job is not necessarily over. Customer service is a vital part of the job, and clients often require technical help until they get accustomed to using a new system. Also, as new components are added, the custom installer will often be called back to integrate them into the whole-house system (resulting in lucrative repeat business for the installer).

Because whole-house systems are usually, though not necessarily, installed during new construction or major renovations, the custom installer must work closely with architects, builders, and interior designers, during all stages of design, building, and finish work. A custom installer should be hired at the same time as those other professionals—in fact, many architects and builders now recommend that their clients hire a custom installer with whom they've worked in the past.

In the absence of such a recommendation, where can you find a custom installer? We tried looking in the Yellow Pages under "Audio-Video," "Custom Installers," "Electronics," and "Home Improvements," before we struck gold under the heading "Stereophonic & High Fidelity Equip.—Dlrs." Judging by the ads and the multi-line listings, most high-end audio dealers in our area provide custom installations of audio and video equipment, although none specifically mentioned that the dealer installed whole-house systems.

Instead of letting your fingers do the walking, try calling 800-CEDIA-30. That's the toll-free number for the Custom Electronic Design and Installation Association, or CEDIA, a nationwide trade association of companies that specialize in planning and installing electronic systems for the home. CEDIA provides consumers with referrals to custom-installation specialists nationwide. (See the box for more information about CEDIA.)

HIRING A CUSTOM INSTALLER

Once you've found a few potential custom-installation firms, the interviewing and hiring process is the same as for any other home contractor. Make sure the firm that is experienced and insured, and request references from other customers. If possible, visit the sites of previous installations, and speak to the homeowners about their experience with the installer. Ask if the installer provides service calls, warranties, operating instructions, and customer service.

The prospective custom installer should have some questions of his own, and he should *listen* to your answers. Those questions should include: In what rooms do you want to provide audio? Video? How seriously do you listen to music? Where would you like the main components to be placed? Which rooms are prime listening areas, and which require only "background" music? Which of the components that you already own would you like incorporated in the whole-house system? How much can you comfortably spend on the system? Every family member who will be using the system should be present during the interview.

As is the case with any home contractor, the custom installer works for the client. The installer should be able to make knowledgeable recommendations about the type of equipment to buy, where to place it, etc., but those recommendations should be based in part on the answers to the above questions—and all final decisions rest with the client.

There are other similarities between custom installers, general contractors, and interior designers. All charge their customers for materials, labor, and designing and/or supervising subcontracted work.

CEDIA

Established in 1989, CEDIA is a not-for-profit corporation that is controlled by its members—more than 300 custom-installation firms—who elect officers and board members annually. Although active membership is restricted to established, insured businesses with at least two years experience in custom installation, manufacturers and their sales organizations can join CEDIA as non-voting associate members. Approximately 200 manufacturers and vendors currently hold associate memberships. Publishers, software, and technology companies participate as affiliate members.

CEDIA members are at the forefront of the custom-installation industry. The organization itself provides support and assistance to its members and a guiding hand to the evolving industry.

As is the case with any new and growing field, there's a flip side to the excitement and profits generated as new products and technologies are introduced. Rapid changes make it difficult for consumers, manufacturers, and installers to keep pace and make informed decisions. Consumers need to know that the custom-installation field exists, and to define what they want to gain from it. Manufacturers need to know what consumers want. Installers need to know what manufacturers are producing, and how to sell it to consumers. Further complicating matters is the lack of established standards.

Part of CEDIA's varied agenda is to address and attempt to resolve those issues by setting standards, establishing relationships with similar industries, and through education. For instance, seeking to play an active role in setting national standards for the design and installation of low-voltage electrical products, CEDIA joined the National Fire Protection Association, which determines the National Electrical Code and influences the design and materials used in many household products, including consumer electronics. CEDIA's Systems Integration Council is charged with establishing cross-discipline ties in several areas, with the goal of setting standards for the integration of various residential electronic systems. Besides establishing relationships with professional and trade associations in such industries as security, lighting, and HVAC, the Council is concentrating on establishing an educational curriculum of systems integration courses, and providing CEDIA members with technical information relevant to systems integration.

In addition, CEDIA's Home Entertainment Council (HEC) was established to define "standards of excellence" for residential audio/video-system design that it hopes will become industry benchmarks. The HEC's standards committee has the task of developing and promoting standards in several areas, including component-design parameters and ergonomics, component interfaces and integration, system-design procedures and practices, language and method of system documentation, methods of system preparation and installation, methods for system maintenance and troubleshooting, and business practices. Once those standards have been developed, the Home Entertainment Council will use them as the basis of educational-training seminars for CEDIA members.

Education is paramount to CEDIA, which increases public awareness through advertising and publicity, and coordinates technical meetings and educational programs for members. The organization also runs a national bulletin-board system for members. Furthermore, CEDIA is actively compiling a library of information to help educate installers, manufacturers, and consumers. Much of that information is garnered from annual polls of members, which are used to monitor industry trends and growth patterns, as well as to profile customers and their spending patterns.

For more information about CEDIA, write to 8335 Allison Pointe Trail, Indianapolis, IN 46250, or call 800-CEDIA30. ■

Materials costs are often offset to some degree by discounts offered to professionals by manufacturers. Also, like interior designers, custom installers are able to purchase goods that are not available to the retail consumer at any price.

WHAT DOES IT COST?

Prices for custom installations vary widely—from less than $100 to well over $100,000—depending primarily upon the complexity of the job and the amount and quality of gear purchased. At the low end, a customer might call in a pro to sort out the tangled mess of an existing audio/video "system," rewiring the components correctly and teaching the client how to use all the components to their fullest. Another small job might be to simply install a pair of in-wall speakers with volume control. Near the high end, you have homes like the one featured elsewhere in this section, in which the whole-house audio/video/telephone/security system cost a whopping $150,000!

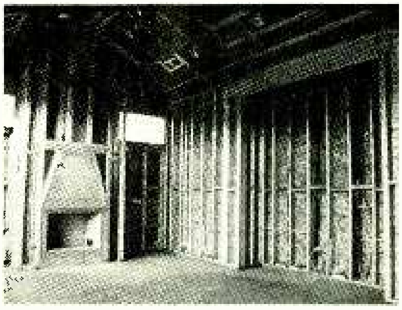
Most jobs fall somewhere inbetween. For instance, another Elan system provides telephone paging, whole-house audio and video distribution, and doorbell integration with prices starting at a reasonable $2500 when installed in new construction.

According to a poll of CEDIA members conducted by Leibowitz/Roher Marketing, Inc., just over half the respondents said their average job was priced over $10,000, with 16% saying their average installations were higher than $20,000. Big-ticket jobs are more common in California, where one third of respondents reported average job prices of $20,000 or more and 58% said that their largest installation in 1992 was more than $100,000. Installations in the central region of the U.S. tend to be a bit smaller and generally less costly.

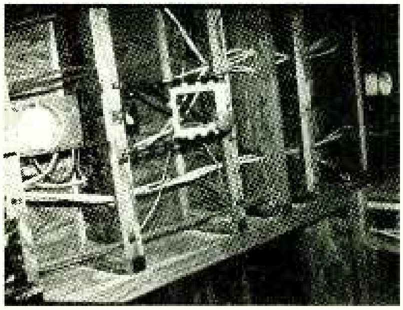
At Audio/Video Entertainment, a custom-installation firm based in Orange County, California, a "typical" job is done during the construction of a new home, and involves setting up a home theater and equipping two or three rooms with remote access to audio and video. The price usually falls between $7000 and $20,000. That broad range is due largely to differences in the quality of the equipment being used, and how much of it must be purchased new.

CAN'T I DO IT MYSELF?

Custom installation of a whole-house entertainment system is not a job we'd advise the average person to tackle. If however, you are knowledgeable about consumer-electronics products and electronics in general, have experience in wiring and electrical work, are comfortable using power tools for home repairs, and have the free time to put all those skills to



Whole-house audio/video systems are most often installed during new construction or major remodeling.



When the walls are open, running wires is a relatively simple task.

use, there are several ways to go about installing your own whole-house audio-video system.

The simplest way to achieve a small-scale multi-room system is to use a commercially available A/V receiver with multi-room control capabilities. Such units are available from several manufacturers, including Onkyo and Luxman.

We took a different route for our whole-house entertainment system. Using Audioaccess' MRX multi-room receiver and remote-access keypads, Multiplex Technologies' ChannelPlus video-distribution system, and Sonance in-wall speakers, we designed and installed a five-zone, whole-house system in a home that will never be featured on "Lifestyles of the Rich and Famous." It's not a job for the novice do-it-yourselfer, and it isn't inexpensive. But for the electronics hobbyist, it's do-able. And for the avid audio-/videophile, the prices won't seem too far out of line.

OPPORTUNITIES ABOUND

If you find the thought of designing and implementing your own system intriguing, perhaps you're ready to consider a career in custom design and installation. It's a fast-growing field, and the demand for professional, qualified, educated installers is keeping pace.

Sean Fields, owner of Audio/Video Entertainment and a member of the Board of Directors of CEDIA, has a couple of suggestions on how to get started. First, you might apprentice with an established company, perhaps moonlighting part-time at first. "A lot of companies are growing and looking for part-time help that can become full time as growth continues," he said. As for the electronics hobbyist, the person who goes home and tinkers because he has a passion for it, that is ". . . just the kind of employee I like."

If you can't connect with an established custom-installation firm in your area, learn by doing, but be sure to practice on your own home—it's better to make mistakes there than on your first paying job! Once you have a successful installation under your belt, show it off as much as possible. Create a demand among your friends, and you may just have your next job.

Sean Fields also points out that, as installations are becoming "more interactive, more centralized, and . . . [we're using] new products and technologies that weren't around a year ago," the competition to create those new products is heated. Equipment manufacturers are looking for creative, knowledgeable product designers. According to Fields, both manufacturers and installation firms have a "demand for people who really know electronics, and know the importance of quality."

GETTING STARTED: TWO CASE HISTORIES

An audiophile friend of ours—one who built his own stereo components as a hobby—put himself through college back in the early days (before home theater, let alone whole-house entertainment), by designing and installing audio and video systems. His best sales technique? Offer to throw the satisfied client a party at which he could show off the new system. Invariably, a couple of his friends or colleagues would want an even better system installed in his home! One-upmanship proved a very profitable selling tool.

In Chicago last summer for the Consumer Electronics Show, we struck up a conversation with the two guys sitting at the next table in our favorite Mexican restaurant. They were from the Minneapolis/St. Paul area, also in town for CES. We asked if they were manufacturers or buyers, and learned that they had recently—and unexpectedly—become custom installers of whole-house entertainment systems.

It seems that they were the guys who were called in to help out every time one of their friends bought a new computer or piece of software. They did such a good job on the computer stuff that they started getting calls to hook up TV's, VCR's, and audio equipment, and before they knew it, they were in business. They traveled to Chicago to learn what equipment was being offered, and what other installers were up to.

(Continued on page 60)

Desert Dream House

Take a Tour of the Elan Showcase Home

Before we even pulled into the circular flagstone driveway with its center fountain, before we stepped into the marble-floored entrance hall with its views of the sunken living room, built-in pool, and cabanas beyond, we had high expectations of the Elan Showcase Home. After all, we'd been clued in that the 5465-square-foot Mediterranean-style home (add another 1740 square feet for the two cabanas), located in the exclusive Sierra Vista Ranch Estates just 15 minutes from the Las Vegas Strip, was just down the street from Wayne Newton's compound and two doors down from Robert Goulet's home. We also knew that the home represented the collaborative effort of a team of pros—including the builder, interior designers, a custom audio/video installer, and a system manufacturer—aiming to "create the ultimate environment for a distributed audio/video/telephone system."

We weren't disappointed. Even without the electronics, the house is impressive, with its spacious, open design; gourmet kitchen; master suite with separate sitting area and opulent bathroom; library with floor-to-ceiling cherry bookcases, family room with bar and three-way fireplace, and three other bedrooms, each with private bath. And let's not forget the yard, with its covered patio, 70-foot pool, and two cabana/guest houses!

THE ELECTRONIC INFRASTRUCTURE

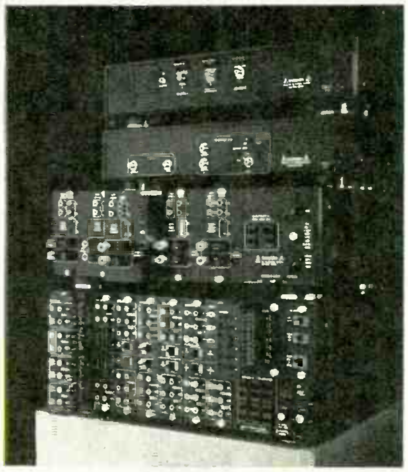
The electronics, however, are just as impressive, and go a long way toward making the house a luxurious place to live. *Square D's Elan Series HD* system provides multi-source distribution of audio, video, and telephone throughout 14 separate zones, some with subzones. Remote operation is achieved through in-wall keypads in each zone as well as by handheld remote controls.

At the heart of the system are two *Series HD Master Control Units*. Each modular unit houses plug-in cards that are chosen by the designer to coincide with the functions required of the system. Depending on how the cards are configured, each Master Control Unit allows the homeowner to watch or listen to up to 10 sources in as many as 20 zones. Each zone can control the volume, bass, treble, and basic control functions for any source listened to in that zone.

In addition to audio-input and -output cards, the Showcase Home uses two *Low-Voltage Relay Cards*, each controlling up to six dry-contact relays. Those cards allow the homeowner to operate lights, motorized curtains and video screens, and other devices, using the system's handheld remote.

A *Telephone Interface Card* integrates the home's telephone and communications systems, adds features to standard touch-tone phones, and provides security. With that card installed, standard phones can be used for whole-house paging, room-to-room communication, off-hook signal, and call hold. The telephone interface card also allows the user to activate speakers placed outside the front and back doors, for indoor/outdoor communication, and to control a relay to operate a door or gate latch. A three-tone door bell chimes when the front doorbell is pressed; two tones for the back doorbell. Both front and back doorbells, as well as incoming phone calls, are heard over the Elan speakers, momentarily interrupting the audio program so ensure that the rings are heard throughout the house.

The control components used in the Elan Series HD installation include, from top to bottom, a camera modulator, a video-distribution amplifier, a multi-zone audio amplifier, and a master control unit.



The modular configuration of the units allow the system designer to select plug-in cards for the master control and audio-distribution amplifier cards, allowing a high degree of flexibility and expandability.

Elan's modular *Multi-Zone Audio Amplifier* amplifies and distributes the controlled, unamplified output from the Master Control Unit. Its five card slots can accommodate any combination of the 50-watts-per-channel *Zone Amp Stereo Card*, the 100-watt *Zone Amp Monaural Card*, and the 100-watt *Zone Amp Monaural Subwoofer Card*.

The *Video Distribution Amplifier* sends high-quality video signals throughout the house via a two-coax wiring system. The unit amplifies and distributes cable-TV signals, and off air signals, to as many as eight rooms. Three Video Distribution Amplifiers are used in the Showcase Home, for security as well as television viewing.

The home's surveillance system also features five *CAM 1010* flush-mount cam-

When the video screen of the family-room home-theater system is retracted into the upper cabinet, a picture window with a view of the pool is uncovered.

The control and source components that comprise "command central" for the whole-house system are mounted unobtrusively in a rack next to the family-room bar.

eras, two digital modulators, and two three-channel modulators, all from Elan. The system allows the homeowner to monitor rooms and outdoor areas from any TV in the home.

TAKING THE TOUR

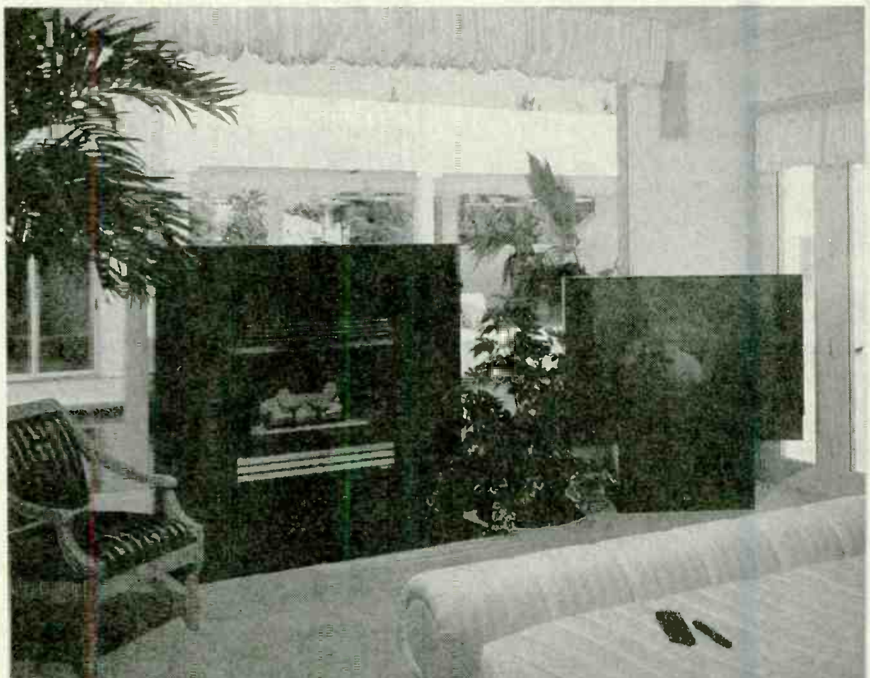
Let's take a condensed tour of the Elan Showcase House, starting in the media room, where the control and source equipment is all discretely housed in a floor-to-ceiling rack built into a custom cabinet behind the bar. At center stage is a custom entertainment center built around a picture window, and nicely framing a view of the pool. Cabinets on the sides of the window each hold a 27-inch monitor and one of the surround-sound system's front-channel speakers; the center-channel speaker was installed in a cabinet below the window. The cabinet that bridges the top of the window holds the 100-inch video screen. The subwoofer is tucked almost invisibly into the kick plate of the bar, and two pairs of Elan 1100 "serious listening" speakers top off the sound system.

When it's time to watch a movie, just press a button on the Elan handheld remote control. The lights dim, the motorized black-out blinds roll down, the video screen drops from the cabinet, an Auton lift lowers a Mitsubishi 1202 video projector from the ceiling, and the laserdisc player and VCR are powered up.

In the master suite, the main room is visually divided into a sitting area and a sunken sleeping area by the bed's headboard. The sitting room is intended for serious music listening on a system that is separate from the whole-house electronics. It includes Kinergetics' KCD 55T CD transport and matching KDP 100 D-A converter/preamp, and Unity Audio's Professional Application Reference Monitor (PARM) five-piece speaker system. Two Cary 100-watt, mono, tube amps drive the satellites and a Bryston 4B amplifier drives the subwoofer.

Next, we'll step down into the sleeping area, with its picture window overlooking the pool, 52-inch rear-projection TV, two in-wall and two "in-headboard" speakers, and gas fireplace. A handheld remote controls the draperies, lights, room temperature, and more.

The master bath, built completely in



The view from the master bed encompasses a remote-controlled gas fireplace, a rear-projection TV, and the backyard deck and pool.

ELAN SHOWCASE HOUSE ZONE/ COMPONENT LISTING

ZONE 1: DINING ROOM

2 Elan 1100 Speakers
1 Elan Keypad

ZONE 2: STUDY/OFFICE

2 Elan 1100 Speakers
1 Elan Keypad

ZONE 3: LIVING ROOM AND POWDER-ROOM SUBZONE

4 Elan 1100 Speakers
2 Elan Keypads

ZONE 4: MASTER BEDROOM AND SITTING-ROOM SUBZONE

2 Elan 1100 Speakers
2 Elan 1000 Speakers
1 Elan Keypad
1 52-inch RCA TV
1 RCA laserdisc/five-CD player
1 ProScan VCR
1 Denon AVR-3000 receiver
1 Elan Audio Distribution system

ZONE 5: MASTER-BATHROOM, STEAM-BATH, AND WALK-IN CLOSET SUBZONES

2 Elan 1000 Speakers
2 Elan Keypads
1 20-inch ProScan TV system
2 Infinity ERS 500 speakers
2 ELAN Classic speakers
2 Elan volume controls

ZONE 6: KITCHEN

2 Elan 1000 Speakers
1 Elan Keypad
1 13-inch RCA TV

ZONE 7: CABANA 1

2 Elan 1000 Speakers
1 Elan keypad
1 35-inch ProScan TV
1 Denon 5-CD carousel

ZONE 8: CABANA 2

2 Elan 1000 Speakers
1 Elan keypad
1 52-inch ProScan projection TV
1 RCA Video Acoustics speaker system
1 RCA laserdisc/5-CD player
1 Denon dual auto-reverse cassette deck
1 Denon AVR 3000 receiver

ZONE 9: PATIO AND POOL BATHROOM

4 Elan outdoor speakers
2 Elan keypads
1 35-inch RCA console TV (on casters)
2 Elan Classic outdoor speakers
1 Elan volume control

ZONE 10: MEDIA ROOM

3 Wallspeaker Technologies Series II loudspeakers
1 DCS custom 18-inch JBL Theater subwoofer
4 Elan 1100 speakers
5 Elan 100-watt amplifiers
1 Soundcraftsmen PM860 600-watt mono amplifier
1 Lexicon CP-1 digital surround-sound processor
1 Audio Control Richter Scale III
1 RCA LDR-500 laserdisc/5-CD player
1 ProScan PSVRS81 VHS HiFi 4-head VCR
1 Denon DRW 840 dual auto-reverse cassette deck
1 Stewart Filmscreen 84-inch Videomatte 2000 electronic screen
1 Mitsubishi 1202 video projector
2 ProScan PS27151 27-inch Invar monitors
2 Denon TU-680 NAB AM/FM tuners
1 NSM 100-disc CD changer

ZONE 11: MAID'S QUARTERS AND LAUNDRY-ROOM SUBZONE

2 ELAN 1000 speakers
2 Elan Classic outdoor speakers
2 Elan keypads
2 Elan volume controls
1 20-inch RCA TV with FM stereo
1 RCA VCR

ZONE 12: GARAGE

2 Elan Classic speakers
1 Elan keypad

ZONE 13: BEDROOM 2 (GUEST ROOM)

2 Elan Classic speakers
1 Elan keypad
1 13-inch RCA TV

ZONE 14: BEDROOM 3 (NURSERY)

2 Elan 1000 speakers
1 Elan keypad
1 ELAN camera

marble, features an enclosed area with a waterfall, a Jacuzzi tub, his' and her's showers, and a steam/mist system. Of course, it has its own set of speakers, a control keypad, and a 20-inch television. In fact, the steam room has its own speakers and volume control, as does the master bedroom's walk-in closet!

The living room, formal dining room, and library each feature in-wall speakers and keypad controls to control any of the audio sources. In addition to audio, the

In-wall speakers and a keypad controller are mounted in the headboard in the master bedroom.

kitchen, guest room, maid's room, and the two cabanas all have TV's for viewing any of the available video sources. The baby's room is equipped to receive and control audio, and an Elan CCTV camera monitors the room.

Outside, the covered patio features four outdoor speakers. The north and south yards are monitored by two CCTV cameras. The front entrance is protected by a CCTV camera and a door speaker at the front gate, which can be opened and closed through the Elan system using a button on the telephone. Another camera and speaker are mounted at the front door.

CREDIT WHERE CREDIT'S DUE

The Elan Showcase Home was designed by Stephen Ball AIA & Associates, Inc., a Brentwood California-based architectural firm that specializes in the design and development of high-end residential renovations and new custom homes. The actual construction was handled by Matthews Development Co., under the supervision of the husband-and-wife team of Bob and Adele Matthews. Two Las Vegas interior designers—Marteen Moore of Designs by Marteen and Jeff Hicks of Interior Design Consultants tackled the challenge of designing an interior around a custom-installed audio/video/telephone system.

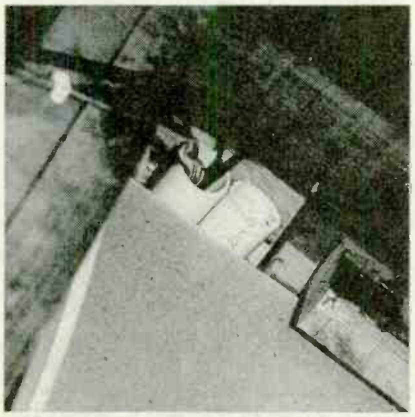
That whole-house electronics system was designed by Don Calley, owner of Las Vegas-based Image and Sound. Mr. Calley is a founding member of CEDIA, and his client list includes Jerry Lewis and Robert Goulet. The actual system was designed around Square D's Elan Series HD Home Electronics Network, with additional components from Thomson Consumer Electronics, Infinity, Denon, Mitsubishi, NSM, Soundcraftsmen, Lexicon, Stewart, and Audio Control. (See the box for a listing of the components used in each zone.) The motorized black-out shades were provided by Bautex USA, the mounting racks by Middle Atlantic Products, and the central lighting-control system by Lutron NeTwork. ■

Just Do-It-Yourself

How we installed our own whole-house audio/video system

Our do-it-yourself whole-house entertainment installation won't make it to the glossy pages of *Audio/Video Interiors*. Unlike most magazine-featured installations, ours did not require a second mortgage. However, it did increase our viewing and listening options and reduce component clutter.

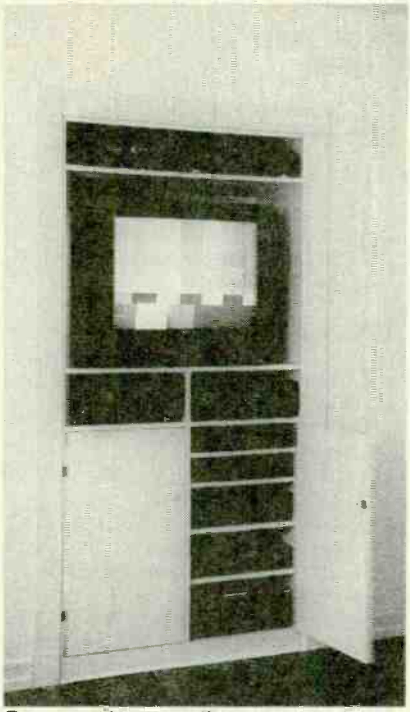
The five-zone installation is based on two main components. The audio portion is controlled by the *Audioaccess MRX Multi-Room Controller*, which provides up to six zones with independent control over source and listening volume. The video-distribution chores are handled by *Multiplex Technology's ChannelPlus Multi-Room Video Distribution System 9020*, which can deliver video signals from three different sources to as many as eight locations. The house has no formal media room, so we placed the controllers and the



PVC pipes, installed inside the walls during a previous kitchen remodeling, run from the basement to a crawlspace under the eaves, providing a handy conduit for wires and cables.

source components in the living room. The four audio keypad controllers were mounted in the kitchen/dining area, the main office, the bedroom, and outside on the deck.

Two of the most important attributes of a good whole-house installation are flexibility and expandability. Although five zones were sufficient for our installation site, a modest, five-room Cape Cod-style home, the system can grow as the need arises. Should we decide at some future date to add a family room, dormer-out for more upstairs space, or convert the garage



Recessed into an adjacent room, the entertainment center houses the source components as well as the MRX and ChannelPlus audio and video distribution controllers, without taking up any floor space in the small living room.

to office space, the entertainment system can keep pace. It can also easily handle the equipment upgrades that are sure to occur.

Although we installed a pair of *Sonance S3500* in-wall speakers in the dining area in all other zones, we used our existing speakers. For source components as well, we made do with what was on hand—our budget didn't allow any upgrades at the time. When we do purchase new gear, however, it can be easily incorporated into our whole-house setup.

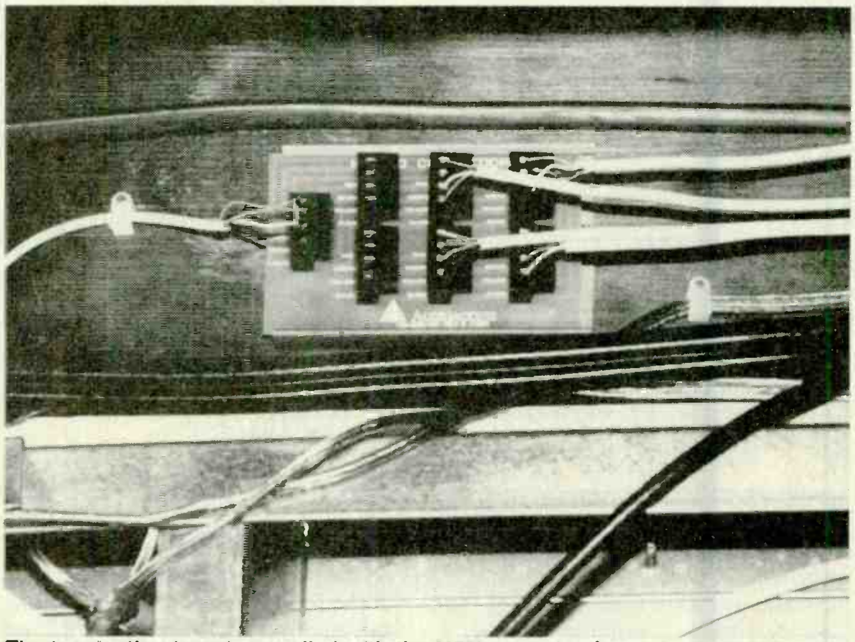
The MRX and ChannelPlus controllers are described in full detail elsewhere in this issue of *Gizmo*. You might want to read about them now, or wait until you've finished following our step-by-step installation. The Sonance speakers will be discussed next month.

LAYING THE GROUNDWORK

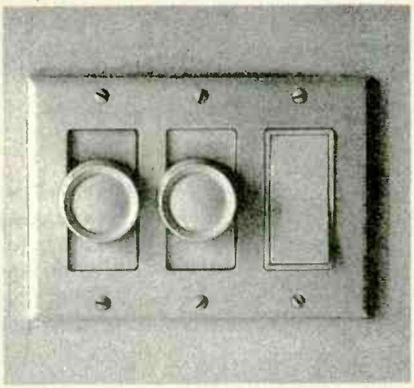
We actually began this project more than a year before we unpacked the audio and video controllers. Our first design hurdle was immediately apparent: How could we install a system without ripping out walls in every room? When a system is being retrofitted into an existing house, the job is twice as difficult. It's much easier to snake wires between wall studs *before* the sheetrock, let alone the paint or wallpaper, goes up.

We managed to circumvent that problem to some extent with advance planning. Last year, during a kitchen renovation, we took advantage of the temporarily open walls and had the contractor run two 2-inch PVC-pipe conduits from the unfinished basement to a crawl space under the eaves. Even though at that time our whole-house entertainment system was only a half-baked idea in the back of our minds, we knew that we were sure to need a way to install wiring throughout the house.

Even if an audio/video distribution system isn't in your family's foreseeable future, plan for it if you're having any remodeling work done around your home.



The termination boards supplied with the MRX control unit can be mounted out of sight—in our case, tucked away in the basement—eliminating unsightly tangles of wires in the entertainment center.



The separate ceiling-fan dimmer and speed controls (center and right) were replaced with one combined light-and-fan control unit to make room for the MRX keypad controller.

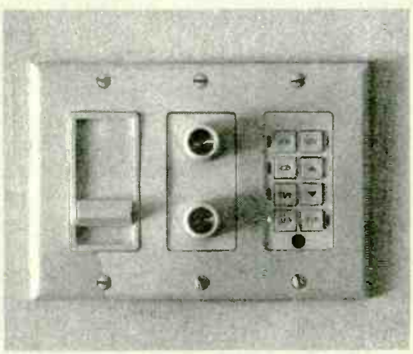
Asking your contractor to run some PVC piping through walls that are already open will add almost nothing to the price of the job at hand.

PLACEMENT PLANNING

With our pre-planning, we started out somewhat ahead of the game, as far as retrofit installations go. We already had a way to string wires throughout the house without breaking into the walls. We also had an entertainment center in the living room that could comfortably and attractively house all the source components and controllers. Next, we had to decide how many zones we needed, and precisely how to wire them.

The living room, of course, was the main zone (MRX Zone 6). The kitchen/dining area was designated Zone 1, and, figuring that we'd probably want to play the same music in the kitchen and out on the deck during summer barbecues, we decided to make the backyard Zone 2. We designated the home office as Zone 3, and the bedroom Zone 4. Then we determined the best locations for the keypad controllers, and where needed, new speakers.

Because the installations were virtually the same for each zone, we'll go into detail on only one room. We chose the kitchen because that zone includes both audio and video distribution, and required the installation of the Sonance in-wall speakers.



In the completed keypad installation, the controls for the kitchen lights and ceiling fan share the space with the MRX keypad controller.

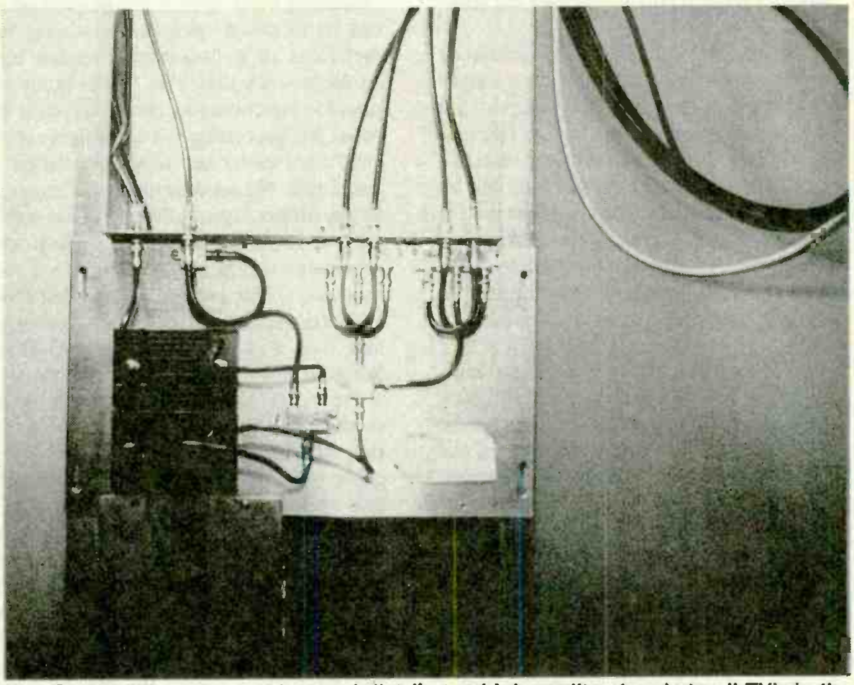
WHOLE-HOUSE AUDIO

We began our installation with the MRX multi-room audio controller, which was given a prominent position in the living-room entertainment center. Because airflow is somewhat restricted where it is installed, we added a fan behind the controller to ensure that it would not overheat. The MRX runs hot for two reasons. First, it is never really off. Even when all zones are turned off, the controller remains awake, monitoring the keypads. Second, the MRX is really six stereo amplifiers packed in one comparatively compact package. Although it is equipped with a thermostatically controlled fan that is set to turn on when the amplifier heatsink rises to about 150°F, additional cooling is required when the MRX is mounted in an enclosed space.

The wiring for the MRX can be kept neat thanks to separate wire-termination boards. They connect to the MRX via ribbon cables or wiring harnesses, and can be mounted to make the wiring most convenient. For example the speaker-wire termination board was mounted on the floor of the entertainment center. A wiring harness neatly connects it to the MRX. The wires to all five sets of speakers go through the floor into the basement, and then throughout the house.

Two other termination boards were centrally mounted in the entertainment center: the audio-input board and the preamp-output board. The remaining termination board is for the keypad controllers. Because there was no need to clutter up the entertainment-center wiring any further, we attached that to a floor joist in the basement. It connects to the MRX via standard 4-conductor telephone wire, and feeds to each keypad the same way. Although all our keypads were run right to the termination board, they can be daisy-chained as well.

The termination boards are easy to install: First, a plastic channel is fastened to the mounting location. Then the boards are simply snapped into position. The boards have a practical advantage besides just keeping the wiring neater. They allow a whole-house audio system to be essentially fully wired without requiring the MRX controller to be on site. That keeps the MRX safe from construction dirt and damage. When construction is complete, the unit can be put in place and attached to the wiring in a matter of minutes.



The ChannelPlus coax cable panel distributes high-quality signals to all TV's in the house.

The keypad controllers are designed to be mounted in standard electrical junction boxes. In new construction, a new junction box can be installed in a matter of minutes. For retrofit installations, things are more difficult. First, of course, you have to cut open the wall to install a box. Then you have to worry about possible obstructions inside the wall that would make it impossible to snake wiring through. In retrofit installations, it is more likely that you will be forced to compromise on the location of the keypad.

For our Zone 1 installation, we took advantage of an existing three-gang junction box. The box originally held two dimmer knobs (for the recessed kitchen lights and the ceiling-fan light) and a fan switch. We replaced the two separate fan controls with a combined fan-speed/dimmer switch. That left an open box for the keypad control. The junction box was deep enough that everything fit without too much effort.

That technique won't always work, of course. The alternative would have been to open the wall to get access to the box, install a new or larger box, and rewire. In either case, you will have to snake wires through the walls. A standard electrician's fish tape is essential.

SPEAKERS

With the keypad installed, we were half way to having audio in our kitchen/dining area. The second half of the job was installing a pair of Sonance S3500 in-wall speakers. Although this was our first in-wall speaker installation, the mounting kits provided by Sonance smoothed the way. The hardest part was getting the wires to the speakers.

The location of a pair of speakers has an important affect on the way they sound. However, not everyone is willing to put speakers where they sound best. Because of aesthetic considerations, we installed the Sonance speakers in anything but an ideal location. Instead of being installed at ear level, the speakers are mounted up near the ceiling. A pivoting tweeter in the S3500 permits the sound to be directed to the listening area and compensates for poor placement.

We chose to mount the speakers horizontally rather than vertically. It's slightly more difficult because the cutout has to be almost perfectly centered between the studs. With careful measuring, however, it's a small obstacle.

Two potential problems threatened to make wiring difficult. First, the wall is insulated, which makes snaking wires difficult (at least for us). Second, the wall has a diagonal "hurricane brace" running through it. We got around both problems by running wires up to the attic and then down through the wall, using the pre-installed PVC conduit.

A template supplied with the speakers makes it easy to mark the speaker location so that the proper holes can be cut. We first opened up pilot holes in the sheetrock to ensure that there were no obstacles in our chosen location. Following a tip in the Sonance installation instruction sheet, we held the sheetrock saw at an angle when cutting out the pilot holes. The intent was to make the hole smaller on the inside than on the outside. Then, if the location proves to be no good, the plug can be re-inserted and patched easily. Luckily, we found no obstacles on our first try.

The Sonance S3500 speakers are equipped with *Flex-bar* brackets that make installation simple. The speaker is simply angled into the hole, and the screws are tightened down. That sandwiches the sheetrock between the Flex-bar brackets and the speaker baffle.

With the keypad and speakers installed, our kitchen and dining area officially became Zone 1. We could now listen to CD's, the radio, tapes, or television audio, in hi-fi stereo, as we cooked, ate, and relaxed in the room that's considered the hub of the house. We particularly enjoyed the addition of stereo sound to our small kitchen TV—and the ability to mute that sound during commercials.

VIDEO THROUGHOUT THE HOUSE

We mounted the *ChannelPlus Model 3100 Coaxial Cable Panel* in the basement. The *ChannelPlus Modulator* was tucked away behind the closed doors of the entertainment center.

The coaxial-cable panel mounts easily to framing studs spaced 16 inches apart. It can be mounted virtually anywhere, but preferably in an accessible location near an AC power outlet. (We had to bring AC power to our chosen location.) Because the panel has preconfigured amplifiers, splitters, combiners, and taps, installation is simplified: No measurements are required to get proper signal strength at the cable outlets. For inexperienced installers, that eliminates mistakes. For pros, it's a real time-saver. Our previously installed PVC conduits made the wiring a much simpler task than it otherwise would have been. We used RG-6 cable for all cable runs.

Next, we installed the ChannelPlus modulator. One length of RG-6 cable carries the modulator output to the coaxial cable panel. There, the modulator output—which contains the outputs of our satellite receiver, VCR, and front-door camera on channels 23, 25, and 27, respectively—is combined with the signals from our TV antenna, and then distributed to the other outputs.

The most difficult part of the modulator installation was getting the outputs tuned to the right frequency. Not all TV's allow their automatic fine tuning to be turned off, and each TV behaves a little differently. At first, we were unable to get perfect audio and video at all TV's. On some TV's, the picture would tear, on others the sound would be filled with an annoying buzz. On others, everything was perfect. We were finally able to get things working properly by measuring the modulator output with a frequency counter, and tuning for the correct center frequency for our desired channel. Now, watching our desired source is simple for everyone in the family. There's no need to throw A/B switches or do anything special. ■

Audio Everywhere

MRX MULTI-ROOM CONTROLLER. From Audioaccess, 26046 Eden Landing Road, Suite 5, Hayward, CA 94545; Tel. 415-293-0183; Fax: 415-293-0189; Approximate retail prices: $4000; Keypads: $250 each; Handheld Remotes: $90 each.

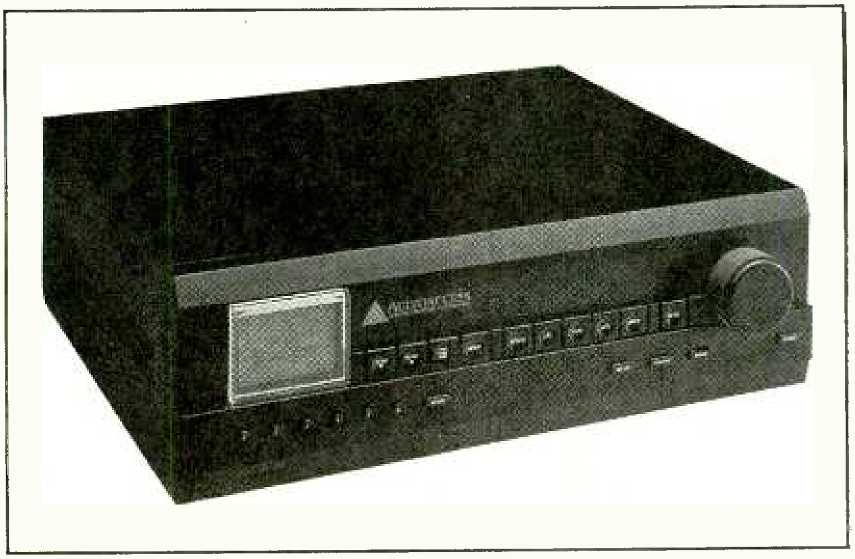
Aiming to provide an "easy-to-install, compact, cost-effective" means to bring "whole-house entertainment control to a wider audience than ever before," *Audioaccess* designed the *MRX Multi-Room Controller.* The AM/FM stereo hi-fi receiver is equipped with six 40-watt-per-channel stereo amplifiers to provide up to six remote zones with independent control of audio-source selection and volume level. Each of those zones—except the one where the MRX itself is installed—must be equipped with an Audioaccess keypad control. Of course, speakers are another requirement.

The MRX controller can be used with virtually any brand of CD player/changer, tape player, VCR, and other source equipment. (Bang and Olufsen and Studer Revox components are not compatible with the MRX.) The sources are controlled with infrared signals, which are "memorized" by the MRX. The components can also be controlled from the MRX's front panel.

That front panel provides simple and straightforward direct control of the main zone and remote control of all other zones. A row of ten large, square buttons dominates the center of the front panel. They include four tuner controls (TUNE UP, TUNE DOWN, AM/FM, and MODE.) Four tuning modes are available: manual and auto mono and stereo. In either of the manual modes, each push of the tuning buttons increases or decreases the frequency one step. In the auto modes, each push puts the receiver into its search mode, where it scans for the next station with adequate signal strength.

The next five square buttons are used for source selection—TUNER, CD, TAPE, AUX, and VIDEO. Used alone, and pressed once, they select the source for the main zone; pressed once in combination with the ROOM button, they select sources for remote zones. Each of the source-selection buttons can also command up to three functions of its source component—the same three functions that can be activated via the remote keypads.

The final square button in the row is MUTE. Used alone, it mutes the current audio source in the main zone. It can also mute the remote zones.



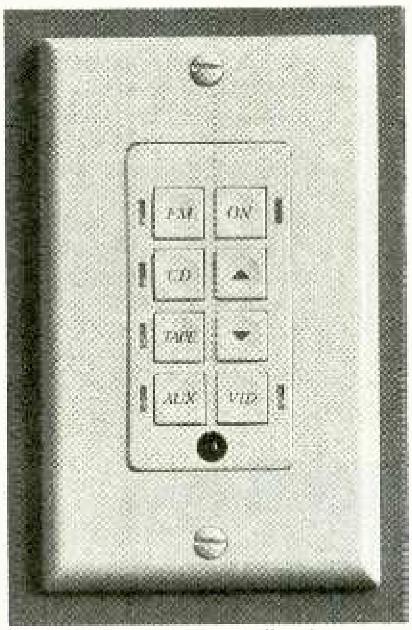
The row of square buttons is flanked by the volume knob on the right side and the LCD readout on the left. The display provides tuner information, including frequency, signal strength, stereo/mono, and preset number. (Up to six stations can be assigned preset numbers.) The LCD indicates the zone name when the ROOM button is used. During programming, the display also shows different programming menus, including the zone-programming menu for zone names, volume settings, bass settings, treble settings, all-on settings, and lockout settings. It also displays menus for infrared programming. Below the display are the infrared input window, tuner preset buttons 1 through 6, and the store button, which is used to store tuner presets, zone settings, and IR commands.

Rounding out the front-panel controls are buttons used for remote control of other zones. The ROOM button selects a zone and permits its status to be changed. When the ROOM button is pressed, the zone name appears in the display. An LED lights in the source button that corresponds to the source that is on in that zone, and the display shows the source name and volume level. While the zone name appears on the display, that zone can be turned on or off, a different source can be selected, and its volume adjusted.

The MRX main unit is a somewhat oversized component that measures about 5⅝ × 17 × 15-inches and weighs about 35 pounds. However, as long as a cooling fan is added, it can fit neatly in most entertainment centers or racks. Put the emphasis on "neatly." Almost everything is wired to printed-circuit boards included in the *MRX Terminator Kit*. Each termination board connects to the main unit via a four-foot cable, so they can be mounted to make wiring convenient.

The kit includes separate termination boards for audio inputs, preamp outputs, and speaker outputs. The speaker-output board is equipped with a cable harness for connection to the MRX, and the preamp-output board connects with a supplied 26-pin ribbon cable. The source equipment is connected to the audio-input board, which connects to the controller via a supplied 20-pin ribbon cable. The board includes jacks for CD, tape, video, and auxiliary inputs. In addition, TAPE OUT will send the selected source to a tape recorder or other device, and LOOP THRU allows a second board to be connected so that sources can be shared with other equipment or to connect additional MRX's.

The use of termination boards is ideal when the MRX is being installed in new construction, or during a major renovation. The termination board can be hidden behind an access panel in a wall, and all necessary wiring run through the walls before sheetrock is installed. In-wall speakers and the keypad controllers would also be installed at that stage. Neither the MRX unit nor any of the source equipment need be on site until construction is complete. Once the pre-wiring is in place, all that's required for the final setup is to connect the source components and any free-standing speakers. Although the MRX Terminator Kit is included with the controller, it can be ordered separately for pre-wiring purposes. A separate termination board is also available for keypad connection; alternately, the keypads can be wired directly to the MRX controller.



The MRX keypad controller fits into a standard "Decora"-style wall box, and provides finger-tip control of up to six audio sources.

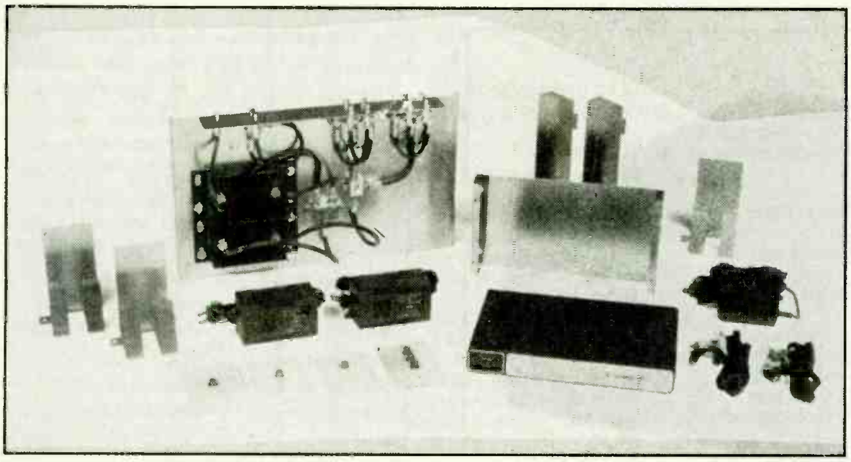
In the remote zones, the keypad is the user interface for the MRX. The keypad, which fits in a standard junction box, has eight pushbuttons and six LED status indicators. Each keypad contains DIP switches so that it can be assigned to a given zone. Multiple keypads can be used in a zone for convenience. In that case, they can both be set to the same zone and are simply wired in parallel.

The keypad also has an infrared "eye" so it can be operated with an infrared remote control. The keypad can send the infrared signals back to the MRX, but it doesn't act like an infrared repeater. The MRX can control your CD player remotely, but not with your CD-player's remote control.

When the keypad ON button is pressed, that zone comes on. It defaults to the tuner mode, and to the programmed turn-on volume. The volume up and down keys will change the volume, if desired. Pressing the FM button changes the tuner to the next station in the preset memory. Only six memory presets are available—our only substantial complaint with the MRX. If the FM button is pressed and held until its status LED blinks, the tuner will enter its search mode.

The other source-selection buttons (CD, TAPE, AUX, and VID) operate the same way. The first press selects the source and turns the source on. A subsequent press sends a command to the source. Pressing and holding the button sends a different command to the source. The CD button, for example, could be programmed to send next-track and next-disc commands. The TAPE button might send an auto music search command and a reverse-direction command.

The MRX controller has an infrared learning remote controller built in. When the MRX receives an input from a keypad or its front panel, it transmits any necessary infrared signals to output jacks on the rear panel. Infrared emitters connected to those jacks transmit the signals to the equipment to be controlled. ■



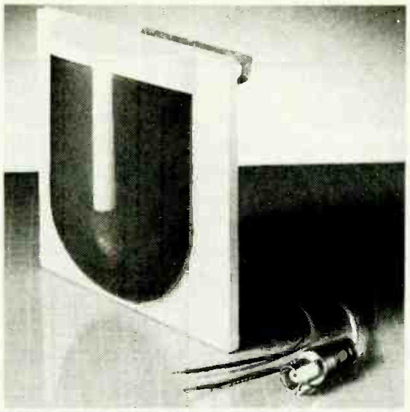
Video on Demand

CHANNEL PLUS 9020 MULTI-ROOM VIDEO DISTRIBUTION SYSTEM. From Multiplex Technology, Inc., 3200 East Birch Street, Brea, CA 92621. Tel. 714-996-4100. Price: $1405.00.

The days when a family would gather in one room around the television set are gone forever. Today's typical family watches more TV than ever, but they watch it scattered throughout the house, each watching something different. Now there's a way to ensure that all TV's receive a quality signal: the *ChannelPlus 9020 Video Distribution System*.

The 9020 contains everything that's required to distribute TV signals throughout a house. Plus, it has the capability of accepting video signals from up to three different sources, and distributing them on unused TV channels. For example, signals from your satellite receiver might be distributed on channel 24 on all TV's throughout the house, and your laserdisc-player's output might be on channel 27.

The 9020 includes a 3-channel modulator, connectors, terminators, attenuators, wall plates, and a coaxial-cable panel that contains amplifiers, splitters, and taps on a base plate. About the only thing to add is coaxial cable and junction boxes for the cable outlets.



The ChannelPlus in-wall camera provides superior image resolution in low-light conditions.

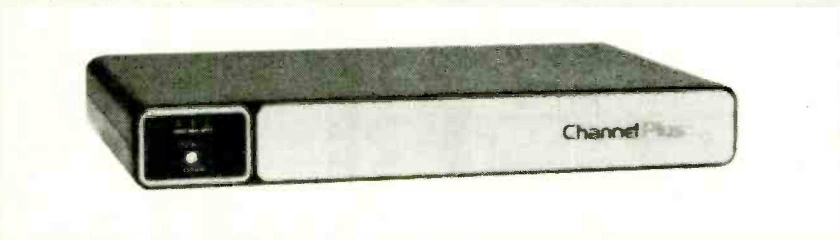
The coaxial-cable panel is the heart of the distribution system. It accepts input from a TV antenna or cable, and up to two modulators. Its mounting holes are designed for easy mounting to the framing studs of a wall. It should be mounted in a central, accessible location because cables from each set in the house are "home run" back to the panel. That provides for the best signal at each set, and guarantees that adequate signal is available.

Four of the eight outputs are designed to supply cable runs between 30 and 90 feet long. The remaining four are designed for cable runs between 90 and 150 feet. An additional amplifier can be added to service more TV's or longer cable runs.

Either a hyperband or UHF modulator is supplied with the 9020. Because we are not cable-TV subscribers, we chose the UHF modulator, which can output signals on UHF channels 14–62. Once installed, the modulator helps to make the system extremely easy to operate. Only one cable needs to be run to each TV. Sources are selected simply by changing the channel. For example, the satellite receiver might be found on Channel 24, the VCR on channel 26, and the front-door camera on channel 28. The frequency of the modulators are set by rotating thumb wheels behind a removable front panel. They are reminiscent of the channel-setting controls on early VCR's. An output-level control is provided so that the signal level of the house-generated channels can be set to match those from cable or terrestrial broadcasts.

Once the system was tuned properly—which was more difficult to accomplish than we expected—the performance at every TV in the house was outstanding. The only drawback is that the modulator transmits only a mono signal. An MTS stereo modulator is available, however, as is a digitally tuned modulator that should make the setup task easier.

Now, instead of falling asleep on the couch watching satellite TV, we can fall asleep in the bedroom. We can even keep tabs on who's at the front door by turning on our TV's picture-in-picture. ■



The ChannelPlus Modulator accepts up to three video inputs, and distributes them on unused TV channels.

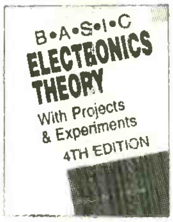
THE GOOD LIFE

(Continued from page 52)

GET EDUCATED!

They were on the right track. It's vital to learn everything you can about the field. Reading magazines like this one is a start, but Sean Fields suggests that you also take advantage of some of the classes offered by CEDIA. Regional seminars are offered throughout the year, and are open to members and non-members (at a higher cost). Manufacturers also offer training courses specific to their own products, usually held at their main offices. However, manufacturer's training programs are often coordinated with CEDIA's regional classes, allowing the manufacturers to reach more people with the closer, more affordable programs. Current information on regional seminars is available from CEDIA.

If you'd prefer to go the total-immersion route, consider attending CEDIA's 1994 Fall Management Conference and Trade Expo, to be held in Dallas on September 8–11, 1994. Although the agenda has not yet been finalized as we go to press, several workshops and manufacturers' seminars will be offered, as well as a series of educational panels focusing on both the basics and the evolving nature of the custom-installation industry. ■



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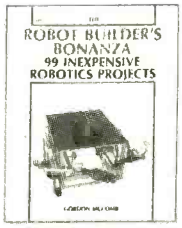

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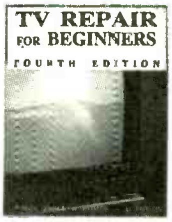

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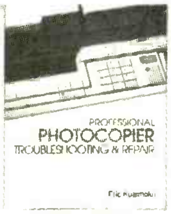

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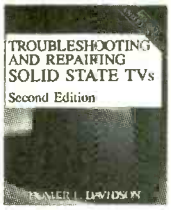

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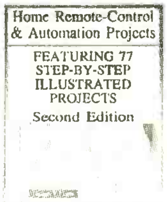

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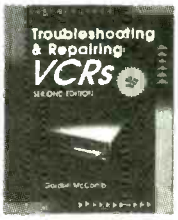

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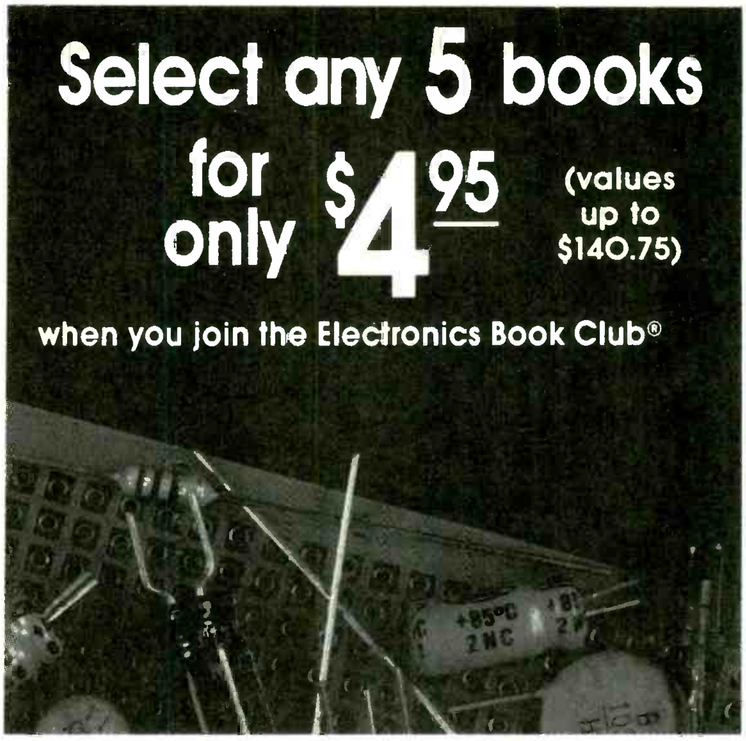

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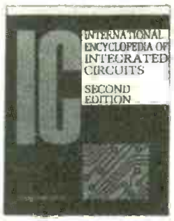

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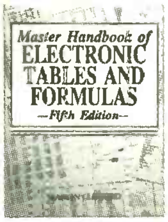

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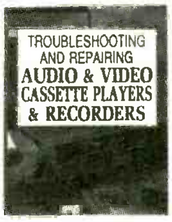

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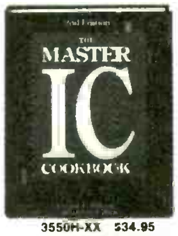

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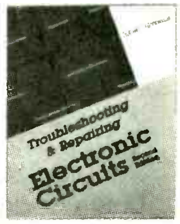

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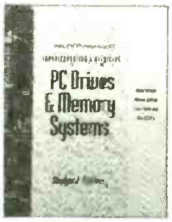

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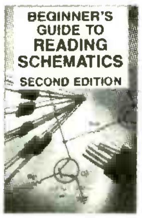

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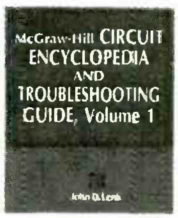

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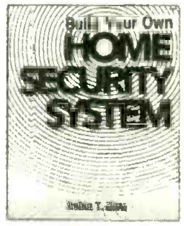

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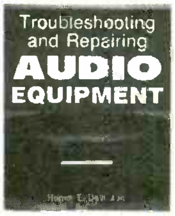

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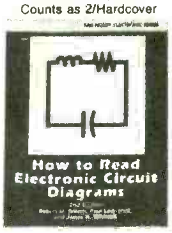

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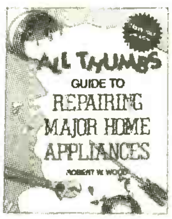

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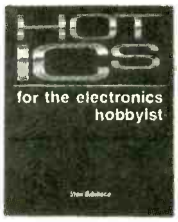

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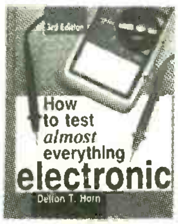

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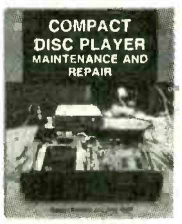

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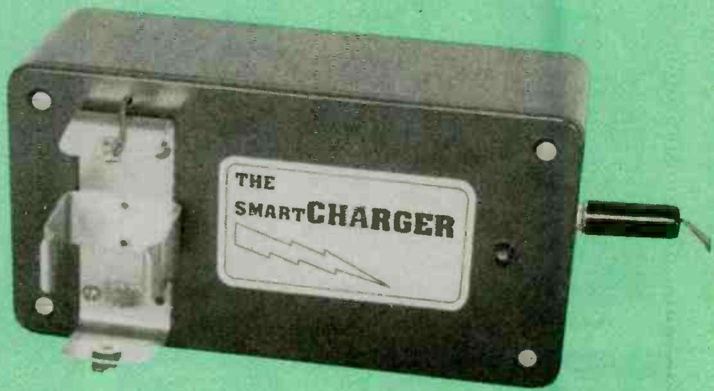
Build the Smart Charger

Is the high cost of replacement batteries affecting your limited household budget? If so, get with the rechargeable revolution

BY ANTHONY J. CARISTI



Do you shudder at the cost of batteries every time you need to buy replacements? Would you like to cut the cost of operating your portable equipment by a factor of 5 to 1 or more? If so, the *Smartcharger* described in this article is for you. With the help of the Smartcharger, you can take advantage of a new type of alkaline battery that can be recycled, instead of thrown away. That considerably cuts the cost of operating your portable radio, cassette player, or almost any battery-operated device.

That's possible because a quiet revolution has taken place in the primary (dry-cell) battery industry. The Rayovac Corp. has developed and patented a rechargeable alkaline battery, called Renewal, which is available in AAA, AA, C, and D sizes. Ordinary alkaline batteries cannot be successfully recharged due to the buildup of gases, the possibility of internal shorting and leakage, and other problems. Before Renewal, battery users could only dream of recharging their alkaline cells. Many have tried, unsuccessfully of course, to charge alkaline cells using either home-made or commercially available chargers.

Alkaline vs. NiCd Cells. Rechargeable alkaline batteries have several important advantages over their NiCd counterparts. In addition to initially costing less, they offer two to three times more energy-storage capacity in any given size, and offer a higher terminal voltage than NiCd's—1.5 volts versus 1.2 volts. Also, alkaline cells retain their full charge for up to 5 years in storage. In contrast, NiCd's have a self-discharge rate of about 1% or more per day, depending on the ambient temperature. That is why a device that is used sporadically often seems to have dead NiCd's when you thought they were charged. Because of the self-discharge characteristic, NiCd batteries must be left on trickle charge or recharged just prior to use; and a full charge can take as much as 16 hours to complete.

Another advantage of alkaline over NiCd units is the ability of the alkaline cell to function at lower operating temperatures. That characteristic could be important for those who must operate portable equipment in very cold climates.

Finally, NiCd batteries are not environment friendly. They are highly toxic and their contents are classified as hazardous waste by the EPA. By comparison, Renewal cells are 99.975% mercury free, contain no cadmium, and use recycled cardboard and plastic packaging.

The New Technology. The rechargeable alkaline battery is a zinc/manganese-dioxide system designed with enhanced electrochemical and mechanical construction that eliminates the problems inherent in ordinary alkaline batteries. One problem with non-rechargeable alkaline cells is the tendency of the outer cathode to separate from the steel jacket, rendering the battery useless. Further, attempting to charge such batteries can generate hydrogen gas, which can create over pressurization resulting in leakage and possibile bursting.

In addition, chemical reactions within an ordinary alkaline battery can form conductive paths within the unit, resulting in a shorted cell. Successful, repeated charge/discharge cycling of an alkaline battery requires that the manganese dioxide contained in the electrolyte not be allowed to form manganese trioxide during discharge. That chemical reaction is not reversible during the recharge process. Rayovac's rechargeable alkaline batteries do not suffer any of those problems.

Performance. New rechargeable alkaline batteries have virtually the same discharge capacity as regular alkaline units. Once fully discharged and recharged, they have a capacity that's slightly less than that of new units. Thereafter, each charge/discharge cycle results in decreasing capacity. However, after 25 full charge/discharge cycles have been completed, the rechargeable alkaline battery's capacity equals that of a consumer-grade NiCd cell. Shallow discharge cycles (25% or less) of the new alkaline units allow 100 or more recharges before it's capacity is reduced to that of NiCd units.

Figure 1 illustrates the typical cumulative number of hours of use available from a rechargeable AA-size alkaline battery when powering a load, perhaps an electronic game or toy. Initially, an ordinary alkaline cell permits about 4 hours of use before it

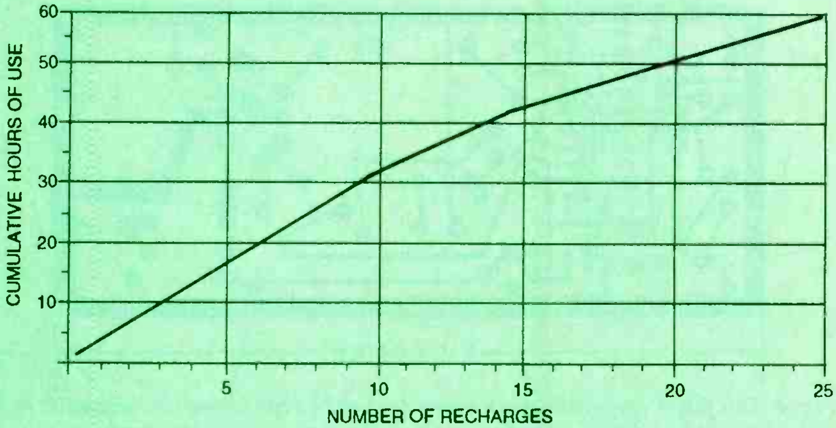


Fig. 1. Shown here is the typical cumulative number of hours of use available from a rechargeable AA-size alkaline battery powering a load.

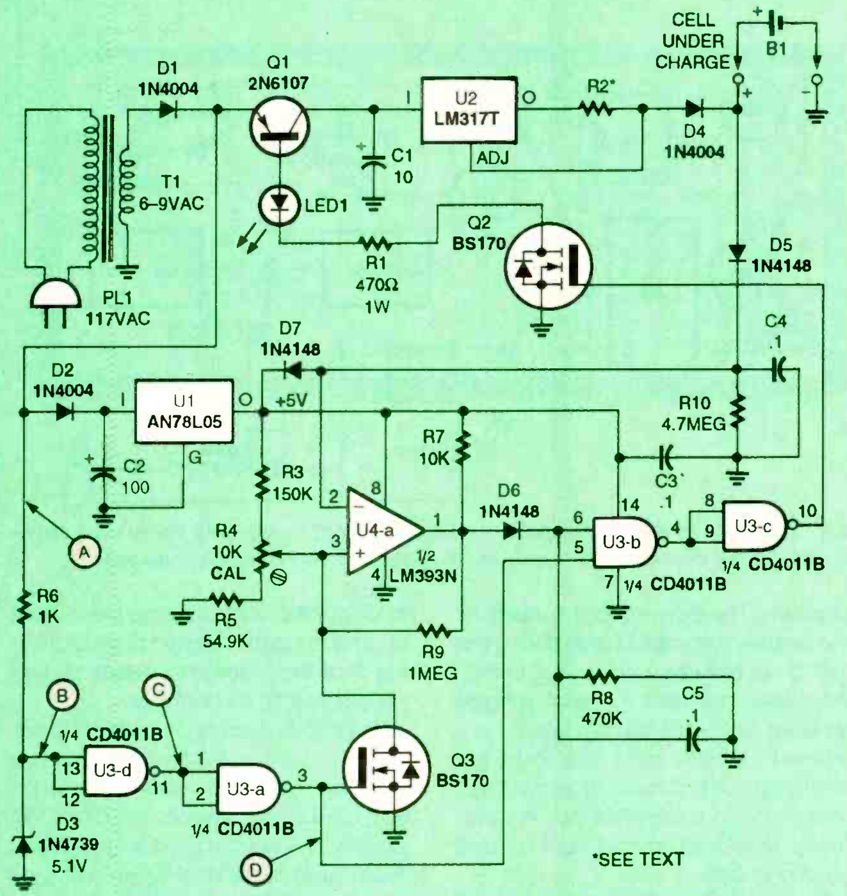


Fig. 2. The Smartcharger is comprised mainly of four chips—an AN78L05 5-volt, 100-mA regulator (U1), an LM317T 1-amp adjustable-voltage regulator (U2), a CD4011BE quad 2-input NAND *gate (U3), and an LN393N dual voltage comparator (U4). The value and rating of R2 is selected as described in text.*

must be discarded. However, a rechargeable cell can provide almost 60 hours of use at the 25th recycle, and still have some life.

Recharging Fundamentals. Rechargeable alkaline batteries cannot be properly charged using an ordinary charger. Such chargers supply a continuous charging current whether or not the battery is fully charged. However, proper charging can be accomplished via the Smartcharger. The Smartcharger is designed deliver a series of discrete charging-current pulses to the battery, while continuously monitoring its condition.

The Smartcharger, using analog and digital-logic circuitry, samples the battery's terminal voltage 60 times per second (during the time between the discrete charging pulses). The constant-monitoring system used in the Smartcharger prevents overcharge, which can damage and/or reduce the performance of the battery. When the battery's terminal voltage reaches the theoretical maximum charge of 1.65 volts, the charging-current pulses are automatically terminated.

How It Works. A schematic diagram of the Smartcharger is shown in Fig. 2. The Smartcharger receives power from a common AC wall transformer that provides 6- to 9-volts rms, at about ¼ to ½ amp; the transformer's current rating depends on the size of the cell under charge. Diode D1, used as a half-wave rectifier, provides a pulsating DC output that is used to power the circuit and provide charging current to charge the battery. Resistor R6 and Zener diode D3 shape and limit the pulsating DC to produce a 5-volt, 60-Hz trapezoidal pulse train that is used to drive the associated logic circuitry.

Diode D2 is used to isolate the pulsating-DC output of D1 from filter capacitor C2. The voltage across C2 is fed to the input of U1, a fixed 5-volt regulator that is used to power the analog and digital sections of the circuit.

The pulsating-DC output of D1 is also fed to the emitter of Q1 (a 2N6107 PNP transistor), which is operated as a switch and controlled by Q2. The output of Q1, at its collector, is fed to the input of U2, an LM317 adjustable-voltage regulator that is configured as a current regulator. Resistor R2 is placed between the adjust and output terminals of U2; that maintains a fixed 1.2-volt reference voltage between those two terminals. Because of the U2/R2 arrangement, only a minimal current flows through D4, regardless of the input voltage or load resistance. The output of U2 feeds pulsating DC to the battery under charge.

Refer to the waveform diagrams shown in Fig. 3. The waveform in Fig. 3A is the 60-Hz, half-wave-rectified output of D1 (at point A of Fig. 2). The waveform in Fig. 3B (point B in Fig. 2) is the clipped waveform (which is regulated to about 5 volts by Zener diode

D3) that is fed to the input of U3-d (¼ of a CD4011 quad NAND gate), which is configured as an inverter. The output of U3-d (shown in Fig. 3C) is fed to U3-a (also connected as an inverter) at point C. The output of U3-a (illustrated in Fig. 3D) is the inverse of U3-d's output waveform. The final waveform, Fig. 3E, represents the current pulses (0.2- or 0.4-amp peak) fed to the battery under charge. Note that all waveforms are synchronized with the 60-Hz, power-line frequency.

The battery's terminal voltage (less the diode drop of D5) appears across R7 and at the inverting input (−) at pin 2 of U4, an LM393N dual voltage comparator. The non-inverting (+) input of U4 at pin 3 is fed a voltage derived from a resistive string composed of R3–R5, which is connected between the 5-volt regulated-supply rail and ground. The output of U4 assumes a logic-1 (5-volt) state when the battery's terminal voltage drops below the threshold set by R4, indicating that the battery needs recharging.

When the battery is fully charged, its voltage hovers above the reference voltage established at pin 3 of U4, causing the output of U4 at pin 1 to go to zero. That characteristic allows U4 to be used to monitor the battery-recharging process. The comparator circuit is designed to have about a 0.1-volt input-voltage hysteresis, as provided by R9. That increases circuit stability and allows the charging current to flow only when the battery's terminal voltage is below the threshold value by a certain amount.

In order to meet the criteria set by the rechargeable alkaline cell's manufacturer, the open-circuit voltage of the battery is sampled only during the idle time between charging pulses. When the battery's terminal voltage reaches 1.65 volts, the battery is considered fully charged; therefore the charging current must be terminated. That function is handled by an automatic shut-down circuit built around U3-b and U3-c.

Transistor Q3 (an N-channel enhancement mode MOSFET) is driven by the output of U3-a. Each time Q3 is turned on, the positive input of U4 is pulled low, inhibiting it during the charging-pulse time. That, in turn, causes the output of U4 to go to zero during the time that charging current is applied to the battery. When the output of U3-a goes low, Q3 cuts off and U4 is free to measure the terminal voltage of the battery. If that voltage is below 1.65 volts, pin 1 of U4 is pulled high via R7. That causes C5 to charge to about 4.8 volts, causing the output of U3-b to go to a logic-1 state, signifying that the charging pulses should be applied to the battery.

The high output of U4 applied to pin 6 of U3-b, plus the simultaneous positive transition of waveform D (at pin 3 of U3-a) applied to pin 5 of U3-b, causes its output at pin 4 to go to zero. That signal is inverted by U3-c to produce a logic-1 output at pin 10, which is then applied to the gate of Q2. With Q2 activated, Q1 is biased on, allowing charging current to flow to U2 and the battery.

Light-emitting diode LED1, which is placed in series with Q1's base and is illuminated by Q1's base current, provides a visual indication of the charger's operation. That LED glows constantly as the battery is being charged. As long as C5 remains charged, current pulses will continue to be applied to the battery. When

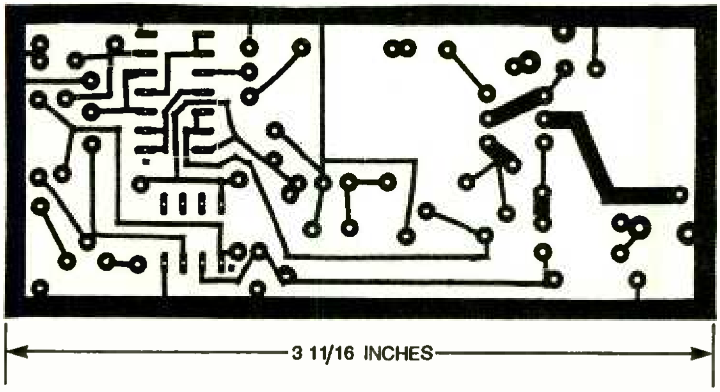


Fig. 4. This full-size template of the author's printed-circuit layout can be used to etch your own board or you can purchase one from the source given in the Parts List.

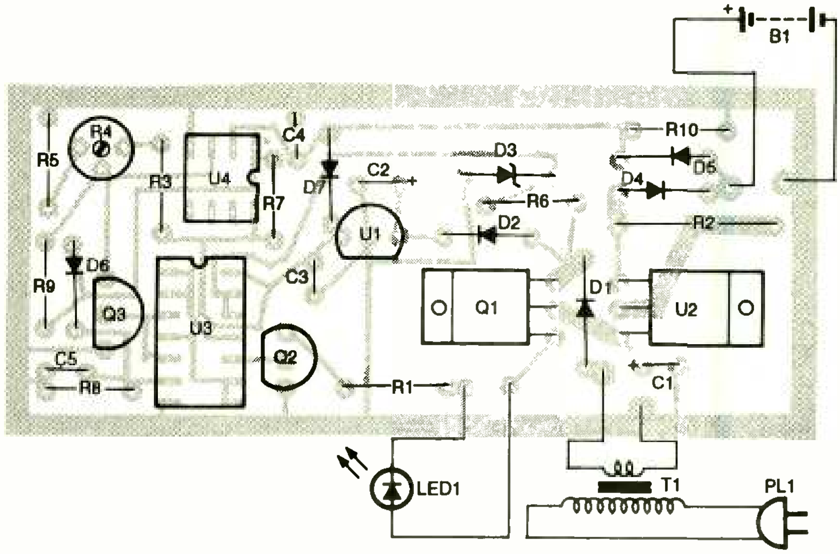


Fig. 5. Guided by this parts-placement diagram, carefully assemble the printed-circuit board, paying close attention to the orientation of all the polarized components.

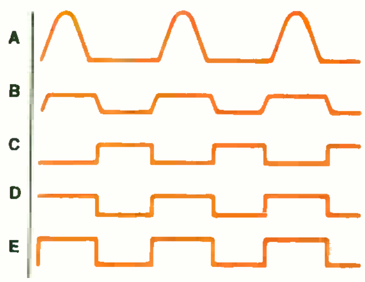


Fig. 3. These are the waveforms that should appear at specified points in the circuit. (See the text for details.) A is the 60-Hz, half-wave-rectified output of D1; B is the clipped waveform that's fed to U3-d; C is the output of U3-d; D is the output of U3-a; and E, represents the current fed to the battery under charge.

the battery approaches full charge, pin 1 of U4 goes to zero. The time constant established by the values of R8 and C5 allow the input voltage of U3-b at pin 5 to decay to zero, cutting off the drive current to Q2 and extinguishing LED1.

In actual operation, the number of charging pulses delivered to the battery is 60 per second when the battery is in a state of low or partial charge. As the battery approaches full charge, the number of pulses decreases, eventually diminishing to just a few pulses per minute. If the Smartcharger is left in operation, the pulses delivered to the battery eventually cease, thereby protecting the battery from overcharging.

Note that the charging circuit is designed to monitor a single cell. If more than one battery is to be charged at once, the main circuit (minus the wall transformer) must be duplicated for each additional battery. A single transformer is all that's needed to feed all of the charging circuits simultaneously, so long as it can deliver the necessary current.

For one AA or AAA cell, a ¼-amp unit is required; a C or D cell requires a ½-amp unit. For a multiple-battery charging station, the transformer rating must be ¼ or ½ amp times the maximum number of cells on charge. For instance, for a multiple-AA or -AAA unit, the transformer must be capable of delivering ¼n amps; where n is the number of cells to be charged.

Construction. The author's prototype of the Smartcharger was built on a printed-circuit board measuring about 3¹¹⁄₁₆ by 1⅝ inches. A full-size template of that printed-circuit layout is shown in Fig. 4. You can etch your own printed-circuit board or one can be obtained from the source given in the Parts List.

Figure 5 shows the parts-placement diagram for the author's printed-circuit layout. When assembling the board, note the orientation of all the polarized components. It is important that none of them is inadvertently misoriented; doing so could result in an inoperative circuit and possible component damage. It is recommended that sockets be used for the DIP IC's. That allows the circuit to easily be serviced should it ever need it. It is very difficult to separate a soldered-in multi-pin device from a PC board without damaging either the board or the chip.

Be sure to use the correct-value resistor for R2, which determines the volume of charge current. For AA and AAA cells, the proper charge current is 200 mA; thus, R2 can be two 3-ohm, 1-watt resistors connected in series, or a fixed value of 6.2 ohms. For C and D cells, the charging current is 400 mA; so R2 should be a 3-ohm, 2-watt unit. The Smartcharger can be configured for all cell sizes by adding a single-pole double-throw (SPDT) switch to the circuit to allow a resistance of 3 or 6 ohms to be placed in the circuit as needed to select the proper charging current. Figure 6 shows how to alter the circuit for that purpose.

The accuracy and stability of the circuit relies on the temperature coefficient of the voltage-divider string composed of R3, R4, and R5. For that reason you should use only metal-film resistors and a cermet potentiometer as specified in the Parts List. Ordinary carbon components are not be stable enough for the circuit, and should not be used.

Transistors Q1 and U2 do not require heat sinking, and are placed on the circuit board with the metal tab facing down. Be careful not to inadvertently interchange those two components, and do not allow any metal part of either component to short to anything else. Be sure to place LED1 in a location where it can be readily seen during charging operations.

Power for the author's unit was provided by a 6- to 9-volt AC, ¼- or ½-amp plug-in wall transformer, depending on the size of the cell to be charged, as previously discussed. A plug-and-jack arrangement was then used for connections between the transformer and circuit board.

Battery holders for the size cells to be charged (AAA, AA, C, and D) are available from a wide range of sources, including Digi-Key Corp. and Radio Shack to name a few. Remember, the Smartcharger can charge only one cell at a time, so if the battery holder that you get is designed for two or more cells, it must be modified to accommodate a single cell. A case in point is Radio Shack's #270-398 "AAA" battery holder, which is designed to hold two AAA units.

Since only one cell compartment is

PARTS LIST FOR THE THE SMARTCHARGER

SEMICONDUCTORS

U1—AN78L05 5-volt, 100-mA, fixed-voltage regulator, integrated circuit
U2—LM317T 1-amp, adjustable-voltage regulator, integrated circuit
U3—CD4011BE quad, 2-input NAND-gate, integrated circuit
U4—LN393N dual, voltage-comparator, integrated circuit
Q1—2N6107 general-purpose PNP silicon transistor
Q2, Q3—BS170 N-channel, enhancement-mode MOSFET
D1, D2, D4—1N4004, or equivalent, 1-amp, 400-PIV, silicon diode
D3—1N4739 5.1-volt, 1-watt, Zener diode
D5–D7—1N4148 general-purpose silicon diode
LED1—Light-emitting diode, 2-volt, 20-mA

RESISTORS

(All fixed resistors are ¼-watt, 5% carbon units, unless otherwise noted.)
R1—470-ohm, 1-watt
R2—See text
R3—150,000-ohm, 1% metal-film
R4—10,000-ohm PC mount, cermet potentiometer
R5—54900-ohm, 1% metal film
R6—1000-ohm
R7—10,000-ohm
R8—470,000-ohm
R9—1-megohm
R10—4.7-megohm

CAPACITORS

C1—10-µF, 25-WVDC, radial-lead electrolytic
C2—100-µF, 25-WVDC, radial-lead electrolytic
C3–C5—0.1-µF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

T1—6- to 9-volt rms AC wall transformer (see text)
B1—See text
PL1—Part of T1 (see text)
Printed-circuit materials, enclosure, IC sockets, optional plug and jack (see text), battery holder(s) and connector(s), wire, solder, etc.

Note: The following parts are available from A. Caristi, 69 White Pond Road, Waldwick, NJ 07463: a printed-circuit board, $10.95; U1, $2.00; U2, $2.50; U3, $2.25; U4, $2.95; Q1, $2.25; Q2, $2.75; Q3, $2.75; set of 2 metal-film resistors, $1.25. Please add $4.00 postage/handling. New Jersey residents please add appropriate sales tax.

required, the other compartment must be shorted by connecting a wire from the positive terminal to the negative terminal. Be sure to observe proper polarity when wiring the battery holder to the Smartcharger. Use a sample rechargeable cell and DC voltmeter to be sure. If the connections are reversed, the circuit will not work.

When the circuit is completely assembled, examine your work very carefully for bad solder joints and shorts, especially between adjacent IC pins and circuit traces. It is much easier to correct problems at this stage than later if the circuit does not work.

Checkout. Checking out the Smartcharger requires an accurate digital voltmeter, and a Renewal rechargeable alkaline cell that is fully or partially charged. Note: Do not insert the battery in its holder until instructed to do so. An oscilloscope is not necessary, but may come in handy if you need to troubleshoot the circuit. With no battery in the holder, apply power to the circuit and measure the DC voltage across C2. It should read 8 to 15 volts, depending on the transformer voltage.

Then, measure the output of U1; it should be somewhere between 4.75 and 5.25 volts. Afterward, measure the pulsating DC voltage at pins 12 and 13 of U3; an indication of about 2 or 3 volts is normal. If you don't get the correct reading, disconnect power, troubleshoot the circuit, and repair the fault before proceeding. Once the proper voltages have been measured, proceed with the checkout. With the power turned off, place a rechargeable cell into the battery holder and set R4 to mid position. Connect the DC voltmeter across the battery; you should get a reading somewhere between 1 and 1.6 volts.

Next apply power to the circuit and observe the meter reading and the LED. If the battery is in a state of partial charge, the LED will light and the battery voltage will increase as it accepts the charge. Adjust R4 very slowly to bring the meter reading to about 1.6 volts, if possible. If the battery is in a very low state of charge, you may have to wait until sufficient recharging time has lapsed to restore battery voltage level.

As the battery recharges further, note that the LED begins to flash off and on. Wait until enough time occurs between flashes so that the voltmeter is able to measure battery voltage when the LED is extinguished. Each time the LED pulses on, note that battery voltage increases by about 0.3 volts. When you can measure battery voltage between charging pulses (LED off), very carefully adjust R4 for a battery terminal voltage of at least 1.62 volts, but not more than 1.65 volts,

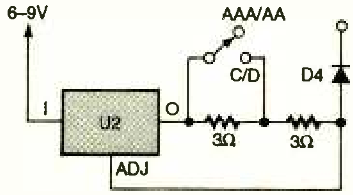
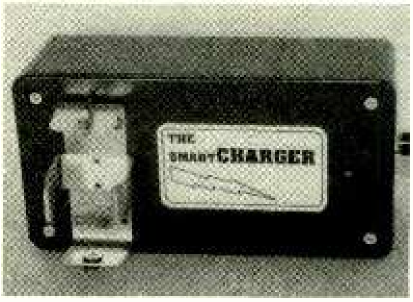


Fig. 6. The Smartcharger can be modified to accommodate all battery sizes by replacing R2 with two 3-ohm units.



Here is the author's prototype of the Smartcharger alkaline-battery recharger. As described in the article, select your cell holder to accommodate the cell type you will be recharging.

when the LED is off. That adjustment is very important to avoid any possibility of overcharging the battery while ensuring that the battery reaches full recharge. When the battery approaches full charge, the LED's flash rate diminishes, eventually going out for minutes or even hours between flashes.

If you do not obtain the results described, try charging a new cell. If that doesn't work, disconnect power to the circuit and review Fig. 5 to verify that all of the components are of the correct values and are properly oriented. Make sure that Q1 and U2 have not been inadvertently interchanged, and that they are positioned on the board with proper orientation. If all appears okay, but the circuit still does not operate properly, try new chips for U3 and U4.

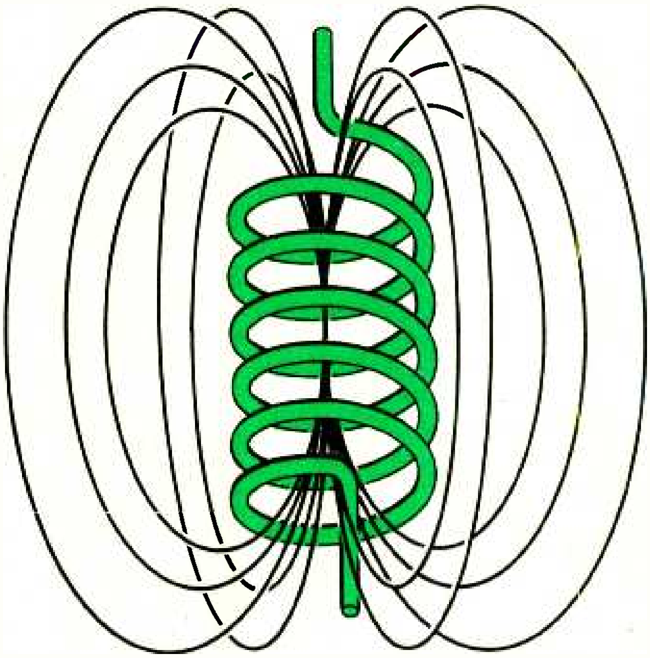
If that does not eliminate the fault, use an oscilloscope to display and measure the pulse trains and logic levels throughout the circuit. Check the signals at points A, B, C, and D indicated in Fig. 2 and compare them with the corresponding waveforms shown in Fig. 3. Temporarily remove Q3 from the circuit and verify that the voltage at pin 3 of U4, varies from about 1.3 to 1.5 volts as R4 is adjusted. If not, check the values of R3, R4, and R5. If the fault still has not been found, check the operation of Q1 and U2 by temporarily connecting the drain of Q2 to ground while monitoring the battery voltage and observing the LED. Grounding the drain of Q2 should cause LED1 to light while increasing the battery's terminal voltage to 1.6 volts or more. If necessary replace Q1 and/or U2.

Use. Best battery life will be obtained if the alkaline cells are not severely discharged. Any battery that is discharged to the point where its terminal voltage is extremely low may not be capable of being rejuvenated by the Smartcharger. When battery-operated equipment exhibits erratic or sluggish operation, it's best to remove the batteries immediately and place them on charge. The charging time will depend on the state of the cells. AAA and AA cells require 3 or more hours of charging; C and D cells may require overnight charging. There is no danger of damaging the cells if the Smartcharger is left on for extended periods of time.

It would be a good idea to keep a spare set of batteries on hand so that the exhausted cells can be placed on charge while the freshly charged ones are placed in service. The charged alkaline cells have an excellent storage life, and will not self-discharge to any great extent after being charged.

When the capacity of the cells is too low after repeated charge/discharge cycles, they should be replaced. That should not occur until after 25 or more cycles have taken place. Even then, such cells can still find use in very intermittent and non-critical service applications, such as in a spare flashlight or perhaps a portable radio. ■

An Introduction



to Reactance

Take a step beyond resistive-circuit analysis.

BY PAUL COXWELL

Simple resistive circuits are fairly easy to understand, but circuits with capacitors and inductors, known collectively as reactive components, are more elusive. This article will attempt to shed light on reactive circuits by comparing them to resistive ones.

Let's start by examining the simple resistive circuit shown in Fig. 1A. When DC is supplied by the battery, the current developed can be determined by using Ohm's Law, the battery voltage (E), and the resistor's value (R). When an AC source is used (Fig. 1B), the instantaneous value of current flowing through the resistor varies with the alternating output voltage of the generator. Ohm's Law applies to the circuit just as it does to the DC circuit; peak current can be calculated from the generator's peak voltage, and rms current from the rms voltage. The graph of one cycle of AC (Fig. 1C) shows that when the voltage reaches a peak, the current also peaks; when the voltage crosses the zero line, so does the current. The two waveforms are said to be in phase, and this condition occurs in any circuit that contains pure resistance with no reactive components.

Inductance. The first reactive element we shall examine is inductance. The basic laws of electromagnetism tell us that whenever current flows through a conductor, a magnetic field is developed around that conductor. Similarly, whenever a conductor passes through a magnetic field, or a magnetic field cuts through a conductor, a current is induced in that conductor.

Figure 2A shows a coil wired into a simple DC circuit. When the switch is operated to connect the battery, current starts to flow through the windings of the coil. As the current builds up, a magnetic field expands from each turn of the coil and cuts across neighboring turns. That expanding field induces a separate current in the coil in the opposite direction to the energizing current from the battery. The induced current, known as counter-EMF (or electro-motive force), can never be as great as the original current, but since it is of opposite polarity, it restricts the rate at which current in the coil can increase. When the field around each turn of wire stops expanding, there is no longer any induced counter-EMF, so the final value of current is limited only by the resistance of the circuit (just R if we disregard the tiny resistance in the coil's windings). It is important to realize that the time constant is affected not only by the inductor itself, but also by the resistance of the circuit to which it is connected.

The build-up of current follows an exponential curve, as shown in Fig. 2B. The period between the application of power and the current reaching 63.2% of its maximum value is called the circuit's time constant. The time constant's value in seconds can be calculated by dividing the inductance in henries by the circuit resistance, in ohms. For most practical purposes, the current is considered to have reached its maximum value after a period equal to five times the constant.

Several factors affect the inductance of a coil: It can be increased by adding more turns, using an iron core, reducing the spacing between adjacent turns, and altering the coil's overall diameter. For example, if a 10-henry coil is used with a circuit resistance of 50 ohms, the time constant is 0.2 second. Current through the coil would reach 63.2% of its final value after 0.2 second, and would be considered to have reached maximum (over 99%) after approximately 1 second. If the coil was changed to one of 20 henrys by adding more turns, the time constant would be increased to 0.4 second. Current would now reach its maximum value 2 seconds after power was applied.

Assume now that the switch in Fig. 2 is moved back to its original position, connecting the coil to the resistor. Even though the battery is disconnected, current will still flow for a short time. With the energizing current removed, the magnetic field around each loop of the coil starts to collapse, and in doing so generates EMF within the inductor. It is that induced EMF that attempts to maintain current flow. After one time constant, the current will have dropped to 36.8% of its maximum value (*i.e.*, 63.2% toward zero), and is considered to be zero after five time constants.

The result of connecting an inductive circuit to an AC voltage source (as in Fig. 3A) is shown in Fig. 3B. The voltage starts to rise from zero at the be-

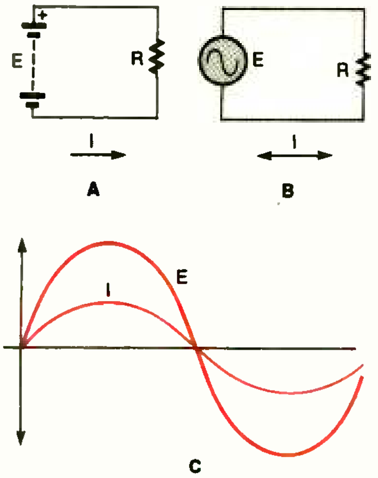


Fig. 1. DC resistive circuits (A) and AC resistive circuits (B) both obey a simple version of Ohm's Law. So in a resistive AC circuit, current and voltage vary in step with one another (C).

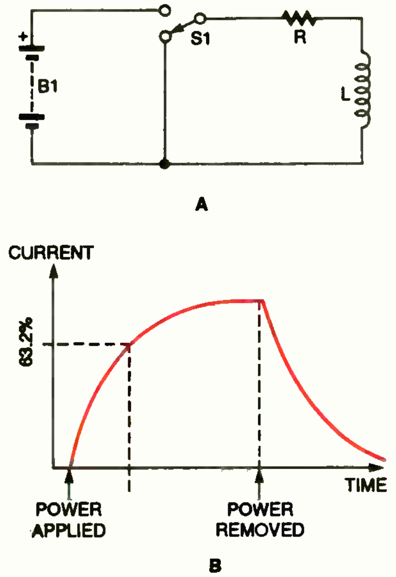


Fig. 2. The inductor in the circuit shown in A causes current to lag behind the applied voltage, as shown in B.

ginning of a cycle, but as you might guess, the circuit current does not rise instantaneously as it would in a purely resistive circuit. The voltage will have passed its positive peak and dropped toward zero before the inductance allows the current to reach its peak value. In other words, the instantanteously current flowing in the circuit is less than what would be calculated from the resistance of the coil wire alone.

The opposition to current flow due to the inductor's induced EMF is called inductive reactance, denoted X_L, and is measured in ohms. If the frequency of the applied AC is reduced, the coil current will reach a higher value before the voltage waveform passes its peak and drops toward zero, so inductive reactance is directly proportional to the applied frequency as follows:

$$X_L = 2\pi fL$$

The formula assumes that the value of inductance (L) is given in henrys and the frequency (f) in cycles-per-second, or hertz.

In a theoretical circuit consisting of pure inductance, with no resistance, the current lags behind the voltage by exactly 90 degrees: When voltage is maximum, current is minimum, and vice versa. Since there is no resistance, the current in the circuit can be determined by substituting X_L for R in the Ohm's Law equation.

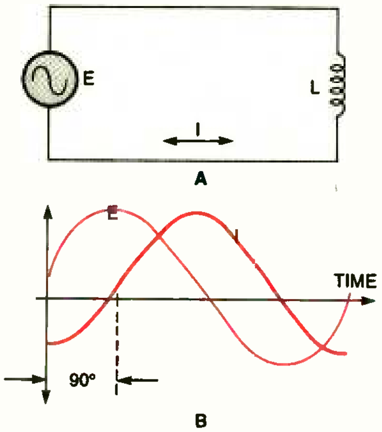


Fig. 3. In a purely inductive AC circuit (A), the current waveform lags behind the voltage waveform by 90 degrees (B).

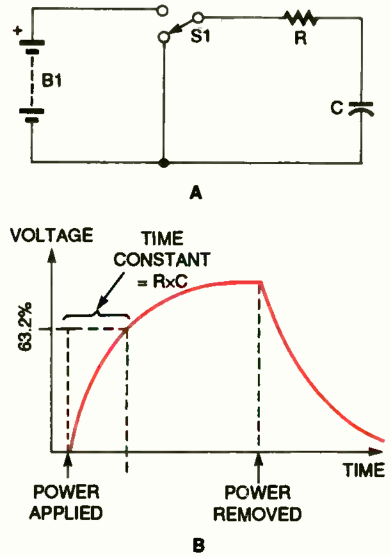


Fig. 4. The charging action of the capacitor in A causes voltage to lag behind current, as shown in B.

Capacitance. The electrically speaking, the opposite of inductance is capacitance. Let's discuss how current flows through a capacitor as it charges from a DC source (shown in Fig. 4A). When the switch is closed, the current immediately rises to a value set by the limiting resistor (R). Electrons from the negative pole of the battery flow to one plate of the capacitor to give it a negative charge, while at the same time, electrons are drawn from the other plate to the positive battery pole. The current gradually drops as the plates charge, and in an ideal capacitor the current would be zero when the plates were charged to capacity.

At the instant that current is applied, there is no voltage across the capacitor (see Fig. 4B). As charge accumulates on the plates and the charging current drops, the capacitor's voltage rises. The plotted curve of the voltage rise is exponential, and is identical in shape to the curve shown earlier for the rise of current in an inductor.

The capacitive time constant is defined as the period between the application of charging current and the point at which the capacitor voltage reaches 63.2% of the supply voltage. It is equal to the product of the capacitance and overall circuit resistance. With the capacitance specified in farads and resistance in ohms, the result will be in seconds. Once again, the circuit is considered to have reached its final values, with the capacitor fully charged, after approximately five time constants.

When the circuit is switched to discharge the capacitor, both the current and voltage decrease gradually, as would be expected. After a period equal to one time constant, the capacitor voltage will be 36.8% of its full value, and after five such periods the capacitor is considered to be fully discharged.

Figure 5A shows the capacitor in an AC circuit. Notice that the relationship between current and voltage in a purely capacitive circuit, as reflected in the graph in Fig. 5B, is exactly opposite to that in an inductive circuit—the current leads the voltage by 90 degrees. Whereas the inductor opposes changes in circuit current by generating a counter EMF, the capacitor opposes changes in voltage by storing and releasing electrons from

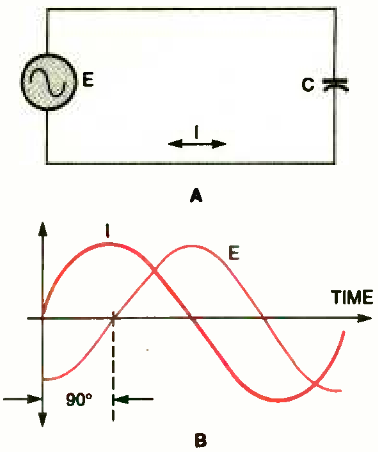


Fig. 5. In a purely capacitive AC circuit (A), the current waveform leads the voltage waveform by 90 degrees (B).

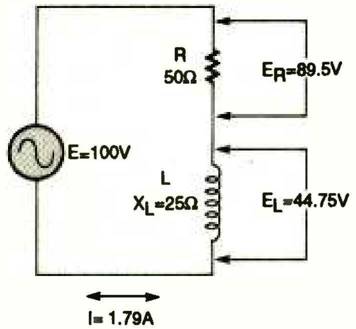


Fig. 6. Voltages in RL circuits like this one, or in RC circuits, are not in phase and cannot be added directly.

its plates. However, the overall affect on current flow is similar: the effect is greater than can be accounted for by resistance alone.

The opposition to current flow in a capacitor is called capacitive reactance, X_C, and is also measured in ohms. As the frequency of the applied AC is reduced, the capacitor will have longer to charge before the supply polarity changes, so the overall current will be lower. Capacitive reactance is therefore inversely proportional to frequency, as indicated by:

$$X_C = 1/(2\pi fC)$$

where the frequency (f) is in hertz, and the capacitance (C) is in farads. Note that is the exact opposite of inductive reactance.

Phase Angle and Vectors. The effects of pure capacitance or inductance can be understood quite simply by remembering that they cause current and voltage to be 90 degrees out-of-phase. However, the situation becomes more complex when both reactive components and resistance are combined, which is the case in any practical circuit.

Look at the circuit of Fig. 6 as we proceed. The components in the circuit shown are in series, so the current flow must be the same through both of them. The resistor has a value of 50 ohms, and we have assumed that the inductor has an inductive reactance of 25 ohms at the frequency in use.

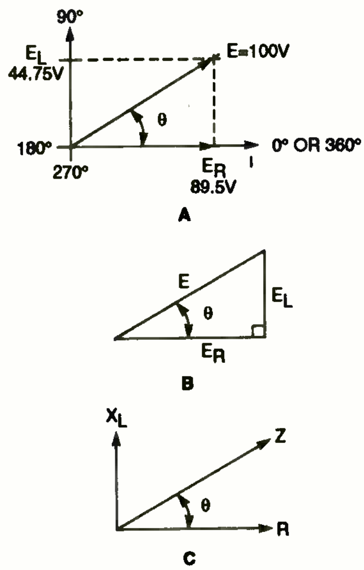


Fig. 7. Vectors can be used to show the relationship between voltages in a reactive circuit (A). By rearranging vectors (B), one can see their geometric relationship. Vectors can also be used to describe circuit impedance (C), too.

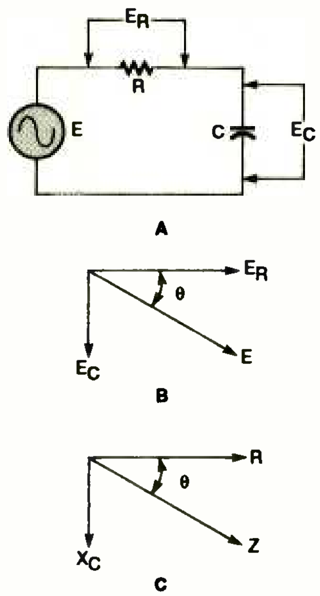


Fig. 8. A capacitive AC circuit (A) falls prey to vector analysis for its voltages (B) and impedance (C) just like an inductive circuit.

The current flow is 1.79 amps, and the voltage drops measured across the resistor and inductor are 89.5V and 44.75V, respectively. At first sight, the voltages shown may appear to be incorrect, because together they total more than the supply voltage of 100 volts. That apparent discrepancy, however, is caused by the fact that the voltage across the resistor is out of phase with that across the inductor.

The voltage and current in the resistive portion of the circuit are in phase with each other. In the inductive portion of the circuit, the voltage leads the current by 90 degrees. Since the current at all points in a series circuit must be of the same phase, it follows that E_R and E_L are out of phase.

One way to represent current and voltage in circuits like that is to use vectors—arrows that start at the origin of a coordinate system and point in a particular direction (see Fig. 7A). The size of an arrow indicates the magnitude of whatever the arrow represents—the bigger the arrow, the larger the value. The angle an arrow makes with the X-axis indicates its phase in degrees. The positive X-axis will be zero degrees, and the degrees increase as you move in a counterclockwise direction.

Because the current in the series circuit of Fig. 6 flows through both components with the same phase, we will use the current vector as the zero-degree reference. In other words, the current vector will lie on the X-axis. Voltage E_R is in phase with the current, so its vector will be placed on that axis, too.

The voltage across the coil, E_L, is 90 degrees ahead of the current, so its vector points straight up (90 degrees) from the X-axis. Because each vector is drawn to scale, we can draw the source-voltage vector (E) by starting it at the origin and ending it at the maximum values of E_L and E_R as shown. The angle of vector E (which is θ) is the phase between the current and source voltage, and its length indicates the voltage's magnitude.

The basic vector diagram can be rearranged to form a right triangle, with the hypotenuse representing the longest vector (see Fig. 7B). Pythagoras' Theorem can be used to calculate any vector when the other two are known, as follows:

$$E = \sqrt{E_R^2 + E_L^2}$$

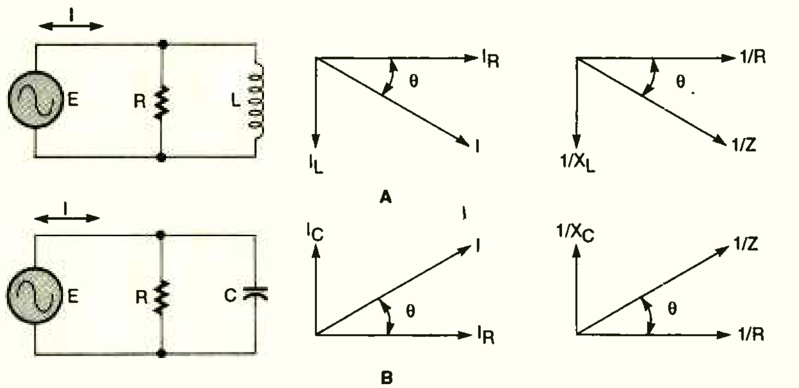


Fig. 9. Vectors can be used to analyze parallel inductive (A) and capacitive (B) circuits, but current flow, not voltage, is the property of import. Also, the only inverse of the impedance vectors are examined.

so scale drawings are not needed to determine magnitudes.

Vector representation also allows us to use trigonometric functions to determine voltages when we know only one voltage and a phase angle, or to determine a phase angle when we know only two voltages. For our example these relationships are:

$$\sin\theta = E_L/E$$
$$\cos\theta = E_R/E$$
$$\tan\theta = E_L/E_R$$

From any of these relations, we can determine that the phase difference between the current and the supply voltage in our example is 26.56 degrees.

A little experimentation with different values for E_L and E_R will reveal some useful tips to remember. Whenever a circuit is purely resistive, the phase angle is zero, because current and voltage are in phase. As the inductive reactance increases, the phase angle becomes greater, until it reaches 45 degrees when resistance and reactance are equal in value. By the time a circuit contains pure reactance, with no resistance, the phase angle has increased to 90 degrees.

Since the current flow is the same through all components in a series circuit, it follows that the voltage drop across any component in that circuit is proportional to the resistance or inductive reactance of that component. In other words, if we draw vectors for the resistance and reactance of the circuit, they would be proportional to the ones we've drawn for the voltages (see Fig. 7C). The resistance, R, would be at 0 degrees and inductive the reactance, X_L, at 90 degrees.

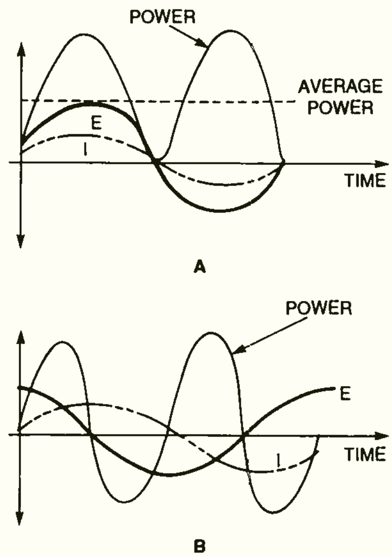


Fig. 10. While power dissipation in a resistive circuit has a non-zero average value (A), in a reactive circuit there is no average or net power loss (B).

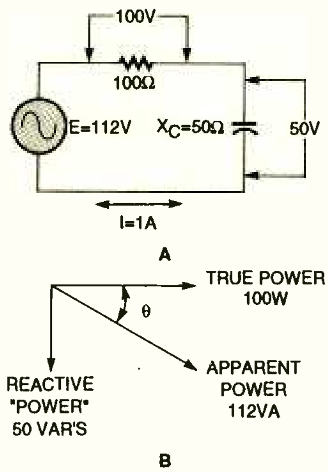


Fig. 11. In a reactive circuit, the true power dissipated in its resistance and the reactive power supplied to its reactance vectorally sum to produce an apparent power vector, even though reactive energy is returned to the circuit.

The combined effect of resistance and reactance is called impedance, which is represented by the symbol Z. It is that value that must be used to calculate the current in a reactive circuit when the supply voltage is known; just dividing the source voltage by the resistance plus the reactance will yield an incorrect answer, since the voltages involved are not in phase.

The series RC circuit in Fig. 8A is described by the vector diagrams in Figs. 8B and 8C. Once again, the current is used as the zero-degree reference point, with E_R at 0 degrees since it is in phase with the current. Recall that in a capacitor, the voltage *lags* 90 degrees *behind* the current, so its voltage vector (E_C) is drawn downward. The phase angle of such a circuit is sometimes given a negative value, although it is just as acceptable to specify "leading" or "lagging" instead. All the same trigonometric equations and the Pythagorean Theorem can be applied to the vectors.

Parallel-Circuit Vectors. Parallel circuits containing capacitors and inductors can also be analyzed with vector diagrams. However, the vectors used are current vectors since the voltages across each component must be equal and in phase with each other.

Figure 9A shows a parallel RL circuit and its resulting vector diagrams. Once again the vector for the resistor is placed at zero degrees. It is now a simple matter to plot the vector for the coil's current, I_L. The current in an inductor lags the voltage by 90 degrees, so the vector is drawn downward.

Figure 9B shows the vector diagram for a parallel RC circuit. Notice that the capacitive and inductive vectors for parallel circuits are drawn the opposite way to those for series circuits. That is simply because we are examining current, not voltage.

Just as the resistance of a parallel resistor network is always less than the value of the smallest resistor, so the impedance of a parallel RC or RL circuit is smaller than both the individual resistance and reactance. Vectors can be used to determine parallel circuit impedance, but the reciprocal values of R, X, and Z must be used. That makes impedance calculations a lit-

(Continued on page 94)

Build The Scanner Silencer

This simple carrier-operated switching circuit eliminates the squealing and howling feedback that's caused by scanner-transceiver interaction

BY BRIAN PLILER

Are you tired of having to turn down the volume of your scanner before transmitting on your rig because of squealing and howling feedback that occurs when you forget? If so, then maybe you should consider building the *Scanner Silencer* described in this article. The Scanner Silencer is basically a carrier-operated-relay (COR) that detects RF energy whenever your transceiver is keyed up. When RF is detected, the circuit instantly mutes scanner audio, effectively eliminating the squealing and howling feedback that would normally occur.

The unit works with both AM and FM transceivers running approximately 4- to 10-watts of RF output power. That allows it to be used by citizens-band (CB) radio operators in the 27-MHz CB band as well as by licensed amateur-radio operators in the 10-meter amateur band.

About the Circuit. A schematic diagram of the Scanner Silencer is shown in Fig. 1. Audio from the scanner is connected to the Scanner Silencer through PL1, a plug that is simply inserted into the scanner's external speaker jack. Through PL1, the scanner's audio output is connected to the wiper or moving contact of K1-a. The normally-closed contact of K1-a is connected to a panel-mounted jack, J1. A common extension speaker is plugged into J1. The normally-open contact of K1-a is connected to resistor R4.

As long as you are not transmitting, scanner audio can be heard through the extension speaker. But the moment that you transmit, the relay energizes and the scanner audio is remove (muted) from the extension speaker and grounded through resistor R4. Resistor R4 absorbs the scanner audio while you are transmitting to prevent possible damage to the scanner's audio amplifier section. The R4 wattage should be chosen so that it can absorb the full audio-output power of the scanner without overheating. The K1-b contacts of the relay are not used in the prototype, since the Scanner Silicencer was originally intended for use with a single scanner. However, provisions have been made on the Scanner Silencer's printed-circuit board to allow the unit to be used with two scanners (assuming, of course, that the set-up contains two extension speakers).

Transmitted RF energy from the transceiver is coupled to socket SO1. From there, the RF signal is applied through C1 to the junction of R1 and R2. Resistor R1 sets the input impedance of the circuit to approximately 4.7k, while R2 is used to limit current flow through D1 and D2. Resistor R2 also helps to isolate the diodes from the antenna feedline to prevent the diodes from generating harmonic interference.

Diodes D1 and D2, along with capacitor C2, form a voltage-doubler circuit that converts the RF energy into a DC voltage. That DC voltage is used to turn on transistor Q1, which, in turn, energizes K1. Diode D3 is used to protect transistor Q1 from possible damage when the magnetic field around the relay collapses.

Assembly. The prototype unit was assembled on a small printed-circuit board, measuring about 2¹⁄₁₆ by 1⁷⁄₁₆

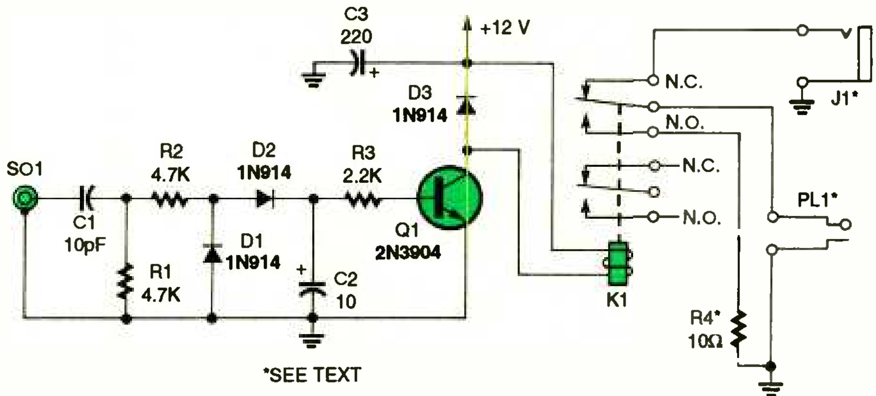


Fig. 1. The Scanner Silencer is nothing more that a carrier-operated relay. When an RF signal is detected, the circuit turns on, removing the connected scanner's audio from an external speaker to prevent feedback.

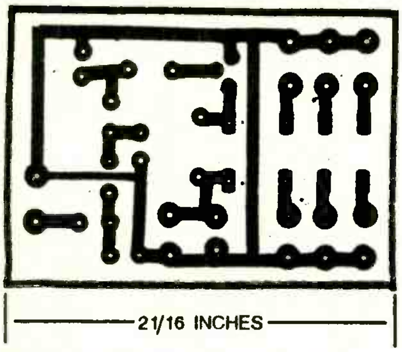


Fig. 2. The Scanner Silencer's was assembled on a small printed-circuit board, measuring about 2¹⁄₁₆ by 1⁷⁄₁₆ inches. A full-size template of its printed-circuit board is shown here.

inches. A full-size template for the Scanner Silencer's printed-circuit board is shown in Fig. 2. Once you have etched your board and obtained all of the components listed in the Parts List, construction can begin.

A parts-placement diagram for the printed-circuit layout is shown in Fig. 3. As usual, it is recommended that you install the passive components first, followed by the semiconductors. After all board-mounted components have been installed, it is time to prepare the enclosure by drilling three holes in suitable locations. Note that a metal (aluminum) enclosure must be used to house the circuit.

Since SO1 is the most difficult to handle, it would be a good idea to deal with it first. Before drilling any holes in the enclosure, make certain that the enclosure is clamped securely to your work surface. Do not try to hold the box while drilling!

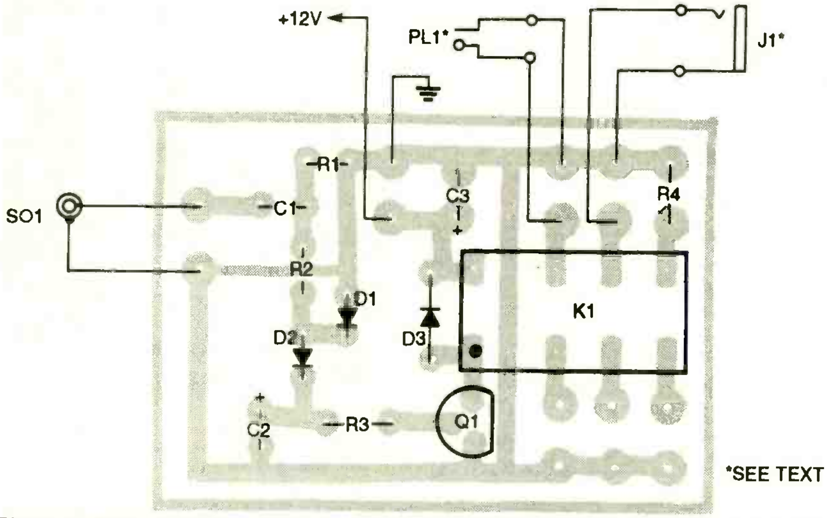


Fig. 3. Once you have etched your board and obtained all of the components listed in the Parts List, assemble your unit using this parts-placement diagram as a guide.

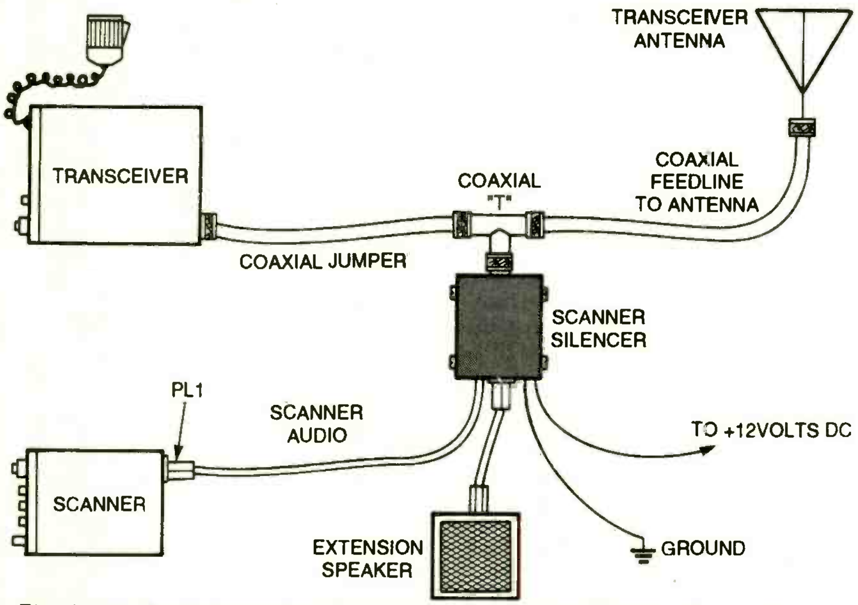


Fig. 4. This illustration outlines how to properly insert the Scanner Silencer into your scanner/transceiver system.

PARTS LIST FOR THE SCANNER SILENCER

SEMICONDUCTORS

Q1—2N3904 general-purpose NPN silicon transistor
D1–D3-1N914 general-purpose silicon diode

RESISTORS

(All resistors are ¼-watt, 5% units, unless otherwise noted.)
R1, R2—4700-ohm
R3—2200-ohm
R4—10-ohm (see text)

CAPACITORS

C1—10-pF ceramic-disc
C2—10-µF 35-WVDC, electrolytic
C3—220-µF, 35-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

SO1—Chassis mount SO-239 connector (Radio Shack #278-201 or similar)
PL1—See text
J1—See text
K1—12-volt DPDT sensitive-coil relay with 1 amp contacts (ITT#RZ-12 or similar)
Printed-circuit materials, metal enclosure (Radio Shack #270-235 or similar), coaxial T-connector (Radio Shack #278-198 or similar) rubber grommet, PL-259 connector (see text), wire, solder, hardware, etc.

Begin by drilling a hole—starting with a relatively small bit (about ⅛ inch in diameter) and then slowly working up—of sufficient size to allow the threaded portion of SO1 to pass through the enclosure. Do not try using a large bit first, you risk tearing or warping the aluminum. After drilling the hole, mount SO1 to the enclosure.

After mounting SO1, drill the appropriate size mounting hole for J1. Drill another hole near the J1 hole. That hole is used to pass the power, ground, and audio-input wires for PL1. Note: PL1 must be selected to mate with the external speaker jack on your scanner. Place a rubber grommet into the hole, route the power, ground, and audio input wires into the enclosure, and solder the wires to the board at the appropriate locations.

Now connect J1 to the board using short lengths of wire. Next, again using short lengths of wire, make the appro-

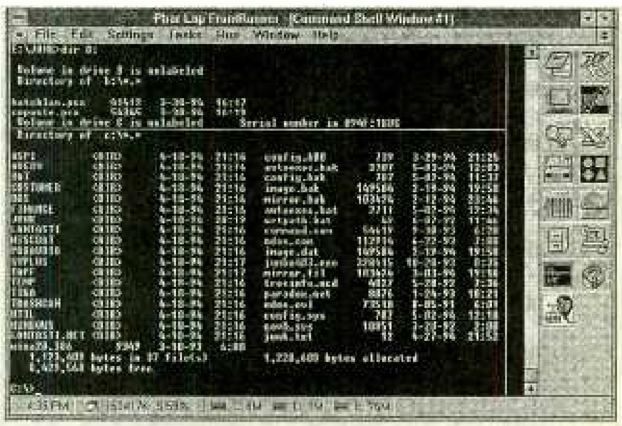
(Continued on page 91)

COMPUTER BITS

By Jeff Holtzman

FrontRunner

It is commonly thought that there are two types of people in the world: Those who like command-line interfaces (DOS) and those who like GUI's (Windows). Actually, there is a third category; those who like both. If you count yourself among the latter, you are going to love a new product called FrontRunner ($139), by Phar Lap Software, Inc. (60 Aberdeen Avenue, Cambridge, MA 02138; Tel. 800-292-9622, or 617-661-1510). I was skeptical at first (you get that way after ten years of reviewing computer products and technologies), but it took less than an hour of playing with this product to make it my primary Windows shell—in the process, giving up what had until then been a good friend; HP's DashBoard.



FrontRunner, a new Windows shell from Phar Lap Software, combines the best of the DOS and Windows worlds.

In a word, FrontRunner gives you the best of both command-line and GUI worlds. It works by "encapsulating" the DOS command-line prompt in a Windows shell, and providing tight integration and communication between them. That's a superior approach to that used by some totally Windows-based DOS command-line emulators, for several reasons. First is that with FrontRunner, you can use your own DOS shell, be it 4DOS, NDOS, COMMAND, or what have you. By using your own shell, you have guaranteed compatibility and no quirks in the use of commands.

You can't say that about DashBoard's command-line interpreter. But there are lots of other things that help FrontRunner pull out in front of the pack. For one, it gives a "scroll-back" or history capability. If you've ever wished you could scroll back through a long directory or text-file listing, FrontRunner gives you a Windows-based means of doing so. The program can capture as many as 16,000 lines in the history buffer. Using a mouse and the Windows scrollbar, you're free to peruse the buffer. And if you get the urge to cut and paste some of that text into another application—Windows or DOS—just drag the mouse pointer through the desired text, select Copy, switch to the other application, and select Paste. (Yes, I know that there are numerous scroll-back utilities for DOS. But I've yet to find one that works reliably under Windows. Furthermore, FrontRunner is currently the only program that allows DOS/DOS cut-and-paste.)

There are even cooler ways of doing things like that. You're probably familiar with DOS command-line redirection. For example, if you type DIR C:\ CDIR.TXT, you'll get a text file with a listing of the contents of your hard drive's root directory. Then you might import that file into some application (*e.g.*, your word processor). FrontRunner gives you a cleaner way. Just type DIR C:\ $CLIP, and the listing will be copied to the Windows clipboard. Just switch to the other application, and select Paste.

I love FrontRunner's ability to interact with the Windows clipboard from both the DOS and Windows side. But that's not the only trick this pony knows. You can launch both DOS and Windows programs from the command line. Sometimes it's faster to just type NOTEPAD than to search through dozens of program groups and icons. In addition, you can launch a Windows program simply by typing in the name of an associated data file. For example, change to your budget directory, type BUDGET94.XLS and Excel will launch with that file loaded and ready to go.

There are other features as well. You can open multiple DOS windows simultaneously. You can direct text-only output to a special text window, essentially a simple text editor. You can define multiple launch-bar configurations, loading and unloading them at will. Each launch bar can be configured to appear along one edge of the FrontRunner window, or totally detached from it. You can search through the history buffer for a specific text string; you can also save the buffer to disk, or print it.

Phar Lap has used the DOS/Windows communications capability in some ingenious ways. For example, the package also includes a pretty good file-find utility that runs from DOS, but prompts you for information about what to search for and where, via a Windows dialog box. Then it goes off searching, in the background, while you do something else. Nice. (Phar Lap should turn the mouse pointer into an hourglass while it's searching to let you know what's going on.)

In fact, you can provide Windows-like front ends for your DOS utilities using FrontRunner's enhanced batch-file commands. Those features only work from a FrontRunner DOS box running under Windows; in other words, they won't work if Windows is not loaded.

WINDOWS CAPABILITIES

From a Windows point of view, FrontRunner provides many of the functions that we've come to expect from a Program Manager replacement, including an icon bar for quick access to your favorite applications, and a full-featured, highly-customizable status bar that can display time (but not date), free memory and system resources, free disk space on one or more drives, current clipboard contents, and more. The only thing lacking in this regard is a quick printer switcher (like DashBoard's). However, a little "spelunking" on CompuServe produced a more-than-serviceable shareware utility, PrintSwitch 1.8a, by Michael Haschka (73027,3307).

FrontRunner's main-menu bar contains one menu that lists active tasks, and allows you switch among them. Another menu allows you to run programs via your program manager groups, which are presented as text-only listings, not as icons. A related feature is a highly capable group and icon manager, which allows you to add, copy, delete, and move program icons and groups. Ironically, the group manager does present groups in icon form, but a bug prevents multiline icon titles from displaying properly.

One anomaly is that you can append text to the clipboard via a batch-language command, but not interactively using the mouse. My only other complaint is that the launch-bar configuration is not quite as versatile as DashBoard's. In particular, icons can be displayed as icon only, or with a two-line caption. In my opinion, that wastes too much screen real estate; I'd prefer a one-line option, and the ability to customize the font.

I found one bug in the early release that I received. When using something other than COMMAND.COM (I use 4DOS) as the primary DOS shell, the history buffer did not work correctly. Running 4DOS under COMMAND provided a work-around; Phar Lap is looking into the problem.

If you're interested in FrontRunner, but would like to try before you buy, Phar Lap has developed a "lite" version; call the company for details. If you're a Windows C programmer, the package also includes a programming interface and documentation that allows you to build your own command-line and status-bar utilities.

I loved DashBoard, but FrontRunner is my new favorite. If version 1 is this good, I can't wait to see version 2! ■

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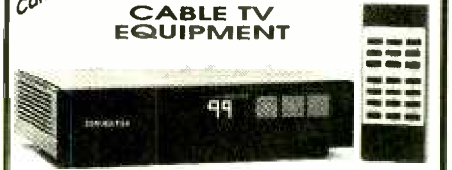

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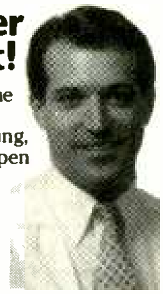

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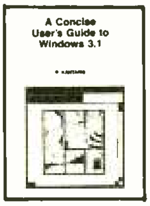

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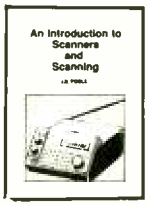

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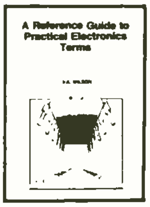

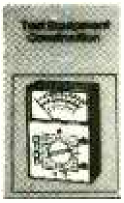

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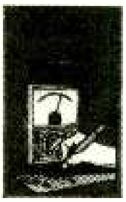

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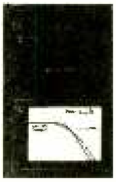

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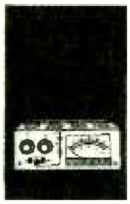

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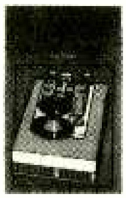

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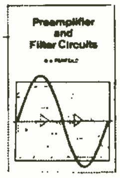

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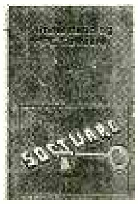

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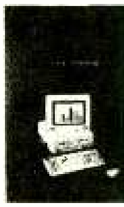

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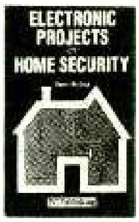

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By Charles D. Rakes

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COIN TOSS

Our simplest entry (see Fig. 1) places the 4017 IC in a coin-toss or decision-making circuit. No, this isn't high-tech gaming, but it is an easy starting point for our circuit adventure.

Integrated circuit U1 is connected in a two-stage counter circuit that counts "one-two" over and over as long as clock pulses enter pin 14 of the 4017. When the clock pulses stop, one of the LED's will remain on, indicating the last even or odd count. Designate one LED as "heads" and the other as "tails" and you have an electronic coin flipper.

The coin flipper's clock has a 2N2647 unijunction transistor in an RC relaxation oscillator. The values of R1 and C1 set the oscillator's frequency. If you like a fast oscillation between the two LED's, lower the value of R1; to slow the rate, increase the value of R1.

To operate the circuit, press S1 for a brief period of time and release. Only one of the LED's will remain on.

CRAPS

Our next entry (see Fig. 2) uses a couple of 4017 IC's in a two-die craps circuit. Two gates of a 4093 quad, 2-input NAND, Schmitt-trigger CMOS IC are connected in astable-oscillator circuits as clocks for the two 4017 IC's. Each of the 4017 IC's have six LED's connected to its first six outputs. As the clock pulses enter pin 14 of the 4017's, the IC's count from one to six over and over as long as the clock pulses are present. When S1 and/or S2 are released one of the LED's in each circuit will remain on indicating a number from one to six.

The circuit is set up so you can roll the dice together by pressing S1 and S2 at the same time, or roll each dice one at a time. The

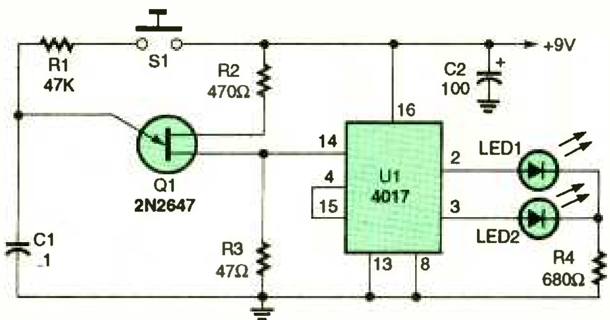


Fig. 1. Our coin-toss (or decision-making) circuit may not be high-tech, but hopefully it will serve as a good circuit for the beginner.

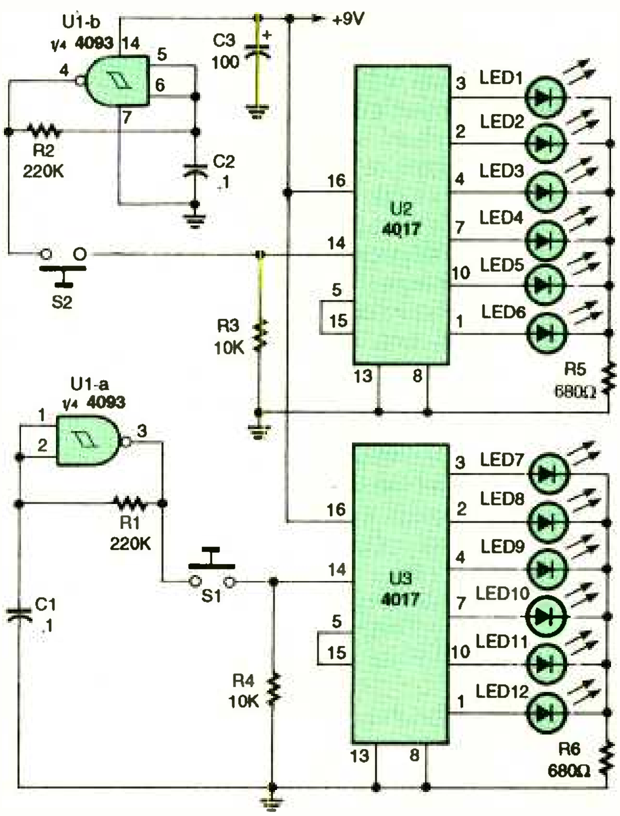


Fig. 2. This craps circuit is set up so you can roll the dice together by pressing S1 and S2 at the same time or roll each die one at a time. The rolling speed is set by the values of R1, C1, R2, and C2.

PARTS LIST FOR THE ELECTRONIC COIN TOSS (Fig. 1)

SEMICONDUCTORS
U1—4017 decade-counter, integrated circuit
Q1—2N2647, or similar type unijunction transistor
LED1, LED2—Light-emitting diode, any color

RESISTORS
(All fixed resistors are ¼-watt, 5% units unless otherwise indicated.)
R1—47,000-ohm
R2—470-ohm
R3—47-ohm
R4—680-ohm

CAPACITORS
C1—0.1-µF, ceramic-disc
C2—100-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
S1—Normally open, pushbutton switch
IC socket, perfboard, solder, wire, etc.

PARTS LIST FOR THE ELECTRONIC CRAPS (Fig. 2)

SEMICONDUCTORS
U1—4093 quad, 2-input, NAND, Schmitt-trigger, integrated circuit
U2, U3—4017 decade-counter, integrated circuit
LED1–LED12—Light-emitting diode, any color

RESISTORS
(All fixed resistors are ¼-watt, 5% units unless otherwise indicated.)
R1, R2—220,000-ohm
R3, R4—10,000-ohm
R5, R6—680-ohm

CAPACITORS
C1, C2—0.1-µF, ceramic-disc
C3—100-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
S1, S2—Normally open, pushbutton switch
IC sockets, perfboard, solder, wire, etc.

rolling speed is set by the values of R1, C1, R2, and C2. Increasing any component value will lower the associated oscillator's frequency, and lowering a value will raise the oscillator's frequency.

TWENTY-ONE

A simplified version of the card game 21 is shown in Fig. 3. Even though the odds are not the same as in the card game of 21, our electronic version is still a lot of fun to play. In a standard deck of cards, there are sixteen cards that count as 10: the 10 card, the Jack, the Queen, and the King of each suit. The Ace can count as a one or eleven. Our game can only display two cards that count ten for each deal of the cards. The Ace can be set to count as one or eleven as in the card game of 21. The circuit only shows one hand of 21. Double the circuit for two players.

Two 2N2647 unijunction transistors serve as the clock generators for the two 4017 IC's. A single "Deal" pushbutton switch, S1, operates both clock generators at the same time. Diodes D1 and D2 isolate the two clock circuits, allowing S1 to operate both.

The 4017 counter/readout circuits are identical in circuitry and operation. As long as clock pulses enter pin 14 of each 4017, the IC's count from one to ten over and over until the clock pulses stop. When S1 is released, the clock pulses stop and one LED from each IC remains on to indicate a card with a number value of one (one or eleven) to ten.

The position of switches S2 and S3 determine whether the number-one ("Ace") output of the 4017's count as an eleven or a one. Both S2 and S3 may

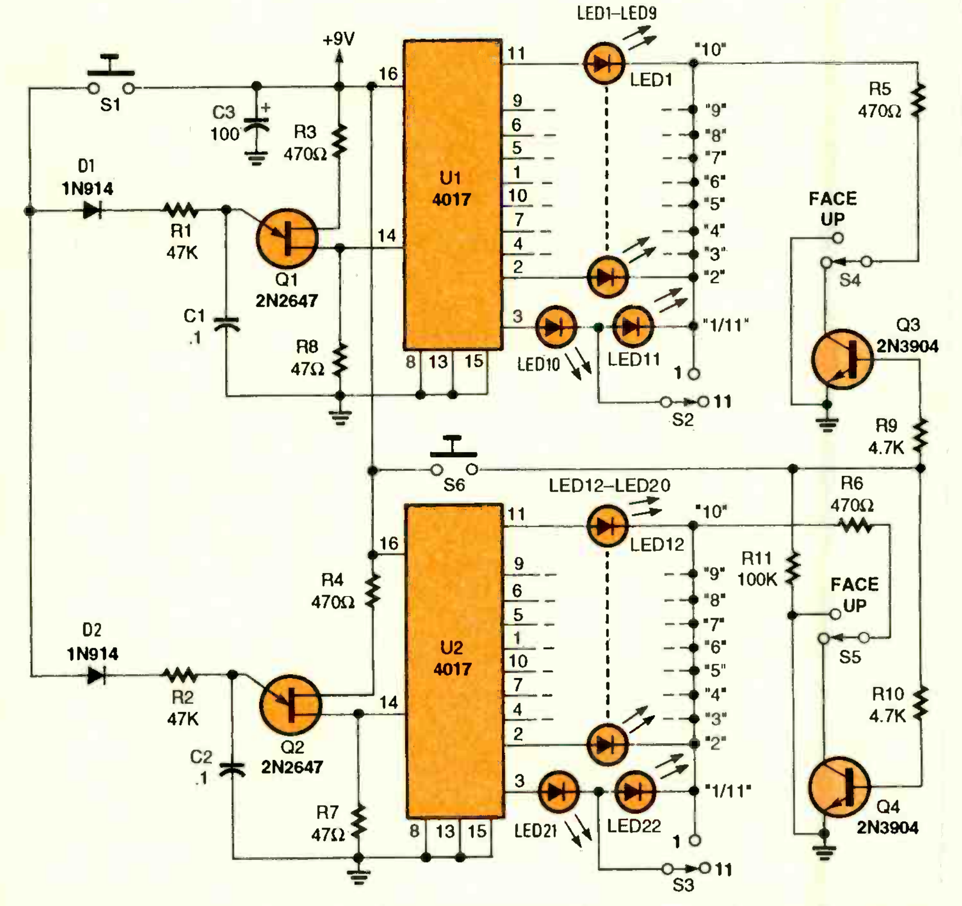


Fig. 3. Even though the odds for this simplified version of the card game 21 are not the same as the real thing, our electronic version is still a lot of fun to play.

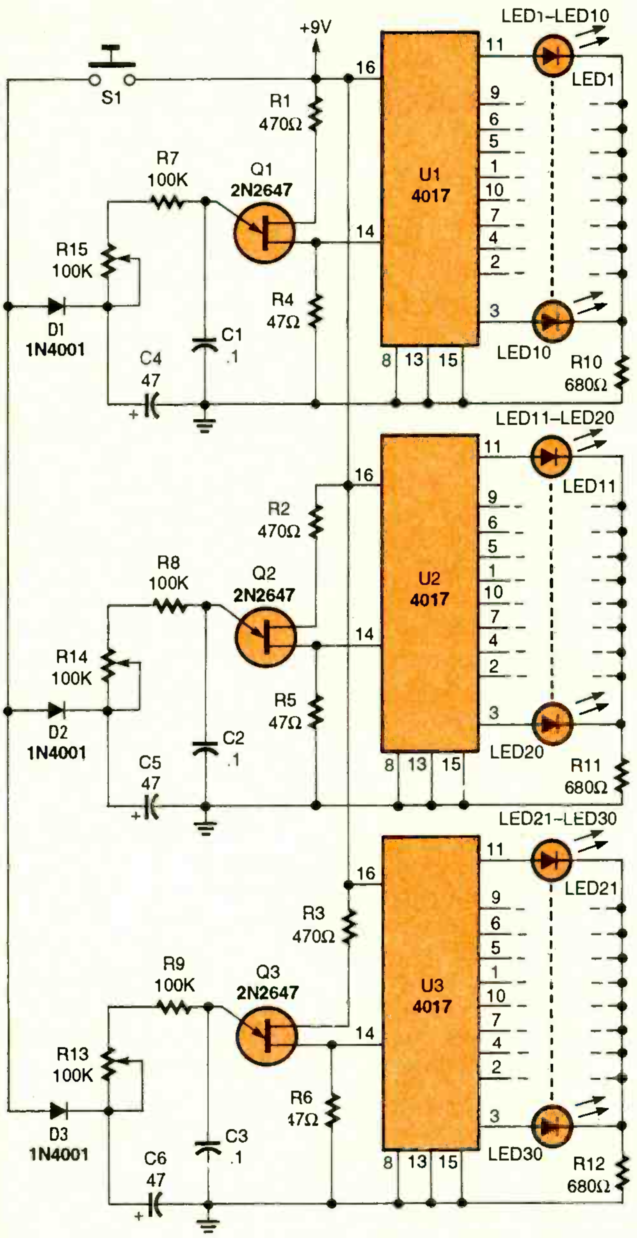


Fig. 4. Our one-arm bandit is made up of three clock circuits and three counter/readout circuits all activated by roll switch S1.

PARTS LIST FOR THE ELECTRONIC TWENTY-ONE (Fig. 3)

SEMICONDUCTORS
U1, U2—4017 decade-counter, integrated circuit
Q1, Q2—2N2647 or similar unijunction transistor
Q3, Q4—2N3904 NPN transistor
D1, D2—1N914 silicon signal diode
LED1–LED22—Light-emitting diode, any color

RESISTORS
(All fixed resistors are ¼-watt, 5% units unless otherwise indicated.)
R1, R2—47,000-ohm
R3–R6—470-ohm
R7, R8—47-ohm
R9, R10—4700-ohm
R11—100,000-ohm

CAPACITORS
C1, C2—0.1-µF, ceramic-disc
C3—100-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
S1, S6—Normally open pushbutton switch. S2–S5—SPDT toggle switch
IC sockets, perfboard, solder, wire, etc.

PARTS LIST FOR THE ELECTRONIC ONE-ARM BANDIT (Fig. 4)

SEMICONDUCTORS
U1–U3—4017 decade counter, integrated circuit
Q1–Q3—2N2647 or similar unijunction transistor
D1–D3—1N4001 1-amp, silicon diode
LED1–LED30—Light-emitting diode, any color

RESISTORS
(All fixed resistors are ¼-watt, 5% units unless otherwise indicated.)
R1–R3—470-ohm
R4–R6—47-ohm
R7–R9—100,000-ohm
R10–R12—680-ohm
R13–R15—100,000-ohm potentiometer

CAPACITORS
C1–C3—0.1-µF, ceramic-disc
C4–C6—47-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
S1—Normally open, pushbutton switch
IC sockets, perfboard, solder, wire, knobs, etc.

be switched in either position before or after the cards are played.

The cards may be played either face up or face down. When switches S4 and S5 are in the position shown in Fig. 3, the cards are dealt face down. Transistor's Q3 and Q4 are turned off in this position and no current can flow through the LED's. Pressing S6 turns both transistors on, lighting the LED's.

The circuit may be modified to allow additional cards to be dealt by adding additional clock and readout circuits. A separate deal switch (S1) for each additional card circuit will be needed to keep the extra card(s) as an option.

ONE-ARM BANDIT

Our last entry into the gaming caper this visit is an electronic version of the one-arm bandit. Ours is a much simpler machine than the ones found in the gambling casinos. Mechanical casino bandits use rotating drums driven by stepper motors that are computer controlled. That allows the bandits to be programmed to pay out a specific percentage of the take to customers.

Take a look at the circuit diagram in Fig. 4 and you will see that our one-arm bandit circuit is made up of three clock circuits and three counter/readout circuits. A single roll switch, S1, turns on all three clocks at the same time. When S1 is closed, capacitors C4, C5, and C6 are charged through D31, D32, and D33 to about 8 volts. After S1 is released, the three clocks

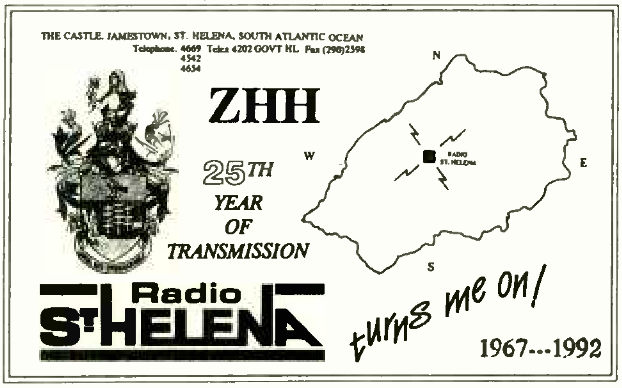
(Continued on page 92)

DX LISTENING

By Don Jensen

Radio St. Helena Day

There was good reason when, in 1815, Great Britain chose to exile Napoleon Bonaparte to the island of St. Helena. Napoleon had been a mighty thorn in the paw of the British lion and the English government. Once they'd finally got their hands on "Old Boney," they wanted to stash him safely away in some out-of-the-way corner of the empire. St. Helena, in the remote South Atlantic, certainly fit the bill.



This verification card was sent by Radio St. Helena for its 1992 special broadcast.

In 1990, shortwave listeners were delighted when a couple of Swedish DX'ers arranged with St. Helena authorities for a special transmission from that remote island, which has no regular SW broadcasts. Its success led the station to repeat the one-day-only single-sideband transmissions in 1992 and 1993. The odds are good that Radio Helena will do it again in this October.

St. Helena, together with the South Atlantic islands of Ascension and Tristan Da Cunha, form one of the oldest British colonies. While Ascension has an airport, the only access to the other two islands is by sea. St. Helena, about midway between Brazil and southern Africa, is served by just one ship, the RMS St. Helena, which operates between Cardiff, Wales, and Cape Town, South Africa.

The island's only significant export seems to be St. Helena's commemorative postage stamps, which are prized by collectors. It is forced to import food, medical supplies, and practically everything else. It is entirely dependent on Great Britain for its funding. However, the island has a local AM radio station, *Radio St. Helena*, which broadcasts to the local population of some 6,800.

Several years ago, Jan Tuner and John Eckwall, two top Swedish DX'ers, persuaded Radio Helena to transmit the special broadcast for SWL's, relaying the medium-wave AM signal on an existing 1.5-kilowatt, SSB communications transmitter owned by Cable and Wireless. That program was heard quite widely in the U.S., Canada, Europe, and elsewhere. The mail response delighted station manager Tony Leo and his staff of three so much that Radio St. Helena Day (as the special broadcasts were dubbed) have been repeated annually.

I have no confirmation, at this writing, but according to preliminary plans, this year's broadcast may be heard on Friday, October 14. Based on last year's schedule, I'd suggest tuning on that day, beginning at around 2000 UTC, and perhaps for several hours afterward, on 11,092.5 kHz.

"Being as isolated as we are," Leo said after the 1993 broadcast, "it was a thrill to have calls from so many of you, backed up by faxes and letters, stating, so genuinely, how happy you were to have received our broadcast."

Radio St. Helena issues a very attractive verification card for correct reports, which can be sent, with a $1 bill for return postage, to Radio St. Helena, The Castle, Jamestown, St. Helena, via Ascension Island, South Atlantic Ocean. Also, you can call the station by international telephone if you wish. The number is 011 290 4669. Check your phone book for international dialing instructions.

FAVORITE FREQUENCY

Readers of Edwin Southwell's "Radio World" column in Contact, the monthly bulletin of the World DX Club in Great Britain, recently offered their answers to this hypothetical question: If, for some reason, you could only receive one shortwave frequency, which would it be, and why?

WDXC member Keith Mellor said his choice was 9,410 kHz, because "it is a reliable frequency for the *British Broadcasting Corporation's* highly regarded World Service. But," he went on to note, "according to the 1994 edition of *Passport to World Band Radio*, 9,650 kHz is used by 18 different stations broadcasting from 21 different countries, with six broadcasters in English, so a receiver on this frequency could provide varied listening."

Keith's letter sent me scurrying to my copy of Passport (which, incidentally, is available at most major book stores) to check that out. He's right. It is a busy channel, with 18 SW stations scheduled here at various hours of the day, with programming in English and a number of other languages.

On 9,650 kHz, there's *Radio Canada International*, broadcasting from Canada and, at other times, from a relay station in Portugal. There's *Radio Denmark* broadcasting from a Norwegian transmitter, and *Radio France International* relayed from Japan. At various hours of the day and night, *Deutsche Welle* programming is aired by German transmitters, and relayed by others in Portugal, Malta, and Rwanda in Africa.

The list goes on: *Adventist World Radio* from Guam, *Radio TV Guineene* from Guinea, *Radio Nederlnad, Radio Korea, Radio Pyongyang, Radio Norway, Vatican Radio, Swiss Radio International* and *Radio Exterior Espana* from Spain.

There is *Trans World Radio* from Monaco and Swaziland, Russia's *Golos Rossii*, South Africa's *Channel Africa, Radio Free Europe/Radio Liberty* broadcast from transmitters in Germany, and *Voice of America* programming relayed by stations in Greece, Morocco, Greece, and Great Britain. Varied listening possibilities on 9,650 kHz? Indeed!

How about you? What's your favorite SW frequency and why? Drop me a line with your answers. The address is *DX Listening,* **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735.

HAPPENINGS

Some interesting SW developments, noted by Canadian DX'er Roger Chambers, writing in DX Ontario, the bulletin of the Ontario DX Association.

The *Australian Broadcasting Corporation*'s home-service, shortwave VLW outlets in Perth, and the VLM and VLW stations in Brisbane have left the air for good. Those domestic SW outlets, intended for Aussie listeners in the "outback," offered separate programming from the international service of Radio Australia.

Increased medium-wave, FM, and satellite communications made those SW stations, with their aging transmitters from the late 1930's and 1940's, redundant, the ABC indicated. As Chambers wrote, "Farewell, old friends!"

He also noted, favorably, the programs of traditional Colombian music aired by *Radio Difusora Nacional Colombia*. "It features a varied mix of popular and folk music," he wrote, "the best Latin music on SW except for Cuba and some of the stations on the shortwave *tropical bands,* where difficult reception may make it hard to enjoy the music." Chambers says it is heard well at about 1830 UTC on 11,785 kHz.

Speaking of Cuban music, one of my favorites is *Radio Rebelde*, the Cuban shortwave alternative to the international broadcasts of *Radio Havana Cuba*. Radio Rebelde, whose name dates way back to the beginnings of the Castro regime, also happens to be one of the easier stations to hear on the 60-meter tropical band.

Look for Radio Rebelde on 5,025 kHz, at around 0200 UTC. Programming is in Spanish but the music is super! The station's address, by the way, is Radio Rebelde, Apartado 6277, Havana 6, Cuba.

DOWN THE DIAL

Here are some of the stations that are being reported lately:

CROATIA—5,985 kHz. *Croatian Radio* has English news, after identification at 2200 UTC—also noted on parallel 5,920 kHz. Another brief newscast in English is heard on both frequencies shortly after 0700 UTC.

LEBANON—6,450 kHz. The *Voice of Lebanon* has been logged here signing on at 0355 UTC with an interval signal, "Colonel Bogey" march, and a choral anthem.

PAKISTAN—15,675 kHz. *Radio Pakistan* has slow-speed English-language news bulletins on this frequency until 1630 UTC.

SINGAPORE—9,530 kHz. *Radio Singapore International*'s new 150-kilowatt powerhouse transmitter is putting in a nice signal. English is noted during the 1100 to 1300 UTC period.

Tanzania—5,050 kHz. *Radio Tanzania* in Dar es Salaam is heard at 0400 UTC, with English-language news, easy-listening music, and identification.

ZAMBIA—7,234 kHz. *Radio Zambia* is not an easy catch. But it has been heard in English until sign off, with a choral anthem, shortly after 2200 UTC. ■

*Credits: Jerry Berg, MA; David Clark, Ont., Richard D'Angelo, PA; William Davenport, TN; Jim Ducharme, MA; William Flynn, OR; Marie Lamb, NY; William McGuire, NY; Marine Papas, SD; Ed Rausch, NJ; Doug Robertson, CA; North American SW Association, Levittown, PA; Ontario DX Association, Willowdale, ONT., Canada; World DX Club, Northampton, England.

HAM RADIO

By Joseph J. Carr, K4IPV

Preamplifier Oscillations

This month we are going to look at two different topics: oscillations in broadband receiver preamplifiers and a new software package that allows you to look at a radio-signal's spectrum.

PREAMPLIFIER OSCILLATIONS

A number of readers have written to me about the MAR-1 preamplifier circuit that was published in this column (November 1993 and March 1994) and elsewhere in *Popular Electronics*. The MAR-1 device offers 15 to 18 dB of gain, with a decent 5-dB noise figure, and operates from DC to 1000 MHz. The MAR-6 is similar, but has a 2.9-dB noise figure and operates from DC to 2000 MHz. A lot of readers built the preamplifier, and reported good results. Two readers, however, reported oscillations rather than amplification. Given the MAR-1 and MAR-6 devices are almost unconditionally stable (not quite, but almost), that surprised me. So, what to do?

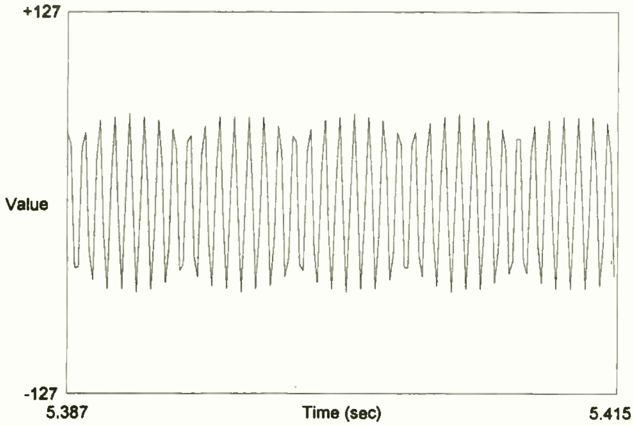


Fig. 1. Here is a time-domain view of the audio output from a receiver tuned to an RTTY signal that has a 800-Hz, mark-space separation.

I went to the workbench and tried a few things that I hoped would help me figure out what went wrong. When I used perfboard rather than the printed-circuit board used in my article, made the leads too long, and deleted the power-supply decoupling capacitor, I achieved oscillations. In another case, when I used an RF choke in the DC power-supply line that had a resonant frequency well within the bandpass of the MAR-1 and left the input unterminated, oscillations were achieved.

Those conditions are pretty easily avoided. In the first case, tightening up the perfboard layout or using a properly designed printed-circuit board will eliminate the oscillations or at least make them highly unlikely.

SPECTRA PLUS SOFTWARE

Pioneer Hill Software (24460 Mason Rd., Poulsbo, WA, 98370; Tel. 206-697-3472) offers a software package that allows you to look at the spectrum of a radio signal, or any other audio signal for that matter. The software can be used for passband monitoring, signal identification and tuning, notch-filter/passband-filter adjustments, and anything else where the bandpass spectrum of the signal is important.

The spectrum of a signal is a plot of the individual frequency components that make up the signal displayed on an amplitude-vs.-frequency plot. Most of us are familiar with time-domain plots of radio signals—the kind of signal displays that normally appear on oscilloscopes. Figure 1 shows the basic time-domain display of a radioteletype (RTTY) signal with an 800-Hz mark-space separation. That plot was taken from the Spectra Plus Time Series View mode, and printed on my laser printer.

Figure 2 shows the same signal displayed in the Spectrum View mode. Note that the signal is now broken into its main components with their amplitudes shown along the vertical axis and their frequencies shown along

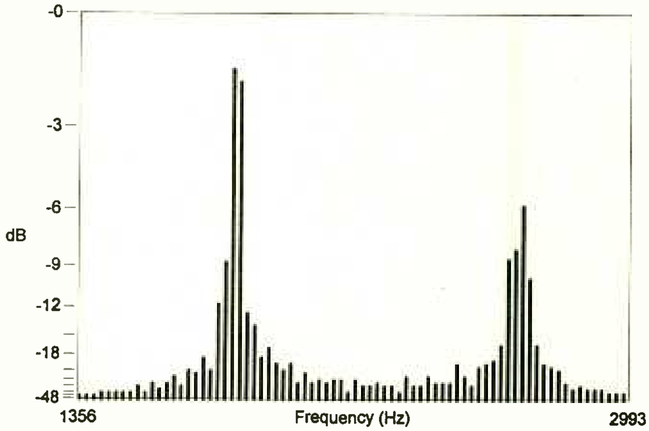


Fig. 2. This is a spectrum plot of the same 800-Hz RTTY signal, plotting amplitude vs. frequency.

the horizontal axis. The mark and space signals, along with their respective sidebands, are clearly shown.

For the sake of comparison, Fig. 3 shows a CW signal that was generated using my electronic-keyer set to produce a chain of "dots." Note that the spectrum represents only one central frequency with its associated sidebands. Those sidebands, by the way, are why you need a 250- to 500-Hz, or wider, filter for CW reception. Although we normally think of CW as being on a single frequency, and as such

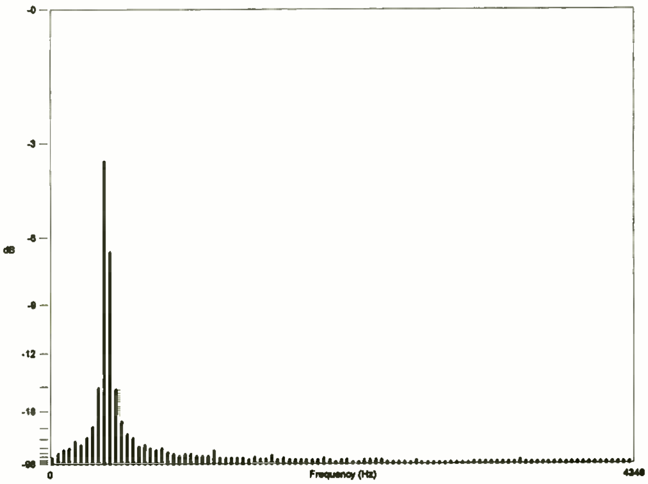


Fig. 3. For the sake of comparison, here is a Spectrum plot of a CW signal (string of dots) generated using my electronic-keyer.

would produce a single spike and no sidebands, the act of pulsing the signal (making "dots") spreads the spectrum out a bit. Also, even a sinewave will have minor sidebands unless it is totally pure—which just doesn't happen.

Spectra Plus also makes a spectrogram, which rotates the spectrum so that the frequency appears along the vertical axis and time appears along the horizontal axis. That allows us to see a time history of the received signal. I couldn't reproduce it for you because it comes out in color, and my printer wouldn't reproduce color. On the VGA screen, however, it was a great-looking presentation. Users with a compatible color printer should experience no problems, however.

The spectrogram mode is especially favored by people looking for "whistlers" (see "The Sky Chorus" by Gary Eggleston, **Popular Electronics**, July 1993, page 46), *i.e.*, those natural radio signals traversing the Earth's magnetosphere from lightning strikes in other parts of the world. Whistler hunters often record the signals on a cassette tape; some later do a spectrogram on the signal to take measurements and make identification.

There is also another mode, the 3-D View mode, which places the time along the vertical axis, the frequency along the horizontal axis, and the amplitude along the Z-axis. What's a "Z-axis?" The Z-axis is the dimension that gives the image an out of the screen (towards the viewer) appearance. The Spectra Plus software (priced at $179) is a useful adjunct to ham radio operators, as well as shortwave listeners, whistler hunters, and amateur-science buffs.

A smaller cousin of the program, Spectra Vision ($89) is available from the same source. Both software packages require a 386 or 486 computer and Windows 3.1. To get the signals into the computer for Spectra Plus or Spectra Vision to analyze, you'll need a Windows compatible sound card. I've seen some off-brand sound cards at relatively low prices; even the 8-bit SoundBlaster at less than $100 will do nicely. I used a SoundBlaster 16-bit ASP to make recordings with my copy of Spectra Plus.

ANTLERS FOR WINDOWS

A new version of Antlers, the antenna-length calculator software is now available. The new software, "Antlers for Windows" (priced at $30 postpaid), calculates the length of a high-frequency antenna and its key elements. It uses a scroll bar to set the frequency, and a menu bar to select the type of antenna. When an antenna type is selected, a schematic of that antenna appears on the screen.

Also available are "Loops for Windows" ($20), and "Antlers for VHF/UHF" ($20). All three programs can be purchased at one time for $40. The programs can be ordered from me at P.O. Box 1099, Falls Church, VA 22041. ■

"Looks like you're picking up some static."

SCANNER SCENE

By Marc Saxon

We got a chance to look at the new *Radio Shack PRO-51* handheld scanner, and are pleased to report that it should find a comfortable niche with serious monitoring enthusiasts. The PRO-51 covers 29–54, 137–174, 406–512, and 806–956 MHz, less the two 800-MHz cellular bands. It also covers the 108–137-MHz aeronautical band.

The Radio Shack PRO-51, a new 200-channel handheld scanner, is ideal for the serious monitoring enthusiast.

The PRO-51 deals with that coverage in 200 memory channels, formatted as 10 bands of 20 channels each. In addition, there are 10 monitor memories that allow for the temporary storage of frequencies discovered during a search.

A service-search feature lets the user check through all aeronautical, fire, maritime, and NOAA weather channels when the proper button for each service is pressed on the keypad. The PRO-51 has "Hyperscan," which means that it scans at 50 channels per second and searches at a peppy 100 channels per second.

The IF frequencies are 450 kHz and 10.8 MHz. Sensitivity at 20 dB S/N is 0.5 µV from 29 to 54 and 406 to 512 MHz; 0.6 µV from 137 to 174 MHz, 0.7 µV in the 800-MHz band, and 1.3 µV from 108 to 137 MHz.

The PRO-51 is fitted with a BNC connector, so it can be used with any antenna. A rubberized whip is furnished. Power comes from four "AA" batteries or a 9VDC adapter. The PRO-51 will retain programmed information for as long as three days without batteries or other power.

This is a good-looking scanner that performs like a champ. Check out the PRO-51 at any Radio Shack store.

SO EASY TO REMEMBER

In past issues, we've mentioned that 123.45 MHz has become an informal and unauthorized chit-chat frequency for airline pilots. That hasn't made everybody happy, particularly those stations licensed to operate there. They complain that it's cluttered with pilots wisecracking about their lives, jobs, and problems.

The 122.75-MHz frequency was set aside by the FCC for interplane communications, but only private pilots use that frequency. Instead, 123.45 MHz was selected because the sequential run of numbers from one to five made it easy to remember. Military pilots have their own offbeat and unofficial UHF-band chit-chat frequencies, also based on memory gimmicks. Most people don't know about them, and they can produce some worthwhile monitoring. So we'll pass them along here.

Taking a page from the airline pilots, military pilots using their 225–400-MHz UHF band picked the sequential run of numbers from two to five as a memory trigger. Therefore, 234.5 MHz became an unofficial interplane frequency.

Military pilots have come up with a couple of other easy-to-recall frequencies, based on firearms. If a person were asked to name two famous and historic rifles, he might pick the Winchester 30–30 and the Remington .30–06. So, if you hear one pilot tell another to switch to Winchester, or Winchester .30–30, that's your clue to direct your scanner to 303.0 MHz. Likewise, pilot instructions to change frequency to Remington, or Remington .30–6, means that the contact is going to turn up on 300.6 MHz. Monitoring 234.5, 300.6, and 303.0 MHz might produce off-the-cuff commentary from military pilots that is funny and insightful, and isn't to be heard on the more formal circuits. The same goes for 123.45 MHz.

JEEPERS BEEPERS

An inquiry from Charles W. Hollinshead, of Fayetteville, Pennsylvania, asks about the data and CW signals he hears on 157.74 MHz. That frequency is used by businesses to send one-way paging messages to their employees' beepers. The CW signal is the FCC callsign of the station being copied, and several might share the frequency in any given area. Some beeper systems use data transmission, but others use voice messages.

Other frequencies used by businesses for voice or non-voice paging include 152.48, 154.625, 158.46, 462.75–462.925, and 465.00 MHz. Medical voice and non-voice pagers use 35.64, 35.68, 152.01, 157.45, 163.25, and 453.025–453.175 MHz. Companies that furnish voice and non-voice beeper service to the general public use 35.20–35.66, 43.20–43.66, 152.03–152.24, 454.025–464.65, and 459.025–459.65 MHz. There are also frequencies above 929 MHz in use.

Beepers are intended to receive data or voice one-way paging signals.

FROM READERS

In the midtown area of New York City, a large, private, merchants' security patrol operates. The patrol's armed, uniformed personnel carry two-way radios and conduct their operations in a very professional manner, reports Bill Incoronato, of Queens, New York. Bill tells us that this patrol is deployed primarily in the area around Grand Central Station, and he wonders if it's possible to find out their frequency.

The highly visible security patrol is run by Grand Central Partners, Inc. They operate on 461.575, 464.675, and 469.675 MHz.

From the Lone Star state (that's Texas, podner), Martin G. wants us to pass along some of the better statewide frequencies that he can monitor.

How about the Texas Rangers on 155.505 MHz? The Texas Highway Patrol dispatchers use 155.46 MHz in most areas. Intercity police communications are on 154.95 and 155.37 MHz. Texas Fish and Game law-enforcement activities can be monitored on 151.31, 151.355, and 151.415 MHz. Various state prisons have discrete channels assigned, but common to all facilities are frequencies such as 153.905, 453.30, 453.45, and 453.525 MHz. The State Alcohol and Beverage Commission operations include 154.905, 155.595, and 156.06 MHz. That should be enough to keep any scanner perking.

The Sunset Limited is the Amtrak passenger train that runs between Los Angeles and New Orleans. Scannist Peggy Marton takes that train from time to time and reports that during the western portion of the trip, the train manager can be seen using a handheld transceiver. Peggy figures that if she knew the frequency, she could listen in.

Our suggestion is to scan 160.44, 160.455, 160.65, and 160.74 MHz. All are in use aboard the Sunset Limited.

KEEP THOSE CARDS AND LETTERS COMING IN

Let's hear from you with questions, comments, and loggings. Write to *Scanner Scene*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■

"Hey, it does find golf balls."

FACTCARDS

■ ALL YOU NEED to know about electronics from transistor packaging to substitution and replacement guides. FACTCARDS numbers 34 through 66 are now available. These beautifully-printed cards measure a full three-by-five inches and are printed in two colors. They cover a wide range of subjects from Triac circuit/replacement guides to flip-flops, Schmitt triggers, Thyristor circuits, Opto-Isolator/Coupler selection and replacement. All are clearly explained with typical circuit applications.

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SCANNER SILENCER

(Continued from page 74)

priate connections between SO1 and the printed-circuit board, as shown in Fig. 3. Once all the connections between the board and the off-board components have been made, mount the finished board in the enclosure. (The author used double-sided foam tape to accomplish that task in the prototype).

Before applying power to the circuit, make absolutely certain that all the circuit connections are insulated from the metal enclosure. Pay extra attention to the wire that connects between C1 and SO1; a shorted connection in that area could permanently damage your transceiver.

Hook-Up and Use. Figure 4 outlines how to properly insert the Scanner Silencer into your scanner/transceiver system. First attach a coaxial T-connector to SO1 of the Scanner Silencer as shown. Disconnect the antenna feedline from your transceiver and connect it instead to one of the female T-connector sockets. Then using a short coaxial jumper made of 50-ohm cable (such as RG58 or similar with PL-259 connectors on both ends), connect your transceiver to the empty T-connector socket. Next insert PL1 into the external speaker jack on your scanner and then plug an extension speaker into jack J1 on the Scanner Silencer.

With your scanner tuned to an active frequency, scanner audio should be heard through the extension speaker. Now connect the Scanner Silencer to a fused 12-volt DC source and key your transceiver; the scanner audio should be muted instantly. Now un-key your transceiver; scanner audio should once again be heard through the extension speaker. (When testing the project for proper operation, it is suggested that you use an RF dummy load in place of your transceiver's antenna so as not to create interference to others.

While the Scanner Silencer was intended to automatically mute a scanner, it can just as easily be used to automatically mute a portable radio while transmitting. Or, it could even be adapted for use as an on-the-air indicator. ■

THINK TANK

(Continued from page 26)

and it can turn on coffee-makers, lights, or even audio equipment. To make it work, you'll need an alarm clock that has an internal light that comes on when the alarm is activated. The supply voltage to the light from the clock should be around 8–10 volts.

Start by taking apart the alarm clock and splicing into the positive and negative supply of the light. By the way, it's not necessary to unhook the bulb. Hook the supply from the lamp to a power jack for which you have a mating plug.

Once the alarm clock turns on at the predetermined time, it sends a signal to the gate of the SCR, forcing it into conduction. The SCR completes the negative supply to K1, which turns on the appliance of choice. (Make sure that the SCR that you use can handle the relay's coil current.) Diode D1 shorts-out the spike voltage of the relay coil.

Switch S1 is a single-pole, single-throw, normally closed pushbutton switch that, when pressed, opens the circuit, stopping the SCR from conducting until another signal is present at the gate again. The alarm clock must be off to allow reset.

Switch S2 is a manual on/off switch for when you wish to use the appliance normally. Resistor R1 controls the gate current to the SCR. If the incoming signal from the lamp in the clock is higher than 10 volts, then increase R1. Device BR1 is a full-wave bridge rectifier, and C1 filters the DC ripple to stabilize the circuit, which never hurts.

Compare the relay-contact current rating to the appliance's current draw to insure safe operation. I used a heavy-duty relay and the circuit turns on a whole entertainment center for me in the morning!

—*Anthony C. Stonerock, Bellefontaine, OH*

I used to have my stereo on one of those motorized timers so it would wake me up in the morning. Of course, I didn't have the fun of building it, and it probably cost more than yours.

Interested readers, for safety, be sure to insulate any AC connections properly (with wire nuts, etc.) and mechanically secure all connections.

Well it's time for us to part again. Until next time, please write to *Think Tank*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. If your work appears here, a book will be your reward. ■

CIRCUIT CIRCUS

(Continued from page 83)

run, taking energy from the three charged capacitors. As the capacitors discharge, the three clocks begin to slow down producing the effect of the drums in a mechanical bandit slowing to a stop.

The 4017's ten output LED's may be numbered or designated as apples, cherries, bells, wild cards, or anything you like to make the game more interesting. Additional logic circuitry may be added to the 4017 outputs to sound an alert or turn on a light when any three numbers or output items match.

The three potentiometers, R12, R13, and R14, may be varied for each roll to change the clock's frequency and the roll rate.

That's all for now; see you next month. ■

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INTRODUCTION TO REACTANCE

(Continued from page 72)

tle more complex for parallel circuits. All the trigonometric functions previously mentioned are just as applicable to the parallel circuit, so long as care is taken to get the vectors drawn correctly in the first place. Mathematically, for Fig. 9A:

$$I = \sqrt{I_R^2 + I_L^2} \quad 1/Z = \sqrt{(1/R)^2 + (1/X_L)^2}$$

and for Fig. 9B:

$$I = \sqrt{I_R^2 + I_C^2} \quad 1/Z = \sqrt{(1/R)^2 + (1/X_C)^2}$$

Power. The power consumption of a purely resistive AC circuit is easy to determine: Simply calculate the product of the rms current and rms voltage to obtain average power. Figure 11A shows a graphical way in which instantaneous power consumption can be calculated by plotting current and voltage on the same axes and then performing successive multiplications to plot the power curve.

The same principle can be applied to the reactive circuit (see Fig. 11B). Recall that in a circuit containing just pure inductance, current lags voltage by 90 degrees. Plotting the power curve for this circuit yields an alternating waveform that is centered on zero. In other words, the net power consumption of an inductive circuit is nil.

That may seem a little confusing, so let's discuss why. During the positive portion of the waveform, the inductor takes energy and stores it in the form of a magnetic field. During the negative portions of the curve, the field collapses and the coil returns energy to the circuit. A similar situation occurs with pure capacitance, except that the capacitor stores energy as an electrostatic field and the current/voltage phase relationship is reversed.

As resistance is introduced to a circuit, the phase angle becomes less than 90 degrees and the power curve will shift to a more positive value, showing that the circuit is taking more energy than it is returning. However, the capacitive or inductive part of the circuit still stores and releases energy and consumes no power whatsoever—the power loss is due entirely to the resistance. Remember this basic rule: Only the resistive part of a circuit consumes power.

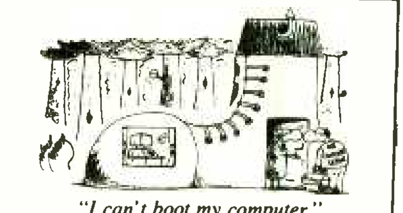
Take the circuit in Figure 11A as an example. Using the Pythagorean theorem, the resistance of 100 ohms and capacitive reactance of 50 ohms gives a combined impedance (Z) of approximately 112 ohms as follows:

$$\begin{aligned} Z &= \sqrt{100^2 + 50^2} \\ &= \sqrt{10{,}000 + 2500} \\ &= \sqrt{12{,}500} \\ &= 111.8 \end{aligned}$$

By Ohm's law, that would allow a current of about 1 amp to flow in the circuit. The voltage drop across the resistor will be 100 volts, so the "true power" dissipated by that resistor will be 100 watts.

We know that the capacitive part of the circuit consumes no power, and yet multiplying the source voltage by circuit current yields an answer of 112 watts. The difference is accounted for, once again, by the difference in phase between the various voltages. As opposed to true power, the figure obtained by multiplying the source voltage and current is known as "apparent power," and it is specified as 112VA or 112 volt-amperes. The true power of the circuit can never be greater than the apparent power, and the ratio of true power in watts to apparent power in volt-amps is called the power factor.

A vector diagram can again be used to analyze the power factor. If the phase angle of the circuit is known, the power factor can be calculated directly by taking the cosine of that angle. In the circuit shown, that figure is the same as the ratio of E_R to source voltage. There are always several ways to obtain the power factor, depending upon the available data. In a purely resistive circuit, the true power is the same as the apparent power, so the power factor is 1. In a purely inductive or capacitive circuit the true power is 0, no matter what the apparent power, so the power factor is 0. Power factor is a very important consideration in heavy industrial power distribution, since cables must be able to handle the apparent-power load. ■



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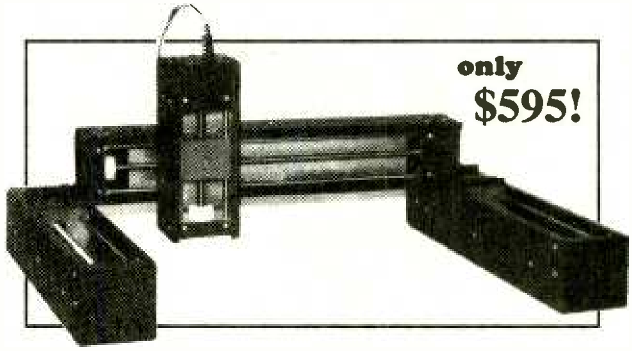

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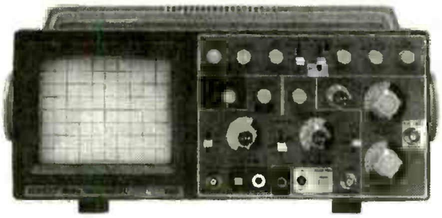

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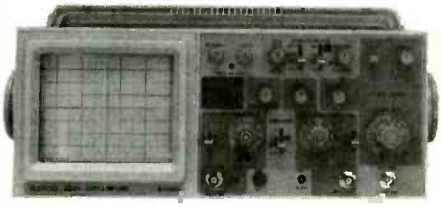

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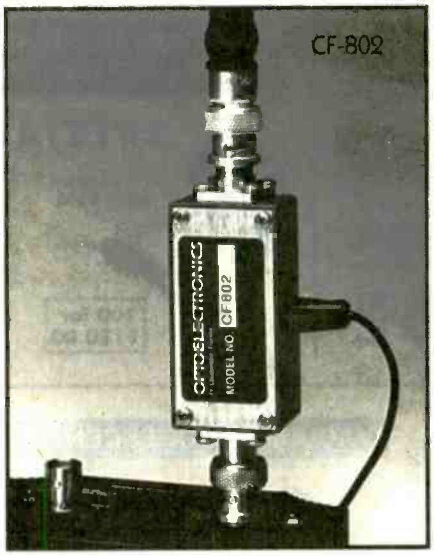

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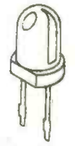

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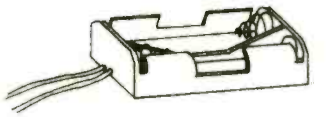

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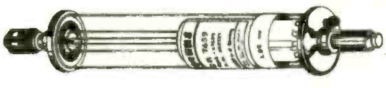
Siemens# LGR 7659



1 mW helium-neon laser tube. 22.5 mm diameter X 146 mm long. 1.7 mrad beam divergence.
7 kV start voltage.
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3.5 mA current.

CAT# LT-1

$25.00 each

4 POSITION SCREW CLAMP TERMINAL STRIP

Four position, dual screw terminal strip for surface mounting. Screw-clamp terminals accept up to AWG 16 wire. Black thermoplastic housing. UL listed. Terminals and mounting holes are on

CAT# TER-41

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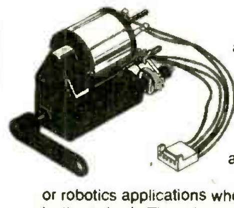
12 Vdc 90 DEGREE GEAR MOTOR

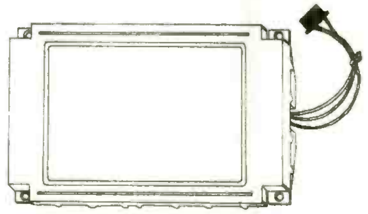


Originally built for electric automobile mirror adjusters, these small 12 vdc gear motor assemblies have quite a bit of torque. Though they only rotate 90 degrees at a rate of about 1 RPM, they could be quite useful for animation or robotics applications where 360 degree rotation isn't required. There is also a variable resistor attached to the back of the shaft which was used as a position sensor. The overall dimensions of the assembly are 1.95" X 1.25." Attached to the 1/8" diameter final drive shaft is a 1.92"

CAT# DCM-49

$6.00 each

640 X 480 LCD DISPLAY



Sharp # LM64P70
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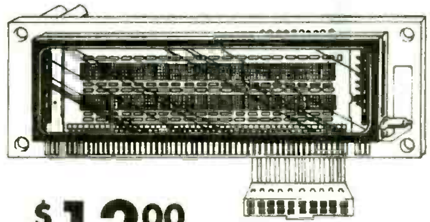
These displays were modified somewhat from original specifications and we do not know the exact nature of the modifications. They work fine in the test mode, but we don't know if the original interface is the same. We supply a data/ hook-up sheet for the pre-modified device which, hopefully, provides most of the information necessary to use the display.



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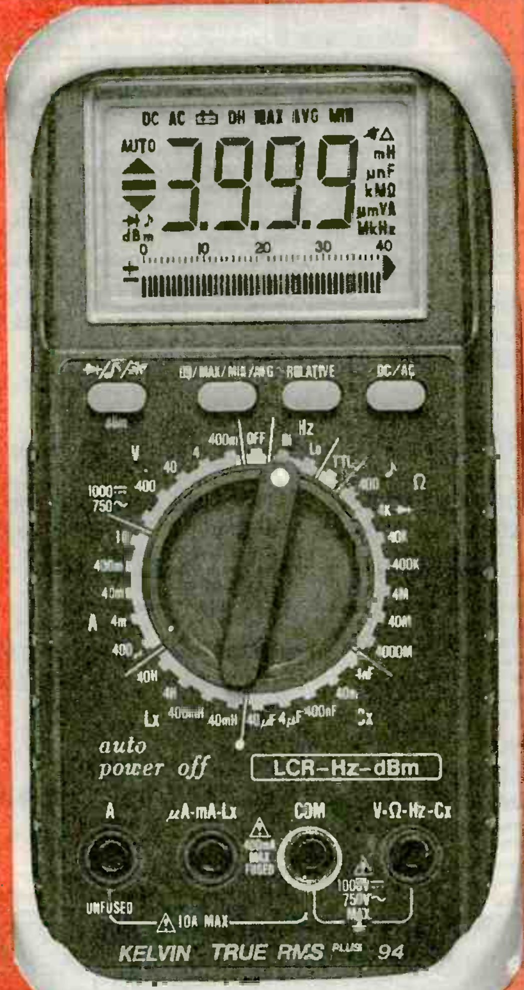

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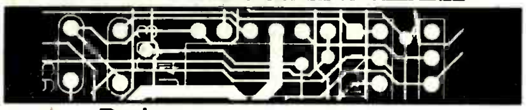

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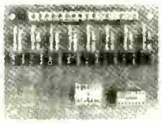

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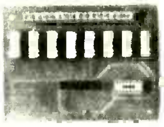

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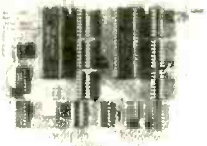

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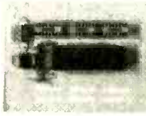

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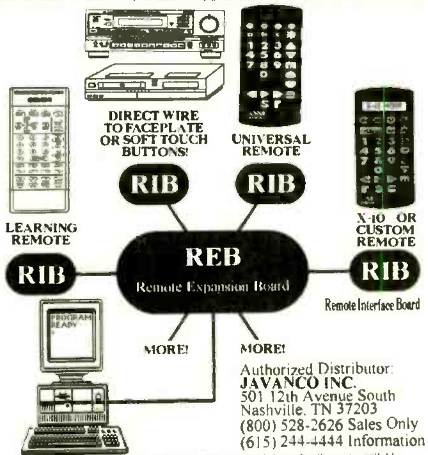

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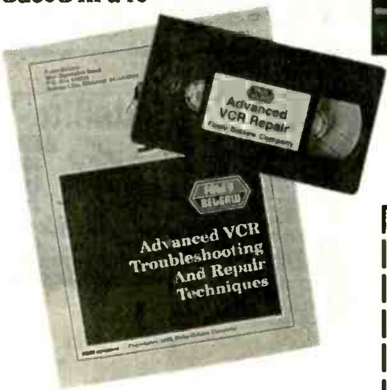

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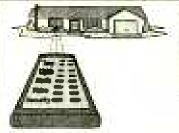

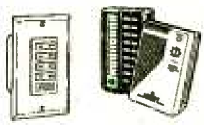

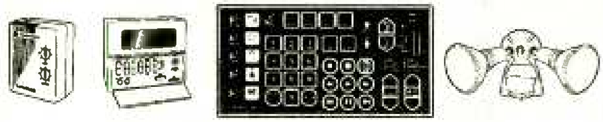

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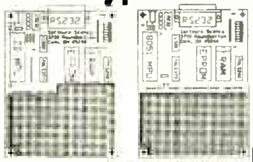

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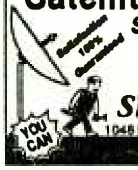

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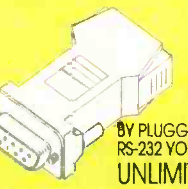

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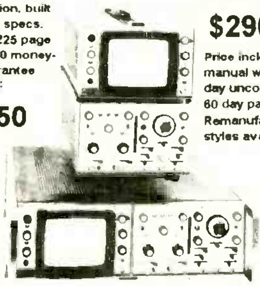

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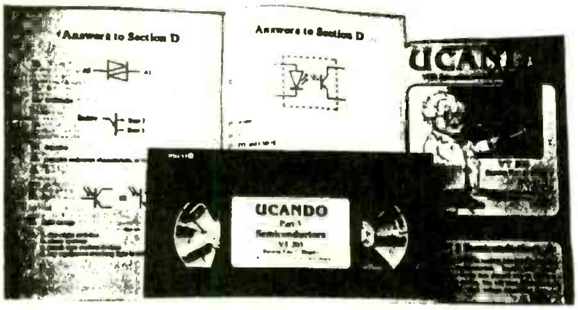

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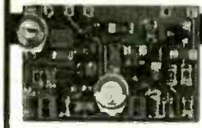

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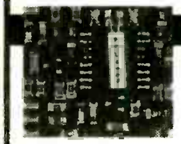

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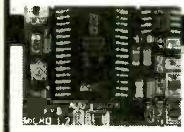

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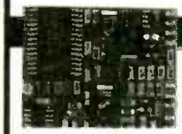

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Leadership in electronics is not just a matter of designing products better and manufacturing them better, but also of marketing them better. And the sponsors of this message understand that better service to customers requires effectively involving distributors as part of their marketing teams.

Distributor involvement means lower prices, quicker deliveries, better service over-all. The Buyer wins...the Seller wins.

Distributors help achieve marketing leadership. So does the manufacturer's involvement in the Components Group of the Electronic Industries Association. EIA fosters better industry relations, coherent industry standards, and the sharing of ideas, which helps one another and serves customers better.

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HAVE YOUR VISA or MC CARD AVAILABLE

Wake up! You may be the victim of stolen words—precious ideas that would have made you very wealthy! Yes, professionals, even rank amateurs, may be listening to your most private conversations.

Wake up! If you are not the victim, then you are surrounded by countless victims who need your help if you know how to discover telephone taps, locate bugs, or "sweep" a room clean.

There is a thriving professional service steeped in high-tech techniques that you can become a part of! But first, you must know and understand Countersurveilance Technology. Your very first insight into this highly rewarding field is made possible by a video VHS presentation that you cannot view on broadcast television, satellite, or cable. It presents an informative program prepared by professionals in the field who know their industry, its techniques, kinks and loopholes. Men who can tell you more in 45 minutes in a straightforward, exclusive talk than was ever attempted before.

Foiling Information Thieves

Discover the targets professional snoopers seek out! The prey are stock brokers, arbitrage firms, manufacturers, high-tech companies, any competitive industry, or even small businnesses in the same community. The valuable information they filch may be marketing strategies, customer lists, product formulas, manufacturing techniques, even advertising plans. Information thieves eavesdrop on court decisions, bidding information, financial data. The list is unlimited in the mind of man—especially if he is a thief!

You know that the Russians secretly installed countless microphones in the concrete work of the American Embassy building in Moscow. They converted what was to be an embassy and private residence into the most sophisticated recording studio the world had ever known. The building had to be torn down in order to remove all the bugs.

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.

CLAGGK INC. PE
P.O. Box 4099 • Farmingdale, NY 11735

Please rush my copy of the Countersurveillance Techniques Video VHS Cassette for a total cost of $53.95 each (which includes $4.00 postage and handling)

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The professional discussions seen on the TV screen in your home reveals how to detect and disable wiretaps, midget radio-frequency transmitters, and other bugs, plus when to use disinformation to confuse the unwanted listener, and the technique of voice scrambling telephone communications. In fact, do you know how to look for a bug, where to look for a bug, and what to do when you find it?

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.

The Dollars You Save

To obtain the information contained in the video VHS cassette, you would attend a professional seminar costing $350-750 and possibly pay hundreds of dollars more if you had to travel to a distant city to attend. Now, for only $49.95 (plus $4.00 P&H) you can view ***Countersurveillance Techniques*** at home and take refresher views often. To obtain your copy, complete the coupon or call.